NARIVA SWAMP
DEVELOPMENT PROJECT
TRINIDAD AND TOBAGO

FEASIBILITY REPORT

APPENDICES

MARCH 1970

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

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General Economy

Background

Location and Climate

Location

Trinidad and Tobago emerged independent in 1962. The Trinidad island is 1,864 square miles in width, averaging 50 miles in length and 37 miles in breadth. It is located very close to the South American Continent or faced to Venezuela, and the shortest distance between the both is measured only at 7 miles. On the other hand, the Tobago island is 116 square miles width, located 20 miles in the east-north of the Trinidad island (Exhibit A-1).

Climate

Precipitation of Trinidad fluctuates according to locality. In regard to annual precipitation, it presents 35 to 66 inches at the light rain areas and 86 to 157 inches at the heavy rain areas. From January to April lasts the dry season at the both areas, and for the period is the monthly precipitation often less than 3 inches. There is not large fluctuation of the temperature in the areas, and the monthly mean of daily maximum tempeature is 90° Fahrenheit in February. The climate of Tobago is as much as that of Trinidad, but the temperature of Tobago tends to be somewhat lower than that of Trinidad subject to the sea breezes to the island. Hurricanes hardly attack Trinidad, but occasionally attack Tobago. In 1963, the Hurricane Flora attacked and caused considerable damage to the Tobago island.

Population and Labor

Population

The population in 1966 is estimated at 950,000 in Trinidad, and at 35,000 in Tobago, totaling 985,000. The population density of the said year is 497 persons per square mile. The natural increase rate of the population from 1946 to 1966 is 2.8 percent each year, relatively high. On the other hand, migration from the islands is found considerably large, 5,140 persons in 1966, and, according to Budget Speech 1969[1/], about 11,000 persons on an average migrated from the country during a year, July of 1967 to June of 1968.

Labor Force

The structural transition of the labor force classes according to the industrial fields of Trinidad and Tobago is shown in Table A-1. The labor force of Trinidad and Tobago, 15 to 54 in age, accounts for about 49 percent of the whole population, but practically only 75 percent of the labor force engages in economically productive activities. About 20 percent of them works in agricultural fields including foresty, hunting and fishery.

Economic Aspects

Gross domestic product (G.D.P.) in Trinidad and Tobago showed an increase of 10 percent in a year 1950. In the initial part of 1960's the annual increase got down to 3.5 percent because the investment to petroleum refinement industry and the increase rate of the petroleum products showed diminished. In recent, however, it has recovered the increase rate again, attaining 6 to 7 percent annually for the period 1963 to 1968, and the composition of each industry in G.D.P. from 1963

1/ Dr. Eric Williams, P.C. Budget Speech. Trinidad and Tobago, 1968.

to 1968 are shown in Table A-2. For this period, the increase rate is 7.4 percent each year, which is relatively high. On the other hand, G.D.P. per capita increases from TT$1,164 of 1963, to TT$1,610 of 1968, averaging the growth rate of 5.4 percent.

Index of retail price has risen by 21 percent at the end of 1967, comparing with that of September 1960, and further the tendency of increase has been going higher in recent. Wage rate during the said period, moreover, became doubled. Unemployees account for 14 percent of the labor population and the under employment for 25 to 40 percent of the labor population. The foreign exchange reserves are expected to be TT$165 million (US$82.5 million) in December 1968, according to I.B.I.D.[1/]

Land Utilization

Total area of Trinidad and Tobago is 1,980 square miles (approximately 1,267,000 acres), of which 6.0 percent or 74,000 acres are measured of Tobago island. Crop fields and pastures account for about 29 percent of the total area. About 50 percent of the total area is the forest zone and its secondary, so that crops and pasture area are respectavely very small, about 0.37 acres per capita. The area the Government owns is about 571,000 acres, 95 percent of which is covered with the forests and the secondary. In the area, 100,000 acres are favorable for agricultural development.

Production of Agricultural Commodity

Agriculture of Trinidad and Tobago including forestry and fishery occupies only a small portion among the entire economic structure of the country. In spite of an increase of the absolute quantity of agricultural products, agriculture has contributed to the Gross National

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1/ Government of Trinidad and Tobago, Third Five-Year Plan, 1969-1973 (Draft). Trinidad: Government Printery, p. 37.

Proruct (G.N.P.) with the decrease rate from 17 percent to 8 percent for the period 1953 to 1968 respectively. Main products for exports include sugar, cocoa, fruit, coffee, banana and coconut. Sugar exports account for 33 percent and cocoa 8 percent of agricultural products. In addition to those products for export, around and suburbs of cities are vegetables farmed in a relatively small scale. Sugar, coconut and fruits are single crops which are cultivated in a large scale, and the products account for two thirds of the entire products. The rest is cultivated in small-sized farms. Farmers who own less than 20 acres are considered to account for approximately 90 percent of the entire farmers, and generally productivity of such farmers is low.

Most of the livestock are raised on the small-sized farms, and the dairy farming is going on the starting stage. Dairy cattle being raised are considered 15,000 heads, of which 80 percent are raised by farmers who own less than 4 heads. On the other hand, the first filial generation and the purebred being raised are not more than 1,500 heads. Although no reliable data are found available, milk produced in the country is considered only to be supplied as much as tenth of the demand. The rest of the demand is supplied by annual imports of raw milk in 22 million gallons worth TT$14 million including the converted quantity of cheese and butter products. The total products of beef are considered nearly 2.6 million pounds, of which rather large quantity is supplied with water buffalo (estimated about 4,000 heads). Approximately 18.0 million pounds of meat (beaf and pork) worth TT$9.5 million are imported every year. In the last three years, importing of chicken of estimated 10.0 million pounds over in a year has been substituted to producing that in the country. The products of pork are still extremely small, 2 million pounds in a year.

Markets and Transportation

In Trinidad and Tobago, petro-chemical industry is so flourish that a great deal of by-product, asphalt, is obtainable, by which whole roads are well paved over the country. Therefore the transportation of materials are conducted promptly through this road system.

Port of Spain, the capital of Trinidad and Tobago, and San Fernando, the second largest city, where 134,000 population inhabits, take a role as the markets for the agricultural products. Further, agencies of the Central Market are distributed all over the country, not only controlling the wholesale and retail market, but also functioning the production adjustment through the Support Prices1/ for prevention of the overproduction.

Foreign Trade

The composition of imports and exports of Trinidad and Tobago in 1966 are illustrated on Exhibit A-2. As the Exhibit shows, petroleum and its productions take a great role in the relationship of imports and exports of Trinidad and Tobago. That is to say, both account for 50 percent in the import and 80 percent in the exports.

On the other hand, in regard to the exports and imports of food which would represent the agricultural products of this country, it shares the imports at a rate of 12 percent, ranking the fourth, whereas export at a rate of 8 percent, ranking the third. The exports and imports status of the representative agricultural products, including the livestock division, are illustrated in Table A-3. It shows that sugar, cocoa and grape fruits account for the most part of the exports, and the milk and cream, rice, wheat, flour, meat, and feeding stuff in order, are included in the imports. In reference, the import status of meat and feeding stuff from 1962 to 1966 are shown in Table A-4. Excluding the crude petroleum for refinement, food imports composes a fourth of the entire amount of the imports. Therefore, the increased agricultural products in the plan would be the substitutes for the imports in the relatively large portion.

The balance of imports and exports of this country was maintained well in the past several years, but since 1963 the country has shown prone to exceed the imports over the exports every year. Above all, in 1965 the

1/ Guaranteed Prices and Contract Prices.

export amount was TT$690.4 million against the import amount, TT$817 million, exceeding by TT$126.6 million (Exhibit A-3).

Further, the balance of foreign trade of the agricultural products, represented by food, is shown on Exhibit A-4. According to this Exhibit, the imports of Trinidad and Tobago increase, proportionated to the steady increase of the population and the economic development, while the exports have decreased since 1963 when the exports were at the peak point, and in 1966 the excess of imports over the exports amounted to TT$33 million.

Basic Objective of Agricultural Policy

As stated in regard to the Second Five-Year Plan (1964 - 1968), the basic objective of the Trinidad agricultural policy is to modernize agriculture and to multiply agricultural products, in order to decrease the conventional export crops such as sugar cane, coconut and grape-fruit to supply most of the food demand with the national products such as paddy rice, maize and soybean. As there is no trouble between the policy of national agricultural promotion and the encouragement of the production of the export products, the Government of Trinidad and Tobago intends to pursue this political objective for the entire period of the Third Five-Year Plan as stated in the scheme. There by, further as stated in Appendix, by the promotion of the Crown Lands Project, the establishment of dairy, hog raising, fruit and vegetable cultivation and tabacco farming are coming in practice. Therefore, for the development of the Nariva Swamp, the crops employed are suggested to be paddy rice, soybean and corn, and raise beef-cattle, in view of the abovementioned status and the international view stated below. For further references, Table A-5 is presented on the prospect of import substitution which could account for a portion in the actual result of major food-and feed imports in 1967 in the period of the Third Five-Year Plan.

International Environment

As the national economy of Trinidad and Tobago depends upon the trades in regard to petroleum and its products, the international relationship with the trading countries is necessary to be studied on.

Population and Paddy Production

The population, the GDP and the products of paddy in countries, as Guayana, Surinam, West Indies and Puerto Rico commercially and geologically related to Trinidad and Tobago, are shown in Table A-6.

Exports and Imports

The import items of agricultural products of Trinidad and Tobago in 1966, main importing countries, the export items, and the main exporting countries are shown in Table A-7, and the imports of meat are presented in Table A-8. The countries with which Trinidad and Tobago has the close relationship are United Kingdom, Canada, U.S.A., Guyana, and New Zealand.

Furthermore, the trade status with both Buyana and Surinam in 1966 are shown in Table A-9.

Rice Production in Guyana and Surinam

The arable land in Guyana is 2,750,000 acres about two times as much as Trinidad and Tobago's and 1,000,000 acres wide is the cultivated land at present, of which 350,000 acres has irrigation and drainage facilities. By establishment of the irrigation and drainage system, the arable land is expected to increase by 1,500,000 acres.

The Black Bush Polder Project completed in 1961 is a good model for the Nariva Swamp Development Project. The gross area is 31,000 acres wide, the irrigation and drainage area is 23,500 acres wide, and 1,500 households are settled to compose the gathered type settlement. Allotment for each family is;

15 acres + 2 acres + 1/2 acre

The area of 15 acres is for paddy field, 1/2 is for domestic uses such as resident lot and self-supply vegetable farm, and 2 acres for the intensive cultivation.

For the reference, in the area of 9,900 acres for the Mahaicony Abary Scheme[1/], tractors and combines are used as a pilot farm scheme for mechanization.

Surinam

Paddy fields in 1956 was 63,000 acres wide, the production of rice was 157 million pounds, and the unit yield is 2,550 pounds/acre, among which the production worth TT$1.82 million was exported. Wageningen Project was financed and conducted by Dutch Government during 1949 to 1957, and the effective area was 14,800 acres wide. The polder by the project was designed for forming gross area of nearly 200 acres covered with the drainage and irrigation system. The 200 acreage was sectioned into 6 paddy fields, each of which had approximately 660 x 220 yards, and the field was provided with irrigation and drainage system.

The growth period for principal species of paddy is April to September. The growth season of the second crop of paddy is October to March and the cultivated area for this is a fourth of the paddy fields. Direct drilling is applied for the paddy cultivation, and the farming area is estimated 500 to 1,500 acres wide, and the species of Dima, Nisherie, and 80/5 are adopted.[2/]

1/ Mexico City, Seventh Congress on Irrigation and Drainage Communications, C.1 - C.19

2/ The Wageningen Rice Project in Surinam, and A Study on the Development of a mechanized Rice Farming Project in the Wet Tropics.

Rice Agreement with Guyana

The following treatment was contracted between the Honourable John O'Halloran, Minister of Industry and Commerce, Trinidad and Tobago, for and on behalf of the Government of Trinidad and Tobago of the One Part and Dr. the Honourable Ptolemy A. Reid, Minister of Finance, Guyana, for and on behalf of the Government of Guyana of the Other Part, in 1968.[1/]

WHEREAS It is mutually desirable that there should be the greatest possible trade between Trinidad and Tobago and Guyana,

AND WHEREAS in accordance with this desire it is considered appropriate to enter into an Agreement providing for the supply of rice by Guyana to Trinidad and Tobago at a reasonable price in quantities sufficient to meet any deficiencies of supplies therein,

AND WHEREAS the said Ministry of Industry and Commerce, Trinidad and Tobago and the said Minister of Finance, Guyana, have been duly authorized by their respective Government to enter into this Agreement,

It is hereby Agreed by and Between the Parties Hereto as Follows

1. Subject to the provisions of this Agreement, Guyana shall supply from production within its own territory and Trinidad and Tobago shall purchase all the rice required to be imported into Trinidad and Tobago to make good any such deficiencies as aforesaid during the currency of this Agreement for local consumption in such quantities with regard to the various grades or qualities as may be required from time to time, save and except a quantity not exceeding 2,500 tons annually of white

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1/ Trinidad and Tobago, Rice Agreement Between Trinidad and Tobago and Guyana, 1968.

rice, which shall be supplied by the Government of Surinam, in accordance with the terms of an Agreement entered into in 1963 between the Government of Trinidad and Tobago and the Government of Surinam, provided however that Trinidad and Tobago may take any quantity of its rice requirements as is found necessary in the form of paddy.

2. In the event of Guyana being unable through any cause whatsoever to supply the quality or grade or the quantity of any quality or grades of rice required by Trinidad and Togabo, that part of the requirement of Trinidad and Tobago which cannot be supplied by Guyana may be imported by Trinidad and Tobago from any other source.

3. Guyana shall not sell or export rice to any country or place unless and untill full provision has first been made to meet the annual estimates of the requirements of Trinidad and Tobago for its local consumption pursuant to the provisions of Clause (5) of this Agreement.

4. - Omitted -

5. - Omitted -

6. - Omitted -

7. (i) The price of all rice sold under this Agreement shall be as follows:

(a) FIRST QUALITY RICE: Up to the 31st December, 1968, the price F.O.B. per bag of 180 pounds gross shall be $23.25;

(b) SECOND QUALITY RICE: Up to the 31st December, 1968, the price F.O.B. per bag of 180 pounds gross shall be $21.00;

(c) PACKAGED RICE: Up to 31st December, 1968, the prices of Packaged Rice shall be as follows:

INDIAN MAID: $11.53 per sack of 60 pounds (containing 30 x 2 pounds polythene bags);

N-RICH: $9.75 per sack of 60 pounds (containing 30 x 2 pounds polythene bags);

PEARL BRAND: $12.25 per sack of 60 pounds (containing 30 x 2 pounds polythene bags);

MILLER'S CHOISE: $5.26 per carton of 25 x 1 pound Kraft bags. 25 pounds container sacks of any of the above-mentioned qualities.

(ii) The contracting parties hereto shall within the last quarter of 1968 and the last quarter of each year thereafter during the currency of this Agreement re-examine the question of the price or prices to be paid for all rice for the ensuring year commencing on the 1st January and fix same by Agreement and in default of Agreement the price or prices shall be fixed by arbitration as provided for in Clause (11) herein.

8. - Omitted -

9. The contracting parties undertake to make such legislation and other provision as may be required to given effect to the provisions of this Agreement.

10. - Omitted -

11. All questions or differences whatsoever which may at any time during the continuance of this Agreement arise between the contracting parties touching or concerning this Agreement or the subject matter thereof or arising out of or inrelation thereto respectively and whether as to construction or otherwise, shall be referred to a single arbitrator in case the contracting parties can agree upon one, otherwise to two arbitrators one to be appointed by each of the contracting parties or to an umpire

to be appointed by such arbitrators before proceeding in the reference. The matter in dispute shall be decided and the arbitration shall be conducted in all respects according to the Law of England and this clause shall be deemed to be a submission to arbitration within the provisions of the Arbitration Act 1950, of the United Kingdom or any statutory modification or re-enactment thereof for the time being in force.

12. This Agreement shall be for a period of three years from 1st January, 1968, until 31st December, 1970, inclusive, provided, however, that the contracting parties, shall in the last quarter of 1968, examine the operation of the Agreement and may then extend the Agreement for such period or periods subject to such modifications and/or alternations and variations as may then be agreed upon.

13. All communications and notices intend for the Minister of Industry and Commerce, Trinidad and Tobago, shall be deemed to be properly and sufficiently served if delivered at or forwarded by registered post to the office of the Minister of Industry and Commerce, Trinidad and Tobago, in Port of Spain, and all communications and notices intended or the Government of Guyana shall be deemed to be properly served if delivered at or forwarded by registered post to the Minister of Finance, Georgetown, Guyana.1/

1/ $ indicates the Trinidad and Tobago dollar.

Table A-1

Component of Labour Force

	Total All (Industry)	Agriculture Forestry Hunting Fishery	Mining Quarrying and Manu-facturing	Construction (including Electricity, Gas & Water)	Co-mmerce	Transport and Communi-cation	Survices	Never Worked
30,6.1966	351,500	71,200	63,200	47,000	56,000	24,300	79,900	9,800
(%)	100	20	18	13	16	7	23	3
31,12.1966	350,600	66,200	70,200	46,600	54,400	23,400	78,300	11,400
(%)	100	19	20	13	16	7	22	3
30,6.1967	3682,00	72,800	71,100	49,700	54,200	26,300	85,500	8,600
(%)	100	20	19	14	15	7	23	2
31,12.1967 1/	363,700	73,700	71,200	48,500	54,100	24,600	81,800	9,800
(%)	100	20	20	13	15	7	22	3

Source: Quarterly Economic Report Oct. - Dec. 1968

Note: 1/ Revised

Table A-2

Composition of the G.D.P. at Factor Cost
1963 - 1968

(T. T. current dollar prices)

	1963		1964		1965		1966		1967		1968	
	$m.	%	$m.	%	$m.	%	$m.	%	$m.	%	$m.	%
Agriculture Forests & Fisheries & Quarrying	115.7	10.8	111.8	9.9	105.5	9.0	107.3	8.4	111.6	8.1	127.0	8.2
Mining and refining of Petroleum and Gas	296.9	27.6	301.0	26.5	284.1	24.2	313.6	24.4	350.4	25.4	379.0	24.6
Manufacturing	141.7	13.2	161.8	14.3	179.2	15.2	198.4	15.4	218.6	15.7	269.9	17.5
Construction	64.4	6.0	57.3	5.1	58.6	5.0	56.2	4.4	53.2	3.8		
Transport and Distribution	175.9	16.3	193.0	17.0	211.7	18.0	235.2	18.3	240.8	17.5	273.0	17.7
Public Utilities	43.8	4.1	53.5	4.7	64.9	5.5	73.0	5.7	72.5	5.3	89.0	5.8
Government	104.3	9.7	115.2	10.2	118.6	10.1	132.4	10.3	149.6	10.9	162.0	10.5
Ownership of dwellings	42.3	3.9	44.3	3.9	47.3	4.0	49.9	3.9	53.7	3.9	54.5	3.5
Banking and Finance	34.7	3.2	37.6	3.3	39.4	3.4	46.2	3.6	47.3	3.4	47.0	3.0
Other Services	56.4	5.2	58.5	5.2	66.6	5.7	72.7	5.7	80.2	5.8	83.7	5.4
Total	1076.1		1134.0		1175.9		1284.9		1377.9		1543.2	

Source: Draft Third Five-Year Plan 1969 - 1973 P.23

Table A-3

Export and Import of Agricultural Products 1966

Export

S.I.T.C. Group No.	Agricultural Products	Quantity (in 000 lb.)	Value (in 000 $)	Supplement Unit Price (F.O.B) TT¢/lb.
061	Sugar	541,577	38,031	7.0
072	Cocoa	10,564	4,264	40.4
051	Grape fruit	11,068	757	6.8
051	Oranges	3,151	201	6.4
051	Limes, fresh	8	1	12.5
(292)	Tonca Beans	233	172	73.8
(231)	Rubber raw	-	-	-
071	Coffee raw	5,320	2,709	50.9
051	Coconuts	1	-	-
221	Copra	-	-	-

Import

S.I.T.C. Group No.	Agricultural Products	Quantity (in 000 lb.)	Value (in 000 $)	Supplement Unit price (C.I.F.) TT¢/lb.
011	Meat	11,090	7,156	64.5
022	Milk & Cream	23,941	9,950	41.6
023	Butter	4,276	3,374	78.9
041	Wheat (unmilled)	69,293	4,259	6.1
042	Rice	69,796	9,292	13.3
044	Maize (unmilled)	66,654	3,946	5.9
046	Wheat flour	85,362	8,979	10.5
054	vegetables	57,481	5,941	10.3
081	Feeding Stuff	50,041	6,026	12.0
121 (122)	Tobacco	1,605	2,332	145.3

Note: Overseas Trade 1966
Annual Statistical Digest 1967

Table A-4

Import of Meat and Feeding Stuff (1962 - 1966)

Commodity		T.T.$1,000			
	1962	1963	1964	1965	1966
Import					
011 Meat (fresh, chilled or frozen)	8,002.3	8,468.2	8,829.3	6,934.8	7,156.0
021 Milk and cream (fresh and sour)	363.8	357.8	203.7	4.0	16.1
TOTAL	8,366.1	8,826.0	9,033.0	6,938.8	7,172.1
081 Feeding stuff for animals (not including unmilled cereals)	4,556.0	4,502.4	4,736.9	6,300.1	6,025.8
043 Barley unmilled	2.5	2.4	1.1	1.5	2.7
044 Maize unmilled	1,420.2	2,083.6	3,041.2	4,319.6	3,946.1
045 Cereals unmilled	282.0	266.4	344.0	256.6	265.4
TOTAL	6,260.7	6,854.8	8,123.2	10,877.8	10,006.0

Table A-5

Import Substitution of Major Food and Feed
(1 9 6 7)

Item	Million T.T.$	Prospects for Import Substitution
Wheat and Flour	11.5	None - domestic milling could be increased
Rice	8.0	Modest - production cost higher than Guiana
Pork, Bacon and Ham	5.5	Very substantial - Recently added negative list
Beef and Mutton	4.1	Very small
Evaporated & Condenced Milk	2.0	Substantial
Dried milk	6.1	(Minor, if any, Fluid milk
Butter	3.0	Too expensive to permit
Cheese	1.9	Production of these products at competitive prices)
Hatching Eggs	1.2	Substantial
Salt & Dried Fish	2.1	(minor in near future)
Canned Fish	1.2	(Eventually good prospects through Commercial Fishing.)
Vegetable Oils	1.5	Moderate
Animal Fats & Oils	1.3	Very little
Tea. Spices, Extracts	1.9	None
Dry Beans and Peas	1.9	Moderate - With some change in Consumer tastes
White Potatoes	1.3	None
Maize for livestock Feeds	4.1	(Negligible in immediate future Some ultimate potential for domestic production.)
Prepared Animal Feeds	4.7	
Soya and Linseed Meal	1.3	
Deciduous Fruits, Fresh Dryed, canned	1.6	Minor

Table A-6

Population and Paddy Production

Country	Population Midyear estimates 1966 (in thousands)	Area (km^2)	Density (persons/ km^2)	Annual Rate of increase 1963 - 66 (%)	GDP in 1966(8) at factor cost (millions of US$)	National(8) Income per capita 1966 (US$)	Paddy Production 1966 (6) 1,000 metric ton	Price(11) Paddy US$/100 kg
Trinidad & Tobago	995(2)	5,128	194	2.7	718	541	10(11)	9.00
Guyana	662(3)	214,969	3	2.7	209	273	294	
Surinam	350(4)	163,265	2	3.5	115(7)	278(7)	112	4.24
West Indies(1)	2,289(5)	14,895	153(5)		853(4)	374(9)		
Puerto Rico	2,668(3)	8,997	300	1.9	3,204	1,040		

Note: (1) Refer to "A Digest of West Indian Agricultural Statistics" excluding Trinidad & Tobago

(2) Refer to "Population and Vital Statistics 1966 Report"

(3) Provisional

(4) United Nation estimate

(5) 1960

(6) Refer to "Statistical Yearbook 1967" United Nations

(7) Figure in 1963

(8) Figure in 1961

(9) GDP in 1961 per capita

(10) 1965

(11) Refer to "the State of Food and Agriculture 1966"

Table A-7

Export and Import
(1 9 6 6)

Import

S.I.T.C. Group No.		Value (1,000$)	Principal Supplying Countries	Value (1,000$)
011	Meat	7,156.0	New Zealand	4,170.2
			Australia	1,860.6
023	Butter	3,373.8	New Zealand	1,693.9
			Norway	725.5
041	Wheat	4,259.2	U.S.A.	4,258.5
042	Rice	9,291.9	Guyana	8,645.3
044	Maize	3,946.1	U.S.A.	3,348.1
046	Wheat Flour	8,979.2	Canada	6,580.6
			U.S.A.	1,354.3
054	Vegetable	5,941.4	Canada	2,785.2
			U.S.A.	1,087.3
081	Feeding Stuff	6,025.8	U.S.A.	3,909.6
			Canada	1,776.5

Export

S.I.T.C. Group No.		Value (1,000$)	Principal Receiving Countries	Value (1,000$)
061	Sugar	38,032.5	United Kingdom	28,847.4
			Canada	4,068.9
072	Cocoa	4,347.9	U.S.A.	1,728.8
			United Kingdom	1,268.8
313	Petroleum products	485,701.3	U.S.A.	185,282.9
			United Kingdom	54,776.0
			Sweden	43,867.1
561	Fertilizer	11,591.3	U.S.A.	2,563.4
			Guyana	1,348.0
			Brazil	1,169.3

Table A-8

Import of Meat
(1966)

S.I.T.C. Group No.	Quantity (lbs)	Value (TT$)	Unit Price (C.I.F.) (TT$/lbs)
011 [fresh, frozen]	11,089,934	7,156,414	0.65
012 [preserved meat not canned]	5,810,024	3,758,246	0.65
013 [canned meat and preparations]	4,968,648	3,335,022	0.67

S.I.T.C. Group No.	Principal Supply Countries	Quantity (lbs)	Value (TT$)	Unit Price (C.I.F.)
011 [fresh, frozen]	New Zealand	6,194,941	4,170,185	0.67
	Australia	2,671,632	1,860,646	0.70
	U.S.A.	1,385,899	788,095	0.57
012 [preserved meat not canned]	Canada	2,632,678	1,668,967	0.63
	U.S.A.	2,611,006	1,765,761	0.68
013 [Canned meat and preparations]	Denmark	2,141,540	1,485,925	0.70
	Canada	921,422	456,121	0.50
	Argentina	832,716	618,642	0.74

Table A-9

Trede with Guyana and Surinum

Trade with Guyana in 1966

Import

		($1,000)
Total Value of Import		10,016.6
042	Rice	8,645.3
541	Medicinal products	287.0
552	Perfumery, cosmetic, soaps	266.6
	Others	817.7

Export

Total Value of Export		18,597.8
313	Petroleum products	11,981.1
661	Building materials	1,615.3
561	Manufactured fertilizers	1,348.0
699	Metal manufactures, n.e.s.	506.5
	Others	3,146.9

Trade with Surinam and Netherland Antilles in 1966

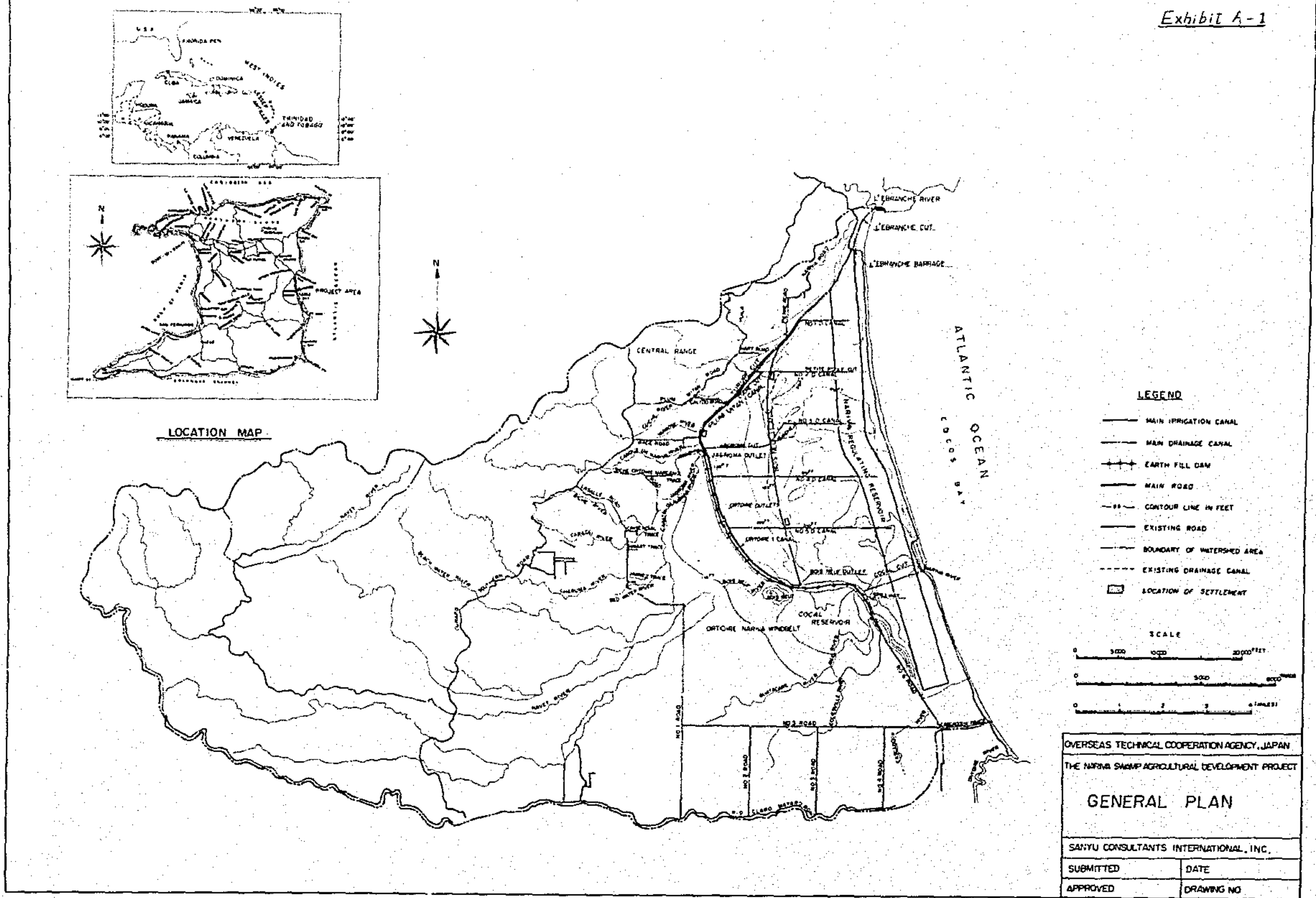
Import

		($1,000)
Total Value of Imports		1,671.7
042	Rice	645.3
631	Veneers, plywood, etc.	308.5
313	Petrolum products	297.8
	Others	420.1

Export

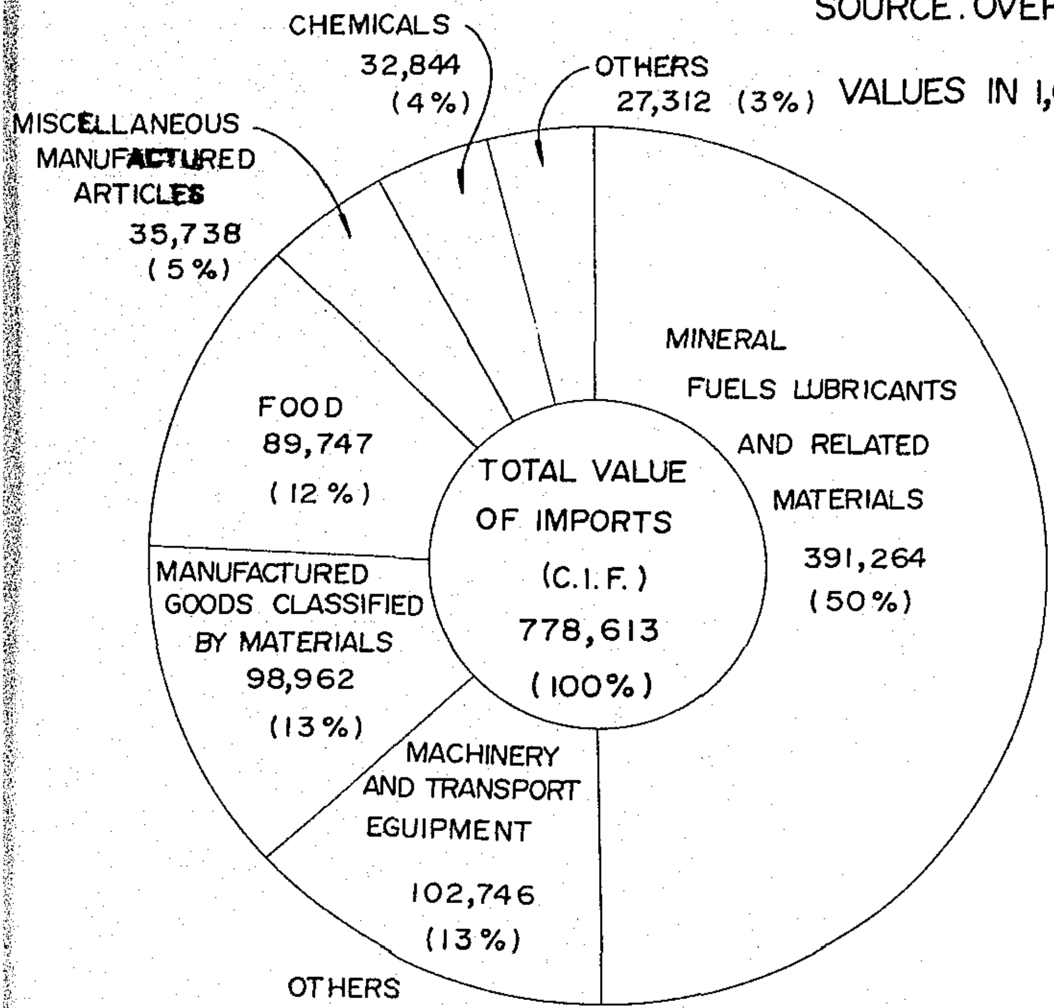
Total Value of Export		22,769.3
313	Petroleum products	21,132.7
931	Returned goods, other transaction	349.9
721	Electric machinery	213.8
	Others	1,072.9

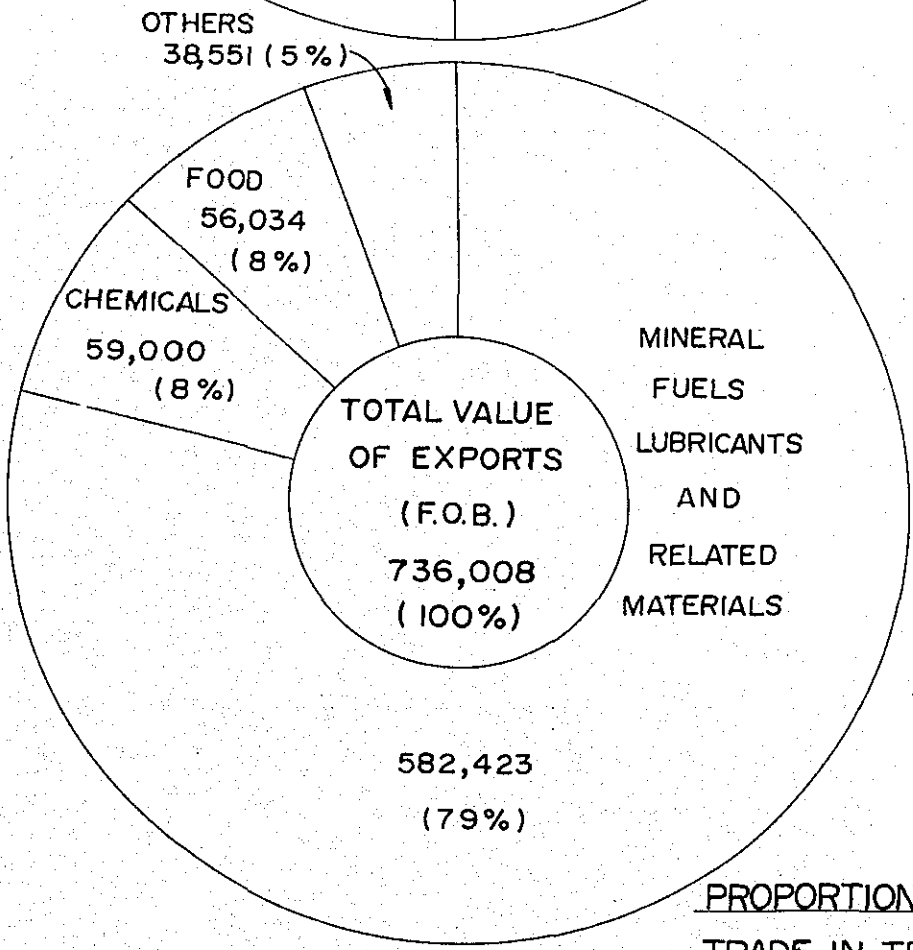
Exhibit A-1


LOCATION MAP
ATLANTIC OCEAN
COCOS BAY
CENTRAL RANGE
L'EBRANCHE RIVER
L'EBRANCHE CUT
L'EBRANCHE BARRAGE
COCAL RESERVOIR
ORTOIRE NARIVA WINDBELT
NARIVA REGULATING RESERVOIR
JAGAOMA OUTLET
ORTOIRE OUTLET
BOIS NEUF OUTLET
COCAL CUT
NAVET RIVER
NO 1 ROAD
NO 2 ROAD
NO 3 ROAD
NO 4 ROAD
TRINIDAD AND TOBAGO
WEST INDIES
VENEZUELA
PROJECT AREA
LEGEND
MAIN IRRIGATION CANAL
MAIN DRAINAGE CANAL
EARTH FILL DAM
MAIN ROAD
CONTOUR LINE IN FEET
EXISTING ROAD
BOUNDARY OF WATERSHED AREA
EXISTING DRAINAGE CANAL
LOCATION OF SETTLEMENT
SCALE
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
THE NARIVA SWAMP AGRICULTURAL DEVELOPMENT PROJECT
GENERAL PLAN
SANYU CONSULTANTS INTERNATIONAL, INC.
SUBMITTED
DATE
APPROVED
DRAWING NO

SOURCE: OVERSEAS TRADE 1966

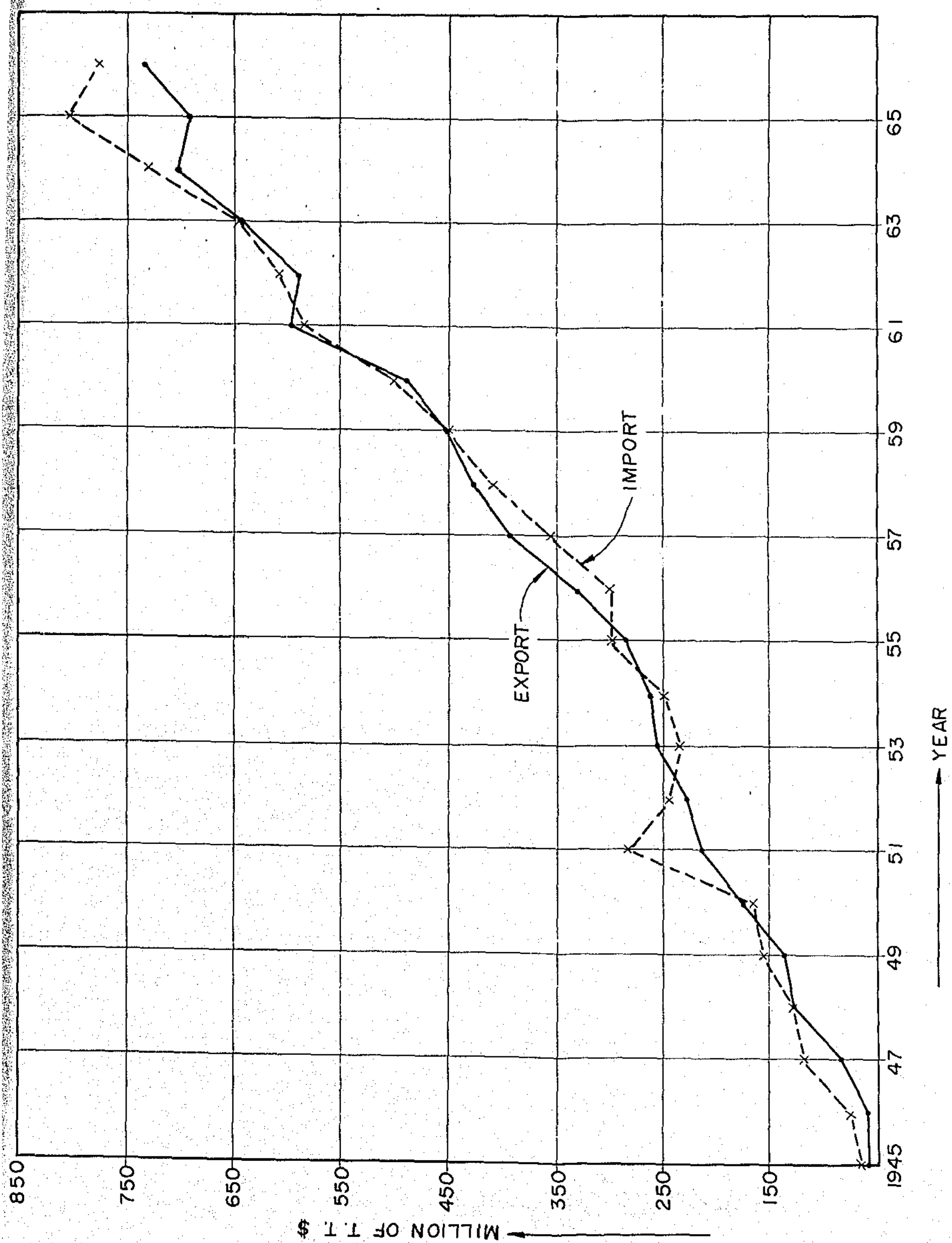
VALUES IN 1,000 T.T. $





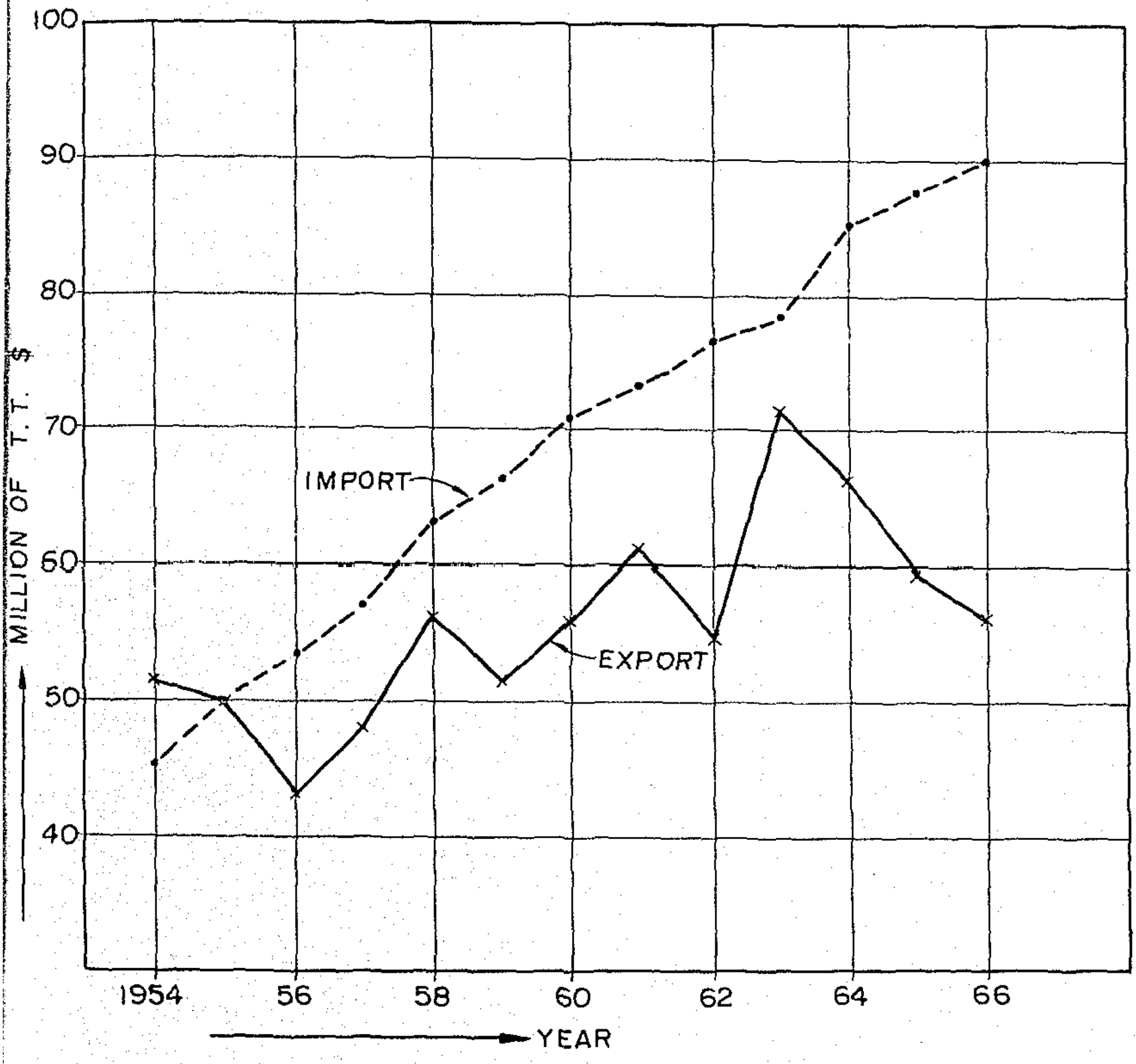
PROPORTION OF FOREIGN TRADE IN TRINIDAD & TOBAGO 1966

EXHIBIT A-3



MOVEMENT OF
EXPORT AND IMPORT

EXHIBIT A-4



TOTAL IMPORTS AND EXPORTS OF FOOD

IN TRINIDAD & TOBAGO

Appendix B

Present Agricultural Economy

Appendix B

Present Agricultural Economy

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APPENDIX B

Present Agricultural Economy

Diversification in Agricultural Development in Trinidad and Tobago

The Crown Lands Program

The original plan of Trinidad and Tobago endorsed by Food and Agriculture Organization of the United Nations (F.A.O.), for the Crown Lands Program, aims at development of the sparse crown lands 20,000 acres located at 200 various places. Under the original plan the Government designed the land reclamation, establishment of farm roads and provision of other infrastructure, and settlement of dairy farmers, hag breeders, orchard crops growers, vegetable crops farmers, other edible crops farmers, and tobacco farmers amounting to 2,400 households. Above all, daily farmers of 700 households are expected to raise 10,000 heads of milk cows for annual 5,000,000 gallons milk production. However, as the scale of the dairy farming project is considered too large for performance capability of the organization, technical experience, and market facilities, merely 200 households of the dairy farmers are anticipated for the development. In practice, in other respects the plan has been reduced, settlers totalling to 1,805 households for the development project. Trinidad and Tobago classes the development period into 3 stages: (a) Full Development Stage; (b) Partial Development Stage; and (c) Basic Development Stage. In the Full Development Stage, —— in which the related farm houses include dairy farmers, hog breeders, and orchard crops growers —— Trinidad and Tobago is to conduct (a) provision of infrastructure or supply of drinking water and power, and provision of roads etc., (b) land reclamation and establishment of farm roads, and (c) implementation of development works of paddy fields. Following the starting of the project, Trinidad and Tobago is to mostly charge unemployed labors, who shall be settled as farmers to plantfruit-trees and breed domestic animal. In the Partial Development Stage, farmers who raise vegetables and food crops amound the present land are to promote development of each paddy field work by using their own funds. In the Basic Development Stage, tobacco and food crops farmers are to be financed by tobacco firms in regards of farmers investment, while, for food crop farmers alone, infrastructure is financed by the Government and others are by farmer's own funds.

Under this program, approximately 12,000 acreage will be developed and milk, pork, vegetables, food crops and tobacco are to be produced by nearly 1,800 farmers (Table B-1).

In spite of the small farming areas, both dairy farmers and hog breeders are producint more than the Government planned in the starting. This Crown Lands Program is to directly bear benefits to about one percent of the total population of Trinidad and Tobago. For the purpose of supplying the demanded domestic animal amount are to be imported the estimated 4,000 heads of dairy cattlers, of which about 1,200 heads are to be imported on the Bilateral Loan Agreement contracted with Canal, and the rest is to be imported from other foreign countries. About 100 heads of hogs are also to be imported in the Government hog-breeding farms where hogs are bred for the distribution to the farmers.

Various facilities are to be constructed as one of the development works. They include, for example, factories for slaughter of hogs and processing the meat, centers for collection, processing and the distribution of milk, markets for vegetable and food crops, and yards of machinery for land reclamation, development and maintenance works. Further, staff who are experienced in maintaining and operating the markets and are capable of giving technical advice are to be provided. Under the experts' guidance in agricultural credit, an independent division is to be provided to keep records of financing by the Agricultural Credit Bank and manage the farmer's loan repayment. The existing regulation does not permit the Crown lands to be individually transfered to farmers. Tentative land cultivation is permitted till they prove the ability of effective cultivation of each unit area. Following that, the farmer is recognized to lease for 25 years with free choice of land. According to the lease, a farmer shall be release from the contract whenever he fails in engaging in the sound schedule of farming work requested in the lease, and in case a farmer dies, the land is allowed to be transferred to his successors, but not to be sectioned.

Support Price Policy and Marketing System

Through the Central Market Agency, Trinidad and Tobago is executing the support policy by parallel ways, guaranteed price and contract price, in order to secure a stable supply of agricultural products. Also the Government is trying the prompt marketing of the agricultural products by the Central Market Agency system.

Guaranteed Prices for 1968

Trinidad and Tobago is filling up the price gap of agricultural productions tended to be over-supplied by encouragement by means of the guaranteed prices. The guaranteed prices of 1968 including the contract prices were regulated by the Central Market Agency as follows and in 1969 there were slight changes.

Guaranteed Prices

	Grade	
	"A"	"B"
Pigeon Peas, Green	10 cnet	-
Pigeon Peas, dry shelled	18 ¢	-
Corn, dry shelled	7 ¢	-
Yams, Lisbon	8 ¢	6 ¢
Yams, Oriental	6 ¢	5 ¢
Yams, Portuguese (Ebo Yam)	6 ¢	-
Cush Cush	14 ¢	-
Sweet Potatoes	5 ¢	-
Plantain	8 ¢	5 ¢

Note: Grade and quality of these crops are based on the standardized grades in a pamphlet which is obtainable from the local storehouse officers of the Central Market Agency or the district extension officers. These crops are purchased at all the storehouses and at the buying sheds of Trinidad and Tobago.

All producers who are interested in selling their productions through the Central Market Agency are requested to register at the Central Market Agency's storehouse in the local regions.

Contract Price for 1968

Through a contract between the Central Market Agency and farmers, Trinidad and Tobago keeps the minimum prices for these crops for the farmers.

The Contract prices of 1968 are as follows:

	Contract Prices		
	"A"	"B"	"C"
Tomatoes	15 ¢	12 ¢	6 ¢
Cucumbers	6 ¢	4 ¢	-
Cabbage	7 ¢	5 ¢	-
Ginger (large)	12 ¢	-	-
Dasheen	6 ¢	4 ¢	-
Tannias	7 ¢	5 ¢	-
Pumpkins (rough skin)	6 ¢		
Red kindy beans	20 ¢		
Black-eyed peas	14 ¢		
Onions, dried bulbs	13 ¢		
Garlic, dried	40 ¢		
Carrots	20 ¢		
Peanuts, sheeled	30 ¢		
unshelled	20 ¢		

(N.B.) Tomatoes with premium are purchased at the prices which are determined by negotiations.

Note: These crops are purchased from the farmers who enter into contract with the Central Market Agency. Since the prices shown here are the minimum, the producers shall receive the higher prices as long as the market condition is allowable.

Marketing System

The Central Market Agency has a large central marketing system for the whole and retail sale for Port of Spain, and has many storehouses and depots in local areas over the country.

Trinidad and Tobago is promoting the agricultural diversification, but limited only to fruits, vegetable and raddish kind. As for many important staple food and meat such as paddy, soybean, maize and beef for import substitutes, there has been neigher specific market system to support the prices, nor at the agricultural experimental station there has been any emphasis placed on technical improvement. Recently, however, improvement is outstanding at many points stated succeedingly.

Stages of Technical Development in Foodstuff

Rice

° The present status of technical development in the agricultural laboratories or institutes.

There are collected several varieties of paddy including IR 8 at the Unviersity of the West Indies, but at the Centeno Central Institute of Agriculture, study on varieties has not yet been conducted.

Therefore, proved that paddy farming is the most adequate crop following completion of irrigation and drainage facilities, the emphasis of experiment and study should be placed on the improvement of the wet paddy cultivation. At the same time, practice of the same mechanized paddy farming as that in Guyana has to be enough studied by Trinidad and Tobago and the farmers.

° The present status of the Paddy Cultivation in Trinidad:

In the Third Five Years Project, the folloiwngs are stated, paddy is farmed over about 10,000 to 15,000 acres, but it is mainly for farmers' self supply, and a small of it may be, however, marketed. But this fact does not degrade the importance of the paddy farming for many small size farmers including sugar cane farmers.

Ten percent of the national demand is supplied by her own production, while the rest 90 percent is all supplied by the imports 67,000,000 pounds under the Rice Agreement with Guyana. The reasonable increase of paddy products in the country owuld not prevent the relatively large amount of consecutive imports from Guyana which produces rice at the lower cost then Trinidad and Tobago. The Government plans to support this agricultural industry by the provision of subsidery for the tentative use of fertilizer, by introduction of new and improved paddy varieties and by encouragement of provision of a few of high efficient rice mills. Furthermore, on the point of large scale development of agriculture, the feasibility study are intended as the second stage of the Nariva Swamp Drainage Scheme and also feasibility study as the second stage for Oropouche Lagoon.

For the Second Five Year Plan are stated the followings: Rice is the most constituent of nation's food consumption. Consumed amount per head has increased from about 86 pounds to 155 - 158 pounds of the present, whereas the nation's production has been at the decreasing tendency. For the period 1952 to 1962, the productions decreased from 12,000 tons to 10,000 tons and accounted for 30 percent in the total supply.

It follows that rice was produced rather as self-supply crop or auxiliary crop than as the market-oriented crop.

Since 1952, the cropping area of rice has decreased from 18,000 acres to about 15,000 acres of the present.

Although Trinidad and Tobago has very proper area for rice production, it is doubtful whether effective methods are practised for its production, comparing with that of other countries such as Guyana of the United Kingdom. It implies that, in regard to the price, rice producers of Trinidad and Tobago can not compete with that of Guyana. That is to say, the production cost per pound of Trinidad and Tobago is higher than that of Guyana of the United Kingdom by 2 cents.

Nevertheless area managed by each farmer is ranged from 2 and 1/2 to 5 acres wide, yet the economic unit is 5 acres to 8 acres wide. In general, yields are 1,500 pounds to 2,500 pounds per acre and 160 pounds of paddy is processed up to 100 pounds of rice. In order to produce more rice in the country, substantial capital investment to the Swamp land-reclamation, modernization by maintenance of rice dry-and-cleaning facilities as well as considerable mechanization of cultivation would be necessary. However, Trinidad and Tobago has no natural conditions to make the highly effective machinery available over the huge area of the country, except the Nariva Swamp, so that the effect shown through the mechanization oblige the people recognize its limitation.

Thus, the benefits which are obtainable if paddy is produced as import substitutes has to be well considered prior to employment of any project planned for promotion of self-supply over the period of 5 years from 1964 to 68. Specifically it must be seriously considered when the country can expectantly purchase much quantity of rice at cheaper price from several countries. Even if the rice imports as stated above are favorablly expected, it does not mean ignoring the possibility of promotion of the expansion of rice cultivation over the specific area through both the implementation of drainage works and further provision of the founds for the construction of a cleaning house in Caroni County as one of the projects by Agricultural Development Committee.

Prospects for Soybean and Maize Production

In order to increase soybean yields in Trinidad many problems have to be settled over the study. However, this is the core that if farmers of Trinidad will have only to farm the lands with much effeciency, Trinidad will come to raise as much as soybean yields of order traditional soybean production countries. At many small-sized experimental stations the production is over 2,000 pounds per acre, so that even at any commercial-oriented farms, it can enough produce 1,600 to 1,700 pound yield.

Rotation of crops has to be based on soybean and maize: (1) as well as soybean, maize, —— of which 80 million pounds are imported —— has a great national market which is able to be enlarged; (2) all the machinery necessary for the soybean farming are also available for maize farming; (3) enough information for both crops farming techniques is available —— Dr. L. Cross, agricultural specialist, has been conducting many experiment as the Central Experimental Station —— ; and (4) both crop farmings are necessary for the cultivation in view of reciprocal relationship —— the one is a crop and the other is bean which raise fertility of land.

Provided that soybean seed is sowed for the period, September to October in order to gather the harvest of soybean in the initial part of the dry season as the second crop following maize which is sowed for the period middle part of April to the end of May (n. the order may be reciprocal), TT$400 to 430 of Gross Value of total production per acre is expected in a year (n. provided that maize has a yield of about 3,000 pounds per acre or TT$7 per pound and soybean has an yield of about 1,700 pounds per acre or TT$12 per pound. Since the production costs of maize and soybean are largely subjected to their production quantity, farming including harvest is necessarily mechanized to be the large size farming for saving the labor force.

A preventative factor for the small size farm is combine operation in the economic view. Using a combine with 14 feet of sicling breadth of which the work quantity is 3 acres per hour, the desirable minimum farm area has to be between 450 acres and 500 acres. For all mechanization of farming on these size farms, at least a couple 65 HP tractors, disk ploughs, disk harrows, rotavators, four-row planters and sprayers are necessary, and they are estimated TT$65,000 in total. Besides, regardless of the poor weather in the harvesting period, dryers are necessary. In addition, necessary fixed facilities include machinery sheds and storehouses of crops.

The farm criteria for the farming of soybean and maize includes the followings:1/

(1) Principal defeciency such as submersion of farms shall be avoided.

(2) For the effective use of the machinery, the broad area enough to ride machinery shall be necessary or farming.

(3) For Support of growth, the farm land shall be the area which has the enough rainfall or is irrigable for the periods May to July, and October to December.

Besides, tested seed of varieties or maize is purchased from foreign contries, but as for soybean it has to be improved to the properer varieties for each area.

1/ Dr. R. W. Radley University of the West Indies, 1968, June.

Characteristics of the Project Area

General Description

The Nariva Swamp Project area faces the Atlantic Ocean coast line of the east part of Trinidad as shown on Exhibit A-1, and at the back is bounded by the Central Range and high land, most of which belongs to the Cocal and Turure Wards. The area is about 45 miles from the Capital, Port of Spain. Around the project area are no large towns besides Sangre Grande, a local town, locating at 15 miles in the north.

The population of Nariva county including the Cocal and Turure Wards, the project area, is estimated at about 17,000, or 2 percent of the total population of Trinidad and Tobago according to the 1960 census. The population density is 84 persons per square mile, or about a fifth of the national average density of about 418 persons per square mile, being lower than those of other cities.

Present Status in Surrounding Area of Swamp

The present status of the Nariva Swamp project area and the surroundings is mainly discussed on a succeeding Table based on the Agricultural Census 1963. Table B-2-a, and b show the sales amount of agricultural products by farmers of the whole area of Trinidad and Tobago. Table B-2-a tells percentage of each county against the national amount of the agricultural products, and on the other hand, Table B-2-b presents a percentage of each crop against the sales amount of each county. According to this, farmers in the Nariva Mayara country including the Nariva swamp sold only 5 percent of the national sales amount and the main crops of the county are coconuts and cocos, and rice accounts for extremely small percent. Table B-3, 4, 5 and 6 are the statistics, from the agricultural census about the Turure and Cocal Wards where the Nariva swamp is dominant.

Rent and Squatting of Swamp Area (Crown Lands) (Borrowing Unauthorized)

Renting:	Short term contract (monthly contract)
Number of Renting:	Approximately 300 persons
Renting Area per Person:	1 - 3 acres
Renting Rate:	50 ¢ One month-acres
	TT$6.00 one year
Lease:	25 years; Coconuts estate (Coast)
Squatter:	About 300 persons

When the inundation of the swamp area is comaratively poor, these people are likely to cultivate water-melon, cucumber, etc. The numbers presented above can be said to express farmers' enthusiasm for improvement of drainage of the swamp.

Outline of Existing Irrigation and Drainage Facilities

In 1955, nearly 1,200 acres of the swamp high elevations along the Plum Mitan Road east-north part of the project area were developed, based on the Rice Expansion Scheme. The foundamental conception of the project was to construct drain canals such as the Jagroma, Cuche and Petite Poole Cut, for prevention of the areas from the flood in the rainy season. Also these cuts take a part of catching excess water from their watershed during the dry season and using it for irrigation.

The main structures relative to the project are as follows:

(Mile)

	Jagroma Cut	Cuche Cut	Petite Poole Cut	Drain 1/ Canal	Total
Drainage Canal	1.8	2.7	3.8	1.2	9.5
Main Road	2.3	2.4	3.8	1.2	9.7 2/

1/ Dain canal leading from the sand hill to the Petite poole.

2/ Besides, about 3.5 miles of the trunk road in the project area was constructed.

At present, the drainage system is less facilitated —— lack of drainage capacity due to sedimentation of mud and sand in the canal terminals —— so that only about 500 acres are temporarily cultivated by using of inundation water during the rainy season and excess water of the watershed during the dry season, while therefore the cultivated areas has been decreasing yearly and most of facilities are worn out.

Table B-1

Stage of Development in The Crown Lands Program

	Number of Farms	Acres per Farm	Total Acreage
	(Figures rounded)		
Full Development			
Dairying	200	20	4,000
Pig Breeding and Fattening	70	5	350
Tree Crops	135	10	1,350
	405		5,700
Partial Development			
Vegetable Crops	395	3	1,185
Food Crops	365	5	1,825
	760		3,010
Basic Development			
Tobacco	80	10	800
Food Crops	560	5	2,800
	640		3,600
TOTAL:	1,805		12,310
Marketing Units			27
Central Machinery Pool			3
			12,340

Table B-2-a

Values of Sales by County and by Type of Crops (10 Acres and Over)

Crop \ County	Total		Nariva Mayaro		St. George		Caroni		St. Andrew St. David		Victoria		St. Patrick		Tobago	
	Value	%	Value	%	Value	%	Value	%	Value	%	Value	%	Value	%	Value	%
Cocoa	5,070,791	100.00	612,232	12.07	806,449	15.90	882,735	17.41	1,956,070	38.58	271,247	5.35	514,361	10.14	27,697	0.55
Coffee	1,397,503	100.00	219,091	15.68	131,498	9.41	96,975	6.94	412,222	29.49	322,909	23.11	214.808	15.37	-	-
Coconuts	3,434,495	100.00	1,197,521	34.87	99,961	2.91	21,972	0.64	334,004	9.72	414,446	12.07	1,360,215	39.60	6,367	0.19
Bananas	352,596	100.00	65,617	18.61	27,726	7.86	124,243	35.23	89,284	25.32	34,573	9.81	8,768	2.49	2,385	0.68
Plantains	30,169	100.00	2,063	6.84	6,711	22.24	972	3.22	9,849	32.64	967	3.21	7,813	25.90	1,794	5.95
Tonca Beans	37,300	100.00	2,148	5.76	12,817	34.36	2,147	5.76	15,024	40.28	1,011	2.71	4,153	11.13	-	-
Rubber	811	100.00	-	-	-	-	393	48.46	275	33.91	143	17.63	-	-	-	-
Citrus	1,315,980	100.00	29,030	2.21	438,517	33.32	192,695	14.64	330,411	25.11	73,841	5.61	251,230	19.09	256	0.02
Other Fruits and Products	81,467	100.00	3,269	4.01	37,802	46.40	16,642	20.43	18,454	22.65	3,297	4.05	1,119	1.37	884	1.09
Sugar Cane	32,423,573	100.00	105,303	0.32	2,171,026	6.70	17,720,597	54.65	767	0.00	11,878,523	36.64	547,357	1.67	-	-
Rice	21,441	100.00	2	0.01	360	1.68	18,217	84.96	420	1.96	906	4.23	1,536	7.16	-	-
Corn	29,332	100.00	1,380	4.70	1,750	5.97	7,483	25.51	1,641	5.59	11,813	40.28	4,304	14.67	961	3.28
Pulses	49,344	100.00	3,879	7.86	20,819	42.19	6,463	13.10	1,874	3.80	7,202	14.60	3,924	7.95	5,183	10.50
Ground Provisions	100,850	100.00	27,254	27.03	6,483	6.43	18,806	18.65	8,194	8.12	13,921	13.80	11,175	11.08	15,017	14.89
Vegetables	146,384	100.00	699	0.48	93,362	63.78	8,152	5.57	27,027	18.46	12,111	8.27	3,775	2.58	1,258	0.86
All Other	109,623	100.00	15,902	14.51	66,153	60.34	15,555	14.19	9,491	8.66	1,089	0.99	565	0.52	868	0.79
Timber	80,806	100.00	1,239	1.53	23,435	29.00	4,606	5.70	21,726	26.89	18,380	22.75	11,420	14.13	-	-
Total	44,682,465	100.00	2,286,629	5.12	3,944,869	8.83	19,138,653	42.83	3,236,733	7.24	13,066,379	29.24	2,946,523	6.60	62,679	0.14

Source: Agricultural Census 1963

Table B-2-b Value of Sales by County and by Type of Crop (10 Acres and Over)

(TT$)

County / Crop	Mariva Mayaro		St. George		Caroni		St. Andrew St. David		Victoria		St. Patrick		Tobago		Total	
	Value	%	Value	%	Value	%	Value	%	Value	%	Value	%	Value	%	Value	%
Cocoa	612,232	26.77	806,449	20.45	882,735	4.61	1,956,010	60.44	271,247	2.08	514,361	17.46	29,697	44.19	5,070,791	11.35
Coffee	219,091	9.58	131,488	3.33	96,975	0.51	412,222	12.74	322,909	2.47	214,808	7.29			1,397,503	3.13
Coconuts	1,197,521	52.38	99,961	2.53	21,972	0.11	334,004	10.32	414,446	3.17	1,360,215	46.15	6,376	10.17	3,434,495	7.69
Bananas	65,617	2.87	27,726	0.70	124,243	0.65	89,284	2.76	34,573	0.26	8,768	0.30	2,385	3.81	352,596	0.79
Plantains	2,063	0.09	6,711	0.17	972	0.01	9,849	0.30	967	0.01	7,813	0.27	1,794	2.86	30,169	0.07
Tonca Beans	2,148	0.09	12,817	0.32	2,147	0.01	15,024	0.46	1,011	0.01	4,153	0.14			37,300	0.08
Rubber					393	0.00	275	0.01	143	0.00					811	0.00
Citrus	29,030	1.27	438,517	11.12	192,695	1.01	330,411	10.21	73,841	0.57	251,230	8.53	256	0.41	1,315,980	2.95
Other Fruits and Products	3,269	0.14	37,802	0.96	16,642	0.09	18,454	0.57	3,297	0.03	1,119	0.04	884	1.41	81,467	0.18
Sugar Cane	105,303	4.61	2,171,026	55.04	17,720,597	92.59	767	0.02	11,878,523	90.89	547,357	18.57			32,423,573	72.54
Rice	2	0.00	360	0.01	18,217	0.10	420	0.01	906	0.01	1,536	0.05			21,441	0.05
Corn	1,380	0.06	1,750	0.04	7,483	0.04	1,641	0.05	11,813	0.09	4,304	0.15	961	1.53	29,332	0.07
Pulses	3,879	0.17	20,819	0.53	6,463	0.03	1,874	0.06	7,202	0.06	3,924	0.13	5,183	8.27	49,344	0.11
Ground Provisions	27,254	1.19	6,483	0.16	18,806	0.10	8,194	0.25	13,921	0.11	11,175	0.38	15,017	23.96	100,850	0.23
Vegetables	699	0.03	93,362	2.37	8,152	0.04	27,027	0.84	12,111	0.09	3,775	0.13	1,258	2.01	146,384	0.33
All Other	15,902	0.70	66,153	1.68	15,555	0.08	9,491	0.29	1,089	0.01	565	0.02	868	1.38	109,623	0.25
Timber	1,239	0.05	23,435	0.59	4,606	0.02	21,726	0.67	18,380	0.14	11,420	0.39			80,806	0.18
Total	2,286,629	100.00	3,944,869	100.00	19,128,542	100.00	3,236,733	100.00	13,066,377	100.00	2,946,523	100.00	62,679	100.00	44,682,465	100.00

Source: Agricultural Census 1963

Table B-5

Number & Acreage of Holdings by Holding Size, 1963

Holding Size (Acres)	TURURE & COCAL		TURURE		COCAL	
	Number of Holdings	Number of Acres	Number of Holdings	Number of Acres	Number of Holdings	Number of Acres
1 - 4	576	1,369	201	479	375	890
5 - 9	704	4,444	302	2,012	402	2,432
Sub-Total	1,280	5,813	503	2,491	777	3,322
10 - 24	672	9,269	400	5,611	272	3,658
25 - 49	147	5,120	98	3,427	49	1,693
50 - 99	54	3,577	25	1,747	29	1,830
100 - 199	21	3,105	15	2,207	6	898
200 - 299	3	778	3	778	-	-
300 - 499	5	1,756	3	1,081	2	675
500 - 699	1	650	-	-	1	650
700 - 999	1	722	-	-	1	722
1000 and over	4	5,879	2	2,192	2	3,687
Sub-Total	908	30,856	546	17,043	362	13,813
GRAND TOTAL	2,188	36,669	1,049	19,534	1,139	17,135

Source: Agriculture Census Section 2 - Land Use by Country and Holding Size.

Table B-4

Acreage of Holdings by Land Utilization and by Holding Size.

Holding Size	Total All sizes (acres)	LAND UTILIZATION											
		CROPLAND				GRASSLAND			FOREST		NON-CULTIVABLE LAND		
		Tree Crop	Non-Tree Crop	Temp. Fallow	New Land Under Prep.	Pangola	Other Cult. Pasture	Rough Pasture	Planted & High	Second-ary & Lastro	Built-on Service	Swamp	Other
1 - 4	1,369	617	430	94	15	-	-	26	-	174	2	11	-
5 - 9	4,444	2,715	360	112	34	-	29	89	67	967	55	14	2
Sub-Total	5,813	3,332	790	206	49	-	29	115	67	1,141	57	25	2
10 - 24	9,269	6,280	279	95	56	5	16	141	169	1,962	141	78	47
25 - 49	5,120	3,682	108	18	18	-	2	55	109	975	76	63	14
50 - 99	3,577	2,717	29	3	17	-	2	70	81	521	55	78	4
100 - 199	3,105	2,299	24	86	-	1	2	56	80	200	270	50	37
200 - 299	778	672	-	-	-	-	-	25	-	75	6	-	-
300 - 499	1,756	1,476	-	-	-	-	5	20	84	126	35	10	-
500 - 699	650	413	-	-	-	15	13	-	12	100	8	49	40
700 - 999	722	501	-	-	50	23	-	-	93	-	22	-	33
1000 & over	5,879	2,521	60	-	-	30	13	4	74	2,852	172	75	78
Sub-Total	30,856	20,561	500	202	141	74	53	371	702	6,811	785	403	253
TOTAL	36,669	23,893	1,290	408	190	74	82	486	769	7,952	842	428	255

Source: Agriculture Census Section 2 - Land Utilization by County and Holding Size

Table B-5

Number of Holdings by Land Utilization and by Cultivation Practices.

Cultivation Practices	Total	LAND UTILIZATION											
		CROPLAND				GRASSLAND			FOREST		NON-CULTIVABLE LAND		
		Tree Crop	Non-Tree Crop	Temp. Fallow	New Land Under Prep.	Pangola	Other Cult. Pas-ture	Rough Pas-ture	Planted & High	Second-ary & Lastro	Built-on Service	Swamp	Other
Irrigation Used	77	56	59	4	1	1	-	2	3	26	6	N.A.	2
No Irrigation	2,110	1,666	607	148	58	5	23	165	114	1,035	246	N.A.	32
Not stated	1	1	-	-	-	-	-	-	-	1	1	N.A.	-
TOTAL	2,188	1,723	666	152	59	6	23	167	117	1,062	253	N.A.	34
Machinery	1,344	1,220	377	111	32	6	15	125	87	658	204	N.A.	27
No Machinery	794	453	283	39	26	-	7	40	24	384	40	N.A.	5
Not Stated	50	50	6	2	1	-	1	2	6	20	9	N.A.	2
TOTAL	2,188	1,723	666	152	59	6	23	167	117	1,062	253	N.A.	34
Fertilizer Used	504	434	170	57	11	5	15	74	39	207	103	N.A.	14
No Fertilizer	1,684	1,289	496	95	46	1	8	90	78	855	150	N.A.	20
Not Stated	-	-	-	-	-	-	-	-	-	-	-	N.A.	-
TOTAL	2,188	1,723	666	152	57	6	23	164	117	1,062	253	N.S.	34

Note: N.A. - Not available

Source: Agriculture Census - Section 2 - Land Use, by Machinery, Irrigation and Fertilizer.

Table B-6

Values of Sales of Each Crops by Holding Size and by Type of Crops.

Crops	HOLDING SIZE													TOTAL
	1 - 4	5 - 9	Sub-Total	10 - 24	25 - 49	50 - 99	100 - 199	200 - 299	300 - 499	500 - 699	700 - 999	1000 & over	Sub-Total	
Cocoa	1,440	13,497	14,937	339,139	185,650	154,925	87,007	40,450	44,104	41,215	-	64,135	956,625	971,562
Coffee	41	1,979	2,020	93,121	47,648	26,646	27,240	1,122	10,350	2,649	-	34,154	242,930	244,950
Coconuts (Green)	-	-	-	1,002	-	1,670	-	-	-	-	-	-	2,672	2,672
(Dry)	-	-	-	2,849	1,085	3,965	880	-	-	-	-	-	8,779	8,779
Copra	-	80	80	7,738	2,363	2,634	4,550	-	51	-	91,900	345,000	454,236	454,316
Fibre	-	-	-	-	-	-	-	-	-	-	-	309,641	309,641	309,641
Bananas	-	2,039	2,039	32,718	7,272	35,567	5,015	369	845	4,832	-	530	83,148	89,187
Tonca Beans	-	33	33	1,310	130	82	487	164	4,800	-	-	-	6,973	7,006
Citrus	-	25	25	4,050	8,391	1,604	10,253	4,530	1,817	361	100	330	31,436	31,461
All Other Tall Crops	-	32	32	1,782	1,333	117	269	7	-	92	1,062	-	4,662	4,694
Timber	-	80	80	961	785	-	285	-	274	-	-	-	2,305	2,385
Non-Tree Crops														
Sugar Cane	-	-	-	512	341	-	4,262	-	-	-	-	-	5,115	5,115
Rice (Paddy)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(Hushed)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corn (Green)	-	-	-	-	-	127	-	-	-	-	-	-	1,127	127
(Dry)	-	-	-	1,069	68	49	-	-	-	-	-	-	1,186	1,186
Pulses	-	-	-	190	1,230	113	20	-	-	-	-	-	1,553	1,553
Ground Provisions	6	21	27	12,327	2,578	2,529	-	-	-	12	-	-	17,446	17,473
Vegetables	-	1,248	1,248	-	864	15	-	-	-	-	-	-	879	2,127
Tobacco	-	-	-	-	3,800	-	-	-	-	-	-	-	3,800	3,800
Pineapples	-	-	-	5	3	-	-	-	-	-	-	-	8	8
Melons	-	-	-	1,554	3,260	-	-	-	-	-	-	12,000	16,814	16,814

Source: Agricultural Census - Section 5

Table B-7

Expenditure Incurred on Plum Mitan Rice Scheme

Year		Expenditure	
1952	-	$31,251	approximately
1953	-	86,994	"
1954	-	Records cannot be located	
1955	-	118,145	approximately
1956	-	124,947	"
1957	-	89,792	"
1958	-	-	
1959	-	-	
1960	-	-	
1961	-	-	
1962	-	-	
1963	-	-	
1964	-	-	
1965	-	-	
1966	-	$81,374	Reactivation of Scheme
1967	-	33,579	" "
1968	-	34,640	" "
	Total	600,722	

Appendix C

Agricultural Land Resources

Appendix C

Agricultural Land Resources

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APPENDIX C

Agricultural Land Resources

Land Area

The boundary of the project area is determined on the result of surveys and investigations on the crown lands excluding the private estate. Gross project area is approximately 26,500 areas, which is devided into two divisions; around 11,000 acres of the gross irrigable area and 15,500 acreages of proposed livestock area.

The land reclamation area to raise beef cattle has to be re-checked by the topographical survey result, but only 50 percent or 7,400 acres of the gross area (15,500 acres) are selected for review.

Outline of Soil and Vegetation

For the soil classifaction and distribution on around the project area, investigations have been already conducted as shown on Exhibit C-1.1/

The Nariva Swamp area faces the east slope of the Central Range in the northwest, and bounded by relatively low hilly land along the Rio Claro-Mayaro Road in the south and in the east, beach dune running north to south facing the Cocos Bay on the Atlantic Ocean. With most of elevations 96 feet to 120 feet (T.G.R.), the area is dead flat, but so vast that there is somewhat difference in the elevations, forming the gradual undulating land. Therefore, some fluctuations are found in the present condition of drainage, soil and vegetation.

1/ Compiled and drawn by Directorate of Colonial Surveys based on field Surveys (1928-1940) by E. Mchenery, F. Hardy, J.A. Macdonald, C.F. Charter, G.C. Witt and geologists of the major oil companies operating in Trinidad.

At the mountains in the hinterland the ground which composes of clay soils was sedimentation by the river water. The sediments around the area, therefore, consist of clay soil and are characteristic of any absence of gravels. In the flood plains, leveled by river flows from the hilly land of the hinterland, the mottled fluvial alluvium is distributed. The area where the rivers fan out from the hilly land into the alluvial low land forms forest zone, and is of mottled clay subject to the forest, and this soil pattern is dominant over the project area. The vicinities of the beach and the areas bounded by northern hills are poor in drainage, covered with herb, and there is found mottled fluvial alluvium affected by the grass land. In the area is exceptionally found sand hills and slightly high elevation such as the Bush Bush and Bois Neuf Hill, but mostly the area forms a leveled marshy clay area by much quantity of sedimenting clay mixed with various soils from the hiterland, forming low plain herebaceous land. Over the considerablly high elevations around and along the rivers running from the old strata north of the alluvial area, fertile fine sandy clay is distributed. Along the beach is dune formed by fine sand, inside which pelite affected by swamp is formed and part of which consists of pelite clay or pelite sand.

As for the vegetation status, hills of the hinterland and relatively high elevations in the river alluvial area from the forest zone, and the swamp close to the beach is a herbaceous plain. Though most of the west side of the north part of the area is also a herbaceous land poor in drainage, yet at part of the Plum Mitan district it is utilized for paddy field and further at the relatively better area of the drainage condition, cocoa is farmed. The beach dune is for coconut plantation.

Field Soil Investigation

The soil investigation has been conducted for the purpose of checking the drainage and irrigation plan and crops to be introduced, and obtaining the principal data for planning of the farming project.

Investigation Program

In advance of the field survey, data collected at the preliminary study, and the result from the profile investigation of several areas and the reconnaissance conducted in 1966 were checked, the team having gained the preliminary information. At the field survey, firstly, in order to understand the drainage status, vegetation and topographical conditions of the whole area, air reconnaissance was carried out. Then, by jeep and on foot, the observation was conducted on the topographical condition, the soil condition of the topsoils, vegetation status, and drainage condition or the varieties of cultivated crops and growing condition at where crops were farmed.

Based on the above stated investigation, soil profile survey and sampling on the representative soil series at the Nariva Swamp were executed.

Investigation Item

Upon surveying the soil profile, after it was confirmed that all soil series were not disturbed and the sampling sites were the representatives of the soil series, test pits with 3.3 feet square wide and 3.3 to 4.5 feet deep were excavated, and then profile strata, soil colors, humus, presence of mottling of hydroxide, glei mottling or strata or texture, presence of gravels, structure, pore spaces, compactness, plasticity, permeability, moisture, groundwater-table, and distribution of plant roots were investigated, and colour photographs were taken at the same time. Also each horizon in the test pits was sampled and in the Central Analytical Laboratory of the University of the West Indies, the sampled soils were analized for PH, loss on ignition, nitrogen, organic carbon, sulphur, potash, magnesia, lime silica alumina, phosphorate, cation exchange capacity and total exchangeable bases.

Results of Investigation

The area of each soil series is as summerized in Table C-1, and result of the profile examination of the soil series is shown on Exhibit C-2, and on the other hand colour photographs on Exhibit C-3. Also result of the chemical analyses of the soil is in Table C-2. Buffer capacity is in Table C-3, and buffer curve on Exhibit C-4, and the required quantity of carbon-oxide calcium is presented in Table C-4 from the graph of the buffer curve.

Features of Each Soil Series

Each soil series of the project area and the surroundings are discussed in relative to the investigation results and the present development project.

No.8. Bois Neuf Clay ----- Drainage impeded

This soil type occurs on the western side of the herbaceous portion of the Nariva Swamp, and covers the area of the westward of sandy hill striking southwest through the east of Bois Neuf Hill. It occupies about 5,000 acres of which 3,850 acres are practically available for this development project. In view of vegetation, most of the area covered by a pure stand of giant sedge with patches of the giant aroid. The representative profile of this type is the one shown in SNo.2. auger hole on Exhibit C-2. The site of this SNo.2 auger is within the herbaceous land around the terminal of the road running east from the already furnished sluice gate of Plum Mitan, but the soil is heavy clay soil in the whole, composing of light clay (LiC) in the surface layer, heavy clay soil (HC) in the second and third horizon, and light clay in the fourth horizon.

The topsoil (A_0 Horizon) is about 4 inches thick and olive-black, containing considerable grass litter mixed, and pore spaces are sized from 0.08 to 0.4 inches in the dry season, but on the other hand in the rainy season when it gets moist the pore spaces are considered to be closed. Permeability is relatively large owing to these pore spaces. The horizon is slightly moist even in the dry season. The plant rootlets are largely dispersed. The whole profile is extremely acid in reaction with pH measured at 4.0 (N.KCl). To mend pH 4.0 to pH 6.5, cabonide calcium ($CaCO_3$) of 2,860 pounds is necessary. Loss on ingnition is 20.0 percent, and the organic carbon is 8.3 percent. Total nitrogen is 0.77 percent. Sulphur is 0.31 percent. Potash (K_2O) is 1.7 percent. Magnesia (MgO) is 0.2 percent. Lime (CaO) is 0.1 percent, and silica is 42.5 percent. Phosphate is 770 ppm. Cation exchange capacity is 43.6 m.e. per 0.22 pound. Therefore the water holding capacity is large.

The second horizon (A_1 Horizon) is about 8 inches thick, and grey with rich humus. Much dendric mottling of roots are present and the structure composes of single grains. Pore spaces are small, ranged from 0.02 to 0.08 inches, and the crack is less 0.5 percent. Compactness is as large as plasticity. Thereby permeability is small. In this horizon, plant roots are recognized. As well as A_0 Horizon, the acidity is high, Ph of 4.1 (N.KCl). Loss on ignition is 9.7 percent. Organic carbon is 2.4 percent. Total nitrogen is 0.24 percent. Potash (K_2O) is 2.0 percent. Magnesia (MgO) is 0.3 percent. Lime (CaO) is 0.1 percent. Silica (SiO_2) is 48.1 percent. Alumina (Al_2O_3) is 23.3 percent. Phosphate is 535 ppm, cation exchange capacity is 30.0 m.e. per 0.22 pound, and the total exchangeable bases 26.0 m.e. per 0.22 pound. In case the horizon is disturbed, the first (A_0 Horizon) and the second horizon (A_1 Horizon) should be mixed, but there is found no trouble for farming crops.

The third horizon (A_2 Horizon) is 24 inches thick, continuously composing of clay. The soil is olive-grey. In the upper part of the horizon, mottling of hydroxide is found and considered to repeat dry and wet, and on the other hand in the lower, the more moisture with glei mottling. Even in the dry season the ground water table is at 24 inches in the depth. The glei horizon spreads below this level. The structure is single-grained. No cracks are found. Plasticity and compactness are extremely large, and thereby permeability is small. Plant roots are hardly distributed. Acidity of this horizon is higher or pH 3.8 (N.KCl) than that of the first (A_0 Horizon) and the second (A_2 Horizon). The third horizon is almost the same as the second horizon except phosphorus is less than the second.

The fourth horizon (B Horizon) occurs at 36 inches in the depth and attains at 50 inches. The texture is characterized black by the light clay (LiC) specifically forming much-like. The soil is ingle-grained in the structure without cracks recognized. Compactness is medium, and plasticity is large. Permeability is small. No plant roots are found. Acidity of the soil is high with pH at 4.5 (N.KCl). Loss on ignition is 21.3 percent. Organic carbon is 12.2 percent. Besides, the rates of total nitrogen, sulphur, potash, magnesia, silica, and alumina in the soil are entirely the same as those of the first horizon (A_0 Horizon) present. The consideration is therefore that the fourth horizon (B Horizon) has once been a topsoil as well as the first horizon (A_0 Horizon) in the course of forming the Nariva Swamp area and covered with swampy plants, and further that rainfalls flowing from the mountains and the watershed later carried mud into the area, only to form the present alluvial type. According to a literature, though it does not refer to the presence of the fourth horizon (B Horizon), it has to be regarded as a variation of the soil series No.8 in view of soil science. However as this horizon occurs at deeper than 36 inches, it is not directly related to irrigation and drainage, reclamation, road construction and housing plan and crops to be introduced. Therefore here, as the soil series No.8, it is stated only according to the conventional classification system of the soil.

In the rainy season, the area of this soil type is inundated by the water of nearly 3 to 12 inches depth, and on the contrary and groundwater-table is reached at 24 inches depth in the dry season. The soil is of heavy clay and considerable labor power is necessary for the farming work. The neutralization of acidity is not trouble and the nutrient is so affluent for plants that the proper irrigation during the dry season and the proper drainage during the rainy season would let the land enough available for the farming. At Plum Mitan district of the west part of this area of the soil type, wet paddy cultivation is executed in the rainy season with high crop yield, and further water melon is considered to be proper crop for the market.

<u>(No.9) Nariva Swamp Clay</u> ----- Drainage impeded

This soil is situated just in the middle of the swamp area covering about 9,000 acres, of which the area under the sea level is usually inundated. The area above the sea level gets so dry in the dry season that it will support a man's weight. The surface ground is covered with the thick mat of grass and grass remains, locally known as Cascadoux grass. Nearly 5,847 acreage is available for the development project.

The first horizon (A_1 Horizon) is about 4 inches thick, and the soil exhibits grey and extremely rich in humus. The soil texture is of heavy clay soil. The pore space is rare and the cracks are almost absent. Compactness is large and the soil particles are large. Therefore, permeability is low. Plant rootlets are distributed thickly.

The profile is very strongly acide, pH of 4.1 (N. KCl). Loss on ignition is 22.4 percent. Organic carbon is 9.2 percent. Total nitrogen is 0.78 percent. Alumina is 19.2 percent. Cation exchange capacity is 39.0 m.e. or 0.22 pound. Total exchangeable bases are 22.5 m.e. per 0.22 pound, so that relatively the soil is nutrient. Sulphur is 0.43 percent, the highest value in the Nariva Swamp soils.

The second horizon (A_2 Horizon) is 4 to 13.6 inches thick under the first horizon (A_0 Horizon). The soil color is grey and in the dry season when the surface horizon is dry the hydroxide staining appears. The soil texture is of a heavy clay soil, with prismatic structure. But there is not found pore space nor cracks. The soil is large in the compactness and plasticity but small in the permeability. Plant rootlets are hardly recognizable. The horizon is more strongly acid, pH of 3.5 (N. KCl), than the first horizon (A_1 Horizon). Loss on ignition is 7.7 percent, and organic carbon is 2.3 percent. Total nitrogen is 0.28 percent. Potash (K_2O) is 2.2 percent. Phosphate is 458 ppm, considerably less than that of the first horizon (A_1 Horizon). Silica is 45.0 percent. Alumina is 24 percent. Cation exchangeable capacity of holding water. Upon the cultivation, reclamation and consolidation, the second horizon is to be mixed with the first horizon above the second. In the case, pH is improved to 6.5 by calcium carbonate of 1,710 pounds per acre, considerably less for the strong acidity.

The third horizon (A_3 Horizon) gradually changes from the second horizon (A_2 Horizon), with 13.6 to 22 inches thickness. The soil is grey and there are hydroxide staining. The soil texture is of heavy clay soil, and the soil is single grained in the structure. The pore spaces are rare, with cracks unrecognizable. Both compactness and particle are large, and thereby the permeability is small. In the dry season, there is the groundwater-table at 22 inches in the depth where the horizon get altered gradually to the fourth horizon. Plant rootlets are almost absent.

The fourth horizon (A_4 Horizon) lies with 22 to 40 inches thickness from the surface and distinguishable from the fifth layer at 40 or below 40 inches. The soil is olive-black in colour, and the glei mottling is found, the so-called Glei Horizon, which is in the moist condition. This horizon is assumed to have never been desiccated. The texture is of a heavy clay soil type, and the soil is single-grained structure, but pore space and cracks are absent. The soils present strongly acid with pH of 4.4 (N. KCl). Loss on ignition is 13.4 percent, and organic carbon is 5.8 percent. Total nitrogen is 0.31 percent. Sulphur is 0.24 percent. These values are measured considerably more than those of the third horizon, and rather similar with the first horizon. It is assumed to have the same meanings as that of the fourth horizon of the soil series No.8.

The fifth horizon (B Horizon) emerges at the 40 inch depth. The soil is black in colour, and the texture is of a heavy clay soil. There are rarely found cracks and pore space.

<u>(No.10) Macaw Peaty Clay</u> ----- Drainage impeded

According to a literature as for this type of Macaw Peaty clay, a belt of inundated area about 1,500 acres in extent, occuring at the eastern marging of the Nariva Swamp is covered with very mixed vegetation, such as high betel nut palm trees, acrostichum, aureum, montrichardia, arborescens, leersia, hexandra, and mangroves. Though the water which may be 4 feet deep, is quite fresh, yet occasional presence of mangroves indicates local saline subsoil condition. The soil profile consists of at least 6 feet of loose dark brown humic clay or silty clay. There is no chemical analytic data available. Upon the last investigation, the team could not get deep into the inside of the swamp area, so that the investigation on the area of which subsoil is clay subject to Nariva Swamp could not be preformed. Thereby here is stated only the profile and the analysis of the samples of the auger of SNo.5 or the left side watershed of the Nariva River upstream. The topsoils (A_0 Horizon) is about 3.6 inches thick, composing of muck. The plasticity is small and the permeability is extremely large. The area where breakdown of the soil is not promoted is covered with grass litter. Due to that, the chemical analysis was impossible to be performed.

The second horizon (A_1 Horizon) is about 6 inches thick, with peaty soils, and the colour is black reddish brown presented. Around 10 inches depth there is the groundwater-table, and the water flowing out of the waterloggins inundated the suger with the depth of 50 inches. According to the chemical analysis, the horizon showed strongly acide with pH of 4.8 (N. KCl) in reaction. The loss on ignition is 42.6 percent and organic carbon is 23.4 percent. Total nitrogen is 1.5 percent. These values are larger than those of any soils of Nariva Swamp area. Cation exchange capacity is 60.7 m.e. per 0.22 pound. Total exchangeable bases are 40.7

m.e. per 0.22 pound, large value present. Against silica of 64.89 percent, alumina is only 1.5 percent, and the water holding capacity is poor.

The third horizon (B Horizon) presents black-olive grey and of silty clay. Plasticity is poor and thereby permeability is extremely large. The pH of the soil is 4.8 (N. KCl), the same strong acidity as that of the second horizon. Loss on ignition is 7.7 percent. Organic carbon is 2.7 percent. Total nitrogen is 0.28 percent, different from that of the second horizon. Cation exchange capacity is 10.1 m.e. per 0.22 pound, total exchangeable bases are 4.9 m.e. per 0.22 pound. Silica is 95.7 percent, alumina is 1.3 percent, and thereby the water holding capacity is extremely small.

The forth horizon (B_2 Horizon) presents bright yellowish brown, and the soils are of fine sand. Thereby permeability is very large. Plant roots are not distributed due to the usual excess-humidity. Among the area of this soil type, at very part where the drainage is facilitated, water melon is raised. But the peat of the topsoils is anticipated to be breakdown and consumed promptly by the cultivation that productivity may be lowered, and in the case of the soil dried, the soil is decreased in volume, so that to level the ground surface by hollowing and disking after plowing is not easy. Therefore, in the concaved portions, the excess water is to be supplied from the lower horizons, and here and there excessively humid portions emerged, resulting in disturbing much for cultivation. Also the place where the soil of this type is distributed is low elevated and therefore the gravity drainage is difficult. By the poor conditions gathered as stated above, these uncultivated areas are not so easy for the agricultural utilization, so that it is not considered worth toiling for the further development.

(No.14) Cocal Fine Sand ----- Drainage free

As this soil type is not directly relevant with the present development project, the profile survey and chemical analysis were not performed. The outline of the investigation is stated below.

This soil type is located over a strip about 3,000 acres in area on the east coast and 16 miles in the length from the L'Ebranche River to St. Margaret Village. The portion North of Point Radix is known as Nariva-Cocal, and is a sand reef protecting Nariva Swamp from salt water.

The soil of south part of Point Radix is derived from beach sand presumably overlying clay at a great depth. Cocal fine sand is considered as high as 3 feet, consisting of uniform yellowish brown fine sand from surface to groundwater-table. At where the forest coveres, there is found dark brown humic sand thick of around 3 inches. Internal drainage is free or even excessive until the groundwater-tables are reached; considerable lateral water movement takes place in the Manzanilla section as the water from the Nariva Swamp continuously seeps through and maintains a hydrostatic head sufficiently high to keep the salt water out. A deficiency of all plant nutrients probably occurs and the soil owes its productivity to perennially high and moving graoundwater which is eminently suitable for coconuts.

(No.19) L'Ebranche Silty Clay ----- Drainage Imperfect

This soil is derived from the alluvial deposits of the smaller rivers of the Central Range, and their outwash into the Nariva Swamp together with the flats of the river. The scope of the location is over the whole area of the west side of the Nariva Swamp, and geographically it belongs to the gentle dulations continuous from the mountainous area to the flats. This type of soil is among the Nariva Development Project Area located at a part around the Cauque River and at a part between the area where the Biche, Caratal, and Charuma River cross with the Lasalle Road and the area where they joint with the flat swamp. The area of both lands is measured at 5,875 acres, but only 75 acres will be selected for the present new project. The topsoil (A_0 Horizon) is covered with the unanalyzed coarse humic clay, yet the layer is less than 1 inche thick although the thickness varies according to the locations.

The second horizon (A_1 Horizon) is extremely thin, not more than 1 inch. The colour is bright brown, and the texture is of heavy clay soil. It has a prismatic structure, and when it is dry, there is found pore space large, accounting for 15 percent of the whole with cracks of more than 0.4 inches. Pore space is closees upon the wet condition, and on the contrary opens upon the dry condition. Thus, by repeating of dry and wet condition, humus of the ground surface flows down, forming black films on the surface of the cracks. Compactness and plasticity are both large, and thereby permeability is small. The distribution of plant rootlets is hardly recognizable. Upon the profile survey, it was assumed to be slightly alkaline in reaction, but the result of the chemical analysis showed that the soil was strongly acid, pH of 3.6 to 3.8 (N. KCl). Loss on ignition is 8.3 percent, organic carbon is 1.8 percent, total nitrogen is 0.22 percent, potash (K_2O) is 1.2 percent, and phosphate is 536 ppm. Also cation exchange capacity is 14.7 m.e. per 0.22 pound, and total exchangeable bases are 3.9 m.e. per 0.22 pound, silica (SiO_2) is 63.3 percent and alumina (Al_2O_3) is 16.0 percent.

The third horizon (A_2 Horizon) is distributed continuously and uniformly from 1 to 17 inches below the surface. The colour is orange, and the soil possesses fimly mottling of manganese as well as that of the third horizon. The soil is heavy clay soil in texture. The soil has the prismatic structure with large pore-spaces. Cracks are larger than 0.4 inches, getting smaller in the set season. By repeating the dry and wet condition as well as the second horizon (A_1 Horizon), the side phase of the prismatic structure opens and closes. The soil is extremely compact and very plastic with small permeability. But due to cracks the permeability is prompt. Therefore, due to the gradual dulation together, the temporal drainage during the rainy period is considerably easy. The soil is strongly acid, pH of 3.6 to 3.9 (N. KCl). In the case of the new reclamation and consolidation, the first, the second, and the third horizon are to be mixed. For improvement of pH of 3.6 to 3.9, to 6.5, calusium carbonate ($CaCO_3$) of 2,810 pounds is necessary. Loss on ignition is 6.2 percent, organic carbone is 1.8 percent, total nitrogen is 0.1 percent, and phosphate is 330 ppm, less than that of the second horizon, but potash (K_2O) is 1.4 percent, slightly more than that of the second horizon. Cation exchange capacity is 13.9 m.e. per 0.22 pound, total exchangeable bases are 3.4 m.4. per 0.22 pound, silica (SiO_2) is 61.8 percent, and alumina (Al_2O_3) is 17.9 percent.

The fourth horizon (B Horizon) occurs below 17 inches from surface, and is persist evenly down to over 40 inches. The soil colour is bright brown, and the soil forms the filmy mottling of hydroxide of manganese as well as that of the third horizon (A_2 Horizon). The soil texture is heavy clay soil, and the structure is platy. Pore spaces and cracks are smaller than those of the third horizon (A_2 Horizon). Compactness is extremely high, and plasticity is also large. Thereby the permeability is small. Among the horizon is the plant roots absent.

This type of soil is good for drainage, allowing least inundation on the ground. Therefore before the advent of the witches-broom disease, the area was among the more important for cacao growing soils of the island. Large areas were abandoned between 1936 - 1945, but with raising prices much of this was brough back into cultivation, but the nutrient of the soil is unfavourable for forming of the cacao judging from the result of the chemical soil analysis. It has been caused by the long term absurption of the nutrition from the soil. However, in the well-farmed estate as an example, it reportedly bears high yields, and therefore cacao does very well on this soil with good cultivation practices.

(No.23) Navet Clay ----- Drainage impeded

The soil of this type widely covers about 40,000 acres on the western side to southwest of Nariva Swamp and to the Vicinity of Bush-Bush, and dominant around this section. The area is no less than 28,695 acres.

Most of this type soil bears devastated forest, almost impossible for cultivation. At part of Nariva Swamp there are wet paddy and cacao farmed. About 11,600 acres among 28,695 acres is considered possible to be cultivated for this development project. This soil is derived from recent riverain clay alluvium, and the land surface is usually covered with a film of reddish brown iron hydroxide due to prolonged flooding. The area is flooded to a depth of 6 to 12 inches for a large part of the wet season but in the dry season the water-table is lowered considerably.

As sampling site of this type soils, augers S.No.1 (Bois Neuf Hill, which is at the boundary of the Swamp area at the east north edge of Bois Neuf Hill and hills), and S.No.4 (th area on the left bank watershed of the upstream of Jagroma cut) are selected and the analytical result of the sample soils is discussed below.

The first horizon (A_1 Horizon) is 16 inches thick, and the soil is reddish grey. The soil texture is of heavy clay soil, and the soil is single grained.

The pore spaces and cracks are small, and compactness is large and plasticity is extremely strong. Therefore permeability is small. Plant rootlets are hardly recognizable. The soil is strongly acid, with pH of 4.3 to 4.5 (N. KCl). Loss on ignition is 12.3 percent, organic carbon is 3.5 percent, total nitrogen is o.3 percent, potash (K_2O) is 2.0 percent, phosphate is 777 ppm, and the soil is considerably neutritious. Cation exchange capacity is 29.3 m.e. per 0.22, and total exchangeable bases are 20.8 m.e. per 0.22 pound. Silica is 64.6 percent and almina is 14.3 percent. Therefore the water holding capacity is assumed excessive over the medium. In order to improve pH of this horizon to 6.5 calcium carbonate of nearly 1,100 per care is necessary, rather small quantity for the strong acidity.

The second horizon (A_2 Horizon) is 12 inches thick, from 16 to 28 inches deep. The boundary with the first horizon is rather distinct, but that with the third (B Horizon) is not. The colour is orange and the texture is of heavy clay soil with hydroxide staining. The soil is single-grained in the structure, pore spaces are small and the cracks are hardly found. Compactness and plasticity are large and the permeability is poor. Even in the dry season, this horizon presents humid. Plant rootlets are already not recognizable, at 16-20 inches deep. The soil is strongly acid with pH of 4.0 (N. KCl). Loss on ignition, organic carbon, total nitrogen, potash (K_2O), and magnesia (MgO) shows small values comparatively with the upper horizons, but phosphate is 770 ppm, almost not different. Judging from the values of cation exchange capacity and total exchangeable bases, as water holding capacity is considered less than those of the first horizon, it is assumed better that this horizon shall not be fallowed.

The third horizon (B Horizon) emerges below 20 inches from surface, persist down to about 3 feet. The soil is brownish grey, and hydroxide staining is recognized. The soil texture is of heavy clay soil, and the structure, pore spaces, cracks, compactness and plasticity are similar with those of the second horizon. The soil is strongly acid, with pH of 3.7 to 3.8 (N. KCl). Both neutirtion and water holding capacity are poorer than those of the second horizon. The soil of the auger S.No.4 is Navet Clay of the soil series No.23 as well as the auger S.No.1. In the devastated woods at the left bank of the upstream of the Jagroma Cut is located at this site, profile of which is shown on the profile S.No.4. On the surface of the site, there is humus horizon (A_0 Horizon) with 1 inch thickness, showing different aspect from the auger S.No.1. The second horizon (A_1 Horizon) with 4 inch thickness, gradually merging with the third horizon (B Horizon). The third horizon appeares at about five inches deep with 7.2 inches thickness, gradually merging with the fourth horizon. Thus, the site of the auger S.No.4 is the same ordered horizon as those of the auger S.No.1 and the way of changing among the horizons are the same as that of the auger S.No.1, but there is slight differences among the thickness of horizons. Also it differs on the point that, because comparing with the auger S.No.1, the contained humus is much and because it is prone to desiccation during the dry period, the soil colour presents a strong tone, dark grey to black.

The second horizon (A_1 Horizon) is grey and heavy clay soil containing humus. The structure is prismatic. Pore space is medium-sized with cracks. On these respects, it is considered under the condition that the site is prone to desiccation much more than that of the auger S.No.1 site. Both compactness and plasticity are large, and permeability is small. However, presence of cracks facilitates the drainage considerably. The soil is strongly acid with pH of 4.8 to 5.2 (N. KCl). Loss on ignition is 13.3 percent, organic carbon is 3.8 percent, total nitrogen is 4.1 percent, potash (K_2O) is 1.8 percent and phosphate is 9.42 ppm. Therefore the soil is nuritious. The cation exchange capacity is 31.0 m.e. per 0.22 pound, total exchangeable bases are 29.4 m.e. per 0.22 pound, silica (SiO_2) is 49.8 percent, and almina (Al_2O_3) is 17.9 percent. Thereby the water holding capacity is large.

The third horizon (A_2 Horizon) is 7.2 inches thick, and is heavy clay soil presenting grey. No gravels are found in the soil. The soil is prasmatic in the structure. Some cracks are recognized as well as those of he second horizon. The soil is strongly acid with pH. 3.8 to 4.0. Computing from the Buffer curve, to improve the pH value to 6.5, 330 pound per acre of calcium carbonate is necessary, is case it is merged with the soil of the second horizon (A_1 Horizon). However, upon computing the required quantity of neutralizer among the cultivation costs, it would be safer to employ 1,100 pounds of the auger S.No.1.

Total nitrogen is 0.23 per cent, potash (K_2O) is 1.8 percent, phosphate is 770 ppm, cation exchange capacity is 26.6 m.e. per 100g, and total exchangeable basese are 20.7 m.e. per 0.22 pounds. Thereby nutrient and the water holding capacity are over the medium, and considered unharmful even if the soil is merged with the upper horizon soil.

The fourth horizon (B_1 Horizon) is 14 inches thick, and the soil is greyish yellow-brown, and of heavy clay soil containing hydroxide staining. The structure is single-grained, and cracks and pore space are hardly found. Compactness and plasticity are large. Plant roots except the direct roots of trees are not recognizable in this horizon. The soil is strong acid, pH of 3.4 to 3.8 (N. KCl), and the buffer curve shows mostly no marked fructuation, so that to improve the acidity of this soil three to five times as much as calcium carbonate is necessary.

The fifth horizon (B_2 Horizon) is 26 inches deep and continuous down to 3 feet from surface. The colour is yellowish grey and is of heavy clay soil containing hydroxide staining recognized. In this horizon, pore space and cracks are seldom recognizable. Acidity is stronger than that of the fourth horizon, and the buffer curve shows remaining lateral. Nutrient and the water holding capacity are not different from those of the forth horizon.

As stated above, considering that the Navet clay is covering the wide area, some differences have to be pointed up among the gradient condition, desposit thickness, repetition of dry and wet or difference between the waterloging duration, difference between the deposit ages and the vegetation differences on the earth. However, as for the result of the chemical analysis of each horizon, almost of them are considered similar.

Navet Clay is rich is nutrient and capable of holding water largely. Nevertheless, due to inundation during the rainy season and the long distance from the surrounding road system, Navet Clay is not almost utilized, and the most part is a forest zone. The forest consists of various kinds of bush, and on the watershed close to the bank roso is growing in groups. Around the area near the roads, logging is performed for timber. This type of the soil is generally nutrient, and if the drainage condition is provided in the rainy season, the area made pasturable without much investment in possible for agricultural development based on the livestock. In this case, avoiding to cultivate the whole area, some trees as the shade for livestock and windbreak are necessary to be left at core sites.

They are also useful for preventing erosion or for soil management.

(No.41) Las Lomas Fine Sandy Loam to Loam ----- Drainage free

Soil of the Las Lomas series extends over lower hills and the surroundings including complexes with other types. The area covers 16,000 acres. But among the irrigable area for the present development project, part southeastern of the area between No.8. Bois Neuf Clay and No.23. Navet Clay, is representative, of which area is about 792 acres. Although there is some areas besides the above stated area, the total area is very small.

The first horizon (A_1 Horizon) is 5.2 inches thick, gradually merging with the soils of the second horizon. The colour of the first horizon presents black, and the soil contains much humus, forming fine sandy loam. Compactness is small and plasticity is naught. Thereby permeability is large. In the horizon there are found many plant rootlets distributed. The soil is strongly acid, pH. 4.0 (N. KCl). Loss on ignition is 15.0 percent, organic carbon is 1.5 percent, total nitrogen is 0.12 percent, potash (K_2O) is 0.1 percent, and phosphate is 184 ppm, small. Magnesia is hardly traceable, but silica (SiO_2) is 82.5 percent, which is considered very large and almina (Al_2O_3) is 3.1 percent, small. Cation exchange capacity is 12.1 m.e. per 0.22 pound, and total exchangeable bases are only 4.0 m.e. per 0.22 pound. Therefore the soil contains small nutrition for vegetation, and the water holding capacity is sterile.

The second horizon (A_2 Horizon) is located 5.2 is 12 inches in the depth, and the boundary with the third horizon is rather distinct. The soil colour is black, and the soil contains slight humus, forming fine silty loam. Compactness is medium, and plasticity is not recognized, and thereby the air and water permeability are large. Plant rootlets can be found. The soil is strongly acid, 4.1 (N. KCl). In the case of cultivation of this area, this horizon is to be merged with the topsoils, when required calcium carbonate ($CaCO_3$) for improvement of pH 4.1 to 6.5 is

465 pounds per acre. The reason why, inspite of the strong acidity, the required small quantity satisfies, is because the buffer curve plots extremely sharp. Loss on ignition is only 1.2 percent, organic carbon is 0.3 percent, total nitrogen is 0.04 percent, potash (K_2O) is 0.1 percent, and phosphate is 81 ppm. Cation exchange capacity is 5.0 m.e. per 0.22 pound, total exchangeable bases are 1.3 m.e. per 0.22 pound, very small, silica is 88.5 percent, and almina (Al_2O_3) is 2.1 percent. It is considered by these values, that the soil is very sterile, and that the water holding capacity is very poor.

The third horizon (B_1 Horizon) is located 12 to 26.4 inches in the depth, the soil is grey, without humus. The texture is fine sandy soil. Compactness is comparatively smaller than that of the second horizon, and there is rarely plasticity found. The soil is single-grained in the structure, with large water permeability. The plant rootlets are almost recognizable. Plant nutrition is far smaller than that of the second horizon, and the soil is steril.

The fourth horizon (B_2 Horizon) occurs below 26.4 to 32 inches from surface, gradually merging with the fifth horizon (B_3 Horizon). The soil is dark olive. The texture is fine sand. Compactness is medium, and plasticity is not recognized. Thereby permeability is large. The groundwater-table is located between the fourth and the fifth horizon, where the fourth horizon marges with the fifth horizon. The soil is weakly acid, pH 6.1 (N. KCl), and both the vegetation nutrient and the water holding capacity are poor. The colour is bright yellowish brown, and the texture is fine sand, which is tightly compacted. Plasticity is not recognized, and thereby permeability is large, but it is excess-humid. The pH is 6.4 (N. KCl), or 7.1 (H_2O), which is weak acid or neutral. The horizon's vegetation nutrient and the water holding capacity are as poor as those of the fourth horizon.

The Las Lomas series have allowed cultivation, so that most of the land has become sterile and devastated. At present in the surroundings of the Kernanham Road led from the Manzanilla-Mayaro Road, settlers are farming water melon, cowpea, okura, maiz, etc, without successful products. Nevertheless, the reason why scores of the farmers cultivate is because of advantages that the elevation is somewhat high in the Nariva Swamp area and the sandy soil is easy to drain, and that as there are no giant trees the cultivation is so easy. This soil requires considerable fertilization and the soil management for grain and vegetable farming, so that though the productivity per unit is low utilization of the area for livestock after the cultivation might as well be taken into consideration.

(No.43) Princes Town Clay ----- Drainage imperfect

Princes Town Clay is noted for the black marl soil of the Princes Town-Rio Claro district. It covers a total area of 14,000 acres in a belt, extending from San Fernando to Ecclesville and a smaller belt just north of Brickfild; and an isolated out-crop occurs to the West of Point Radix. This soil, in the project area, locates over the northern area of the Mayaro Road, about 1,924 acres. However, there is no area proper for the development. According to the section of the soil, the surface horizon is characteristic of humus clay, tending to change into Rendzins series. The surface is 4 inches to 24 inches thick, and the surface has a coating of humus crumbs about half inches thick and below this its structure is cloddy in the dry season and massive in the wet season. Below the black topsoil is a horizon of pale yellowish brown lime-free clay about 6 inches thick overlying olive grey and putty coloured calcareous clay containing small white calcium carbonate concretions (1/8 inch diameter). Slight orange staining may appear between 24 and 42 inches. Below about 42 inches the parent marlstone is found which may contain up to 60 percent of calcium carbonate. It is soft and when dry breaks with a conchoidal fracture; black manganese dioxide and orange ferric hydroxide staining and calcium carbonate concretions are often but not invariably present. Plant nutrient status is high in all respects except available phosphate.

The most important crop on this soil type is sugar-cane which gives profitable yields even in the wetter, eastern localities which were formerly under cacao. Cacao was highly productive during the first two decades of its existence but yields declined severely from witches-broom infection and large areas were abandoned during the slump. Rising prices have recently encouraged planters to rework their fields but most of them were too far gone to make this worth while complete replanting with high bearing strains would still be profitable.

Conspicuous features of the land in the Ste. Madeleine district are the white capped hills. These are the result of thorough cultigation of whole slopes from top to foot, whereby the black topsoil was washed and the white marl exposed at the surface.

(No.47) Tarouba Clay ----- Drainage impeded

This soil type is confined to the peneplained country south of the Central Range. It is most extensive in the San Fernando-Princes Twon district with discontinuous outcrops stretching to the Nariva Swamp. It is derived from green clay shales of Oligo-Miocene Age. The total area covered is about 23,000 acres. For the present development project, the area is selected where the series are located mainly close to No.49 Ecclesville series in the south division of the area, and besides of it, where partially the series are lying here and there, totaling to about 666 acres. The topsoil in an undisturbed profile is dark olive brown clay 6-12 inches deep which overlies grey or olive grey clay, mottled olive and yellowish brown, merging into grey-green caly shale at a depth of 4 to 6 feet.

The clay below the above-stated horizon compses of calcareous family containing calcium carbonate, forming small white or cream coloured concretions.

Gypsum is almost invariably present as veins and nests of crystals beginning at about 30 inches from the surface. Shining slip surfaces are a marked feature of the deep subsoil. Land-slips are common and give rise to eroded phases having yellowish brown topsoils and calcium carbonate at, or near, the surface.

The reaction is slightly acid to midly alkaline, the available potash content is high but not as the Talparo clay (about 150 ppm.).

Tarouba clay is an important sugar-cane soil and at one time a productive cacao soil too, but this cultivation has become practically extinct through neglect and disease.

<u>(No.49) Ecclesville silty clay loam to clay</u> ----- Drainage impeded

Ecclesville clay is found in a broad belt on the northern flank of the middle part of the Central Range. Smaller areas occur in the limestone country near Biche, in the type localities at Ecclesville and in several other much smaller and widely scattered spots. The total acreage is about 30,000, but the soil is distributed connecting to No.47 Taruba Clay of the south part in the development area, totalling to nearly 893 acres.

This soil type is derived from non-calcareous clay shales of Miocene Age. The topsoil is dark yellowish brown silty clay loam. Grey mottling appears at 12 inches and becomes more marked with depth. Black manganese dioxide stains frequently occur below 24 inches. Shaly clay stone or siltstone is usually found at about 6 feet from the surface; this is some shade of grey stained yellowish brown in fissures and bedding planes. Gypsum crystals may occur below 3 feet, but they are not invariably present.

The profile is strongly to medium acid (pH 5-6.5) being about 50 percent saturated with calcium. Much of the area was formerly planted with cocoa but very little survives tody.

(No.50) Talparo silty clay to clay ----- Drainage impeded

These soil types distributed mainly over the central Trinidad is derived from non-calcareous clay shales. This soil covers about 104,000 acres in two broad belts on either side of the Central Range and a few small areas at Mayaro, Manzanilla, and Matura. However, in the project area, the soil of this type distributed near Mayaro, about 2,412 acres, at the southeastern part of the area. This soil is in general noted for red clay or reddish weathering clay. An disturbed profile has four distinct horizons; (1) dark to light yellowish brown silty clay or clay for the first 6 inches; (2) yellowish brown silty clay or clay mottled orange for about 12 inches; (3) red clay, mottled pale grey or olive grey for 2 to 4 feet, becoming grey mottled red with depth; (4) more or less laminated grey clay, which varied from olive to blue or even purplish grey stained yellowish brown in fissures and bedding planes. The yellowish brown topsoil is not very often seen in the sugar-cane belt as it has either been lost by erosion or has been incorporated with the red subsoil. The general appearance of the cane fields on this soil type under the plough, is bright brick red, when wet or light reddish brown when dry, but closer inspection always reveals the grey mottling of the exposed subsoil. When the parent claystone is carbonaceous much of the mottling in the deep subsoil is purpole in colour. Gypsum crystals almost invariably occur below 4 feet and sometimes as high as 2 feet from the surface. They may be found in sporadic nests, irregular veins or in massive crystals up to 2 lb. in weight. The larger crystals are usually found near the line of contact of the acid Talparo clay with the highly calcareous Princes Town clay, always on the clay side of the line and never in the marl. Iron concretions, crimson or orange in colour, soft, semi-hard or hard may be seen in any horizon but they are rarely abundant; they seem to be more frequent in the drier areas. They vary considerably in size and shape from roads about 1 inch diameter and 4 inches long to flat angular pebbles besides the common pisolithic form. Black manganese dendritic staining may be found below 2 feet from the surface. Internal drainage is impeded and is certainly very little in amount after the dry season cracks have sealed up. But during the time the cracks are open a great deal of water may find its way to the shaly clays via gypsum veins, old root traces and bedding planes. If the slope is long and steeper than about 60 and especially if it is a dip slope the wet clay --- dry clay shale contact will be lubricated to such an extent that the wet mass will slide over a large concave area.

Heaviness in texture and high acidity (pH 4.0-5.0) combine to make the Talparo clays have one of the highest lime requirements of all Trinidad soils (5 to 7 tons per acre) but some of this requirement may be met by the gypsum, in so far as calcium nutrition is concerened. Available potash is usually present in adequate quantities and is sometimes as high as 1,000 ppm. Avilable phosphate is usually very low in amount and the capacity for fixing phosphate is very high. Under estate management these soils can produce good crops of hardy sugar-cane, but high levels of nitrogen and phosphate manuring are necessary as well as liming and contour planting. Large area are under peasant cultivation, in which case, yields are very much lower. Cacao was formerly planted over most of the eastern side of the red clay belt, but only when the trees were young and well cared for, were good crops obtained. Most of the cacao trees are now extinct or abandoned.

(No.51) Tamana Clay ----- Drainage excessive

Tamana clay is derived from orange coloured limestone which occurs in thin outcrops, striking SW-NE from Point-a-Pierre to Manzanilla, covering about 3,000 acres. However, this is not included in the area selected for the development. They are comparatively shallow soils and consist of a topsoil about 9 inches thick of dark brown humic clay with a fine clod structure overlying 3 to 12 inches of yellowish brown clay. Below this is the parent material which is a bright orange brown clay full of limestone brash. Massive rock usually appears within the top 3 feet.

This soil is remarkable in that it supports a xerophytic type of natural vegetation --- Semi evergreen seasonal forest, accounting for in the steepness of slope and the non-availability of subsoil water.

No.53 Mayaro sand to fine sand ----- Drainage excessive

This top soil type is derived from soft Miocene sandstone or conglomeritis sandstone, covering an area of 9,500 acres in the Central Range and at Mayaro, of which the small part is included in the development project area.

Apart from a slightly darker topsoil the whole profile of the normal phase is undifferentiated into horizons and is a uniform yellowish brown sand or loamy sand down to 6 feet. Solid sandstone occurs at an undetermined depth below this, but a few erratics may be scattered on the surface or may be exposed in deep cuttings. In the stony phase which is derived from conglomerate small black cherty pebbles may occur sporadically throughout the profile or be restricted to definite strata. Mayaro sand is less acid and richer in potash than other desentary sandy soils. Where slopes are not too steep and the sites are sheltered from drying winds good stand of cocoa are carried.

No.55 Brasso clay ----- Drainage imperfect or free

Brasso clay is the most widespread soil type of the higher parts of the Central Range. In Nariva Swamp, Bois Neuf Hill support this type soil. An active mud volcano is in Nariva Swamp and the gushed mud is alkalin, pH 8.0 - 8.6 (N. KCl). Parent rock of Brasso clay is a silt stone. The topsoil is a dark brown humic clay rarely more than 4 inches deep, below which is about 12 inches of a yellowish olive clay. The ground colour of this is light olive brown, inconspicuously mottled shades of yellowish brown. Free calcium carbonate, is usually found at about 30 inches from the surface.

Plant nutrient content is fairly good, cocoa is highly productive on on young estates but the trees decline severely after about 30 years. Teak trees attain their maximum height on this soil type. Sugar-cane, maize and ground provisions do very well with normal care.

However, the part of Bois Neuf Hill has high elevation among Nariva Swamp, and the part is too much in drainage and excessively desiccated on the ground surface in the dry season, and therefore field irrigation is necessary for water supply, leading to the high cost of the development cost. Therefore, study on availability of Bois Neuf Hill in view of leaving the area for residence area, green zone or other public uses, is considered rather reasonable than striving for agricultural development.

No.56 Marper silty clay and clay ----- Drainage imperfect

Associated with the Montserrat and Brasso series is an intermediate series of clays derived from contemporaneous Miocene deposits. These were first described in the Marper-Canterbury Estates region of the E. Central Range but were later found to be extensive in the Montserrat Hills. The total area of Marper series is about 2,000 acres, of which a small area is included in the development area. The topsoil in the normal phase is about 6 inches deep of a very dark brown almost black crumbly to nuttly clay which may be as much as 15 inches deep in the deep phase. Below is a uniform yellowish brown to brownish orange, more compact clay which frequently contains an abundance of white calcium carbonate concretions. When there are no concretions this orange coloured horizon may have a reddish cast. Yellowish olive mottling may appear below 4 feet and this merges into yellowish brown to yellowish olive clay shale. Seom exceptional profiles are bright yellowish brown to 10 feet. Free calcium carbonate may occur in definite horizons or less frequently, not at all, but the whole profile is more than half saturated with calcium. Limestone chips or rocks may occur at any depth especially in the more easterly outcrops of this soil. The deep phase is found chiefly in the vicinity of San Salvador and Tortuga Estates in the Montserrat District, where occupies well defined upland terraces. In this locality it is distinguished from the Montserrat clay in having a darker and deeper topsoil, larger calcareous concretions, slightly mottled, compact or shaly subsoil, larger calcareous concretions, slightly mottled, compact or shaly subsoil clay instead of friable clay.

Plant nutrient status is above the average, especially in the deep phase where both available potash and phosphate may be high. Excellent stands a cocoa are to be seen on the Marper clays but in the flatter spots young trees are difficult to grow compared with the surrounding chocolate coloured soil.

No.57 Canterbury silty clay ----- Drainage imperfect

Canterbury silty clays is practically confined to the eastern half of the Central Range, with small outliers near Guaracara and Point-a-Pierre, covering in all about 4,000 acres which is not selected for the development. It is derived from black or dark grey, hard carbonaceous shales of Eocene to Lower Cretaceous Age. The topsoil is a dark to light brown silty clay overlying yellowish brown, orange mottled horizon about 12 inches thick. This grades into an unconsolidated mass of brashy shale fragments dark brown in general colour and stained orange brown. At 5 to 7 feet below the surface the parent rock appears; this is hard, black, calcareous and very micaceous shale venined with white clayey films which are believed to be kaolin. Hard, crimson purple haematite concretions are a marked feature of this soil type, being found at any depth from the surface to the parent rock and any size up to 1-1/2 inches diameter.

The nutrient status of this soil type is not outstanding, apart from high topsoil orange matter content (6-8 percent).

No.59 Moruga loam ----- Drainage imperfect

Moruga loams are located on the northern flank of the Central Range and to the South of the most southerly red clay belt. Altogether about

30,000 acres of the area are covered by these loams, of which dispersed 192 acres is selected for this development project, for the vicinity of the upstream of the Guatacare River and the area north of Rio Claro-Mayaro Road south-east of the area. They are derived from very variable, fine sand-silt clay shales of Miocene Age, which have been folded and faulted into most complex geological structures. The weathering products are shallow loams which on account of steepness of slope (young topography) do not display any striking pedological characteristic. The topsoil is yellowish brown fine sandy loam or fine sandy clay loam merging into paler yellowish loam which may be slightly mottled with orange brown. The whole profile is very micarceous but never calcareous nor gypseous. Plant nutrient status is medium to low in every respect and this is reflected in the agriculture.

No.60 Mount Harris Catena ----- Drainage imperfect

Soils of this category are widely distributed on the southern flank of the Central Range where they occupy about 10,000 acres, but the soil is not found in the project area. They are catenary because they follow a topographic sequence and have the same parent materials, viz. gritty sand. They are derived from the weathering products of narrow bands of gritty sandstone outcropping in red mottled clays of Eocene-Miocene Age. The actual area of the sand outcrops is usually small and confined to ridge crest, but the loose coarse sand into which it breaks down is washed over a considerable area of the lower clay slopes. Fragments of coarse griffy sandstone are also scattered erratically, both on the surface and within the soil profile. The net result if normally a soil similare to the Prarco series but with larger sand grains, overlying a red mottled clay subsoil. The topsoil consists of humus coated quartz sand, dark brown at the surface and paler below. This overlies a very light grey silty clay mottled bright orange for almost 20 inches then the mottling changes abruptly to crimson mottling. Orange mottling appears again at about 3 feet from the surface and finally replaces the red. Owing to great irregularities in topography deep accumulations of sandwash are produced in clay hollows and form small areas of almost perennially water-logged soil.

The mineral nutrient status of these soils is very low and they are extremely acid throughout the profile, and accounted for non-availability for agriculture. Fortunately the largest area of the Mount Harris Catena is in a permanent Forest Reserve.

<u>No.61 Mitan fine sandy loams to silty clays</u> ----- Drainage imperfect

These soils are practically confined to the eastern half of the Central Range with three small lenses South of the Guaracara Limestone outcrops covering about 6,000 acres in all. But these soils are dispersed over only 37 acres in the project area. The are derived from non-calcareous silty shales of Eocene to Cretaceous Age. Profile horizons are rather ill defined but are characterized by an abundance of angular fragments of semi-hard brown or green shale. The topsoil is very variable in texture, patches of yellowish brown fine sandy loam to silty clays being found within very short distances. These overlie at 6-12 inches an orange or orange red mottled horizon which at about 2 feet 6 inches changes to brashy shale. Grit fragments and crimson iron concretions may occur at any depth. Black manganese dioxide staining and white kaolin films are often found below 2 feet.

The mineral nutrient status is low and the profile is acid throughout. Most of the land of this series is under high forest and the small areas that have been cleared for agriculture are now abandoned. Brigand Hill but nearly all died out soon after coming into bearing from lack of subsoil moisture reserves and root-room as well as mineral nutrients.

Land Classification

Relationship of each area of the soil series of the surveyed area with the area selected for the development is shown in Table C-1. These areas are classed according to the deposit pattern and availability of drainage system, and also soil condition and avilability of drainage system control vegetation status. In other words, Nariva area is classified into the following five groups, according to the geological condition, propriety of drainage, soil profile, and vegetation status.

Topographical and Geological Classification

(1) Plain alluvial area at the low elevations situated at the back of the natural dike of the eastern part.

(2) Plain alluvial area among slightly higher elevations than the high tidal level.

(3) Slightly high island-shaped land and low hilly land located in the plain area stated in (2) (On Bois Neuf Hill is an active mud volcano.)

(4) Alluvial area which slopes down from the western gradually sloping area to the plain area extending toward the southwestern part.

(5) Beach dunes striking from north to south along Cocos Bay.

Land Classification by Drainage Ability

(1) The area which is lower than the high tidal level and impeded in drainage, partitally forming swamps.

(2) The area which flooded and inundated, caused by the relationship of the flows from the mountains and drainage ability with topography and elevations in the rainy season.
(In the dry season, the area between central and southwestern part is droughty and at the north eastern part, there is some areas where the water is stagnant.

(3) Drainage is free

(4) Drainage is imperfect. In the dry season the land is draought.

(5) Drainage is extremely free.

Land Classification by Soil Texture

(1) Soil Series No.10 Macow Peaty Clay is the representati-e of the area, of which topsoil is characteristic of being covered with grass litter and peat and the subsoil is of clay. Near the beach dune sandy soil partially locates in the subsoil.

(2) Soil Series No.8 Bois Neuf Clay, No.9, Nariva Swamp Clay, and No.23, Navet Clay are the representative of the area, of which the area is very wide and dominant in the Nariva Swamp area. The profile of the most of the area is strongly acid just under the topsoil, and of heavy clay soil including no gravels.

(3) Soil series No.41. Las Lomas Fine Sandy Loam to Loam, No.50 Talparo Silty Clay to Clay and No.55 Brasso Clay are representative of the area, and dispersed. Dune is of sandy soil, Soil Series No.41 is of silty loam, and the Bois Neuf Hill is of humus. Judging from the soil texture, Bois Neuf Hill should be classed in other way, but from respect of topography, vegetation and propriety of drainage, the Bois Neuf Hill is dealt with classed as this group.

(4) Soil Series, No.9. L'Ebranche silty Clay to Clay, No.43 Princes Town Clay, No.47. Turuba Clay and No.49. Ecclesville silty clay loam to clay classed as this group. Most of the area is clayly soil presenting Manganese oxide mottling and partially silty clay to silty clay loam.

(5) Soil Series No.14. Cocal Fine sand is component of the area, and it

entirely covers the area.

Land Classification by Vegetation

(1) In tidal compartment mangroves grow thick, and partially land of humic grass, mainly sedges, is formed.

(2) The central part is thickly covered with giant aroid and giant sedge, and partially around the Plum Mitan rice, and water melon are farmed. In the northeastern part, cascadoux grass and the litters are laipd up, locally wild tanian forming groups. Forests and woods covers the southwestern slightly high elevations.

(3) Jungles composing of various kinds of vegetation covers the area, of which southeastern part, soil series No.41, is cultivated.

(4) The area is partially utilized as estate, and the others are covered with extinct copses.

(5) The area has been utilized as coconut plantation.

About 26,500 acres for the project is classed based upon each section stated above as follows. However, soil series No.10, Macaw Peaty clay is not included because of impossibility of cultivation.

Land Classification	1	2	3	4	5
Land Area (Acres)	-	21,295	3,608	1,634	19
Percentage	-	80.2	13.5	62	0.1

Except for the southern hilly land in the project area, most of the area is of the slightly higher elevations, plain alluvial area, than the high tidal water. In the rainy season most of the area is inundated and relatively higher elevations is droughty in the dry season. The profile is strongly acid from the undernearth of the surface, including no pebbles, and of heavy clay soil. Most of the area is thickly covered with giant sedges and giant aroids. Around the Plum Mitan, the area is under the temporary cultivation. As most of the project area is not to be inundated in the near future as the project is promoted. Therefore, for the land utilization scheme, the soil texture which has been stated above must be taken into the consideration as among the most important factors.

Land Use Plan

The Nariva Swamp area was classified into 5 groups according to the natural condition as stated previously. From the features of each group, the followings are stated as the conclusive understandings.

Land Use of Group I

The feature of this groups is characteristic of peat in the top soil and clay soil in the under layer, with sandy soil partially distributed. Judging from the drainage condition and the distribution of elevation, this group is considered hard to be actively developed for the agricultural land.

Land Use of Group II

As the feature of this group is of strongly acid heavy clay soil just from the undernearth of the humus topsoil, full consideration is necessary for planning of drainage, irrigation, decision of the introductive crops and farming program. Since also permeability coeffeciency is small, the density of the canals must be considered as high as possible upon the drainage planning. Upon the irrigation planning, the followings shall be considered: as the permeability of the soil is small, required water quantity is not always large but because of occuring of cracks by the soil drought, the initial water quantity shall be much; and as the water distribution is not well due to the cracks the water does not reach to every terminal smoothly, if the span of irrigation canals are too large; lastly if the depth of excavation is properly adjusted, it is considered that canals are to bear the both functions of irrigation and drainage. Upon selection of crops which are to be introduced, the crops shall have to be considered so as to grow on the heavy clay soil has to be taken into con sideration, as for the effeciency and selection of models of agricultural machinery.

Land Use of Group III

The soil let the drainage free, but the Sand Hill is poor is holding water. As at the Bois Neuf Hill is of humus and sloped, it is expected that the soil is excessive droughty and therefore that irrigation is needed. However, as the water has to be pumped up, the cosr is to be high. Also considerable soil improvement of Sand Hill as well as Neuf Hill is necessary, and therefore the cost is to be high also.

From what have been discussed above, it is reasonable that the area is planned not as agricultural land but as picking place for sand and soils for construction or green zone for the future. In the southeastern part there are some areas which settlers cultivate. The area, belonging to the Soil Series No.41, is free for drainage, with scarce giant trees, so that it is concluded that there is no good condition except for easiness of land reclamation.

In case uncultivated land is developed in the future, it is hopeful that the land is used for the pasture farming with every several years' ploughing, for being restore organic matters to the soils.

Land Use of Group IV

The area of the Soil Series No.19 among the group is used as the estate where cacao, coffee and banana are planted together, and some of the area are successfully producing the crops. But in general the yields are considered lower. As the most of the soils belong to this group have been utilized, it is not to be selected for the present development project. However it can be said that the area where is inundated in the rainy season will give benefits by the drainage of the water. The group includes the Series No.43, No.47, and No.41, being distributed mainly in the southwestern part, where wind belt is formed.

Land Use of Group V

About 100 percent of the whole areas belonging to this group is beach dune having been used for coconut plantation since before, and is excluded for the present development project.

Judging from the soil texture, it is hopeful that the group (2) with parts of group (3) and (4) shall be used for the agricultural development.

Table C-1 Area by Soil Series

Soil No.	Soil Series	Area for Soil Survey	In Project Area: Area	In Project Area: Percent	Inundated Area	Excluded Area	Area for Project: Area	Area for Project: Percent	Vegetation
		acres	acres	%	acres	acres	acres	%	
8	Bois Neuf Clay	5,653	5,653	9.1	1,802	-	3,851	14.5	Grass land
9	Nariva Swamp Clay	7,920	7,895	12.8	2,048	-	5,847	22.0	Grass land
10	Macaw Peaty Clay	1,612	1,612	2.6	670	942	-	-	Forest or grass land
14	Cocal Fine Sand	1,211	1,001	1.6	-	1,001	-	-	Coconut plantation
19	L'Eeranche Silty Clay to Clay	5,875	2,978	4.8	-	2,903	75	0.3	Forest land and partly cultivated land
23	Navet Clay	28,695	27,910	45.1	3,788	12,525	11,597	43.7	Forest or grass land
41	Las Lomes Fine Sandy Loam to Loam	2,428	2,385	3.9	172	1,421	792	3.0	Frass land and partly cultivated land
43	Princes Town Clay	3,194	1,924	3.1	-	1,924	-	-	Forest land and partly cultivated land
47	Jarouba Clay	2,761	1,905	3.1	-	1,239	666	2.5	Forest land and partly cultivated land
49	Eulesville Silty Clay Loam to Clay	2,527	1,881	3.0	-	988	893	3.4	Forest land and partly cultivated land
50	Jalparo Silty Clay to Clay	5,547	3,734	6.0	6	1,316	2,412	9.1	Forest land and partly cultivated land
51	Jamana Clay	389	306	0.5	-	306	-	-	Forest land
53	Mayaro Sand to Fine Sand	31	31	0.1	-	12	19	0.1	Forest land
55	Brasso Clay	1,211	352	0.6	195	12	145	0.5	Forest land
56	Marper Silty Clay and Clay	154	165	0.2	-	124	30	0.1	Forest land
57	Canterbury Silty Clay	229	229	0.4	-	229	-	-	Forest land and partly cultivated land
59	Moruga Loams	1,168	254	0.5	-	62	192	0.7	Forest land and partly cultivated land
60	Mount Harris Catena Silty Clay	1,483	1,035	1.7	-	1,035	-	-	Forest land and partly cultivated land
61	Mitan Fine Sandy Loams to Silty Clay	964	596	0.9	-	559	37	0.1	Forest land
	Total	73,052	61,835	100	8,681	26,598	26,556	100	

Table C-2 Chemical Analysis of Soil

Soil Series No.	Sample No.	Horizon	pH (1:2.5) Wet Soil H_2O	pH (1:2.5) Wet Soil N.KCl	pH (1:2.5) Air-dry Soil H_2O	pH (1:2.5) Air-dry Soil N.KCl	Percents of Oven-dry Soil: Loss on Ignition (500°C)	Total Nitrogen	Organic Carbon	Sulphur S	Potash K_2O	Sodium Na_2O	Magnesia MgO	Lime CaO	Silica SiO_2	Alumina Al_2O_3	p.p.m. in Oven-dry Soil: Phosphorus P	m.e. per 100Gm. Oven-dry Soil: Cation Exchange Capacity	Total Exchangeable Bases
23	1-1	A1 Top Soil	5.6	4.5	5.3	4.3	12.3	0.30	2.5	0.0656	2.0	0.5	0.2	Nil	64.6	14.2	777	29.8	20.8
	1-2	A2 Sub Soil	5.0	4.0	5.0	4.0	5.3	0.10	0.9	0.0598	1.3	0.6	0.1	Nil	78.0	13.4	770	14.0	10.4
	1-3	B Deep Sub Soil	4.9	3.7	4.6	3.8	5.0	0.09	0.4	0.0884	1.5	0.7	0.1	0.1	78.0	12.1	478	17.1	8.8
8	2-1	A0 Surface	4.9	4.2	4.7	4.1	20.0	0.77	8.3	0.3134	1.7	0.5	0.2	0.1	42.5	20.3	850	43.6	22.9
	2-2	A1 Top Soil	5.3	4.4	5.0	4.1	9.7	0.24	2.4	0.1311	2.0	0.3	0.3	0.1	48.1	23.3	535	30.0	26.0
	2-3	A2 Sub Soil	5.0	4.2	4.6	3.8	8.3	0.24	1.8	0.1299	2.1	0.4	0.2	Nil	50.9	24.6	254	31.9	23.1
	2-4	A3 Deep Sub Soil	5.6	5.0	5.2	4.5	21.3	0.59	12.2	0.4548	1.4	0.4	0.2	0.5	42.4	23.3	565	45.0	37.1
19	3-1	A1 Top Soil	5.0	3.8	4.6	3.6	8.3	0.22	1.9	0.0876	1.2	0.4	0.1	Nil	63.3	16.1	536	14.7	3.9
	3-2	A2 Sub Soil	5.2	3.9	4.6	3.6	6.2	0.10	0.6	0.0155	1.4	0.4	0.1	Nil	61.8	17.9	330	13.9	3.4
	3-3	B Deep Sub Soil	5.2	3.9	4.9	3.6	5.0	0.07	0.5	0.0721	1.2	0.6	0.1	Nil	72.6	11.9	371	9.3	5.2
23	4-1	A1 Top Soil	5.6	5.2	5.5	4.8	13.3	0.41	3.8	0.1338	1.8	0.3	0.2	Trace	49.8	17.9	942	31.0	29.4
	4-2	A2 Sub Soil	5.1	4.0	4.8	3.8	8.6	0.23	1.8	0.0348	1.8	0.3	0.2	0.4	51.4	21.3	770	26.6	20.7
	4-3	B1 Deep Sub Soil	4.7	3.8	4.4	3.4	8.2	0.18	1.5	0.0954	1.9	0.3	0.2	0.2	49.3	22.6	382	26.1	15.4
	4-4	B2 Deep Sub Soil	4.6	3.7	4.3	3.5	8.8	0.18	1.3	0.1696	2.0	0.3	0.2	Trace	55.7	20.5	382	26.1	14.1
10	5-1	A0 Surface	5.4	5.0															
	5-2	A Top Soil	6.1	5.2	5.4	4.8	42.6	1.50	23.4	N.D	0.2	0.2	0.1	1.9	64.9	1.5	585	60.7	40.7
	5-3	B1 Sub Soil	6.1	5.1	5.6	4.8	6.9	0.28	2.7	"	0.3	0.1	Trace	Nil	95.7	1.3	102	10.1	4.9
	5-4	B2 Deep Sub Soil	6.2	5.6	5.0	4.2	1.7	0.04	0.3	"	0.3	0.2	"	Nil	96.0	1.3	101	5.1	Trace
9	6-1	A1 Top Soil	-	-	4.8	4.1	22.4	0.78	9.2	0.4263	1.8	0.4	0.1	0.1	36.0	19.2	1,628	39.0	22.5
	6-2	A2 Sub Soil	-	-	4.7	3.8	7.7	0.28	2.3	0.1063	2.2	0.5	0.2	0.1	45.0	24.0	458	31.8	21.3
	6-3	A3 Deep Sub Soil	-	-	4.8	3.9	7.3	0.24	1.9	0.0918	2.2	0.5	0.2	0.1	43.5	24.6	410	36.0	21.4
	6-4	A4 Deep Sub Soil	-	-	5.1	4.4	13.4	0.31	5.8	0.2484	2.0	0.5	0.2	0.1	45.0	22.9	497	41.4	25.3
41	7-1	A1 Top Soil	-	-	5.2	4.0	15.0	0.12	1.5	N.D	0.1	0.4	Trace	0.1	82.5	2.1	184	12.1	4.0
	7-2	A2 Sub Soil	-	-	5.1	4.1	1.2	0.04	0.2	0.0177	0.1	0.1	"	0.1	88.5	2.1	81	5.0	1.3
	7-3	B1 Deep Sub Soil	-	-	5.9	5.3	0.8	Trace	Trace	0.0606	0.1	0.1	"	0.1	93.0	0.8	40	1.1	0.3
	7-4	B Deep Sub Soil	-	-	6.9	6.1	1.1	"	"	0.0900	0.1	0.1	"	0.4	90.0	0.8	80	1.9	1.3
	7-5	B Deep Sub Soil	-	-	7.1	6.4	1.0	"	"	N.D	0.1	0.1	"	0.2	93.4	0.8	80	1.1	1.0
	Mud		8.4	8.0	8.6	8.0	5.3	0.16	0.8	0.5327	1.8	1.7	0.2	0.3	66.8	12.3	488	15.0	

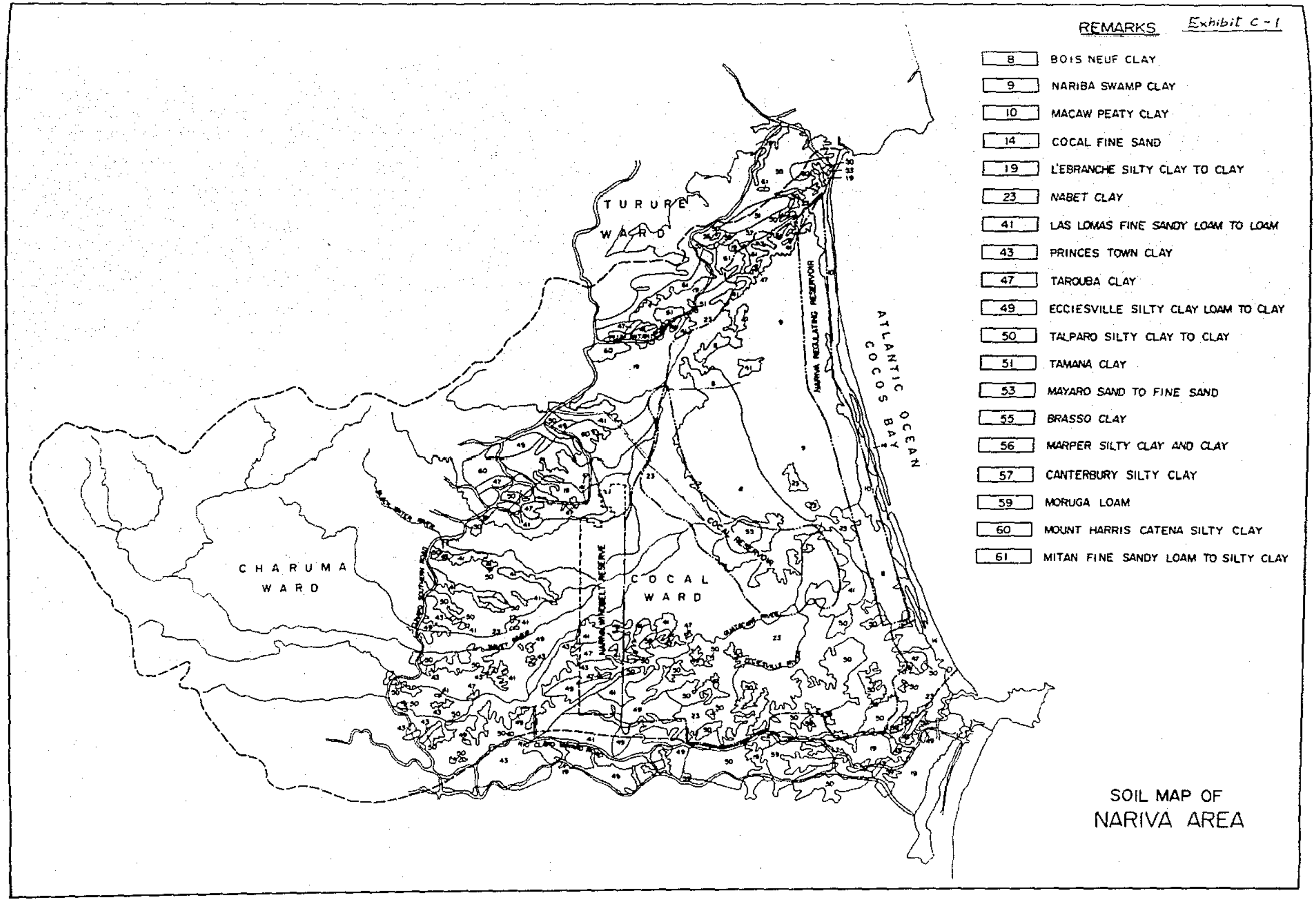
N.B.
1. As for Soil Series No.9 (Sample 6) and Soil Series No.41 (Sample 7), pH of Wet Soil could not be investigated because about 10 days had passed from sampling to the analysis.
2. Sample 5-1 could not be accurately investigated because it was grass litter. The grass litter is of undisolved matters of marshy arbor plant covering the top soil surface.
3. Mud is vomitted matter from the active mud volcano of Bois Neuf Hill.
4. N.D. : Not determined.

Table C-3 Buffer Capacity

Soil Series No.	Sample No.	P.R. Values m.e. Base (0.IN NaoH) odded per 100gm Air-dry Soil 0	1	2	3	4	5	6	7	8	9
	1-1	5.2	6.5	7.7							
23	1-2	5.2	6.4	7.1							
	1-3	4.9	5.8	6.3	7.0						
	2-1	4.7	5.4	6.0	6.4	6.7	7.1				
	2-2	5.1	5.3	6.2	7.0						
8	2-3	4.7	5.8	6.7	8.0						
	2-4	5.3	5.9	6.5	6.8	7.1					
	3-1	4.7	6.0	6.6	7.7						
19	3-2	4.9	6.1	6.4	6.7	7.0					
	3-3	4.8	6.1	8.1							
	4-1	5.5	8.0								
23	4-2	5.1	7.7								
	4-3	4.5	5.6	5.8	6.5	6.6	6.9	7.5			
	4-4	4.4	5.0	5.4	5.7	6.0	6.4	6.5	7.4		
	5-1										
10	5-2	5.4	6.3	7.3							
	5-3	5.5	9.5								
	5-4	4.9	9.7								
	6-1	5.1	5.8	6.7	7.0						
9	6-2	5.0	6.2	7.5							
	6-3	5.2	6.5	7.5							
	7-1	5.3	7.5								
	7-2	5.4	9.5								
41	7-3	5.9	11.4								
	7-4	7.0									
	7-5	7.1									

Table C-4 $CaCo_3$ for Hydrating into PH6.5

Soil Series No.	Sample No.	Required quantity of NaOH m.e. for raising pH of Air-dry soil 100 gm to pH 6.5	Required quantity of $CaCo_3$ for raising pH of Air-dry soil 100 gm to pH 6.5	Soil weight within 25cm of the depth ton per 10acre	Required quantity of $CaCo_3$ kg per 10acre	Required quantity of $CaCo_3$ kg per acre
23	1-1	1	50	250	125	500
8	2-1	3.1	155	100	155	1,340
	2-2	2.4	120	150	180	
19	3-1	1.8	90	50	45	1,280
	3-2	2.5	125	220	275	
23	4-1	0.3	15	250	37.5	150
10	5-1	1.1	55	150	82.5	340
	5-2	0.1	5	50	2.5	
9	6-1	1.8	90	100	90	774
	6-2	1.2	60	160	96	
41	7-1	0.5	25	130	33.5	209
	7-2	0.3	15	132	19.8	


REMARKS
Exhibit C-1
8 BOIS NEUF CLAY
9 NARIBA SWAMP CLAY
10 MACAW PEATY CLAY
14 COCAL FINE SAND
19 L'EBRANCHE SILTY CLAY TO CLAY
23 NABET CLAY
41 LAS LOMAS FINE SANDY LOAM TO LOAM
43 PRINCES TOWN CLAY
47 TAROUBA CLAY
49 ECCIESVILLE SILTY CLAY LOAM TO CLAY
50 TALPARO SILTY CLAY TO CLAY
51 TAMANA CLAY
53 MAYARO SAND TO FINE SAND
55 BRASSO CLAY
56 MARPER SILTY CLAY AND CLAY
57 CANTERBURY SILTY CLAY
59 MORUGA LOAM
60 MOUNT HARRIS CATENA SILTY CLAY
61 MITAN FINE SANDY LOAM TO SILTY CLAY
ATLANTIC OCEAN
COCOS BAY
TURURE WARD
COCAL WARD
CHARUMA WARD
NARIVA REGULATING RESERVOIR
NARIVA WINDBELT RESERVE
SOIL MAP OF
NARIVA AREA

LEGEND							
Boundaries	*Mottling*		Structure		Porosity		Texture
Sharply defined	Thready	Da	*Platy*	Pl	*Very fine cavity*	a 0.5 mm >	HC
Clearly defined	Cloudy	Db	Prismlike	Pr	Fine cavity	b 0.5 - 2	SiC
Gradually merging	Stains	Dc	Blocky	Bl > 2	Medium cavity	c 2 - 10	SC
Shapes	Vein tubular	De		Bl < 2	Large cavity	d 10 <	LiC
Smooth			Granular	Gr > 2			CL
Wavy	Very rich	+++		Gr < 2	Crack	Cr	SiCL
Irregular	Rich	++	Pores	D	Some	1.05% <	SCL
	Some	+	*Single grained*	Sn	*Rich*	2.25 - 15	L
			Massive	Ms	Very rich	3.15 <	SiL
			Pan	Pd			SL
							FSL
							LS
							S

S. No.1

Auger: *Northeastern edge of Bois Nenf Hill, bounded between the swamp and the hill*

Soil Series No.23

Horizons, Soil Profile		*Samples*	Colour	Humus Peat Muck	Mottling	Glei Horizon	Texture	Gravel	Structure	Pore space	Minuteness	Ortstein	Plasticity	Permeability	Humidity Groundwater table	Plant root
A1	20cm	1-1	Reddish Gray 2.5YR6/1	-	-	-	HC	-	Sn	Ch.a Cr.-	Compact	-	Plastic	Small	-	+
A2	40 / 60	1-2	Orange 7.5YR6/8	-	DC++	-	HC	-	Sn	Ch.a Cr.-	Compact	-	Plastic	Small	Exist	-
B	80	1-3	Brownish Gray 7.5YR6/1	-	DC+	-	HC	-	Sn	Ch.a Cr.-	Compact	-	Plastic	Small	Exist	-

Soil Profiles

S. No.2

Auger: Right side at the terminal of the roat running east from Plum Mitan

Soil Series No.8

Horizons, Soil Profile	Samples	Colour	Humus Peat Muck	Mottling	Glei Horizon	Texture	Gravel	Structure	Pore space	Minuteness	Ortstein	Plasticity	Permeability	Humidity Groundwater table	Plant root
A0 10cm		Olive 5Y	Grass	-	-	LiC	-	-	Ch.c Cr.1	-	-	-	Large	dry	+++
A1 20	2-1	Black 3/2	Litter	Da++	+	HC	-	Sn	Ch.b Cr.1	Compact	-	Plastic	Small	Moist	++
30		Gray 5Y5/1	Humus+++												
A2 40 50 60	2-2	Olive Gray 5GY5/1	-	Da+	++	HC	-	Sn	Ch.a Cr.-	Compact	-	Plastic	Small	Groundwater table	-
70 80 B 90	2-3	Black 2.5GY2/1	Muck+++	-	-	LiC	-	Sn	Ch.a Cr.-	Medium	-	Plastic	Small		-

S. No.3

Auger: At an angle of Wade Road, among estate

Soil Series No.19

Horizons, Soil Profile	Samples	Colour	Humus Peat Muck	Mottling	Glei Horizon	Texture	Gravel	Structure	Pore space	Minuteness	Ortstein	Plasticity	Permeability	Humidity Groundwater table	Plant root
A0 2cm	-	-	Humus++	-	-	-	-	-	-	-	-	-	-	-	+++
A1	3-1	Bright Brown 7.5YK 5/6	" +	-	-	HC	-	Pr	Ch.d Cr.3	Compact	-	Plastic	Small	-	+
A2 20 40	3-2	Orange 5YR6/8	-	Db++	-	HC	-	Pr	Ch.d Cr.2	Compact	-	Plastic	Small	-	-
B 60 80	3-3	Bright Brown 7.5YR5/8	-	Db++	-	HC	-	Pl	Ch.b Cr.1	Compact	-	Plastic	Small	-	-

S. No.4

Auger: Left side at the Upstream of the Jagroma Cut

Soil Series No.23

Horizons	Soil Profile (cm)	Samples	Colour	Humus Peat Muck	Mottling	Glei Horizon	Texture	Gravel	Structure	Pore space	Minuteness	Ortstein	Plasticity	Permeability	Humidity Groundwater table	Plant root
A0	2															
A1	12	-	-	+++	-	-	-	-	-	-	-	-	-	-	-	++
	20	4-1	*Gray 5Y4/1*	+	-	-	HC	-	Pr	Ch.d Cr.2	Compact	-	Plastic	Small	-	+
A2	30															
	40	4-2	Gray 5Y5/1	-	-	-	HC	-	Pr	Ch.c Cr.2	Compact	-	Plastic	Small	-	-
B1	60															
	65															
B2	80	4-3	Grayish Yellow Brown10YR6/2	-	DC++	-	HC	-	Sn	Ch.a Cr.1	Compact	-	Plastic	Small	-	-
	100															
		4-4	Yellowish Gray2.5Y6/1	-	DC+	-	HC	-	Sn	-	Compact	-	Plastic	Small	-	-

S. No.5

Auger: Left Side of the Upstream of the Nariva River (The site of the Swamp close to Post 39-1/2 miles from Manzanilla Mayaro Road)

Horizons	Soil Profile (cm)	Samples	Colour	Humus Peat Muck	Mottling	Glei Horizon	Texture	Gravel	Structure	Pore space	Minuteness	Ortstein	Plasticity	Permeability	Humidity Groundwater table	Plant root
A0	9	5-1	Black7.5Y2/1	Peat +++	-	-	-	-	-	Ch.a Cr.-	-	-	*Very Slighty* Plastic	Large	Dry	-
		5-2	Black reddish Brown5YR3/3	Peat +++	-	-	-	-	-	Ch.a Cr.-	loose	-	Non Plastic	Large	Very Wet Groundwater table	++
A1	20															
	24															
	40	5-3	Dark olive Gray2.5GY4/1	-	-	-	FS	-	-	Ch.a Cr.-	loose	-	Non Plastic	Large		+
B1	54															
	60															
B2		5-4	Bright Yellowish Brown2.5Y6/6	-	-	-	FS	-	-	Ch.b Cr.-	*loose*	-	*Non Plastic*	*Large*	*Very Wet*	-
	90															
B3	100	-	Dull yellow 2.5Y6/4	-	-	-	FS	-	-	Ch.b Cr.-	Medium	-	Non Plastic	Large	Very Wet	-

S. No.6

Auger: Plum Mitan Side of the Road Trench

Soil Series No.9

Horizons	Soil Profile	Samples	Colour	Humus Peat Muck	Mottling	Glei Horizon	Texture	Gravel	Structure	Pore space	Minuteness	Ortstein	Plasticity	Permeability	Humidity Groundwater table	Plant root
A1	10cm	6-1	Gray 7.5Y4/1	Humus +++	-	-	HC	-	-	Ch.a Cr.1	Compact	-	Plastic	Small	Exist	++
A2	20, 34, 40	6-2	Gray 7.5Y6/1	-	+++	-	HC	-	Pr	Ch.a Cr.1	Compact	-	Plastic	Small	Exist	+
A3	55, 60	6-3	Gray 5Y5/1	-	++	-	HC	-	Sn	Ch.a Cr.-	Compact	-	Plastic	Small	Exist Groundwater table	-
A4	80, 100	6-4	Olive black 5Y3/1	-	-	++	HC	-	Sn	Ch.a Cr.-	Compact	-	Plastic	Small	Very wet	-
B		-	Black5Y2/1	-	-	-	HC	-	Sn	Ch.a Cr.-	Compact	-	Plastic	Small	Very wet	-

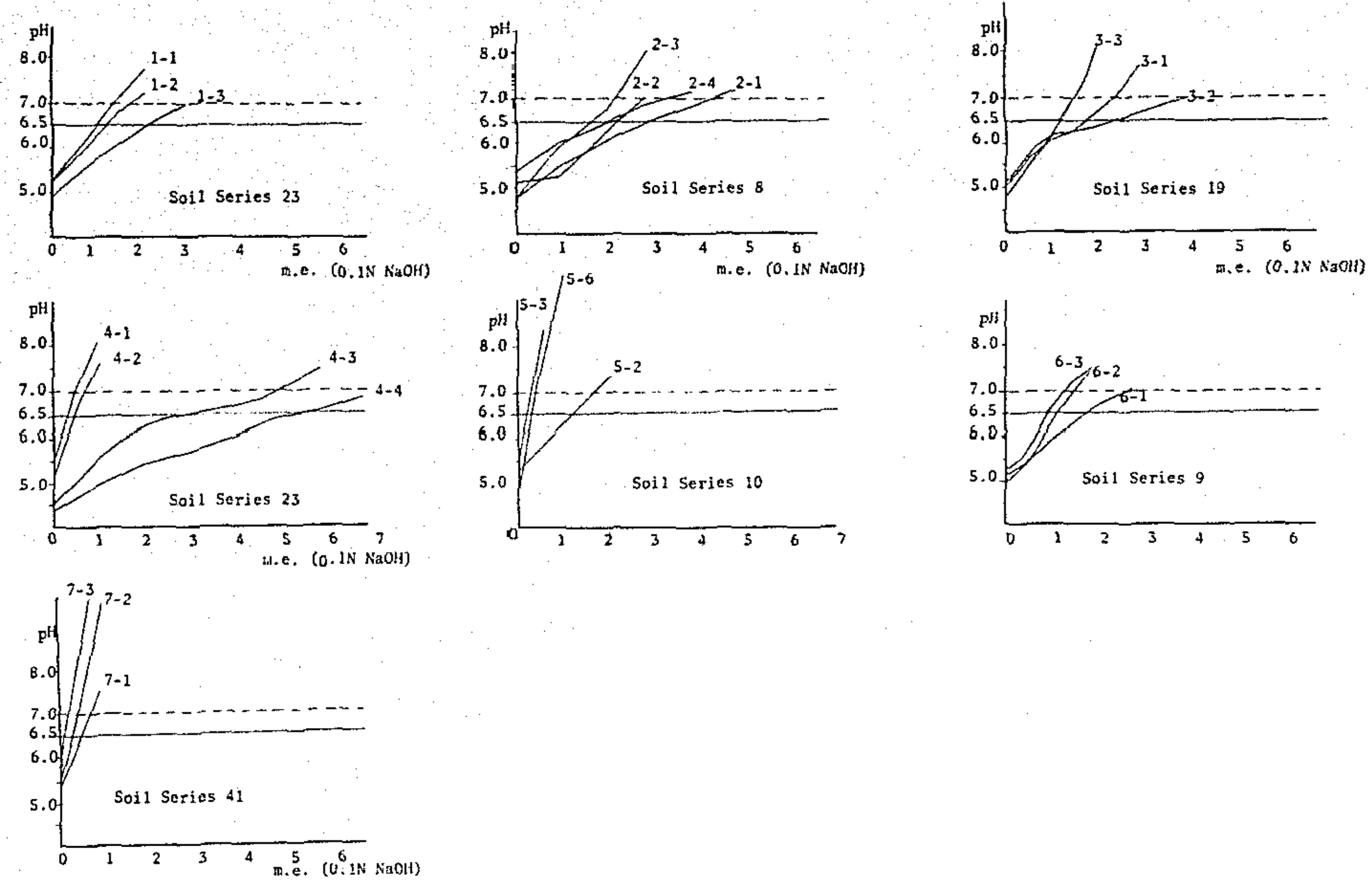
S. No.7

Auger: Within the Reclamed area at the terminal of Kernanham Road

Soil Series No.41

Horizons	Soil Profile	Samples	Colour	Humus Peat Muck	Mottling	Glei Horizon	Texture	Gravel	Structure	Pore space	Minuteness	Ortstein	Plasticity	Permeability	Humidity Groundwater table	Plant root
A1	13	7-1	Black 5Y2/1	Humus ++	-	-	FSL	-	-	Ch.a Cr.-	Loose	-	Non Plastic	Large	-	+++
A2	20, 30	7-2	Black 7.5Y2/1	+	-	-	SiL	-	-	Ch.a Cr.-	Medium	-	Non Plastic	Large	Exist	++
B1	40, 60	7-3	Gray 7.5Y6.1	-	-	-	FS	-	Sn	Ch.a Cr.-	Loose	-	Non Plastic	Large	Exist	+
B2	66, 80	7-4	Dark olive 7.5Y 4/3	-	-	-	FS	-	Sn	Ch.a Cr.-	Medium	-	Non Plastic	Large	Groundwater table	-
B3	100	7-5	Bright Yellowish Brown 2.5Y6/6	-	-	-	FS	-	Sn	Ch.a Cr.-	Compact	-	Non Plastic	Large	Very wet	-

Exhibit C-4



Buffer Curve

Appendix D

Hydrology

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Hydrology

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Appendix D

Hydrology

General Descriptions

The project area shows topographical features that it is a swamp-land of alluvial deposits, surrounded by the Central Range on the north and the west border and by the hilly lands on the south, sloping gently down toward the Atlantic Ocean on the east. Topographically, the project area can be divided, on hydrological analysis, into following two divisions; about 11,000 acres of a swamp plain facing Cocos Bay, the Atlantic Ocean, and about gross 15,500 acres of hilly lands on the southern part of the project area.

Most of these areas are covered with heavy clay soil and vegetation in the area presents two aspects; the one is a tropical jungle in the hilly land and the other is a grassy plain in the swamp area. There exists no bare land in the project area.

Almost all rivers of the project area originate in the Central Range. Dendritically joinning their tributaries, the rivers flow down, losing the river traces around the plain of the swampside and in the wet season inundate over the vast area.

River System

The watersheds adjacent to the project area are divided into small divisions by many rivers, which flow down to the project area. The watershed divisions of some main rivers are shown on Exhibit D-1. Each river cuts a valley to flow through the watershed joinning dendriformed tributaries. Around the transitional portion between the hilly land and the plain at elevation 110 feet (T.G.R.), rivers leave only their traces, losing the river route around the swampside. Under the situations, in the wet season, the natural flow from the watershed comes flooding to the low plain, and after inundation on the vast area, the water drains off to the Atlantic Ocean through the Nariva River running along narrow beach bank on the eastern eadge of the swamp.

The main rivers flowing into the project area are the Anho, Jagroma, Navet and Cuche River, and, above all, the most important one is the Navet River having the largest watershed.

Navet River

The watershed of the Navet River occupies nearly 65.60 square miles, about 46.6 percent of the total watershed. It originates at elevation 500 feet (T.G.R.) in the Central Range, and flows down joinning many tributaries. It is the longest river in the project area, with about 20 miles long, that flows into the irrigable area and loses the river trace around Bois Neuf. At the upper reach of the river in the Central Range, there exist the Navet Dam (7.0 square miles of the basin, total storage capacity 15,481 acre-feet) for municipal water services, and at the dam site, the hydrometeorological station and the stream gauging station. Also, there are the rainfall gauging station and stream gauging station at the Cunapo Southern Road on the mid-part of the Navet River.

Anho River

The Anho River has a watershed about 37.6 square miles in the southern hilly land adjacent to the irrigable area, and about 5 miles long, flowing through a low land between Bush Bush and Bois Neuf. Around the transitional portion between the hilly land and the low flat lands, the Anho River bifurcates in "Y" shape and each branch is renamed as the Guatacre River and the Ecciesville River.

Jagroma River

The watershed of the Jagroma River adjoins to that of the Navet River. The Jagroma River has its origin in the Central Range and the watershed about 5.3 square miles, which is divided into two divisions, the Jagroma River and the Charuma River by the hydrological analysis. The watershed is ramified by the Biche, Cartal, Charuma, Black Water and Red Water River. The natural flows from these watersheds are conducted to the lower part of the swamp with the Jagroma Cut constructed in the Plum Mitan Rice Scheme.

Cuche River

The Cuche River, starting in the Central Range, has a watershed about 11.9 square miles and plays a vital role in the Plum Mitan Rice Scheme. The watershed is ramified by the Cuche, Rarrow, and Congue River. The floods in the wet season are conducted to the Nariva River through the Cuche and Petite Poole Cuts, and then drained off to the Atlantic Ocean. These Cuts are utilized as the irrigation cnals in the dry season.

The watershed adjacent to the project area is covered with heavy clay soil and forms a shallow and comparatively gently valley in "V" shape by erosion of the river flows. There can be found neither gravel nor cobbles in the river beds. These rivers lose their traces around the irrigable area and the clayish soil carried by erosion is deposited there.

Climate

The irrigable area is a low swamp land facing the Atlantic Ocean and is under an influence of the predominant easterly trade wind which is the most remarkable meteorological element over the area, and the easterly trade wind carries moist air from the Atlantic Ocean to the área. This air mass reaches mountains of the Northern Range or the Central Range, where the moisture contained in the air transforms to the rainfall, which characterizes the distribution of the annual rainfall in Trinidad Island. Exhibit D-2 presents the annual mean rainfall in Trinidad Island. In the project area as well, the rainfall has a tendency to increase more in its amount gradually from the coastal to the mountaineous area. The annual rainfall in the project area ranges in amount for 80 to 110 inches. As the secondary element of the climate, there are storms with rainfalls amount are irregular. The foregoingly stated rainfalls are the water sources for irrigation in the project area, and under the topographical conditions, the climate shows two aspects which are in the mountaineous area with watershed and in the low swamp area close to the coast. There is, however, no remarkable difference between these climates in the project area.

Precipitation

In the project area and its watershed, many rainfall gauging stations are established in the scheme of the Trinidad Water Resources Survey, and various observations are taken. Their locations, observation terms, and observation objects for each gauging station are shown on Exhibit D-1.

The rainfall distribution characterizes the seasonal fluctuation, and the climate divides into two seasons; the dry season from January to April and the wet season from May to December. The driest month is March and the wettest June and November. The monthly rainfall data recorded are shown in Table D-1 on the representative gauging stations as the Newland Estate, the Plum Mitan, the Cocal Estate, and the Bush Bush Camp. And the illustrated mean monthly rainfall is shown at the upper part on Exhibit D-3.

Temperature

Around the project area, only meteorological observation is carried out in the hydro-meteorological station at the Navet Damsite. The observation has been conducted since May, 1967. According to the data observed in 1968, the average mean daily temperature for the month is 78° Fahrenheit, and the mean daily maximum temperature for the month 85° Fahrenheit, the mean daily minimum temperature for the month 70° Fahrenheit. The annual fluctuation of the temperature is very small.
Under the circumstances, the crops are little restricted with the seasonal fluctuation of the temperature. The meteorological observation records at the Navet Damsite in 1968 are shown in Table D-2, and its illustration is at the lower part on Exhibit D-3, together with the illustrated record at Piarco Airport. Little differences of the temperature between at the Navet Damsite and Piarco Airport can be found from the said observation results.

Table D-2 Meteorological Data

Station: Navet Damsite (3-8)

(1968) Lat. 10° 25' 41" N
Long 61° 7' 56" W

Month	Evaporation		Total sunshine hours	Monthly mean wind velocity	Temperature			Monthly mean humidity
	Measured water loss from pan.	Estimated free water evaporation			Mean daily for the month	Mean daily maximum for the month	Mean daily minimum for the month	
	inches	inches	hours	mile per hour	°F	°F	°F	%
Jan.	5.51	4.00	237.0	2.62	77	82	71	89
Feb.	5.81	4.36	220.7	3.49	77	82	72	87
Mar.	7.50	5.82	261.7	3.90	78	85	70	84
Apr.	6.60	5.17	204.1	3.29	79	85	72	89
May	7.03	5.30	203.3	4.46	79	84	72	84
Jun.	6.12	4.73	192.1	4.39	79	84	73	91
Jul.	6.39	4.85	240.5	3.89	78	84	73	90
Aug.	5.39	3.76	180.6	2.62	76	84	73	92
Sep.	5.40	4.09	172.4	2.56	79	85	73	93
Oct.	5.65	4.33	231.9	2.89	79	84	73	93
Nov.	5.35	3.97	277.1	2.02	78	84	72	87
Dec.	5.96	4.55	273.4	2.44	77	82	71	92
Total	72.71	54.93	2,694.8	38.57	936	1,005	865	1,071
Average	6.06	4.58	224.6	3.21	78	84	72	89

Wind

As mentioned before, the predominant easterly trade wind blows from the east or the northeast to the west in the project area all the year round, and occasionally brings rainfall. The wind velocity observation records in 1968 at the Navet Damsite near the project area are presented in Table D-2, and those ranging in date from 1948 to 1964 at Piarco Airport in Table D-3. A considerable differences of the observation value between them are recorded owing to their differences in elevation and topography.

Humidity

The observation results on humidity at the Navet Damsite and Piarco Airport are shown in Table D-2 and D-4 respectively. Since the Navet Damsite has much rainfall due to its higher elevation, humidity is higher at 35 percent than that of Piarco Airport.

Sunshine Hours

The observation records on sunshine hours at both sites of the Navet Damsite and Piarco Airport are shown in Table D-2 and D-5 respectively. Both sites are almost on the same latitude, and are not different on the sunshine hours.

Evaporation

The observation records at the Navet Damsite shows a very high evaporation value and the annual evaporation from the free surface is about 60 percent of the annual rainfall. The evaporation by the pan at the Navet Damsite and from the free surface in 1968 are shown in Table D-2.

Hydrologic Records

The hydrologic data in the present report are obtained from observations by Trinidad Water Resources Survey, Water and Sewerage Authority of the Ministry of Public Utilities, Drainage Division of Agriculture, and Lands and Fisheries Central Experimental Station. Their locations, observation objects on the climatology, and those of the stream gauging stations are shown on Exhibit D-1.

Climatological Records

Collection and recording of the climatological data are carried out based on the interim report No.1, No.2 and No.3 by the governments of

Trinidad and Tobago and Canada in cooperative project for Trinidad Water Resources Survey. The observation by Trinidad Water Resources Survey started in 1967 and covers various items such as rainfall, sunshine hour, wind velocity, temperature, humidity, evaporation, river discharge and sediment with the country-wide observation net-works, but due to the short-term observation, the said data are insufficient in the statistical treatment. They are, however, very useful for making the present report. The data at the Navet Damsite very closely relating with the project area, are shown in Table D-3, and other data by various gauging stations in Table D-1, D-3, D-4 and D-5, and further on Exhibit D-3.

Stream Flow Records

The discharge observations on the Navet River are conducted at the Navet Damsite and Cunapo Southern Road by Trinidad Water Resources Survey and Water and Sewerage Authority of the Ministry of Public Utilities. The locations of the gauging stations, the area of watersheds, observation starting time, and the observation agencies are shown in Table D-6.

Table D-6

Index to Stream Gauging Station

Station			Drainage area sq.miles	Location		Gauge type 4/	Start of records	Recording agency
No.	Name	Class 1/		Lat. (North)	Long (West)			
3.1	Navet	P	18.0 2/	10°21'00"	61°10'47"	A35	1JUN'67	T.W.R.S.
3.2	Navet reservoir	P	7.0 3/	10°23'57"	61°15'06"	R	1JUN'61	W.A.S.A. T.W.R.S.
4.2	Pure	S	7.4	10°20'14"	61°18'08"	L	14JUL'65	W.A.S.A. T.W.R.S.

1/ Class P: Primary station, Class: Secondary station.
2/ Excludes Areas above Navet Dam.
3/ Includes Reservoir Water Surface Area.
4/ A·35: Leupold & Stevens A35 Continuous Strip Chart Recorder.
R: Reservoir Station. L: Lea Rotary Horizontal Drum Type Recorder.

The water balance in the Navet Reservoir is composed of various factors; discharge overflowing spillway, rainfall, evaporation, leakage from dambodies and the foundations, and water intake from the reservoir. The resume on the relation between mean annual rainfall and the run-off for the period 1967 and 1968 are shown in Table D-7.

The summary of annual stream flow data of the Navet River in the period of 1967 and 1968 is shown in Table D-8. Though many rivers flow into the project area, the observation of discharge is conducted only on the Navet Fiver. And yet the observation term is not sufficient with the obtained data as basic materials for statistical treatment of the hydrologic analysis. The establishment of the additional gauging stations is required as well as the continuous observation.

Water Quality

The measurement of the irrigation water quality is conducted on PH value, electric conductivity and salinity of the water of the rivers around the project area and the results are shown on Exhibit D-1. The water flowing down from the watershed except the tidal compartment of the Nariva River and L'Ebranche River, proves harmless to all crops in the area. The result of the water quality survey is shown in Table D-9.

Table D-1 Precipitation Data

Station: New Land Estate Biche

Lat. 10°25'41" N
Long. 61°07'56" W

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Wet season	Dry season	Max. in year
1929					12.37	12.82	16.98	13.95	4.99	4.95	15.20	3.49		84.75		
1930	6.15	3.00	1.45	5.49	4.48	11.64	11.97	5.57	11.14	8.62	5.06	10.28	84.85	68.76	16.09	2.24
1931	3.50	2.03	0.20	0.95	3.52	8.39	10.96	11.86	7.81	10.98	14.45	22.79	97.44	90.76	6.68	3.20
1932	9.88	3.12	12.57	2.96	11.08	16.89	13.29	14.19	8.61	3.96	5.51	16.34	118.40	89.87	28.53	10.30
1933	10.54	3.45	4.75	5.38	5.45	14.39	12.89	10.97	7.42	11.03	19.90	16.07	122.24	98.12	24.12	2.60
1934	7.48	3.46	2.36	0.87	7.53	5.50	10.02	7.43	8.20	12.67	11.43	8.60	85.55	71.38	14.17	2.38
1935	1.82	1.78	7.16	0.66	9.62	5.84	10.96	12.25	13.07	10.57	12.62	13.08	99.43	88.01	11.42	2.69
1936	4.68	2.80	2.54	6.30	6.29	16.11	13.92	12.50	6.99	7.64	11.63	12.53	103.93	87.61	16.32	2.30
1937	12.23	2.84	1.98	5.40	1.06	9.22	7.21	10.91	9.31	2.82	8.84	10.56	82.38	59.93	22.45	2.23
1938	7.04	5.57	7.64	13.60	8.85	9.15	12.59	10.65	12.74	7.62	16.28	16.45	128.23	94.38	33.85	2.32
1939	5.21	5.67	2.49	3.58	6.80	12.08	9.47	7.37	7.19	11.10	6.39	9.50	88.85	71.90	16.95	2.32
1940	5.08	2.07	1.89	1.30	4.62	10.52	9.47	11.65	4.48	4.80	17.22	11.53	84.63	74.29	10.34	5.00
1941	8.39	2.05	1.47	0.97	5.70	12.43	12.21	20.12	8.47	15.05	12.75	6.41	106.02	93.14	12.88	2.83
1942	3.85	0.42	0.36	2.66	12.23	6.77	16.35		10.22	7.99	2.43	18.55			7.29	
1943	13.78	5.56	5.67	1.71	16.37	6.29	14.44	11.27	9.57	8.18	6.56	13.31	112.71	85.99	26.72	2.61
1944	5.22	1.62	4.99	3.89	13.62	23.74	13.42	11.67	9.77	5.34	14.35	10.97	118.60	102.88	15.72	3.85
1945				8.11												
1946	7.37	2.30	1.62	1.80	19.98	18.60	8.94	15.39	11.35	5.92	12.80	11.98	118.05	104.96	13.09	
1947	13.65	0.94	0.95	0.68	6.32	15.40	11.97	10.72	3.02	8.61	7.74	8.89	88.89	72.67	16.22	7.05
1948	7.08	4.53	4.64	9.48	6.62	16.93	16.06	8.75	7.92	12.00	12.39	8.20	109.59	83.86	25.73	2.65
1949	1.75	7.78	2.51	0.75	6.18	14.45	8.67	13.29	5.55	7.30	8.21	12.12	88.62	75.83	12.79	2.85
1950	11.14	11.18	4.88	7.40	6.88	21.00	14.94	13.73	6.11	11.64	8.02	15.50	132.42	97.82	34.60	3.75
1951	14.53	15.64	8.34	3.10	9.80	19.30	10.92	9.48	13.70	10.89	14.61	10.77	141.08	99.47	41.61	2.40
1952	2.34	2.05	2.27	2.74	4.75	13.71	12.27	9.20	8.52	10.31	4.85	19.05	92.06	82.66	9.40	2.50
1953	11.16	6.05	4.16	1.07	13.00	8.89	12.58	19.16	12.89	9.39	9.72	11.46	119.53	97.09	22.44	3.45
1954	3.63	5.55	3.77	4.77	5.14	10.60	9.29	8.22	10.19	16.25	16.50	15.04	108.99	91.27	17.72	7.86
1955	3.38	4.73	4.89	3.67	3.29	15.51	14.88	9.08	10.89	9.06	20.20	8.32	107.90	91.23	16.67	3.30
1956	4.21	6.06	6.75	4.44	6.93	13.64	6.38	18.04	13.43	13.89	11.69	18.98	124.44	102.98	21.46	6.07
1957	5.57	2.29	0.26	8.77	7.89	10.46	12.49	7.77	7.18	6.86	13.43	10.10	93.07	76.18	16.89	3.75
1958	7.34	3.18	1.93	8.14	14.85	14.73	14.01	8.46	6.93	12.79	9.88	9.46	111.70	91.11	20.59	4.82
1959	3.43	1.37	1.11	2.82	4.60	9.63	7.52	10.72	5.50	12.43	14.00	11.95	85.08	76.35	8.73	2.57
1960	3.14	4.10	1.41	8.18	5.00	11.12	9.54	10.29	3.05	11.73	11.03	15.68	94.27	77.44	16.83	3.45
1961	5.12	0.96	2.64	1.53	2.54	10.08	13.15	7.98	11.12	12.64	13.65	4.60	86.01	75.76	10.25	3.71
1962	4.30	4.25	0.48	3.16	3.27	11.23	9.35	14.03	5.00	6.99	9.26	10.17	81.49	69.30	12.19	4.00
1963	5.36	5.01	4.60	3.44	11.08	13.29	14.59	8.64	16.36	2.72	19.70	11.27	116.06	102.65	18.41	4.90
1964	4.88	3.04	1.37	7.64	7.56	19.73	21.25	13.00	15.57	15.10	12.13	10.40	131.67	114.74	16.93	4.80
1965	8.64	3.50	2.30	1.61	6.41	13.73	14.00	13.25	6.14	13.45	16.05	16.29	115.37	99.32	16.05	2.85
1966	2.25	2.20	1.02	5.47	6.57	26.95	13.40	15.05	19.31	6.42	11.23	10.05	119.92	108.98	10.94	3.50
1967	7.07	3.03	4.89	3.19	3.71	11.73	15.03	12.30	3.00	9.91	18.88	12.75	105.49	87.31	18.18	4.00
1968	10.43	4.65	3.73	5.13	10.45	13.63	12.57	10.46	12.67	9.45	10.25	6.05	109.47	85.53	23.94	3.10
Total	252.62	149.83	128.04	162.81	302.41	516.12	479.95	441.37	355.38	369.07	466.84	469.54	3,914.43	3,326.28	675.19	134.20
Average	6.65	3.94	3.37	4.17	7.75	13.23	12.31	11.62	9.11	9.46	11.97	12.04	105.80	87.53	17.77	3.73

Table D-1 Precipitation Data (cont'd)

Station: Plum Mitan Rice Scheme

Lat. 10°26'56" N
Long. 61°05'13" W

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Wet season	Dry season	Max. in year
1956	4.48	5.47	5.12	6.32	6.57	9.89	6.23	15.71	11.50	13.58	13.56	15.18	113.59	92.20	21.39	5.04
1957	6.42	2.57	0.53	10.15	7.23	9.68	13.67	7.21	6.86	4.45	15.28	10.49	94.54	74.87	19.67	3.23
1958	6.68	3.72	1.21	4.17	11.53	17.67		7.47	5.65	14.90	8.68	7.17			16.78	
1959	2.05	0.97	0.61			9.15	6.57	10.38	5.24	13.91	16.49	7.26				
1960	3.24															
1961						6.37	10.52	8.39	13.59	16.01	15.04	4.69				
1962	4.10	5.66	0.42	2.02	1.88	9.45	9.54	10.81	1.89	1.30	8.71	9.31	65.09	52.89	12.20	2.96
1963	2.54	5.77	2.07	1.53	7.72	16.52	13.52	3.73	17.38	2.21	11.31	12.05	96.35	84.44	11.91	3.05
1964	3.55	1.69	2.08	4.91	7.36	23.29	16.16	7.38	11.10	16.18	13.54	14.52	121.76	109.53	12.23	3.92
1965	9.19	3.62	1.15	1.60	6.34	11.81	12.42	10.88	3.29	10.85	17.63	15.29	104.07	88.51	15.56	4.89
1966	2.37	2.05	0.17	6.19	5.28	20.01	10.40	11.08	12.07	7.01	13.29	16.04	105.96	95.18	10.78	3.70
1967	5.37	2.06	3.51	2.91	1.91	7.09	13.20	9.68	3.99	9.93	19.79	14.98	94.32	80.47	13.85	4.32
1968	7.63	4.71	3.75	7.22	7.70	12.67	8.60	11.10	10.28	8.84	8.37	5.31	96.18	72.87	23.31	2.75
Total	57.62	38.29	20.62	47.02	63.52	153.58	120.83	113.82	102.84	119.17	161.69	132.29	891.86	750.96	157.68	33.86
Average	4.80	3.48	1.87	4.70	6.35	12.80	10.98	9.49	8.57	9.93	13.47	11.02	99.10	83.44	15.77	3.76

Station: Maridale Estate

Lat. 10°29'11" N
Long. 61°04'25" W

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Wet season	Dry sseason	Max. in year
1956								17.11	9.19	9.09	18.54	15.88				
1957	5.85	2.81	00.51	7.62	7.20	12.23	12.34	5.24	6.29	4.94	13.38				16.78	
1958	4.53	2.27	0.97	8.81	13.29	13.62	15.02	9.87	5.43	12.80	9.03	8.68	104.32	87.74	16.58	5.48
1959	1.74	1.60	0.76	1.24	3.71	11.57	4.52	7.91	4.83	14.56	17.85	7.05	77.64	72.30	5.34	2.36
1960	2.59	2.30	0.54	5.79	2.41	9.44	7.65	11.19	5.73	9.99	15.35	16.51	89.69	68.47	11.22	4.35
1961	2.58	1.60	1.54	0.84	2.48	11.45	13.35	9.60	10.70	10.81	17.89	3.39	86.23	80.67	5.56	6.26
1962	3.52	4.99	1.01	1.24	3.75	10.30	10.50	14.43	8.46	2.06	8.31	7.64	76.22	65.46	10.76	3.22
1963	6.22	2.65	2.52	2.29	8.14	9.50	10.68	5.02	17.97	3.36	10.56	10.30	89.21	75.53	13.68	3.58
1964	3.76	3.15	2.35	6.97	11.48	9.56	17.17	6.76	14.89	10.39	5.99	7.63	100.10	83.87	16.23	3.22
1965	9.28	1.69	1.89	1.46	3.26	8.07	12.89	9.25	6.35	13.62	17.96	19.19	104.91	90.59	14.32	5.30
1966	1.42	2.68	0.41	4.32	4.05	19.07	7.87	11.23	11.15	6.67	13.29	14.75	96.91	88.08	8.83	4.30
1967	7.07	2.16	4.32	3.18	2.88	7.91	12.76	7.93	3.48	8.38	20.07	13.46	93.60	76.87	16.73	4.00
1968	6.98	4.79	4.56	5.23	6.95	3.82	7.40	8.31	10.70	7.40	10.53	6.55	83.22	61.66	21.56	2.85
Total	55.54	32.69	21.37	48.99	69.60	126.54	132.15	123.85	115.17	114.07	178.75	131.03	1,002.05	851.24	157.59	44.92
Average	4.63	2.72	1.78	4.08	5.80	10.55	11.01	9.53	8.86	8.77	13.75	10.92	91.10	77.39	13.13	4.08

Table D-1 Precipitation Data (cont'd)

Lat. 10°31'10" N
Long. 61°05'27" W

Station: Marper Farm Manzanilla

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Wet season	Dry season	Max. in year
1929																
1930																
1931	3.83	2.74	0.44	5.08	2.63	9.09	9.61	11.74	7.55	11.56	11.09	22.02	97.38	85.29	12.09	
1932	9.22	2.84	4.42	4.14	7.89	14.26	12.06	13.65	7.48	4.61	4.96	16.10	101.63	81.01	20.62	
1933	11.35	3.81	6.72	5.47	6.06	11.50	19.91	13.62	9.38	12.38	23.58	18.10	141.88	114.53	27.35	
1934	7.51	3.30	2.89	0.96	7.57	4.77	8.78	6.90	7.27	10.55	14.24	8.91	83.65	68.99	14.66	
1935	2.13	2.46	6.86	1.00	8.12	7.02	10.61	12.86	14.87	14.18	15.70	13.87	109.68	97.23	12.45	
1936	6.51	2.91	1.91	4.57	8.99	14.09	10.65	10.11	6.63	8.43	15.60	13.45	103.85	87.95	15.90	
1937	9.48	2.06	1.76	7.16	0.91	7.20	7.45	10.05	4.27	2.65	7.30	10.03	70.32	49.86	20.46	
1938	7.63	7.94	8.94	16.52	9.45	9.55	12.12	11.63	10.16	7.33	17.13	19.86	138.26	97.23	41.03	
1939	4.48	4.69	2.79	3.51	9.05	12.82	9.64	12.10	9.49	11.87	8.72	6.58	95.74	80.27	15.47	
1940	2.90	1.63	2.31	2.28	5.37	10.37	10.21	11.37	5.65	7.28	14.68	11.91	85.96	76.84	9.12	
1941	3.99	2.42	2.03	1.36	4.23	12.81	13.27	20.90	6.75	15.57	11.98	8.88	104.19	94.39	9.80	
1942	2.52	1.15	0.50	2.40	12.60	7.35	16.48	7.10	10.91	11.37	1-81	17.64	91.84	85.26	6.58	
1943	14.44	7.47	3.34	4.19	16.16	6.62	13.68	15.33	9.66	11.02	19.02	11.95	132.88	103.44	29.44	
1944	4.07	1.28	4.13	3.65	12.50	19.60	13.78	11.57	6.10	4.84	16.44	9.75	107.71	94.58	13.13	
1945	3.90	2.44	1.91	7.76	5.68	15.17	7.89	7.12	11.89	10.69	16.54	7.14	98.13	82.12	16.01	
1946	3.84	2.13	1.19	1.14	4.88	6.53	5.07	11.55	9.36	5.10	11.05	11.68	73.52	65.22	8.30	
1947	10.22	0.53	0.99	1.02	3.96	10.55	10.31	7.84	2.36	7.56	8.95	9.50	73.79	61.03	12.76	
1948	6.57	4.58	4.19	7.50	5.85	15.08	9.72	13.95	6.72	6.20	18.45	8.14	98.95	76.11	22.84	
1949	2.28	7.63	2.82	1.28	6.90	13.38	6.93	15.65	7.91	9.72	6.28	11.29	92.07	78.06	14.01	
1950	13.17	10.17	3.82	4.24	4.62	18.79	10.64	13.34	4.92	5.54	8.68	15.18	113.11	81.71	31.40	
1951	11.92	21.87	6.80	5.76	8.89	19.69	6.34	9.00	7.57	12.18	13.47	11.90	135.39	89.04	46.35	
1952	1.60	1.65	1.33	2.62	5.31	14.20	9.81	10.79	8.18	9.60	6.77	11.86	83.72	76.52	7.20	
1953	9.50	4.17	3.97	1.09	9.62	6.76	14.42	16.73	12.62	6.64	8.94	14.53	108.99	90.26	18.73	
1954	4.35	2.94	3.46	5.65	4.99	11.92	13.28	10.83	6.83	12.15	21.98	15.87	114.25	97.85	16.40	
1955	4.16	4.82	5.29	2.06	3.50	17.37	11.70	12.42	9.14	10.02	18.00	6.10	104.58	88.25	16.33	
1956	5.65	7.92	7.16	6.00	7.34	11.55	5.50	16.31	7.49	9.80	14.46	17.11	116.29	89.56	26.73	4.82
1957	8.76	2.76	1.41	8.55	6.00	12.03	12.64	8.56	6.09	4.41	11.81	10.85	93.87	72.39	21.48	3.55
1958	5.39	3.16	1.62	9.47	14.98	16.76	15.66	9.32	10.35	11.93	8.66	6.63	113.93	94.29	19.64	3.86
1959	1.97	1.52	0.87	1.15	3.03	10.79	5.89	7.91	4.98	16.26	15.70	6.02	76.09	70.58	5.51	2.60
1960	2.83	2.71	1.21	5.28	2.86	9.50	7.07	11.26	4.39	9.75	15.08	13.19	85.13	73.10	12.03	5.41
1961	3.43	1.02	1.02	0.52	2.68	10.77	11.01	10.62	14.82	12.42	19.18	5.26	92.75	86.76	5.99	6.05
1962	3.97	5.33	0.68	1.98	3.13	9.61	13.01	17.21	8.12	2.61	8.79	6.50	80.94	68.98	11.96	2.99
1963	6.08	3.98	3.37	2.87	8.02	11.88	10.02	7.58	19.67	3.58	11.13	8.76	96.94	80.64	16.30	4.25
1964	5.72	2.41	1.89	11.74	5.32	16.59	19.60	9.85	13.52	14.53	10.98	8.45	120.60	98.84	21.76	4.58
1965	11.47	6.22	2.49	0.57	3.55	10.35	12.96	9.66	5.48	13.23	21.06	20.63	117.67	96.92	20.75	5.37
1966	1.33	3.55	0.84	4.54	5.86	15.13	9.80	11.87	11.49	6.87	9.07	11.82	92.17	81.91	10.26	2.90
1967	7.59	3.31	4.73	3.57	3.84	9.27	12.72	10.82	4.04	10.54	21.12	9.70	101.25	82.05	19.20	2.90
1968	8.78	4.65	5.38	5.56	6.31	10.93	10.61	10.66	8.98	9.15	11.23	6.35	98.59	74.22	24.37	3.20
Total	234.55	158.17	117.48	164.21	248.65	451.65	420.85	439.78	323.09	354.12	491.63	443.51	3,047.69	3,173.28	674.41	52.48
Average	6.17	4.16	3.09	4.32	6.54	11.89	11.08	11.57	8.50	9.32	12.94	11.67	101.26	33.51	17.75	4.04

Table D-1 Precipitation Data (cont'd)

Station: Cocal Estate Manzanilla

Lat. 10°26'06" N
Long. 61°02'10" W

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Wet season	Dry season	Max. in year
1949	1.90	5.27	1.05	0.65	3.75	11.28	6.38	12.53	10.89	9.70	12.65	8.98	85.03	76.16	8.87	
1950	8.05	10.50	3.45	5.30	4.99	16.27	10.48	11.15	4.69	5.22	5.88	15.50	101.48	74.18	27.30	
1951	12.95	16.29	1.00	0.53	3.60	7.17	3.65	5.54	7.17	9.03	8.16	2.72	77.81	72.00	5.81	
1952	1.92	0.61	1.13	2.15	3.18	10.85	8.54	7.99	6.24	8.11	3.48	12.50	66.70	60.69	6.01	
1953	9.87	5.26	3.93	0.56	12.94	6.27	8.84	14.37	12.73	8.23	5.04	10.81	98.85	79.23	19.62	
1954	3.45	2.50	4.35	3.89	2.95	8.51	11.80	6.25	6.86	10.16	16.07	10.92	87.71	73.52	14.19	
1955	2.53	3.24	2.48	1.71	2.56	13.30	11.32	9.84	6.95	9.01	13.83	5.42	82.19	72.23	9.96	
1956	2.58	3.70	2.88	2.61	4.23	7.36	2.89	15.13	9.66	7.20	7.06	14.12	78.42	66.65	11.77	2.92
1957	2.99	0.74	0.33	6.30	5.45	8.33	9.50	7.14	6.79	6.62	11.85	7.98	74.02	63.66	10.36	3.14
1958	7.93	2.77	1.25	6.43			10.94	7.85	3.11	11.07	6.42	6.30				
1959	1.67	1.28	0.63	1.90	3.61	6.82	4.30	7.21	3.88	10.71	13.22	9.99	65.22	59.74	5.48	4.00
1960	2.31	2.13	0.77	5.85	2.19	8.79	7.99	10.57	3.96	9.96	10.08	12.30	76.90	65.84	11.06	3.25
1961	2.66	0.66	0.62	0.97	1.66	6.63	9.67	6.52	7.43	9.06	11.10	2.90	59.88	54.97	4.91	3.70
1962	1.98	2.17	0.43	2.07	2.48	7.20	7.31	11.23	3.89	2.06	7.10	4.83	52.75	46.10	6.65	2.49
1963	5.51	2.79	1.90	1.02	7.94	6.06	13.87	3.85	9.63	7.12	10.30	7.18	77.17	65.95	11.22	3.56
1964	3.10	0.82	1.12	8.65	3.78	12.32	12.74	7.09	12.84	9.18	9.95	9.68	91.27	77.58	13.69	5.15
1965	6.12	2.82	1.16	0.18	3.80	8.07	9.70	10.95	2.77	14.93	14.47	12.29	87.26	76.98	10.28	4.96
1966	0.73	1.63	0.42	4.73	3.22	14.31	8.24	14.18	14.28	3.98	10.94	16.26	92.92	85.41	7.51	4.49
1967	4.78	0.61	3.26	2.02	2.56	7.96	11.08	8.53	3.29	7.67	19.13	11.95	82.84	72.17	10.67	4.58
1968	3.93	3.58	4.77	4.55	8.86	12.02	8.62	9.98	9.55	5.66	10.33	3.66	85.51	68.68	16.83	3.24
Total	86.96	69.37	36.93	61.54	83.75	179.52	177.86	187.90	146.61	164.68	207.06	186.29	1,523.93	1,311.74	212.19	45.48
Average	4.35	3.47	1.85	3.08	4.41	9.45	8.89	9.40	7.33	8.23	10.35	9.31	80.21	69.04	11.17	3.79

Station: Navet Damsite

Lat. 10°24'05" N
Long. 61°15'18" W

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Wet season	Dry season	Max. in year
1955	3.32	3.55	3.68	0.19	3.43	16.32	19.08	8.52	11.36	7.26	14.66	6.75	98.12	87.38	10.74	
1956	6.23	6.37	5.60	6.45	10.90	11.95	8.87	14.66	12.26	11.88	9.64	12.65	117.46	92.81	24.65	
1957	4.83	2.45	0.36	3.27	8.15	8.23	10.42	11.22	5.72	3.02	11.39	11.08	80.14	69.23	10.91	
1958	4.51	1.89	0.65	6.13	7.58	16.41	14.05	6.38	4.09	9.01	4.02	6.33	81.05	67.87	13.18	
1959	2.35	1.95	1.13	1.51	3.19	9.35	9.18	10.78	5.78	10.03	11.62	6.19	73.06	66.12	6.94	2.82
1960																
1961																
1962	2.94	3.41	0.21	2.22	2.76	10.48	14.17	11.83	6.09	4.47	9.68	8.66	76.92	68.14	8.78	2.93
1963	3.62	3.20	2.51	2.24	11.37	12.24	10.43	7.61	14.87	1.31	9.84	6.95	86.19	74.62	11.57	2.95
1964	3.75	1.96	1.08	5.86	4.54	19.54	15.33	6.40	13.38	16.05	7.83	12.00	107.72	95.07	12.65	4.02
1965	7.38	2.79	1.50	0.90	8.05	13.54	9.24	10.42	7.91	11.45	12.99	9.14	95.31	82.74	12.57	2.87
1966	1.61	1.80	0.80	1.17	4.99	27.59	12.21	6.52	12.49	8.79	15.54	7.56	101.08	95.69	5.39	3.00
1967	5.98	2.08	4.08	3.03	3.99	9.84	15.88	13.13	4.45	3.67	17.93	6.80	90.86	75.69	15.17	2.36
1968	4.35	4.05	3.17	3.06	5.77	11.42	11.48	13.35	7.74	7.11	10.67	5.30	87.47	72.84	14.63	2.20
Total	50.88	35.50	24.77	36.03	74.72	166.91	150.34	120.82	106.14	94.05	135.81	199.41	1,095.38	948.20	147.18	23.15
Average	4.24	2.96	2.06	3.00	6.23	13.91	12.53	10.07	8.85	7.84	11.32	8.28	91.28	79.02	12.27	2.89

Table D-1 Precipitation Data (cont'd)

Station: Navet Presbyterian School

Lat. 10°20'57" N
Long. 61°10'47" W

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Wet season	Dry season	Max. in year
1950					8.35	19.58	14.14	9.04	4.21	4.40	7.66	17.04		84.42		
1951	13.94	14.18	7.11	4.30	10.75	20.73	9.79	10.17	9.16	10.47	14.85	8.00	133.45	93.92	39.53	
1952	1.98	3.00	0.93	4.26	4.48	19.92	13.84	12.82	9.48	9.06	4.19	16.69	100.65	90.48	10.17	
1953	8.65	5.71	6.21	1.10	9.07	4.94	12.15	13.54	10.26	3.64	1.82	6.20	83.29	61.62	21.67	
1954	2.47	0.67	0.85	1.75	3.87	6.41	11.08	6.71	6.07	12.88	14.40	9.61	76.77	71.03	5.74	
1955	1.77	4.46	4.82	1.28	0.55	4.36	7.65	9.06	5.51	6.07	9.12	3.57	58.22	45.89	12.33	
1956	2.90	0.75	3.85	3.00	7.80	1.48	2.83	13.02	11.67	9.04	8.91	17.51	82.76	72.26	10.50	3.10
1957	3.34	0.60	0.61	4.73	13.35	8.24	7.65	10.70	7.80	1.93	10.43	4.70	74.14	64.86	9.28	3.71
1958	2.68	2.35	1.16	3.11	7.05	13.75	14.50	6.31								
1959		1.06	0.63	2.92	3.22	9.43	9.87	6.86	3.87	6.36	7.69	6.78		58.69		
1960	3.41	2.96	1.32	3.36	4.75	10.61	9.46	12.05	1.84	11.66	10.79	13.47	85.71	74.66	11.05	2.00
1961	4.07	0.87	1.32	0.75	1.21	9.74	10.66	6.15	6.91	11.00	9.87	1.93	64.48	57.47	7.01	1.85
1962	4.00	4.45	0.22	2.15	3.21	11.17	13.56	10.53	4.94	4.99	10.54	4.95	74.71	63.89	10.82	2.03
1963	4.54	0.85	0.54	1.92	8.98	12.23	8.66	4.75	3.05	3.00	5.95	5.94	60.41	52.56	7.85	2.24
1964	4.38	0.70	0.53	1.10	2.18	3.19	3.07	0.94	1.02	1.01	1.18	2.81	22.11	15.40	6.71	1.10
1965	2.43	5.77	1.93	0.92	4.57	15.37	7.18	13.57	4.56	11.31	14.40	8.97	91.04	79.99	11.05	2.50
1966	2.11	1.35	0.40	2.42	4.08	23.48	10.73	11.57	13.06	5.98	11.89	6.19	93.26	86.98	6.28	3.01
1967	6.52	2.44	3.60	2.34	3.58	6.77	13.13	12.34	1.63	3.33	16.93	9.67	82.28	67.38	14.90	2.29
1968	7.67	5.06	4.30	3.93	12.95	12.43	10.40	16.30	10.02	7.61	13.68	4.87	109.22	88.26	20.96	2.51
Total	76.86	57.23	40.33	43.34	114.00	213.83	190.35	186.43	115.06	123.74	174.30	148.90	1,292.50	1,229.76	205.85	26.34
Average	4.52	3.18	2.24	2.52	6.00	11.25	10.02	9.81	6.39	6.89	9.68	8.27	80.78	68.32	12.87	2.39

Station: Bush Bush Camp

Lat. 10°23'31" N
Long. 61°02'11" W

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Wet season	Dry season	Max. in year
1961					1.66	7.15	10.42	6.96	10.97	13.06	13.78	3.11		67.11		
1962	3.20	4.20	0.10	1.86	2.41	5.72	7.40	15.77	4.74	6.23	8.45	6.85	66.93	57.57	9.36	2.80
1963	6.00	2.04	2.16	2.30	9.00	9.09	11.72	5.99	8.67	13.72	11.92	6.29	88.90	76.40	12.50	4.72
1964	3.64	0.91	1.48	8.58	5.87	16.11	14.17	7.44	16.54	11.38	8.78	12.01	106.91	92.30	14.61	4.70
1965	5.85	3.71	2.00	1.47	4.96	10.65	8.83	8.57	6.34	13.22	18.03	15.86	99.49	86.46	13.03	5.58
1966	1.51	2.59	0.80	5.83	5.63	17.70	8.23	12.85	18.69	4.66	11.76	15.88	106.13	95.40	10.73	4.06
1967	10.79	1.97	7.15	1.86	1.84	7.55	15.94	8.57	3.90	10.27	17.97	11.17	98.98	77.21	21.77	4.37
1968	5.57	4.43	3.23	6.16	7.73	11.97	6.84	12.27	13.84	6.69	7.44	6.67	92.84	73.45	19.39	3.81
Total	36.56	19.85	16.92	28.06	39.10	85.94	83.55	78.42	83.69	79.23	98.13	77.84	660.18	625.90	101.39	30.04
Average	5.22	2.84	2.42	4.01	4.89	10.74	10.44	9.80	10.46	9.90	12.27	9.73	94.31	78.24	14.48	4.29

Table D-3

Mean Windspeed in mile per hour (Piacro Airport)

Year	Annual Mean	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1948.............	6.1	6.2	7.9	8.6	6.6	7.0	6.1	5.2	3.8	4.7	4.3	6.2	6.6
1949.............	6.2	4.5	6.8	7.5	8.5	9.4	8.2	5.4	4.3	4.8	5.6	4.5	4.7
1950.............	5.5	5.9	5.9	7.7	7.4	6.1	6.7	4.6	2.2	4.1	4.0	4.7	6.1
1951.............	5.2	5.4	4.9	4.9	6.8	6.2	6.7	4.6	4.0	4.9	4.6	4.5	5.1
1952.............	5.6	4.9	6.8	7.5	8.2	6.8	6.3	4.8	4.0	4.0	4.9	4.5	4.0
1953.............	5.5	6.7	7.1	7.0	7.4	7.0	5.6	5.2	4.3	4.1	3.7	3.0	4.3
1954.............	6.2	7.0	7.6	8.2	8.4	7.4	7.7	5.5	3.9	4.1	4.7	4.4	6.2
1955.............	5.0	5.2	6.6	7.8	6.6	9.1	5.9	4.6	3.6	2.2	2.2	2.8	3.7
1956.............	6.0	4.7	6.6	7.6	7.5	8.3	7.0	6.2	3.7	4.4	4.7	4.5	7.0
1957.............	6.4	7.1	8.5	8.1	8.9	7.3	7.2	5.7	4.8	4.5	3.7	5.6	5.2
1958.............	6.8	4.6	6.9	8.5	6.3	5.0	5.3	5.6	4.5	5.5	6.1	5.1	5.1
1959.............	5.7	5.6	6.8	7.6	7.4	7.3	6.7	5.2	3.9	4.3	4.4	4.5	5.1
1960.............	5.4	6.5	6.6	7.3	6.6	7.3	6.0	4.5	4.0	3.5	4.5	4.0	4.7
1961.............	6.1	5.9	6.9	7.8	8.9	9.4	7.4	4.4	4.4	3.8	5.0	3.7	5.1
1962.............	6.3	6.1	6.9	8.0	9.5	8.2	6.9	5.5	3.9	5.1	6.1	4.5	4.6
1963.............	6.5	6.1	6.9	9.4	7.8	7.8	7.9	5.5	5.1	4.8	5.4	5.2	6.5
1964.............	5.8	6.6	7.3	9.4	8.5	8.9	6.7	2.9	4.0	4.0	3.9	4.7	2.9
Average	5.9	5.8	6.8	7.8	7.7	7.6	6.7	5.0	4.0	4.3	4.6	4.5	5.1

Note; Wind data are now given for Piarco Airport where the recording anemometer is in a well exposed position and the data are more representative of general wind conditions on the island.

The effective height of the anemometer is 33 feet above ground.

Table D-4

Mean Monthly Relative Humidity, in per cent (Piacro Airport)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1951	68	74	63	61	70	73	77	76	75	70	80	72	72
1952	58	55	52	54	59	71	73	74	73	71	71	69	65
1953	68	64	64	52	68	71	73	72	72	71	73	74	69
1954	66	60	62	63	62	70	73	74	72	73	77	73	69
1955	62	61	61	57	55	74	74	71	76	75	70	65	67
1956	66	62	65	63	69	71	68	73	69	73	72	71	69
1957	64	61	53	58	64	70	70	70	65	65	73	71	65
1958	66	55	52	56	75	75	73	69	62	67	72	67	66
1959	58	52	56	53	55	70	66	69	69	73	69	69	63
1960	61	57	53	59	57	67	72	74	70	71	69	68	65
1961	69	53	51	52	53	72	70	70	71	70	71	60	63
1962	60	57	51	48	56	69	75	79	66	60	61	66	62
1963	59	52	56	52	69	69	68	68	74	63	70	65	64
1964	60	55	54	58	56	73	72	69	74	75	70	68	65
Mean	63	58	57	56	62	71	72	72	71	70	71	68	66

Source; Data observed at Piarco Airport from 1951 to 1964

Table D-5

Hours of Sunshine

Year	Annual Mean	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Noc.	Dec.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Average 1924 - 1932[1]	6.5	6.4	7.2	7.6	7.2	6.8	5.7	6.1	5.7	6.1	6.6	6.4	5.9
" 1929 - 1954[2]	7.3	7.5	7.9	7.9	8.2	7.8	6.7	7.1	6.8	6.5	6.9	7.0	7.0
1948[3]	7.1	8.1	8.2	7.4	6.7	8.3	5.4	6.6	7.0	7.1	6.5	6.9	7.0
1949	7.2	8.2	7.6	7.6	8.4	8.4	6.6	7.8	6.2	6.5	6.9	7.1	5.2
1950	6.5	5.4	6.0	6.5	7.6	6.5	5.2	7.5	6.4	6.8	7.0	7.2	6.5
1951	6.7	7.0	4.6	7.3	8.4	8.3	5.9	6.1	7.0	5.9	7.2	6.2	7.0
1952	7.7	8.4	9.2	8.7	10.0	8.3	6.6	7.1	6.8	7.3	6.2	7.6	6.5
1953	6.8	6.8	7.4	7.1	9.4	6.0	7.0	6.4	6.8	5.3	6.7	6.3	6.4
1954	6.8	6.8	8.1	8.7	6.5	8.5	7.1	6.5	6.3	5.0	6.3	5.6	5.5
1955	7.0	8.5	8.2	6.2	6.8	9.1	6.4	7.0	7.0	5.8	5.3	6.1	7.2
1956	6.9	6.7	7.4	7.9	7.3	7.3	7.0	7.8	6.6	5.9	6.4	6.6	5.8
1957	7.4	7.3	8.1	9.1	8.0	6.9	5.8	7.4	7.5	8.1	7.3	6.5	7.1
1958	7.3	7.2	8.9	9.7	8.1	6.7	5.6	5.8	7.6	8.4	6.3	6.8	5.6
1959	7.9	8.3	9.0	9.0	9.1	8.4	6.8	7.8	7.6	7.6	6.1	7.4	7.5
1960	7.9	9.2	9.6	8.5	7.4	9.9	7.8	7.8	6.2	7.2	6.4	7.5	7.5
1961	8.1	8.7	9.6	8.2	10.1	9.6	7.2	7.2	7.6	6.1	7.1	6.4	9.5
1962	7.6	8.4	7.5	9.0	9.5	8.3	6.9	6.4	6.4	6.8	8.9	6.5	6.4
1963	7.6	8.2	8.8	8.3	7.7	5.3	7.2	7.4	7.9	6.1	9.1	6.5	8.3
1964	7.5	8.9	9.6	8.8	6.9	9.2	6.4	6.0	8.0	6.6	6.3	7.2	6.5
Average	7.3	7.7	8.0	8.1	8.1	7.9	6.5	6.9	6.9	6.6	6.8	6.7	6.8

1. Recordings from St. Clair Experimental Station of the Department of Agriculture.
2. Recordings from University of the West Indies, St. Augustine.
3. From 1946 onwards the data shown are the average of two stations - Pearco Airfield and University of the West Indies St. Augustine. Both stations are at approximately the same altitude; they are about 6 miles apart.

Table D-7

Navet Damsite Rainfall-Runoff Comparison in inches

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1961	Ra	4.73	1.39	1.85	0.75	2.30	9.68	13.75	6.21	12.38	13.19	7.90	4.06	78.64
	Ru	0.52	0.28	Nil	Nil	0.59	0.91	4.17	Nil	7.13	6.10	1.82	1.22	22.74
1962	Ra	3.34	3.90	0.33	2.33	3.31	11.18	12.87	11.55	6.60	5.37	9.53	8.52	78.83
	Ru	0.61	0.10	Nil	Nil	Nil	2.70	4.20	5.36	1.10	1.34	0.80	2.80	19.01
1963	Ra	3.80	2.80	2.50	2.24	11.37	12.24	10.43	7.61	14.87	1.31	9.84	6.95	85.96
	Ru	1.40	0.64	Nil	0.37	2.40	3.60	5.30	0.98	2.00	0.24	3.20	3.20	23.33
1964	Ra	3.75	1.96	1.08	5.86	4.45	19.54	15.33	6.40	13.38	16.88	7.85	12.00	108.48
	Ru	0.63	0.35	0.17	0.34	0.13	7.83	8.75	Nil	5.00	7.30	4.80	5.30	40.60
1965	Ra	8.27	3.05	1.88	1.19	8.23	14.16	9.00	10.85	7.89	11.70	13.24	9.19	98.65
	Ru	1.98	0.66	Nil	0.06	0.44	5.16	3.78	4.34	1.52	2.47	4.41	4.36	29.18
1966	Ra	2.18	1.87	0.87	1.03	5.28	26.88	12.34	6.97	13.05	9.85	15.15	8.18	103.95
	Ru	0.46	0.13	0.12	Nil	Nil	12.20	4.96	3.45	2.42	4.87	1.70	4.34	34.65
Total	Ra	26.07	14.77	8.51	13.70	34.94	93.68	73.72	49.59	68.62	58.30	63.51	48.90	554.51
	Ru	5.60	2.16	0.29	0.77	3.56	32.40	31.16	14.13	19.17	22.32	16.73	21.22	169.51
Mean	Ra	4.35	2.50	1.42	2.28	5.82	15.61	12.29	8.27	11.44	9.72	10.59	8.15	
	Ru	0.93	0.36	0.05	0.13	0.59	5.40	5.19	2.36	3.20	3.72	2.79	3.54	
Mean Runoff Ratio		21.4	14.4	3.5	5.7	10.1	34.6	42.2	28.5	28.0	38.3	26.3	43.4	30.6
Determined Runoff Ratio		21.0	14.0	0	0	10.0	34.0	42.0	28.0	28.0	38.0	26.0	43.0	

here; Ra .... Rainfall Ru .... Runoff in inches.

Table D-8

Navet River Annual Summary of Stream-flow Data

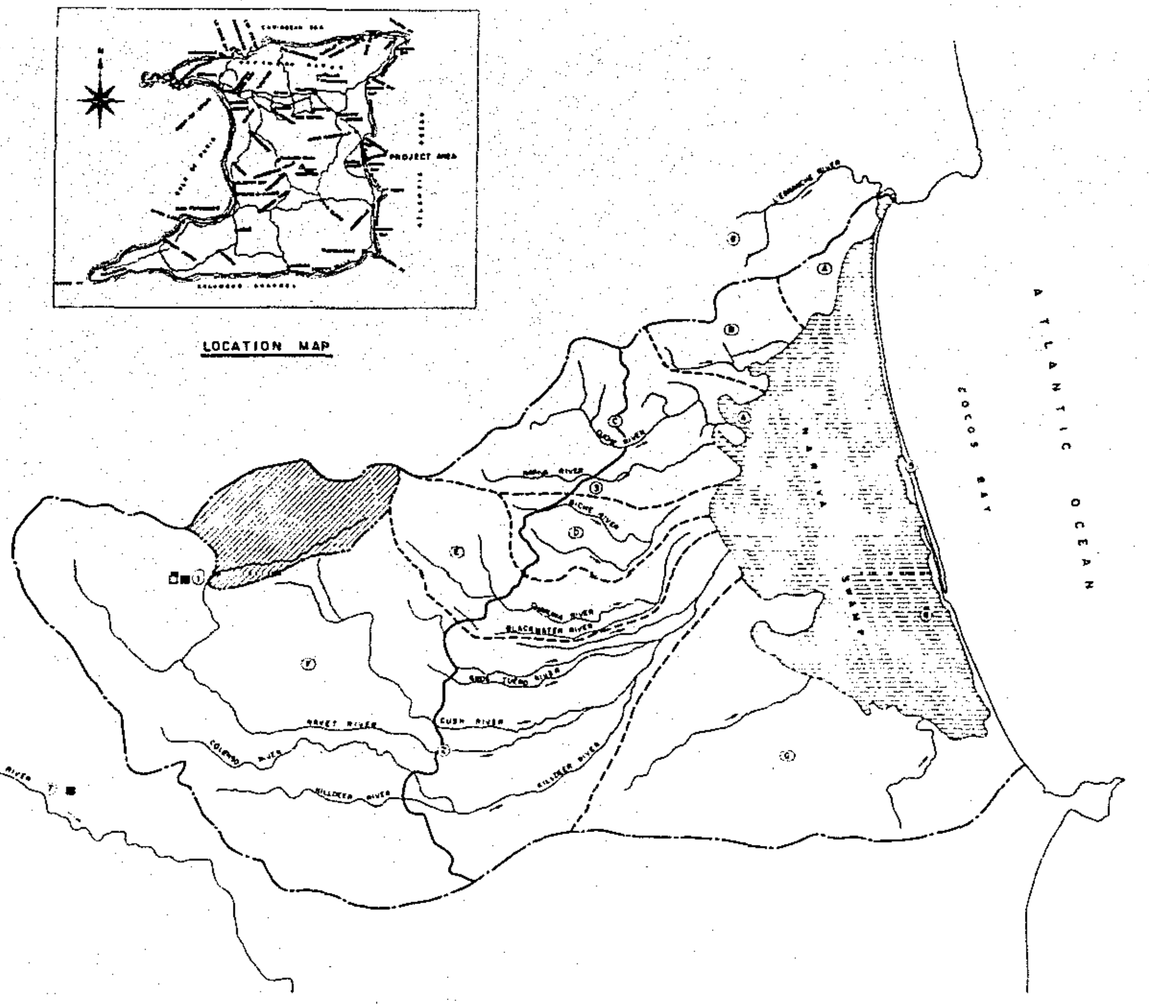
1967 Month	Mean Dis-charge C.F.S.	Runoff: Acre-feet	Runoff: Millions imperial Gallons	Runoff: Inches	Mean areal Rainfall Inches	Extreme discharge: Instantaneous Peak C.F.S.	Extreme discharge: Instantaneous Peak Date	Extreme discharge: Min. daily Mean C.F.S.	Extreme discharge: Min. daily Mean Date
JAN					6.49				
FEB					2.63				
MAR					4.27				
APR					2.58				
MAY					4.22				
JUN	21.1	1,256	340.9	1.31	9.82	320	24	0.14	8
JUL	168.0	10,330	280.4	10.76	15.89	537	8	9.99	20
AUG	134.0	7,701	2,090	8.58	14.04	595	9	4.24	22
SEP	12.3	732.0	198.7	0.76	4.06	219	25	0.54	15
OCT	69.2	425.5	115.5	0.44	3.36	165	2	0.26	25
NOV	129.0	7,677.0	2,084	8.00	18.72	595	20	2.57	16
DEC	77.4	4,738.0	1,286	4.96	7.70	425	2	3.97	29
Year					93.78	-	-	-	-

	Mean Dis-charge C.F.S.	Runoff: Acre-feet	Runoff: Millons imperial Gallons	Runoff: Inches	Mean areal Rainfall Inches	Extreme discharge: Instantaneous Peak C.F.S.	Extreme discharge: Instantaneous Peak Date	Extreme discharge: Min. daily Mean C.F.S.	Extreme discharge: Min. daily Mean Date
JAN	15.46	950.6	258	0.99	5.01	203	23	1.57	17
FEB	20.32	1,169.	317.3	1.22	4.13	298	9	1.20	27
MAR	1.87	115	31.2	0.12	3.60	18.1	20	0.79	8
APR	2.27	135.1	36.7	0.14	3.20	46.5	20	0.36	5
MAY	14.74	906.4	246	0.94	7.56	204	30	1.14	13
JUN	88.19	5,248.2	1,424.4	5.47	11.61	595	15	1.68	23
JUL	93.58	5,754.2	1,561.7	5.99	12.73	572	24	5.28	8
AUG	193	11,867.6	3,220.9	12.36	13.98	765	13	10.6	25
SEP	97.31	5,790.9	1,571.7	6.03	8.11	668	2	5.01	23
OCT	51.85	3,188.3	865.3	3.32	7.22	386	28	2.28	25
NOV	103.00	6,129.5	1,663.5	6.38	10.87	800	14	2.43	8
DEC	30.4	1,869.3	507.3	1.95	5.09	300	8	3.10	31
Year	59.33	43,124.1	11,704.0	449.1	93.61	-	-	-	-

Table D-9 Water Quality Data

Measurement Location No.	Survey Location	Survey Date	Water Temperature (°C)	pH	Electric Conductivity (μv/cm)	Salinity (ppm)	Remarks
1	Midstream of Cuche River	24th 3. 69 9. 4.	26 29	 6.6	1,300 1,800	300 440	Droughty state at weir site in Cocoa Estate.
2	Jagroma	24. 3. 10. 4.	29 30	 (9.0)	1,100 1,100	250 250	Stationed water at the end of upstream of the canal of Plum Mitan Gate.
3	Downstream of Cauque River	10. 4. 13. 4.	27 28	 7.1	1,900 1,500	460 350	Before confluence with canal at upstream of Plum Mitan Gate.
4	Midstream of Nariva River	25. 3.	27		20,000	10,000	At the back of Coconut Plant.
5	Kernanham	25. 3.	37		4,300	1,600	Stationed water in ditches at the terminal point of the road running in the development area.
6	Kernanham	25. 3. 13. 4.	36 28	 5.5	3,300 4,000	1,150 1,500	Stationed water in trench, at 100m off from Beach Bank, of the road running in the development area.
7	Downstream of Navet River	27. 3.	25		1,200	270	After confluence with a tributary.
8	Upstream of Bios Neuf River	27. 3.	25		1,100	250	Nearest to Bois Neuf Hill.
9	Plum Mitan	9. 4.	29	6.4	1,400	320	Stationed water in the canal, and the same location as soil sampling No.6.
10	Plum Mitan	9. 4.	29	7.4	2,000	500	Stationed water in the canal, and the same location as soil sampling No.2.
11	Midstream of L'Ebranche River	10. 4.	30	7.5	22,000	11,500	Cross point of the L'Ebranche River with the Eastern Main Road.
12	L'Ebranche River Mouth	13. 4.	28	7.9	25,000	13,000	At the ferry 200m upper from River Mouth.
13	Dabllon Bason	13. 4.	28	7.1	2,800	720	Swamp water in Dabllon Bason.
14	Downstream Nariva River	13. 4.	28	7.2	25,000	13,000	At the Nariva River Bridge.

Exhibit D-1



PLAN OF WATERSHED FOR PROJECT AREA & LOCATION OF RAINFALL STATIONS

SCALE

INDEX TO RAINFALL STATIONS

NO	STATION	LOCATION LAT. NORTH	LOCATION LONG WEST	GAUGE TYPE R	GAUGE TYPE N	DAILY RECORDS START FROM	MONTHLY RECORDS START FROM	DISCONTINUITY FROM	DISCONTINUITY TO	RECORDING AGENCY
1	NAVET RESERVOIR DAMSITE	10° 24' 05"	61° 15' 18"	R	N	AUG 1955	AUG 1955	JAN. 1960	DEC. 1961	W.A.S.A. T.W.R.S. D
2	NAVET PRESBYTERIAN SCHOOL	10° 20' 37"	61° 10' 47"	R	N	1950	1950			D
3	NEWLAND EST. BICHE	10° 25' 41"	61° 07' 56"		N	MAY 1929	MAY 1929			D
4	PLUM MITAN RICE AREA	10° 26' 56"	61° 05' 13"		N	1960	1960			D
5	COCAL EST MANZANILLA	10° 26' 06"	61° 02' 10"		R	1949	1949			D
6	BUSH BUSH NARIVA	10° 23' 31"	61° 08' 11"		N	MAY 1961	MAY 1961			D
7	PURE RIVER TABAQUITE	10° 20' 10"	61° 18' 10"	R	N	JUNE 1965	JUNE 1965	12 JULY 1966	10 AUG 1966	W.A.S.A. T.W.R.S. D
8	HARPER FARM MANZANILLA	10° 30' 10"	61° 05' 27"	R	N	1931	1931			D

WATERSHED AREA

DIVISION OF WATERSHED	AREA IN SQ MILES	NAME OF THE PRINCIPAL RIVER
A	1.85	———
B	4.17	PETITE POOLE CUT
C	13.90	CUCHE, CANQUE RIVER
D	5.33	JAGROMA CUT
E	13.05	CHARUMA RIVER
F	65.60	NAVET RIVER
G	37.64	ANNO RIVER
TOTAL	141.94	———

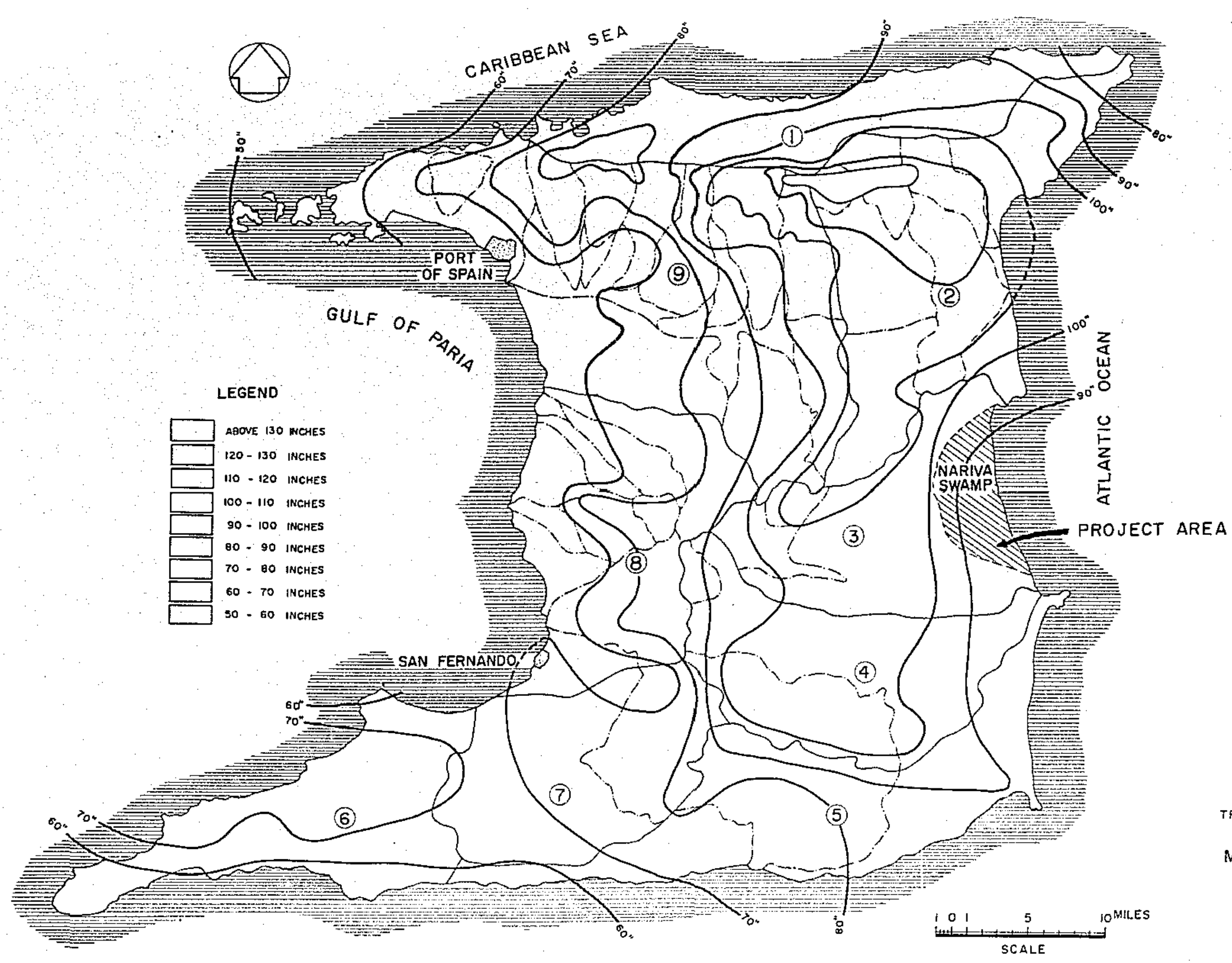
INDEX

ABBREVIATIONS	TITLE
W A S A	WATER & SEWERAGE AUTHORITY OF THE MINISTRY OF PUBLIC UTILITIES. TRAGARETE ROAD.
D	DRAINAGE DIVISION OF THE MINISTRY OF WORKS LONG CIRCULAR ROAD
T W.R.S	TRINIDAD WATER RESOURCES SURVEY, LONG CIRCULAR ROAD
R	RECORDING RAIN GAUGE.
N	NON-RECORDING RAIN GAUGE

LEGEND

- BOUNDARY OF PROJECT AREA
- WATERSHED
- BOUNDARY OF WATERSHED
- WATERSHED OF NAVET RESERVOIR
- SWAMP
- STREAM GAUGING STATION
- HYDROMETEOROLOGICAL STATION (INCLUDE STANDARD EVAPOLATION PAN, THERMOMETERS, ANEMOMETER AND SUNSHINE RECORDER)

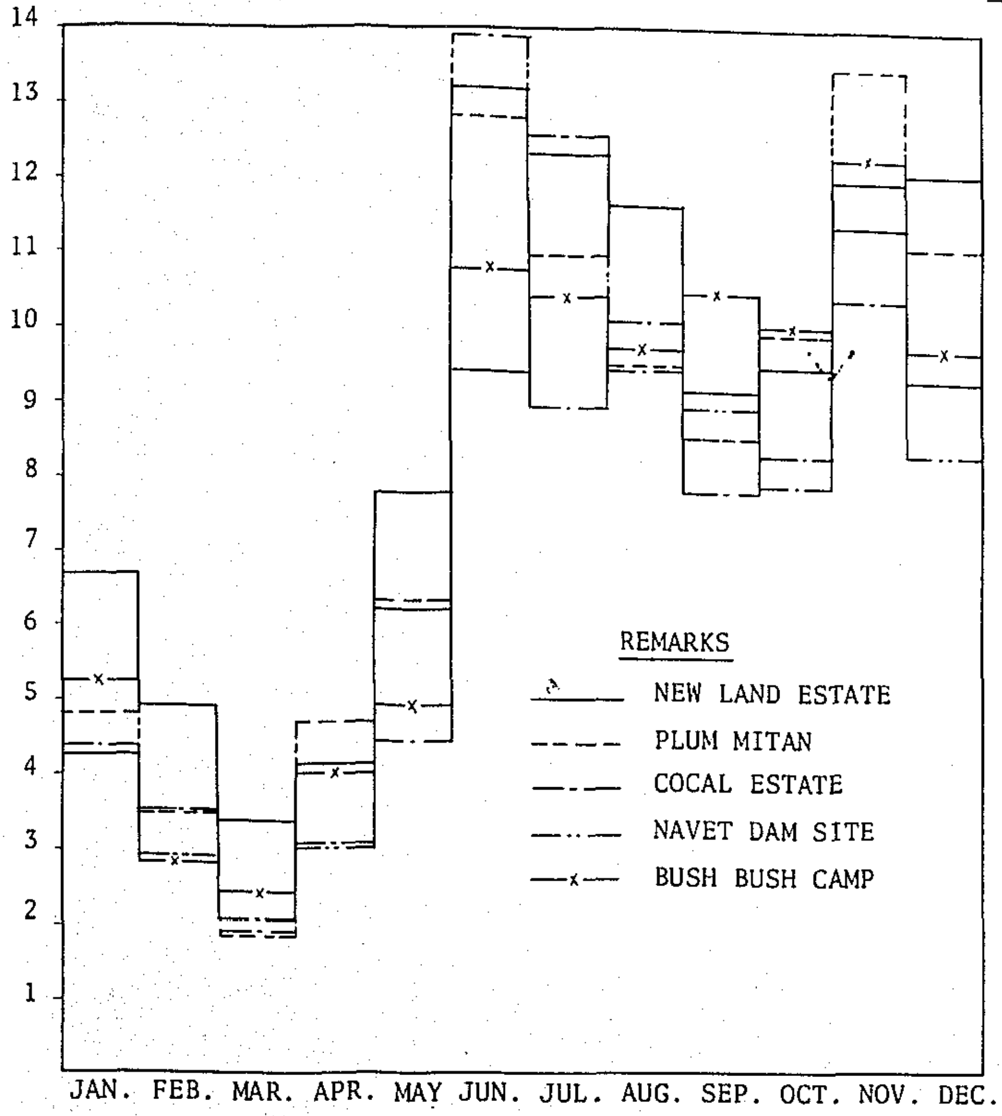
Exhibit D-2



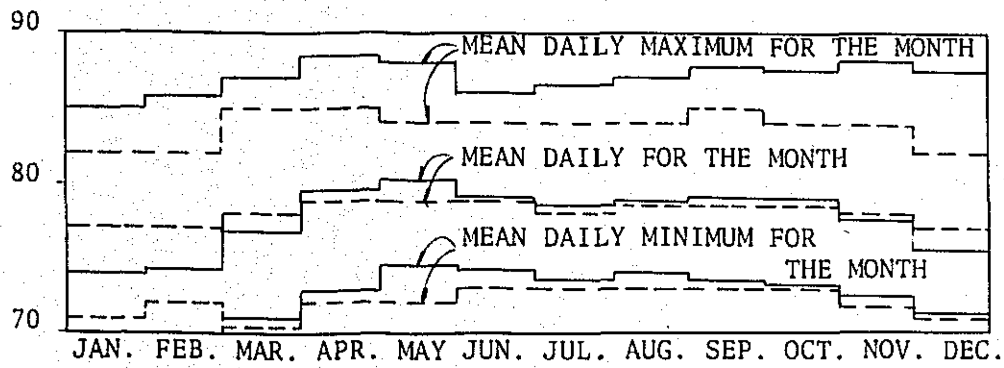
TRINIDAD WATER RESOURCES SURVEY

MEAN ANNUAL RAINFALL OF TRINIDAD

Exhibit D-3



MEAN MONTHLY PRECIPITATION



MEAN MONTHLY TEMPERATURE

REMARKS

——— PIARCO AIRPORT (FRM 1951 TO 1964)

– – – NAVET DAM SITE (IN 1968)

GRAPHIC PRECIPITATION & TEMPERATURES

Appendix E

Runoff Analysis

Appendix E

Runoff Analysis

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List of Exhibit (cont'd)

Appendix E

Runoff Analysis

General Descriptions

It is required to clarify the hydrological and hydraulic condition of the project area in order to make the drainage plan. In the present project, assumption is required on the flood curves of the rivers to and from the swamp area. A rainfall pattern and a unit hydrograph are used for that in the present report. The relation between precipitation and runoff is based on successive three days rainfall for 10 year probability of exceedence (Refer to Appendix F). It is, however, the precipitation per day that mostly affects to hydrographs of outflow from various watersheds. Lack of records on the suitable hourly rainfall made it impossible to analyze completely on the rainfall pattern. In the present project, the basic precipitation pattern is adopted from the record of the maximum daily precipitation on 23rd January, 1968, at Presbyterian School Gauging Station. The said precipitation pattern is considered as the typical one in the area, but a review on it would be expected with the records to be obtained in future.

Making hydrographs for each river is made on the rainfall and discharge data of the Pure River by the Tatsugami's Method, which is widely used in Japan. Comparison of the result of this analysis with the actual measurement value can prove it very reliable.

Hydrographs for each watershed are obtained from application of the above-mentioned designed rainfall pattern to the unit hydrograph. The hydrograph of outflow from the irrigable area is analyzed under consideration that precipitation to the paddy fields is regulated with fields notches and with conveyance capacity of secondary canals.

Precipitation

Probable Rainfall

Though there are many rainfall gauging stations in the watershed of the project area, it is only the Newland Estate Biche Rainfall Gauging Station that keeps long-term observation records, by which an assumption can be made about the daily precipitation in probability of exceedance at 1/10. The relative calculation is, therefore, made on the data at the Newland Estate Biche. It is well-known that the frequency curve for annual maximum daily precipitation shows an abnormal and asymetorical distribution pattern, and finally it is necessary to obtain a function to represent the asymmetorical distribution of these hydrological data for the assumption of the probability.

For the present project, the Log Normal Distribution with wide applicability is adopted. The theory of "Log-Normal Distribution Function" is as follows.

$$F(x) = \frac{1}{\sqrt{x}} \int_{\infty}^{\xi} e^{-\xi^2} d\xi$$

where $\xi = a \log_{10} [(x+b)/(x_0+b)], \; -b < x < \infty$

where a, b, and x_0 are constants.

There are various methods to determine these constants based on empirical distribution functions. The Dr.Iwai's Method, which is used widely in Japan, may be applied herein.

First approximate value of ;

$$\log_{10} x_0 = \frac{1}{n} \sum_{x=1}^{n} \log_{10} xi$$

Assumption of b;

$$bi = \frac{xixs - x_0^2}{2x_0 - (xi+xs)}$$

$$b = \frac{1}{m} \sum_{x=1}^{m} bi \qquad m \doteqdot \frac{N}{10}$$

Assumption of x_0;

$$x_0 = \log(x_0+b) = \frac{1}{n} \sum_{x=1}^{n} \log_{10}(xi+b)$$

Assumption of a;

$$\frac{1}{a} = \sqrt{\frac{2}{n-1} \sum_{x=1}^{n} (\log_{10} \frac{xi+b}{x_0+b})^2}$$

$$= \sqrt{\frac{2n}{n-1}} \cdot \sqrt{\overline{X}^2 - X_0^2}$$

$$\overline{X}^2 = \frac{1}{n} \sum_{i=1}^{n} \{\log_{10}(xi+b)\}^2$$

Where x_i is the observation value whihc is located at ith in order from the largest, and x_s is the obasevation value which is located at ith in order from the smallest and $(n-s + 1)$th in order from the largest, and n is number of samples, and $M \fallingdotseq n/10$ is integer.

After determination of the above-mentioned constants, the probable hydrologic data for the optional probability of exceedance are presumed in the following formula.

$$\log_{10} (x+b) = \log_{10} (x_0+b) + (1/a)\xi$$

Where ξ is the normal variables in relation to a return period T. Exhibit E-1 shows the probable daily precipitation at the Newland Estate Biche for various return periods obtained by the Dr. Iwai's Method.

Daily precipitation 5.62 inches
Successive two day precipitation 6.43 inches
Successive three day precipitation 7.50 inches

Furthermore, the necessary daily precipitation for probability of exceedance at 1/100 in devision of the scale of the spillway is 10.20 inch per day.

Schematic Rainfall

The various probable rainfalls at each gauging station can be estimated on the basis of the previously stated rainfalls at the Newland Estate Biche. Regarding with the daily rainfalls over 1 inch per day and the total rainfall in the wet season, correlation coefficients between these of the Newland Estate Biche Gauging Station and those of the other gauging stations are shown in Table E-1.

Table E-1 Correlation Coefficient Among Precipitations

Station	Daily Rainfall(over 1 inch/day)	Total Rainfall in Wet season
1. Newland Estate Biche	1	1
2. Navet Damsite	0.52	0.83
3. Bush Bush Camp	0.39	0.93
4. Cocal Estate	0.52	0.65
5. Plum Mitan Rice Scheme	0.63	0.94

The study on the above table can find that there is no correlation in the daily rainfall among them but considerable high correlation in the total rainfall in the wet season. The fact that no correlation exists in daily rainfall of gauging stations, shows that there is very little even rainfall for the area but that there is a locality with the tropical shower.

In the present project, the probable rainfall at each gauging station is computed in the use of the total rainfall ratio of the wet season in considerable higher correlation. And they are shown in Table E-2. Since both of the observation data of the daily rainfall and total rainfall by the Navet Presbyterian School in the wet season have no correlation each other, the observation data are excluded, but it is desirable that the further detailed investigation will be conducted, based on the data in future.

Table E-2 Rainfall in Probability at 1/10 at Each Rainfall Gauging Station

Station		Remarks	Daily Rainfall	2 days Rainfall	3 days Rainfall
			inch	inch	inch
1. Newland Estate Biche	1		5.62	6.43	7.50
2. Navet Damsite	0.858	1955-1968 except 60,61	4.82	5.52	6.44
3. Bush Bush Camp	0.842	1961-1968	4.73	5.41	6.32
4. Cocal Estate	0.769	1948-1968 except 58	4.32	4.94	5.77
5. Plum Mitan Rice Scheme	0.887	1956-1968 except 58-61	4.98	5.70	6.65

This table, "The Probable Rainfall", shall be applied to the analysis of a hydrograph at the outlet of a watershed in the assumption of rainfall. If the schematic rainfall for each watershed shall be determined in ramification of the total watershed as in the conventional ways, it would be useless and less reliable in general because the process is much complicated for the calculation. Accordingly, on using the weighted mean rainfall for the total watershed, as the schematic rainfall, the results obtained by the Thiessen Method are shown in Table E-3.

Table E-3 Calculation of Schematic Rainfall

Station	Area	%	Daily Rainfall		Successive 2 day Rainfall		Successive 3 day Rainfall	
	sq.mile	%						
1. Newland Estate Biche	51.32	29.70	5.62	1.67	6.43	1.91	7.50	2.23
2. Navet Damsite	56.68	32.80	4.82	1.58	5.52	1.81	6.44	2.11
3. Bush Bush Camp	36.81	21.30	4.73	1.01	5.41	1.15	6.32	1.35
4. Cocal Estate	6.39	3.70	4.32	0.16	4.94	0.18	5.77	0.21
5. Plum Mitan Rice Scheme	21.60	12.50	4.98	0.62	5.70	0.71	6.65	0.83
Total	sq.miles 172.80	100%		5.04 ≑ 5.0		5.76 ≑ 5.8		6.73 ≑ 6.7

The schematic rainfall on 10-year probability, therefore, shall be determined as in Table E-4.

Table E-4 Schematic Rainfall

Rainfall	Schematic Rainfall		inch	mm	Ratio of Daily Rainfall
Daily Rainfall	5.0	= 5.0	5.0 =	127.0	74.7
2 Days Rainfall	5.0 + 0.8	= 5.8	0.8 =	20.3	11.9
3 Days Rainfall	5.0+0.8+0.9	= 6.7	0.9 =	22.9	13.4

Schematic Rainfall Pattern

The schematic rainfall pattern is an important factor for assumption of the floods, and rainfall duration, rainfall intensity and hourly rainfall distribution are affected. Distribution of rainfall over 1.5 inch per day is shown on Exhibit E-2 on the basis of the data of hourly rainfall at the Navet Damsite and Navet Presbyterian School Gauging Station in the watershed. From this exhibit, the dividing ratio of the schematic rainfall pattern shall be determined with rainfall distribution ratio of the maximum daily rainfall recorded at Navet Presbyterian School on 23rd, 22nd and 24th January, 1968. The daily dividing ratios of this three day rainfall in this pattern are respectively 79.3 percent, 6.9 percent and 13.8 percent, each of which is almost equivalent to the schematic rainfall dividing ratio. As for hourly rainfall intensity, 1.54 inches/hr or 39.0 mm/hr, it is in the reasonable range in consideration of the record, 1.32 inches/hr, obtained at Navet Presbyterian School Gauging Station on 8th December, 1967. The result of the estimation on the schematic rainfall pattern is shown in Table E-5 and on Exhibit E-3.

Unit Hydrograph

Unit Hydrograph Method is applied when discharge is estimated from the rainfall. The conception for this method comes from the hypothesis that hydrographs at a certain point of a river derived from a unit effective rainfall in a unit hour are always of the same curve. Further explanation to the method can be given as follows.

1) An effective rainfall with even intensity, always brings a constant runoff in the same watershed, and in a constant hour.

2) Fluctuation of the effective rainfall intensity does not make a fluctuation of the hourly distribution of the discharge. In other words, hourly discharge fluctuates in proportion to total discharge.

3) Discharge by rainfall for a long duration is equal to the added amount of each discharge obtained on dividing the discharge by a short duration.

To the computation of discharge in the watershed of the present project, the Tatugami's Method, widely used in Japan, is applied. The method is clarified in the following section.

The basic unit hydrograph is developed from the observed data of rainfall and discharge at the Pure River in the watershed adjacent to the project area. That is because the observation of the discharge at the Navet Damsite is based on the water level of the reservoir so that they are of low reliability, and because furthermore the data at the Cunapo

Southern Road Gauging Station on the middle reash of the Navet River is of low reliability as well due to its discharge affected with that from the Navet Reservoir. Explanation of utilization of the unit hydrograph is given in the section on the Tatugami's Method. Exhibit E-4 clarifies that the Navet River Watershed is approximately nine times as large as the Pure River Watershed, and the flood transit time through the watershed to its outlet is quite different from each other. Under the circumstances, another unit hydrograph must be made from the data on analysis of the records at the Pure River.

Tatugami's Method

Under one unit rainfall on a watershed, a unit hydrograph at an outlet of the watershed is derived from consideration that transit time through the watershed to its outlet and storage in a river channel is affected by the runoff path and distance from each sub-area of the watershed. The computation for the above storage is made by following equations.

Storage Equation : $S = Kq$

Continuity Equation : $ds = (i-q)dt$ (E-1)

Where S is a storage capacity, i is an inflow, q is an outflow, t is time, and K is a constant.

Thus, multiplying the effective rainfall with the unit hydrograph stated above, a tentative hydrograph is obtained. Furthermore, the rainfall loss in the watershed is quantitatively computed by inserting an index of runoff rate, which is a ratio of the direct discharge against the tentative hydrograph. The unit hydrograph is made as follows.

Initial loss of rainfall

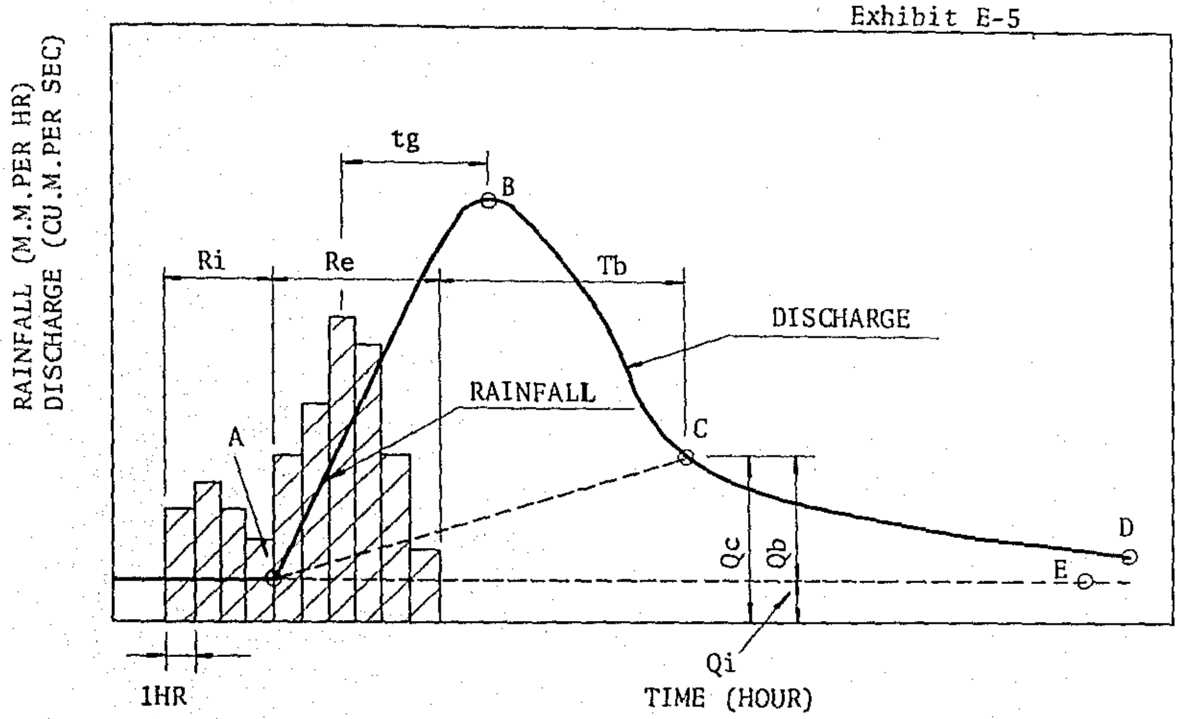
Reviewing the flood data for a rainfall in a watershed, an increased discharge does not appear instantly, but it usually needs some time-lag. In reference to Exhibit E-5, the rainfall upto point (A), where the discharge starts to increase, is computed as the initial loss of rainfall. The initial loss may be considered to depend on the retention in the watershed, and as for an index, it is adequate to take the base flow prior to the direct discharge increase; the initial discharge.

The relationship between initial discharge and initial loss of rainfall may be represented by the following linear equation:

$$Ri = -3.6 \frac{P}{A} Qi + R_o \quad \ldots\ldots\ldots\ldots \quad \text{(E-2)}$$

Where P(hr) and R_o(mm) are constants and A is the watershed (Square kilometers). These constants are derived from observation data.

Exhibit E-5



Direct Discharge and Base Flow

Direct Discharge:

Direct discharge is defined as a discharge following a rainfall and flowing out in a relatively short time, hence forming the main portion of hydrograph. This portion is expressed as the area ABC on Exhibit E-5.

Base Flow:

The discharge continues much longer than that of the direct discharge and constitutes the base portion of hydrograph other than the direct discharge. Dischages from the ground water and its similarities fall in this category, and they are indicated as the area ACDE on Exhibit E-5.

In order to divide the total discharge into two parts mentioned above, the recession portion of hydrograph is plotted on the semi-log paper, and point C is selected from the variation point where the recession tendency breaks its continuity as indicated on Exhibit E-5, and point C may be considered as the termination point of direct discharge. Qb obtained by deducting the initial discharge Qi from the discharge Qc at the point C is essential to make the hydrograph, and it has also a correlation with the effective rainfall Re which is obtained in deduction of the initial loss Ri from the total rainfall R as follows.

$$Qb = Qc - Qi \quad \text{..............} \quad \text{(E-3)}$$

$$Qb = b \cdot Re^{n} \quad \text{..............} \quad \text{(E-4)}$$

Concentration Phenomenon

The essence of unit hydrograph is the lag phenomenon, which may be broken down into the concentration phenomenon derived from flowing route length and the storage phenomenon in the watershed. With an assumption that the concentrated velocity is a flow velocity without consideration on the lag caused by the storage phenomenon, the concentrated time T is expressed in the relation of concentrated distance L over concentrated velocity. Although this concentrated time is actually dominated by the distance, slope, hydraulic depth and roughness, it is empirically expressed in the equation,

$$T = \alpha L^{0.7} \quad \text{...........} \quad \text{(E-5)}$$

Where α is a constant and L is distance.

Watershed Lag

The watershed lag, which is expressed in tg, is a duration between a center of the time distribution curve of rainfall and the peak dischage at outlet of watershed (Refet to Exhibit E-5) and it is an important element of the flood phenomenon.

Storage Phenomenon

The storage phenomenon is one of the other elements constituting the lag phenomenon of flood. The influence of inflow against the storage is comparatively small, and that the storage is expressed in the following equation.

$$S = KQ \quad \text{.............} \quad \text{(E-6)}$$

Where S is the storage, K is a constant and Q is the outflow. At the recession portion of hydrograph, the inflow is zero, and therefore, "Continuity Equation" is,

$$ds/dt = Q \quad \text{...........} \quad \text{(E-7)}$$

Differentiating the equation (E-6),

$$ds = K \cdot dQ \quad \text{..........} \quad \text{(E-8)}$$

Substituting the equation (E-8) in the equation (E-7), and simplifying,

$$k = \frac{dq}{dt} = -Q \quad \text{.........} \quad \text{(E-9)}$$

Therefore, $\frac{dQ}{Q} = -\frac{dt}{K}$ .... (E-10)

Integrating the equation (E-10), and letting $Q = Q_o$ at $t = 0$,

$$Q = Q_o\, e^{-t/k} \quad \text{..........} \quad \text{(E-11)}$$

The above equation indicates that the recession portion of hydrograph is an expotential function, and constant $1/k$ is called the recession coefficient. Thus, k in the equation (E-6) is given by obtaining the recession coefficient.

Composition of Unit Hydrograph

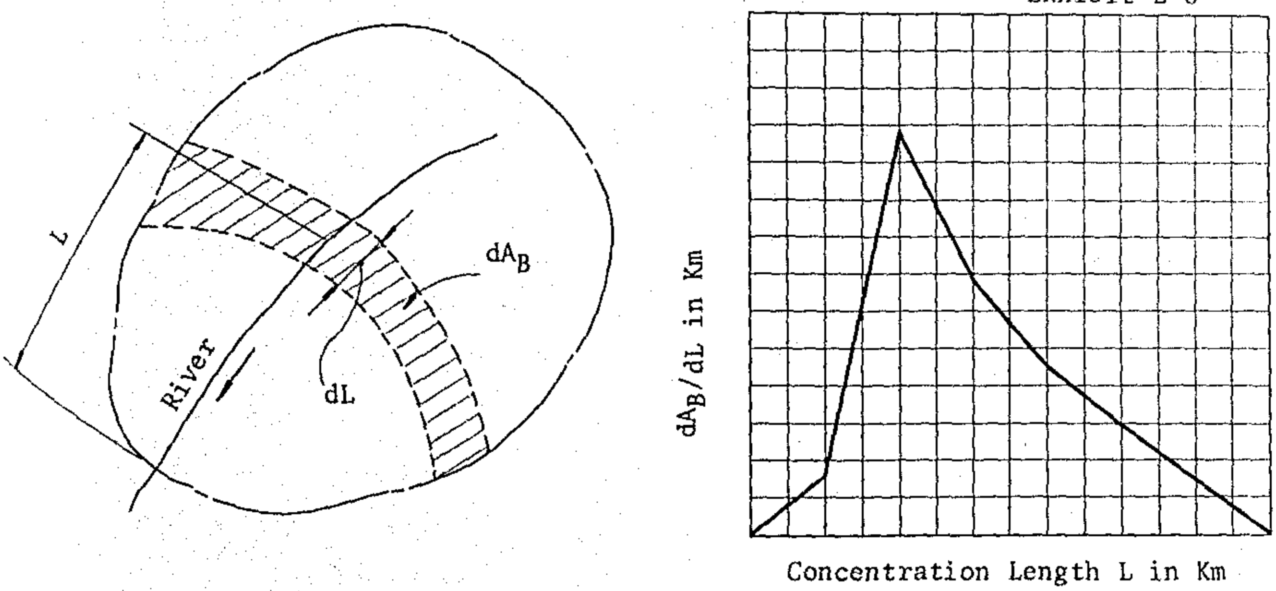
Unit hydrograph is derived from the following sequence; concentrated area diagram - concentrated time diagram - concentrated curve diagram - unit hydrograph. Concentrated area diagram may be defined as a diagram derived from the sub-areas obtained by dividing the entire watershed by respective travel time, and the areas are determined on the topographic map by measuring the distance along the river channel from the outlet of the watershed and the distance with right angle to the contour lines for areas where the river channel do not exist. The concentrated area diagram developed as above is given on Exhibit E-6. In the next stage, the concentrated time diagram is derived from the concentrated area diagram. The work involved here is to modify the realtion between the concentrated area and concentrated distance into the relation between the concentrated area and the concentrated time. From the equation (E-5),

$$T/\alpha = L^{0.7} \quad \dots\dots\dots\dots \quad \text{(E-12)}$$

Letting $T/\alpha = T'$, the equation (E-12) becomes,

$$T' = L^{0.7} \quad \dots\dots\dots\dots \quad \text{(E-13)}$$

Exhibit E-6



CONCENTRATION AREA DIAGRAM

Differentiating the equation (E-13),

$$dL = \frac{L^{0.3}}{0.7} \cdot dT' \quad \cdots\cdots\cdots \quad \text{(E-14)}$$

Devided dA by the equation (E-14),

$$\frac{dA}{dT'} = \frac{L^{0.3}}{0.7} \cdot \frac{dA}{dL} \quad \cdots\cdots\cdots \quad \text{(E-15)}$$

In order to convert T' into time unit, multiplying an arbitrary constant α by T',

$$T'' = \alpha' T' = \alpha' L^{0.7} \quad \cdots\cdots\cdots \quad \text{(E-16)}$$

Substituting the equation (E-16) in the equation (E-15),

$$\frac{dA}{dT''} = \frac{1}{\alpha'} \cdot \frac{L^{0.3}}{0.7} \cdot \frac{dA}{dL} \quad \cdots\cdots \quad \text{(E-17)}$$

A concentrated time diagram is made from the equation (E-16) and (E-17) as indicated on Exhibit E-7. α' is unknown, and so an assumed value is used. A concentrated curve diagram is obtained by applying the rainfall conditions to the concentrated time diagram. The discharge from each sub-area may be expressed by γdt, provided that there is a uniform distribution of effective rainfall with an intensity γ for the entire watershed during a finite time increment dt. This may be obtained by multiplying the effective rainfall γ by dA/dT'' of the concentrated time diagram. The tentative concentrated volume i'' is expressed as

$$i'' = \gamma \cdot \frac{dA}{dT''} \quad \cdots\cdots\cdots \quad \text{(E-18)}$$

The tentative unit hydrograph curve is developed by introducing the tentative concentrated curve diagram to the storage effect.
Differentiating the equation (E-1),

$$(i - q) = K(dq/dt)$$

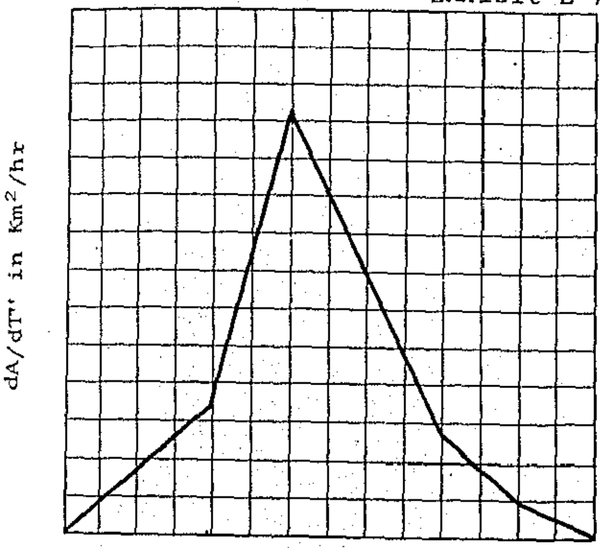
Taking that the inflow be i_1 and the outflow be q_1 at the beginning of $dt=a$, and the inflow be i_2 and the outflow be q_2 at the end of $dt=a$, the above equation may be replaced as follows.

$$\frac{i_1 + i_2}{2} - \frac{q_1 + q_2}{2} = \frac{K}{a}(q_2 - q_1)$$

When K_1 is $\frac{2K}{a}+1$ and K_2 is $\frac{2K}{a}-1$, K may be obtained as a reciprocal number of recession coefficient, and assuming a to be 1 hour, K_1 and K_2 may be computed. Hence, q_2 may be obtained from the equation (E-19) as follows. (Refer to Exhibit E-8)

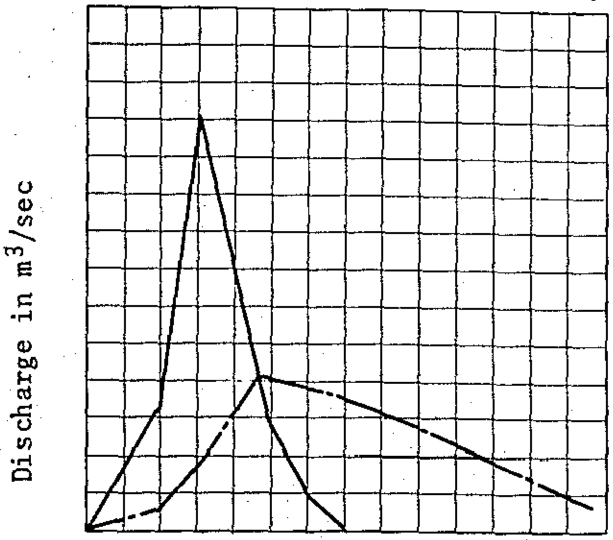
$$q_2 = \frac{i_1 + i_2 + K_2 q_1}{K_1} \quad .... \quad \text{(E-19)}$$

Exhibit E-7



CONCENTRATION CURVE

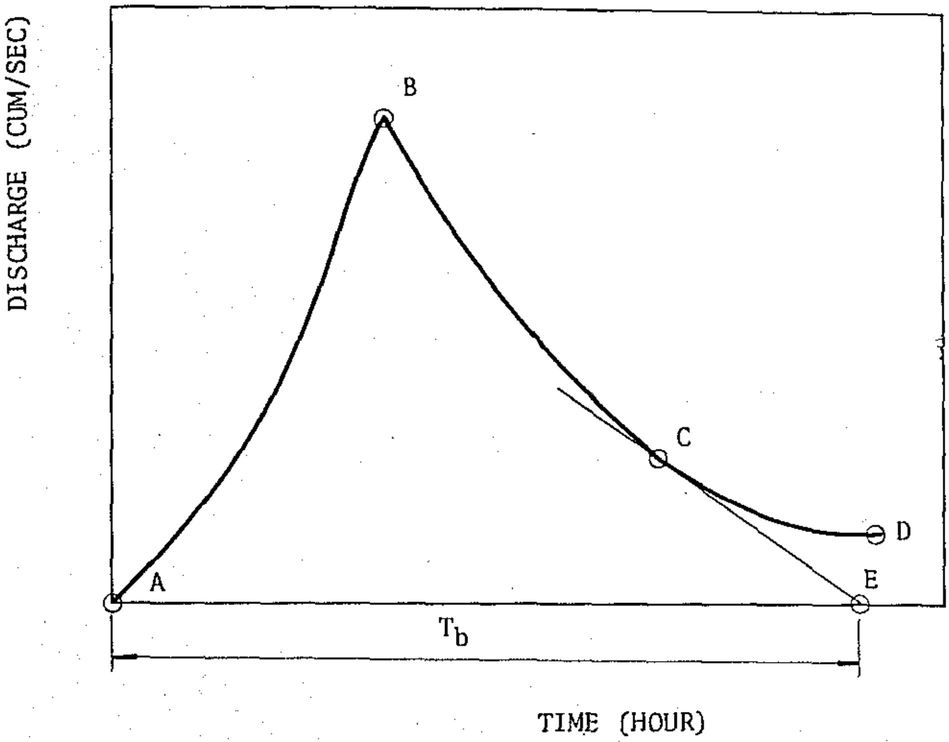
Exhibit E-8



OUTFLOW HYDROGRAPH

The tentative unit hydrograph curve developed by applying the storage phenomenon differs from the actual watershed lag, and therefore to be re-assumed and recomputation to Exhibit E-9, where the unit hydrograph curve is indicated by teh curve ABCD. Drawing a tangent to the curve ABCD from point E, the contact point is expressed as C. The area V formed by the curve ABCE should be equivalent to unit rainfall (mm) x A(sq.km) = $0.2778A$ (cu.m/sec/hr). Therefore, taking β as V/V_1, the unit hydrograph is derived by multiplying β by the curve ABCD.

Exhibit E-9



UNIT HYDROGRAPH

Modification of Tentative Hydrograph

The discharge curve, in consideration that the rainfall excluding the initial loss *Ri* is discharged in its entirety, is designated as a tentative hydrograph, which is derived from multiplying the unit hydrograph by the hourly rainfall. Actually, the rainfall does not discharge in its entirety, and it usually accompanies a loss. The ratio of the peak flow *Pp* of tentative hydrograph and the peak flow *Qp* of actual hydrograph is called the index of runoff rate, expressed by *fp* as follows.

$$fp = Qp/Pp \quad \ldots\ldots\ldots \quad \text{(E-20)}$$

In comparison with Qp and Pp, fp may be empirically written as follows.

$$fp = MQp^{m} \quad \cdots\cdots\cdots \quad \text{(E-21)}$$

Where M and m are constants.

Solving Qp from the equation (E-20 and E-21),

$$Qp = M^{\frac{1}{1-m}} Pp^{\frac{1}{1-m}} \quad \cdots\cdots\cdots \quad \text{(E-22)}$$

In order to modify the tentative hydrograph by the index of runoff rate, the rising portion of hydrograph is obtained by the equation (E-22), and the recession portion is calculated by applying fp at the top of hydrograph.

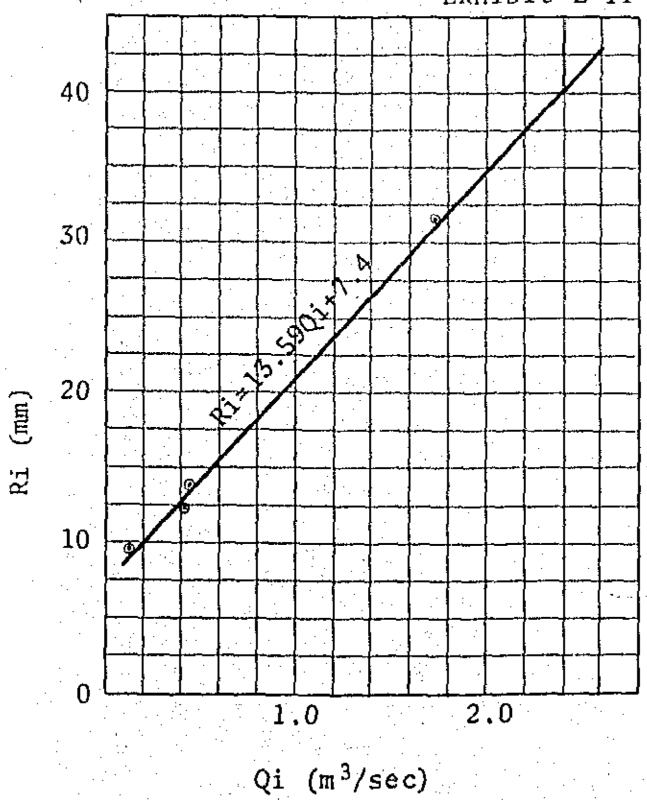
Unit Hydrograph for the Pure River Watershed

Analysis is carried out by abstracted six samples of flood from the discharge records at the Pure River Gauging Station with the rainfall records. These flood samples are designated as No.1 - No.6 respectively and the relation between rainfall and discharge is given on Exhibit E-10.

Initial Loss of Rainfall (Ri)

Exhibit E-11 illustrates a relation between Qi and Ri, which is given by the equation (E-2).

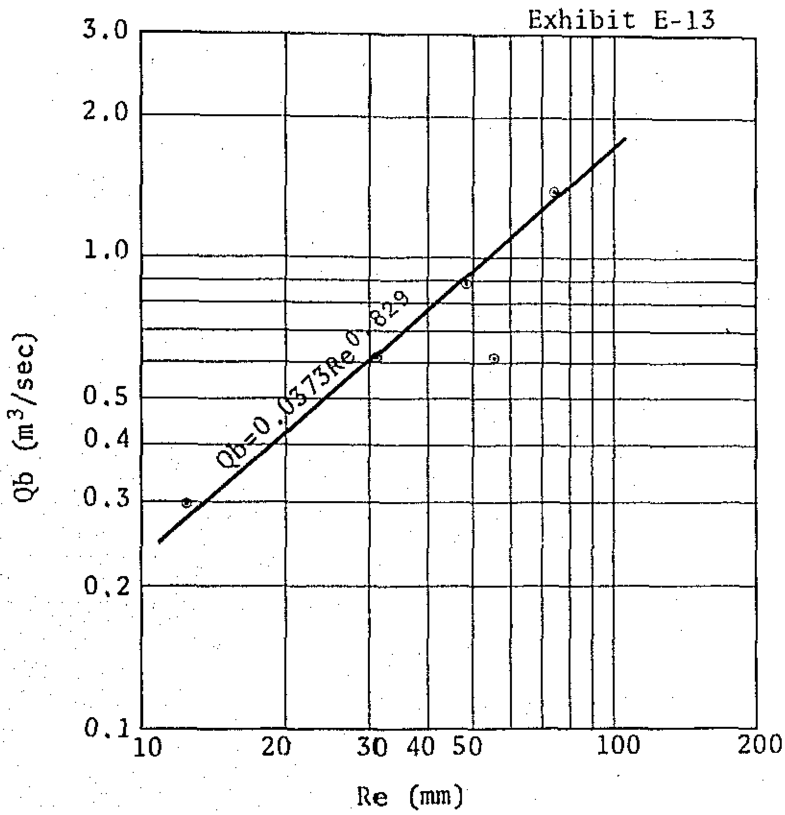
Exhibit E-11



No.	Qi m^3/sec	Ri mm
1	0.47	13.8
2	1.75	31.2
3	-	-
4	-	-
5	0.14	9.7
6	0.40	12.3

Separation of Base Flow and Direct Discharge

There is a relation between *Re* and *Qb* as given by the equation (E-3) and (E-4). The bending point *C* is found on the discharge recession curve plotted on the semi-log paper as shown on Exhibit E-12. By computing *Re* and *Qb* from Exhibit E-12, the result is obtained as shown on Exhibit E-13.



No.	*Qi* (m^3/sec)	*Qc* (m^3/sec)	*Qb* (m^3/sec)	*R* (mm)	*Ri* (mm)	*Re* (mm)
1	0.47	0.77	0.30	26.4	13.8	12.6
2	-	-	-	-	-	-
3	0.31	1.00	0.69	51.1	20.1	31.0
4	0.22	1.60	1.38	95.4	19.9	75.5
5	0.14	1.02	0.88	59.4	9.7	49.7
6	0.40	1.02	0.62	68.1	12.3	55.8

Watershed Lag (Tg)

Tg, representing the watershed lag, is obtained by adding 1/2 of the unit hour, that is, 0.5 hour, to time lag between the maximum rainfall intensity and the maximum discharge, as shown in the following table.

	No.1	No.2	No.3	No.4	No.5	No.6	Mean
tg	6.5	5.5	5.5	6.5	6.5	5.5	tgm = 6.0 hour
		$Tg = tgm + 0.5 = 6.5 \doteqdot 7.0$ hour					

Time Base (Tb)

Time base, expressed as Tb, is obtained from the following process. Firstly, duration between the time at the end of rainfall and at the end of direct runoff, i.e. the time upto the beginning point C on Exhibit E-5, shall be obtained and expressed as tb on each runoff in a watershed. Secondaly, unit hour, one hour, shall be added to the mean figure of these durations, which is represented as tbm to obtain the Time Base of the unit hydrograph.

	No.1	No.2	No.3	No.4	No.5	No.6	Mean
tb	14	11	13	16	14	15	tbm = 13.8
		$Tb = tgm + 1.0 = 14.8 \doteqdot 15$ hour					

Recession Coefficient $C(hr^{-1})$

The time T_2 for the discharge to be reduced to a half is found on Exhibit E-12 and C, recession coefficient, may be computed from $\log e_2/T_2$ and shown as follows.

	No.1	No.2	No.3	No.4	No.5	No.6	Mean
T_2	3.0		4.0	3.0	4.0	2.0	3.2 → 3.0

$$C = \frac{\log e_2}{T_2} = \frac{0.6931}{3.0} = 0.231$$

Constant K(hr) of Storage Equation

K in the equation (E-1) has a relation of $C = 1/K$

Preparation of Concentrated Area Diagram

The drainage watershed shall be divided into each 2.0 km zone to compose the concentrated area diagram as shown on Exhibit E-15. (Refer to Exhibit E-15).

Zone No.	Path line length Range (dL=2km)	Mean Length (L)	Area dAB (km^2)	Width $\frac{dAB}{dL}$ (km)
1	0 - 2	1.0	7.8	3.9
2	2 - 4	3.0	6.9	3.5
3	4 - 6	5.0	1.9	1.0
4	6 - 8	7.0	2.6	1.3

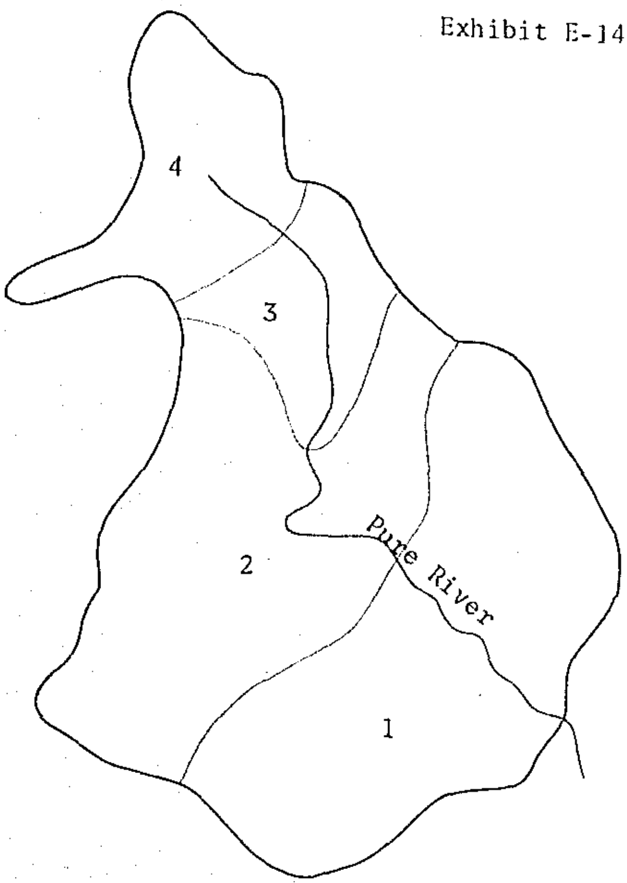
Tentative Concentrated Time Diagram and Tentative Unit Hydrograph

A tentative concentrated time diagram and tentative unit hydrograph shall be made in the method explained in the paragraph on Tatugami's Method. The tentative concentrated volume i'' with the equation (E-16), (E-17) and (E-18) can be computed as shown in Table E-6. But α in the relative equations is decided at 2.5 hr/km$^{0.7}$ as the result of calculation.

Table E-6 Calculation of Tentative Concentrated Volume i''

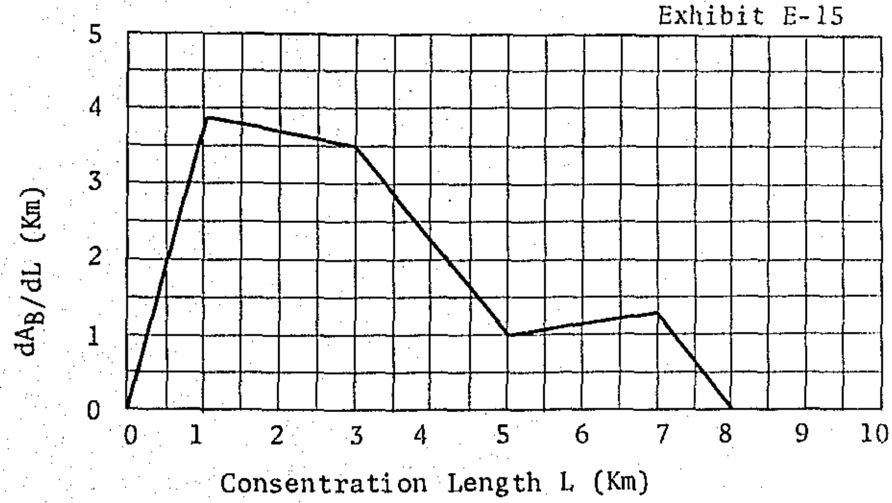
L	$T''=\alpha' L^{0.7}$	$\frac{1}{0.7} L^{0.3}$	dA/dL	$dA/dT''=\frac{L^{0.3}}{0.7\alpha'} \cdot \frac{dA}{dL}$	$i=0.2778 \frac{dA}{dT}$
0	0	0	0	0	0
1.0	2.5	1.43	3.9	2.23	0.62
3.0	5.40	1.99	3.5	2.81	0.78
5.0	7.73	2.32	1.0	0.94	0.26
7.0	9.75	2.56	1.3	1.33	0.37
8.0	10.73		0	0	0

Exhibit E-14



DIVIDING THE PURE RIVER BASIN

Exhibit E-15



CONSENTRATION AREA DIAGRAM

The tentative unit hydrograph is calculated with both results of foregoing calculations and equation (E-19), and shown in Table E-7.

$$K_1 = \frac{2K}{a} + 1 = 2 \times 4.33 + 1 = 9.66$$

$$K_2 = \frac{2K}{a} - 1 = 7.66$$

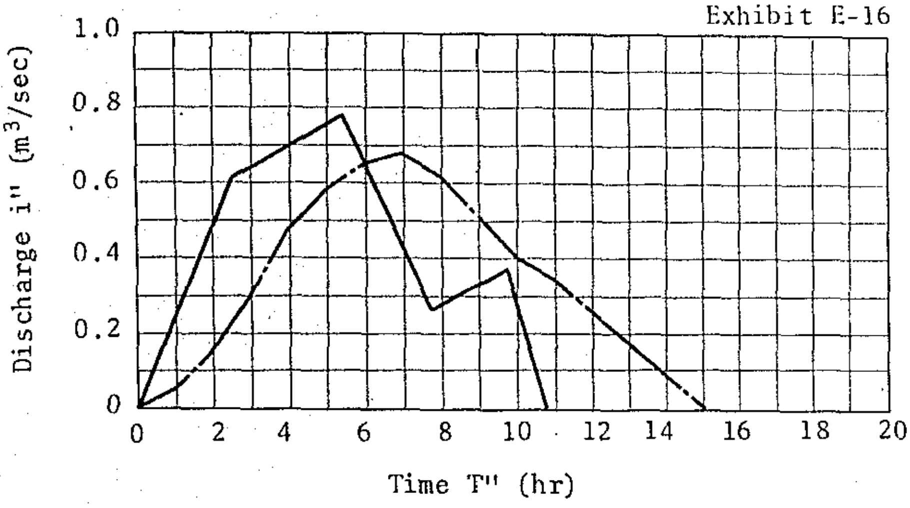
Table E-7 Calculation of Tentative Unit Hydrograph

t	i	i_1+i_2	$7.66q_1$	$i_1+i_2+7.66q_1$	$q_2=\frac{i_1+i_2+7.66q_1}{9.66}$	Modified Tentative Unit Hydrograph
0	0	0	0	0	0	0
1	0.24	0.24	0	0.24	0.02	0.05
2	0.50	0.74	0.15	0.89	0.09	0.15
3	0.65	1.15	0.68	1.83	0.19	0.31
4	0.70	1.35	1.46	2.81	0.29	0.48
5	0.76	1.46	2.22	3.68	0.38	0.58
6	0.64	1.40	2.91	4.31	0.45	0.65
7	0.43	1.07	3.47	4.52	0.47	0.68
8	0.28	0.71	3.60	4.31	0.45	0.62
9	0.32	0.60	3.45	4.05	0.42	0.51
10	0.26	0.58	3.22	3.80	0.39	0.40
11	0	0.26	2.99	3.25	0.34	0.34
12			2.60	2.60	0.27	0.25
13			2.07	2.07	0.22	0.17
14			1.69	1.69	0.17	0.09
15			1.30	1.30	0.13	0
16						
17						

The estimated unit runoff q_2 is shown on Exhibit E-16 after modified by the actual runoff V and time base Tb=15(hr). The actual runoff is obtained as follows.

$V = A(\text{km}^2)$ x unit rainfall (1 mm)

Exhibit E-16

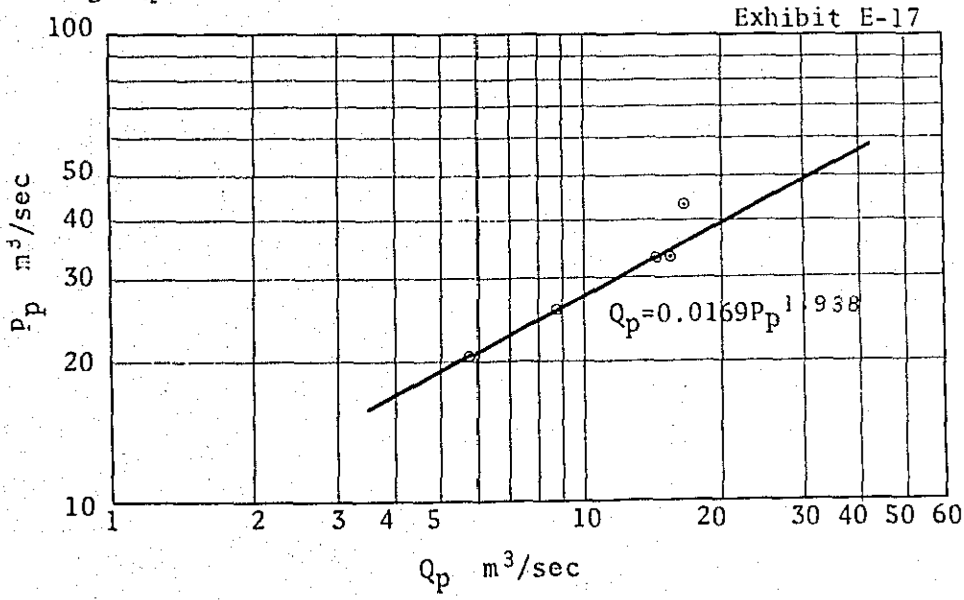


OUTFLOW HYDROGRAPH

Modification on Tentative Hydrograph

The tentative hydrograph is calculated in a manner that the initial loss of rainfall *Ri* is obtained with the initial discharge *Qi* measured at the Pure River gaging Station on the floods No.2 - No.6 respectively. The relation between the peak discharge *Pp* and the corresponding observed piak discharge *Qp* is as shown on Exhibit E-17.

Exhibit E-17



RUNOFF COEFFICIENT FOR
PEAK DISCHARGES

No.	*Pp*	*Qp*	*fp*
1	-	-	-
2	25.94	8.83	0.340
3	20.22	5.72	0.283
4	43.45	16.84	0.388
5	33.56	14.63	0.436
6	33.75	15.57	0.595

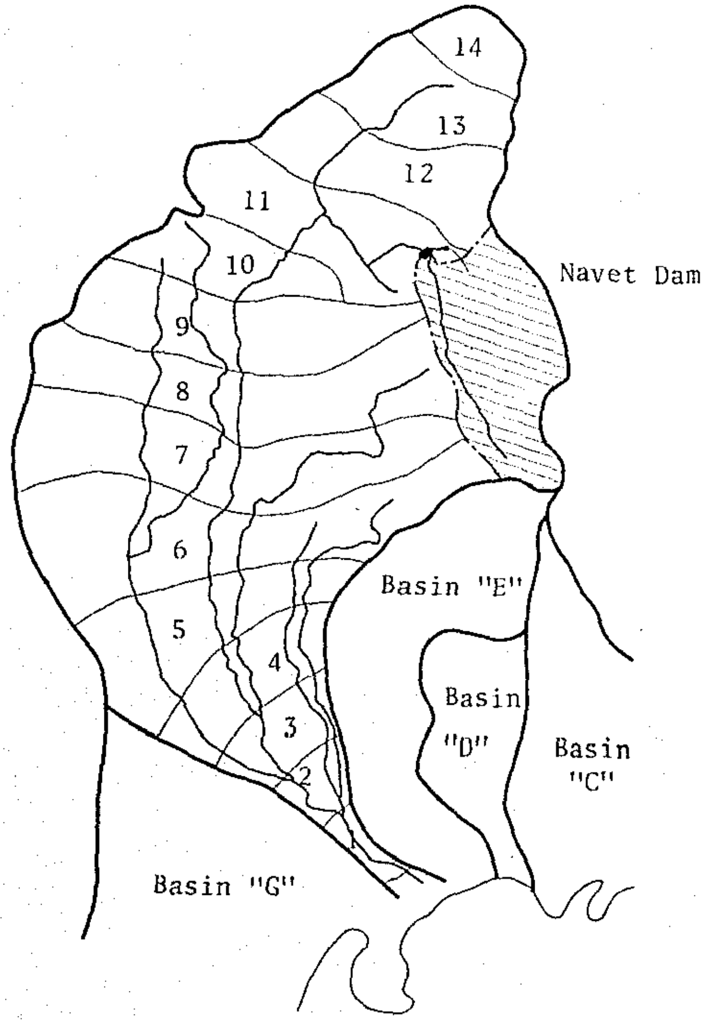
The value in the equation (E-22) will be written as $Qp=0.0169Pp^{1.938}$. The tentative hydrograph is modified by applying the above equation to the discharge rising portion and $f_b = 0.0169Pp^{1.938}$ in the peak discharge *Pp* to the recession portion. Exhibit E-10 shows the relation of hydrographs between on the basis of computation and actual observation for No.2, No.5 and No.6 runoff, and hence their curves nearly fall on each other.

Unit Hydrograph for the Navet River Watershed

The unit hydrograph for the Navet River watershed shall be made from the various values obtained in the analyses on the Pure River.

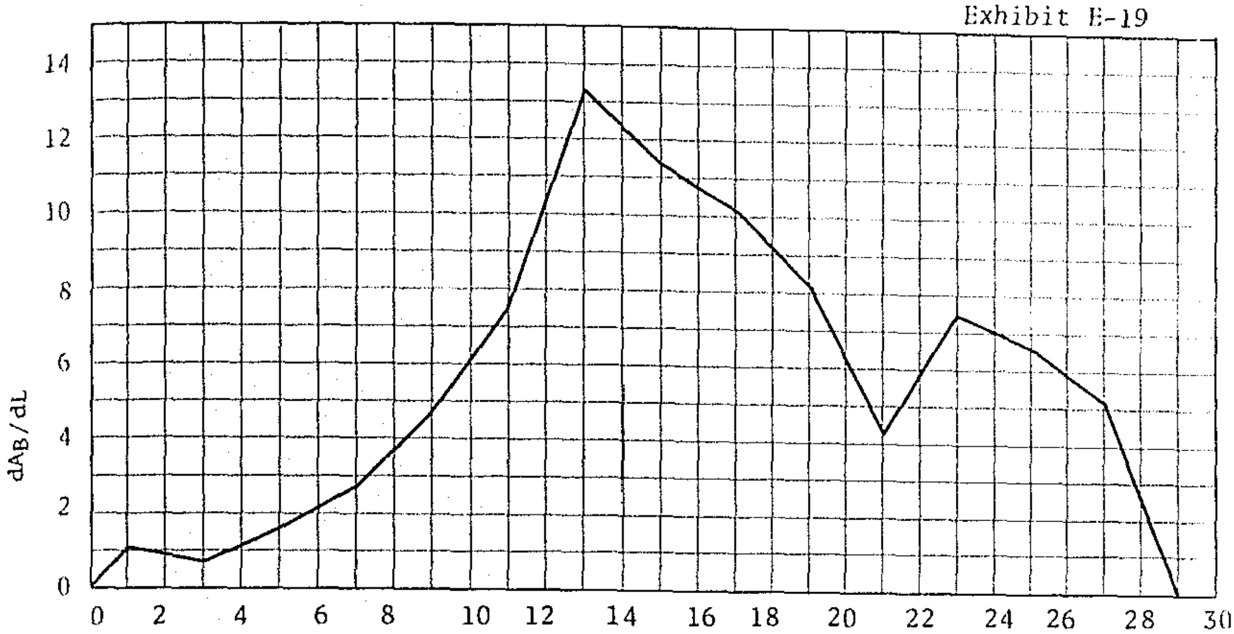
Concentrated Area Diagram

Table E-8 and Exhibit E-19 can be obtained from the concentrated area diagram from Exhibit E-18 in the ramification of the total area with every 2 kilometer zone.



DIVIDING BASIN "F"

Exhibit E-19



CONSENTRATION AREA DIAGRAM

Table E-8 Calculation of Concentration Area Diagram

Zone No.	Path line length Range (dL=2km)	Mean Length (km)	Area dAB (km^2)	Width $\frac{dA}{dL}$ (km)
1	0 - 2	1	2.2	1.1
2	2 - 4	3	1.4	0.7
3	4 - 6	5	3.1	1.6
4	6 - 8	7	5.4	2.7
5	8 - 10	9	9.4	4.7
6	10 - 12	11	15.1	7.5
7	12 - 14	13	26.7	13.4
8	14 - 16	15	22.8	11.4
9	16 - 18	17	20.4	10.2
10	18 - 20	19	16.4	8.2
11	20 - 22	21	8.5	4.2
12	22 - 24	23	15.1	7.5
13	24 - 26	25	13.1	6.6
14	26 - 28	27	10.3	5.1

Tentative Concentrated Time Diagram and Tentative Unit Hydrograph Curve

The results of computation on the tentative concentrated quantity i'' and the tentative hydrograph curve are shown in Table E-9 and Exhibit E-20 respectively.

Table E-9 Calculation of Tentative Concentration Volume i''

L	$T''=\alpha' L^{0.7}$	$\frac{1}{0.7} L^{0.3}$	dA/dL	$dA/dT''=\frac{L^{0.3}}{0.7} \cdot \frac{dA}{dL}$	$i''=0.2337 dA/dT''$
km	hr		km	km^2/hr	m^3/sec
0	0				
2	4.9	1.76	1.1	0.65	0.18
4	7.9	2.17	0.7	0.51	0.14
6	10.5	2.45	1.6	1.27	0.35
8	12.9	2.67	2.7	2.40	0.67
10	15.0	2.85	4.7	4.46	1.24
12	17.1	3.01	7.5	7.57	2.10
14	19.0	3.15	13.4	14.05	4.90
16	20.9	3.29	11.4	12.53	3.48
18	22.7	3.40	10.2	11.61	3.23
20	24.4	3.51	8.2	9.58	2.66
22	26.1	3.61	4.2	5.10	1.42
24	27.8	3.70	7.5	9.30	2.58
26	29.3	3.79	6.6	8.27	2.30
28	30.9	3.89	5.1	6.66	1.85
30	2].3	2.95	0	0	0

On computation of the above values, the constant has been fixed as $\alpha = 2.5$ hr/km$^{0.7}$, and for the computation of the tentative unit hydrograph curve, K_1=9.66, K_2=7.66 has been determined on the basis of the values of the Pure River.

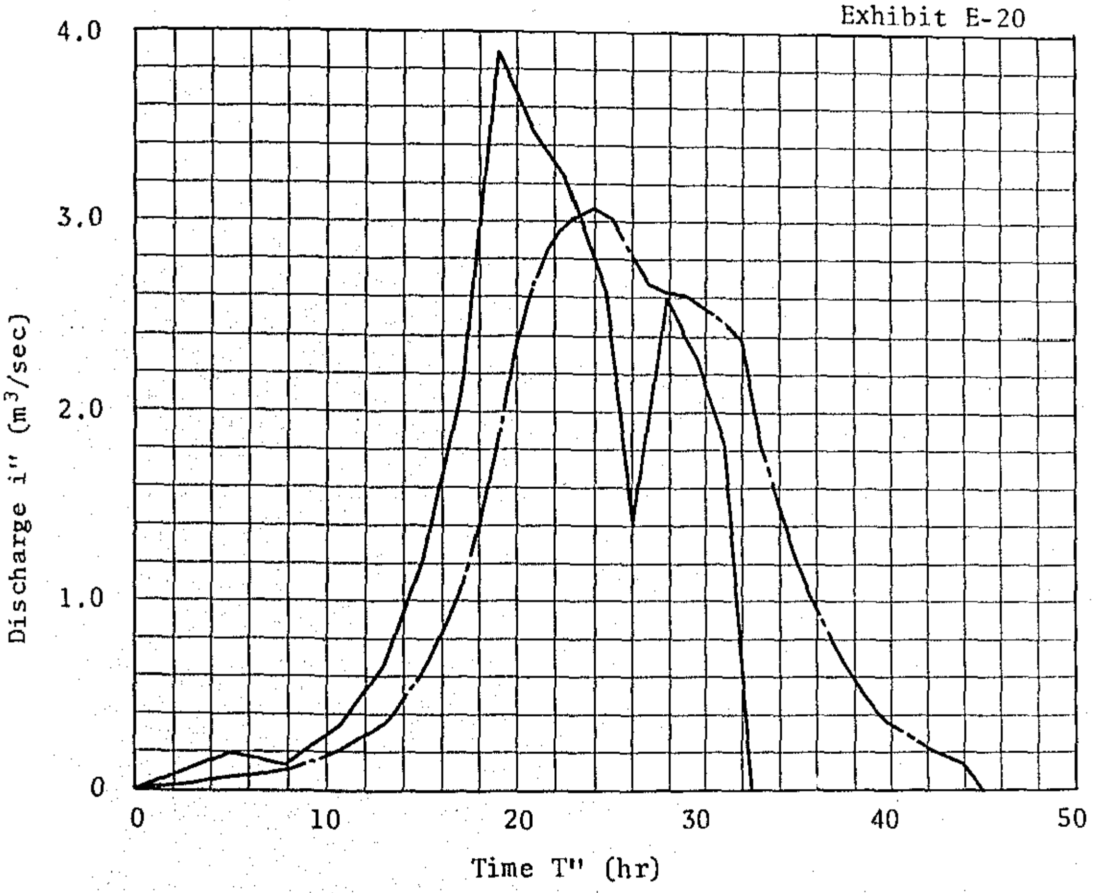
Modification of Modified Rainfall Diagram

The actual peak discharge Qp is calculated on the basis that the observation data of runoff index, $fp=Qp/Pp$ for No.1 to No.6 at the Pure River Gauging Station shall be fixed and proportioned to watershed area, and the result of the computation is shown on Exhibit E-21.

$$Qp = Qp' \times \alpha$$
$$Pp = Qp/fp$$

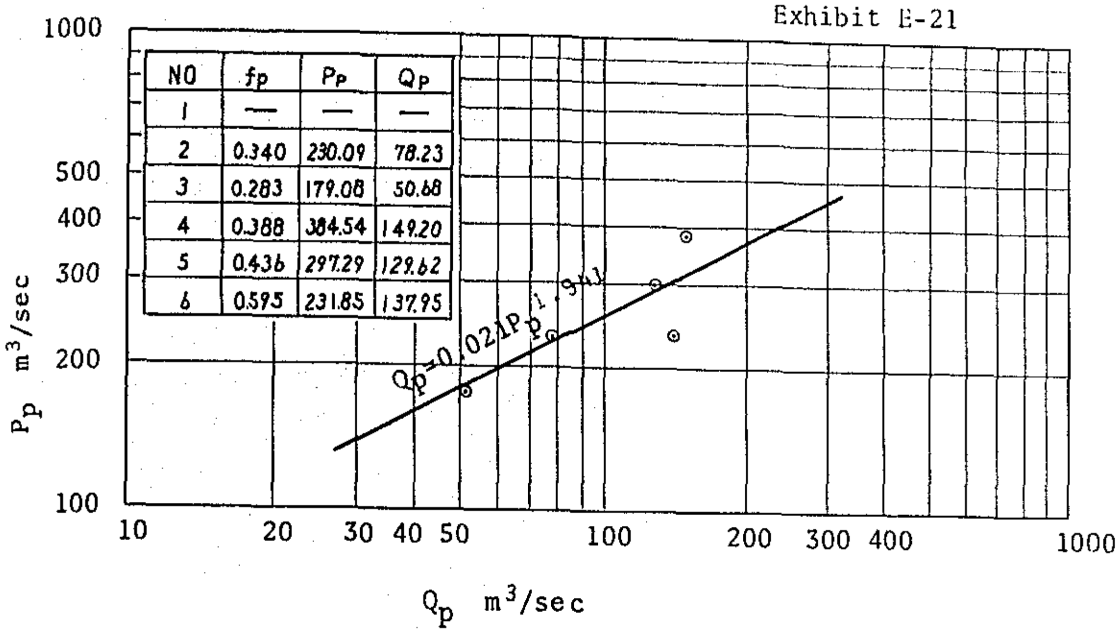
Where Qp is the actual peak discharge on the Pure River, and α is the ratio of the watershed, that is, $\frac{170.2 \text{ km}^2}{19.2 \text{ km}^2} = 8.86$.

Exhibit E-20



OUTFLOW HYDROGRAPH

Exhibit E-21



NO	fp	Pp	Qp
1	—	—	—
2	0.340	230.09	78.23
3	0.283	179.08	50.68
4	0.388	384.54	149.20
5	0.436	297.29	129.62
6	0.595	231.85	137.95

Therefore, the modification of the rising portion of the modified rainfall diagram shall be made with the value $Qp=0.0021Pp^{1.941}$ and modification of the value after peak discharge shall be made with $fp=0.0021Pp^{1.941}$.

Hydrograph in Each Watershed

The unit hydrograph shall be applied to the schematic rainfall pattern as shown on Exhibit E-3, in order to compose the modified rainfall diagram, and then the index of the runoff rate shall be multiplied by the foregoing unit hydrograph to make the hydrograph for each watershed.

In the case that the unit hydrograph shall be applied to each watershed divided into the parts shown on Exhibit E-4, the folloiwng procedure shall be taken.

Hydrograph in Watershed "A", "B", "C", "D", "E" and "G"

Each hydrograph for the captioned watershed can be obtained from the procedure that the unit hydrograph of the Pure River is to be applied to the schematic rainfall pattern to compose a hydrograph, and after that the hydrograph shall be multiplied by the area ratio for the Pure River Watershed and each watershed.

Hydrograph in Watershed "F"

For the captioned watershed, the unit hydrograph of the Navet River watershed shall be applied and the result of the said computation is shown in Table E-10. In this computation, the rainfall loss and base flow shall be neglected because of their setoff each other.

Each hydrograph for the watershed "A"-"G" is shown on Exhibit E-22.

Hydrograph in Irrigable Area after Development

In the irrigable area, the paddy fields shall be developed in the wet season. Except the loss in evaporation and seepage, most of rainfall to the paddy fields shall be drained through the notches on the fields to the lateral drainage canals.

The drainage canals in the project area are to be provided with the reasonable drainage capacity for their irrigable areas. The drainage capacity of the canals, therefore, will regulate the outflow from the paddy fields, in case of the increment of the overflow at the notches in the considerable inundation on the paddy fields.

When the hydrograph shall be plotted for the outflow of the irrigable area, it is required that the lag phenomenon from regulation of the outflow of the water by the capacity of canals and notches is considered.

The development of the hydrograph for the irrigable area shall be based on the standard paddy fields blocks shown on Exhibit E-23.

Exhibit E-24

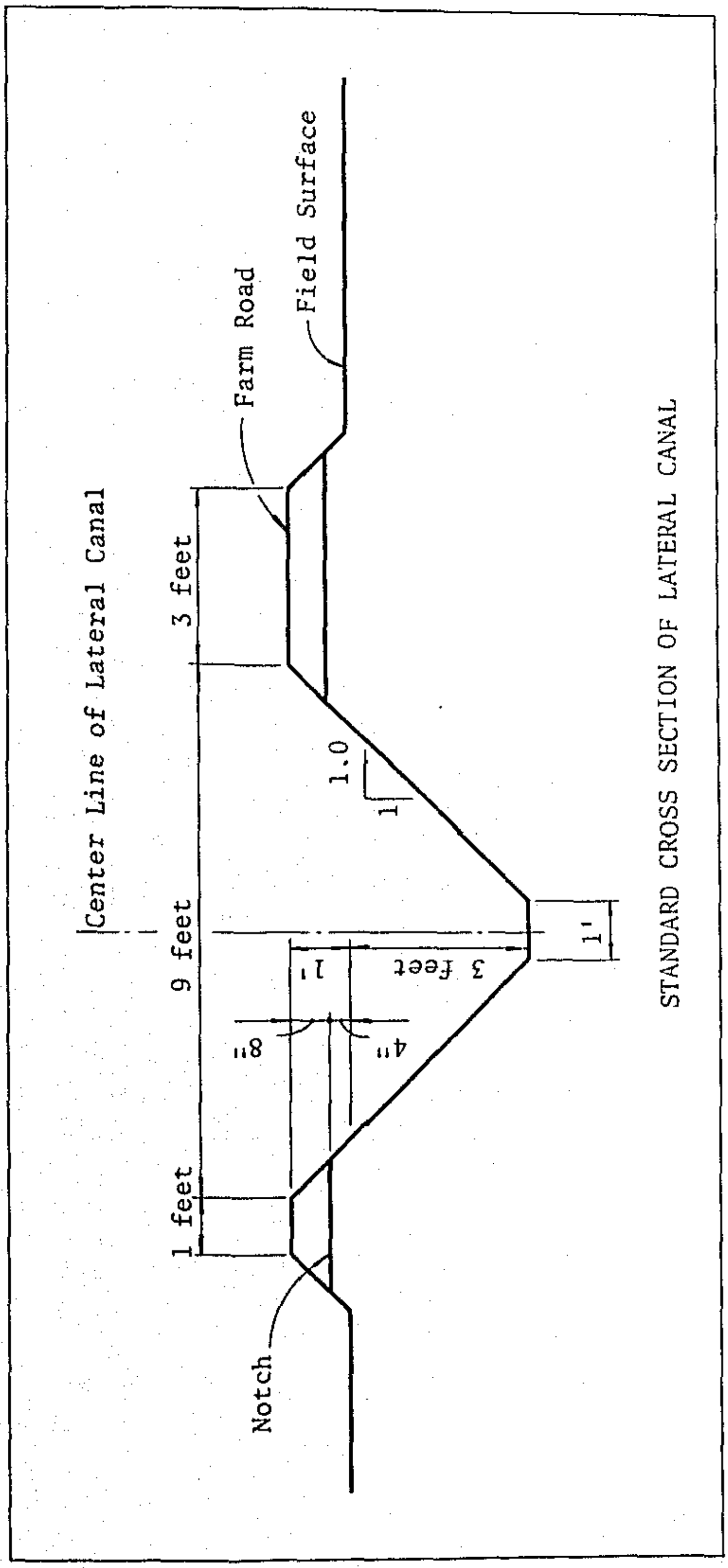
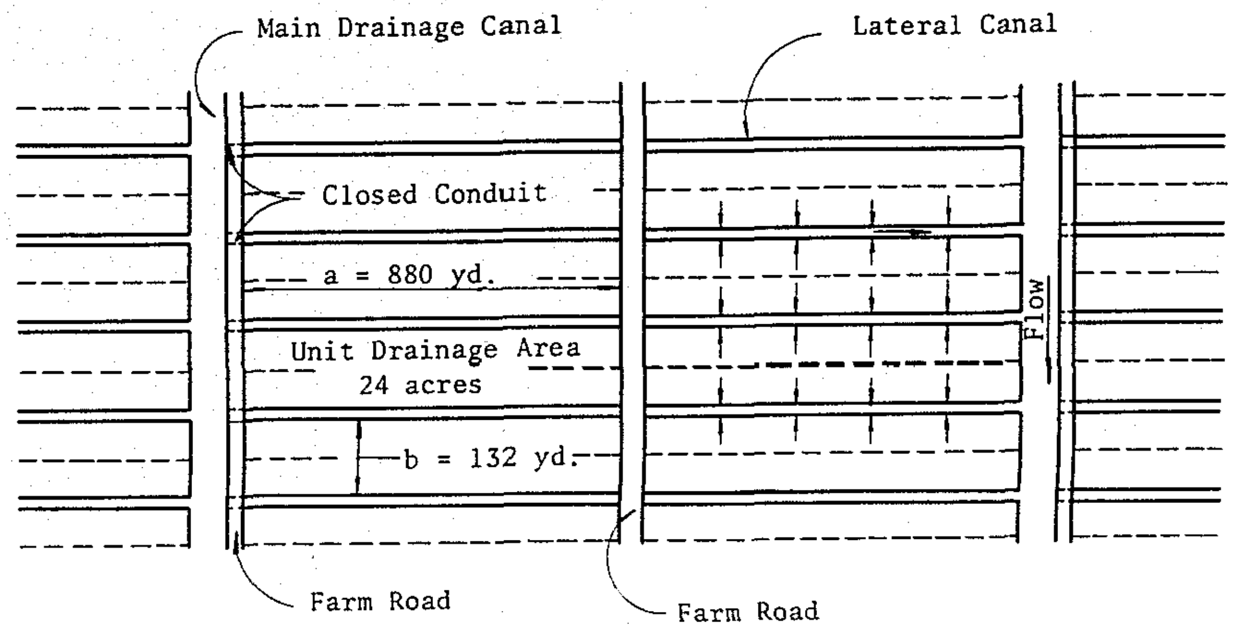

Center Line of Lateral Canal
Farm Road
Field Surface
3 feet
9 feet
1 feet
1.0
1
3 feet
1'
8"
4"
1'
Notch
STANDARD CROSS SECTION OF LATERAL CANAL

Exhibit E-23



Note:
All canals are
dual purpose
canal.

STANDARD FARMLAND BLOCK

Discharge Capacity from Notches

Discharge capacity of the notches on the ridges in the fields shall be estimated at h=200m (h represents overflow water depth) and γ_0=3mm/hr. The calculation is shown as follows.

$$Q = a \times b \times \gamma_0/3,600 = 805 \times 121 \times 0.003/3,600 = 0.08\ m^3/sec.$$

Adn from the equation $Q=CHh^{3/2}$,

$$B = \frac{Q}{Ch^{3/2}} = \frac{0.08}{1.7x0.03^{3/2}} = 16.6\ m$$

Where C is 1.7 as discharge coefficient, and B is total length of the notches in meter.

$$Q = 1.7 \times 16.6 \times h^{3/2}(m^3/sec) = 28.22h^{3/2}\ m^3/sec.$$
$$= 1,043h^{3/2}\ \ (mm/hr)$$

The unit of the above h shall be meter.

Discharge Capacity from Lateral Canal

Discharge capacity of lateral canal is γ_0=4mm/hr in consideration of an allowance for capacity of field notches.

$$\text{Discharge} = 805 \times 121 \times \frac{0.004}{3,600} = 0.11\ m^2/sec$$

Provided that this discharge is conducted down at the water level near the level of the bottom field notches, the cross-section of the lateral canals is designed as shown on Exhibit E-24. The discharge in consideration of the roughness coefficient on the canals is estimated by the Manning's Formula as follows.

$$Q = \frac{A}{n} R^{2/3} \sin\theta^{1/2}$$
$$= \frac{A}{0.03}R^{2/3} \times \left(\frac{1}{5,000}\right)^{1/2}\ \ m^3/sec$$
$$= 0.417AR^{2/3}\ (m^3/sec) = 14.14^{2/3}\ \ (mm/hr)$$

Where n is the coefficient of roughness n=0.03, slope of water surface is considered as nearly sin θ=I=1/5,000 = constant, and unit of A is in m^2 and R is meter.

Outflow Hydrograph in Irrigable Area after Development

When the above-mentioned hydrograph shall be made by the graphical solution, the water balance between the rainfall as input to the paddy fields and the discharge as output from notches or lateral canals is considered to be stored in the fields. The result is shown on Exhibit E-25.

Table E-5 Schematic Rainfall Pattern

	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	Total
Observation Value on 1st Day										0.04	0.52		0.02										0.10		0.68
Modified Value										0.05	0.69		0.03										0.13		0.9
Observation Value on 2nd Day	0.02	0.02	0.12	0.52	0.78	0.08	0.08			0.05	0.20	0.32	1.20	0.52											3.91
Modified Value	0.03	0.03	0.16	0.65	1.00	0.10	0.10			0.07	0.25	0.40	1.54	0.67											5.0
Observation Value on 3rd Day			0.16		0.16																		0.02		0.34
Modified Value			0.38		0.38																		0.04		0.8
Total Value																									5.39
Modified Value																									6.7

Source: Records observed by automatic recorder at Navet Presbyterian *gauging Station from 22nd to 24th January, 1968.*

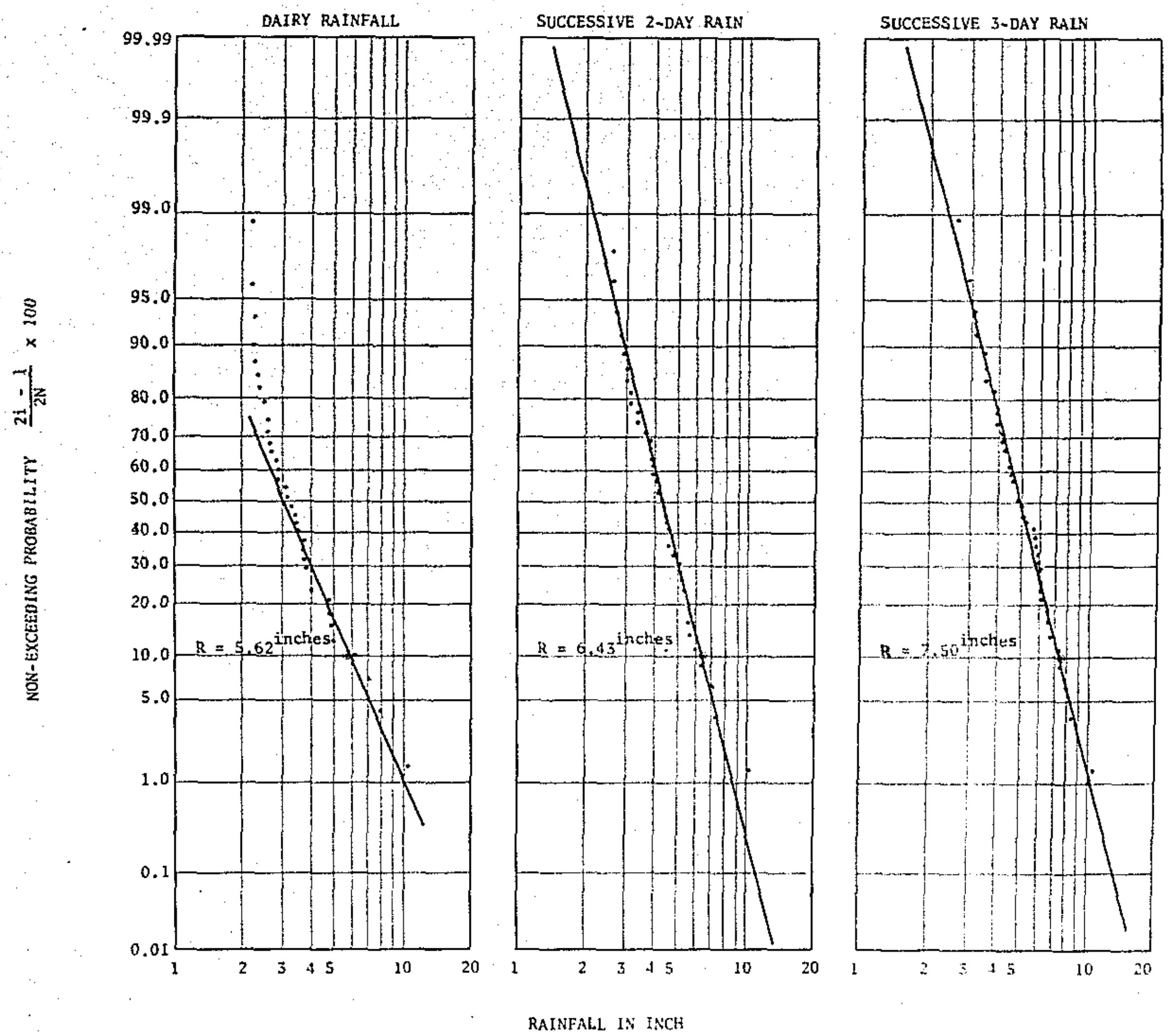
Table E-10 Calculation of Tentative Unit Hydrograph

t	i	$i_1 + i_2$	$7.66q_1$	$i_1 + i_2 + 7.66q_1$	$q_2 = \frac{i_1 + i_2 + 7.66q_1}{9.66}$	Modified Tentative Unit Hydrograph
0	0	0	0	0	0	0
1	0.03	0.03	0	0.03	0.00	0.0
2	0.07	0.10	0	0.10	0.01	0.01
3	0.10	0.17	0.08	0.25	0.03	0.03
4	0.14	0.24	0.23	0.47	0.05	0.06
5	0.17	0.31	0.38	0.69	0.07	0.08
6	0.16	0.33	0.54	0.87	0.09	0.10
7	0.15	0.31	0.69	1.00	0.10	0.11
8	0.16	0.31	0.77	1.08	0.11	0.12
9	0.23	0.39	0.84	1.23	0.13	0.14
10	0.31	0.54	1.00	1.54	0.16	0.18
11	0.42	0.73	1.23	1.96	0.20	0.22
12	0.55	0.97	1.53	2.50	0.26	0.29
13	0.70	1.25	1.99	3.24	0.34	0.37
14	0.96	1.66	2.60	4.26	0.44	0.48
15	1.24	2.20	3.37	5.57	0.58	0.64
16	1.64	2.88	4.44	7.32	0.76	0.84
17	2.05	3.69	5.82	9.51	0.98	1.08
18	2.97	5.02	7.51	12.53	1.30	1.43
19	3.90	6.87	9.96	16.83	1.74	1.91
20	3.68	7.58	13.33	20.91	2.16	2.38
21	3.45	7.13	16.55	23.68	2.45	2.70
22	3.32	6.77	18.77	25.54	2.64	2.90
23	3.12	6.44	20.22	26.66	2.76	3.04
24	2.82	5.94	21.14	27.08	2.80	3.08
25	2.30	5.12	21.44	26.56	2.75	3.03
26	1.52	3.82	21.07	24.89	2.58	2.84
27	2.07	3.59	19.76	23.35	2.42	2.66
28	2.51	4.58	18.54	23.12	2.39	2.63
29	2.18	4.69	18.31	23.00	2.38	2.62
30	1.98	4.16	18.23	22.39	2.32	2.55
31	1.70	3.88	17.77	21.65	2.24	2.46
32	0.50	2.20	17.16	19.36	2.00	2.20
33	0	0.50	15.32	15.82	1.64	1.80
34	0		12.56		1.35	1.49
35	0		10.34		1.07	1.18
36	0		8.20		0.85	0.94
37	0		6.51		0.67	0.74
38	0		5.13		0.53	0.58
39					0.42	0.46
40					0.33	0.36
41					0.26	0.29
42					0.21	0.23
43					0.17	0.19
44					0.13	0.14
45					0.10	0

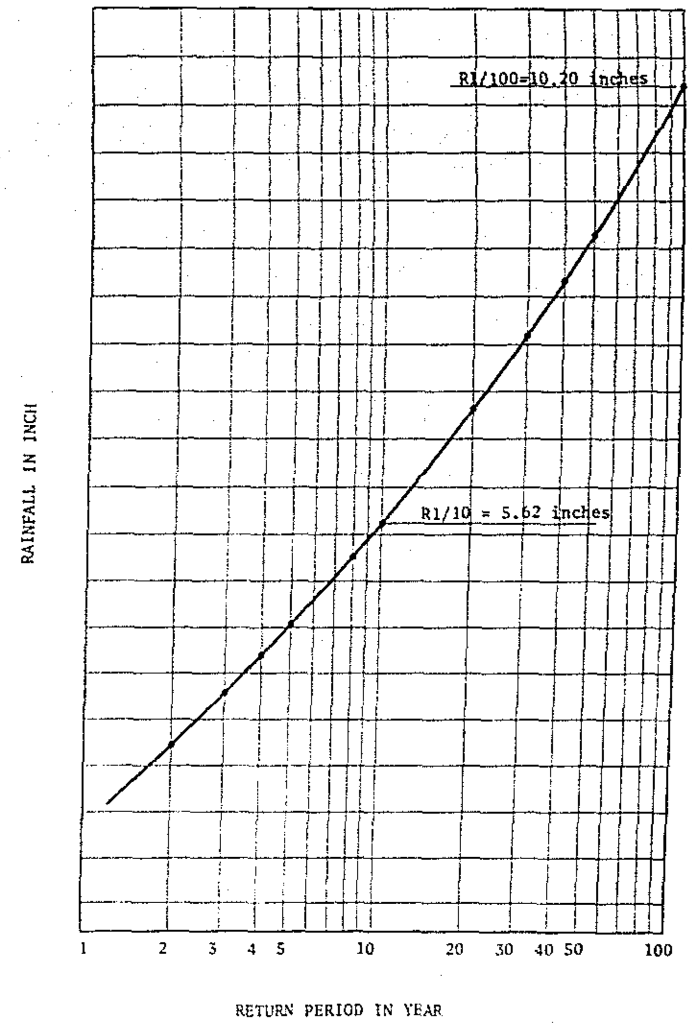
Exhibit E-1

PROBABLE RAINFALL

NON-EXCEEDING PROBABILITY (by Harzen Paper)



PROBABLE DAIRY RAINFALL (by Iwai Method)



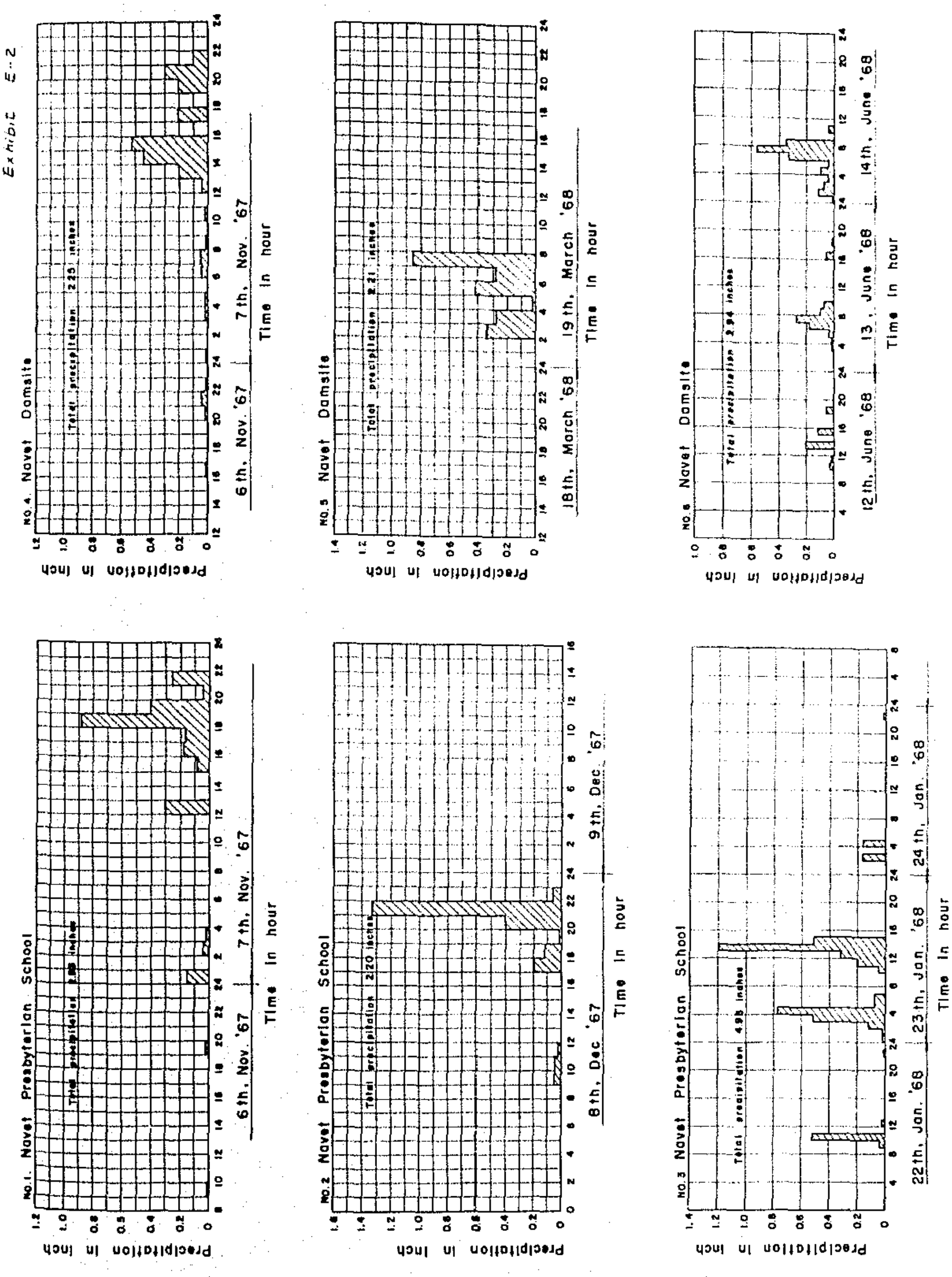
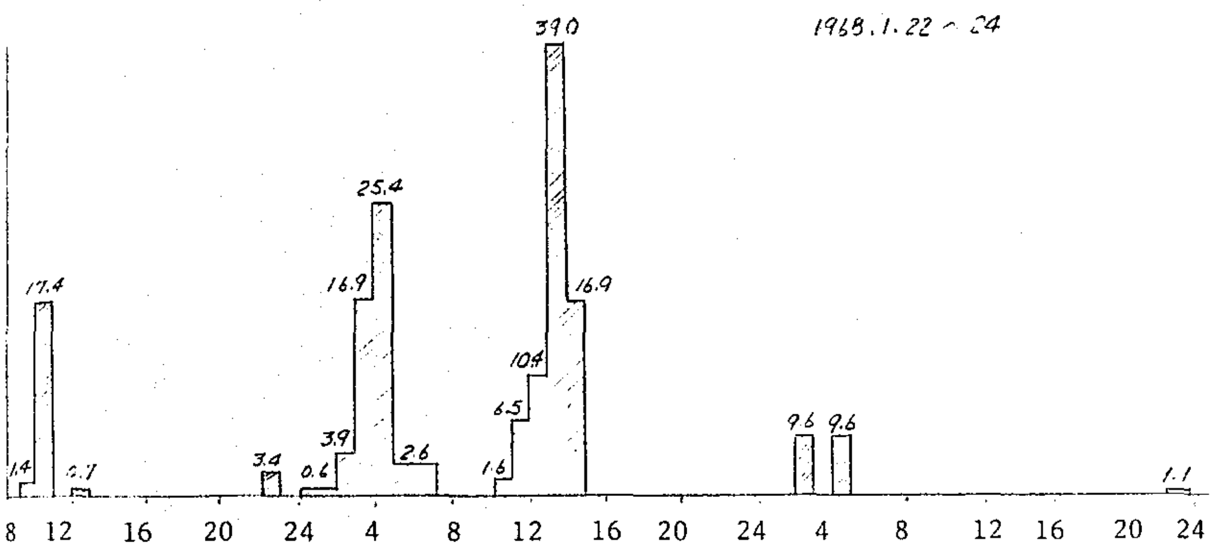


Exhibit E-2
No.1 Navet Presbyterian School
6th. Nov. '67
7th. Nov. '67
No.2 Navet Presbyterian School
Total precipitation 2.20 inches
8th. Dec '67
9th. Dec. '67
No.3 Navet Presbyterian School
22th. Jan. '68
23th. Jan. '68
24th. Jan. '68
No.4 Navet Damsite
Total precipitation 2.25 inches
6th. Nov. '67
7th. Nov. '67
No.5 Navet Damsite
Total precipitation 2.21 inches
18th. March '68
19th. March '68
No.6 Navet Damsite
Total precipitation 2.94 inches
12th. June '68
13. June '68
14th. June '68
Precipitation in inch
Time in hour

Exhibit E-3

Schematic Rainfall Pattern

Unit: mm



Time in hour

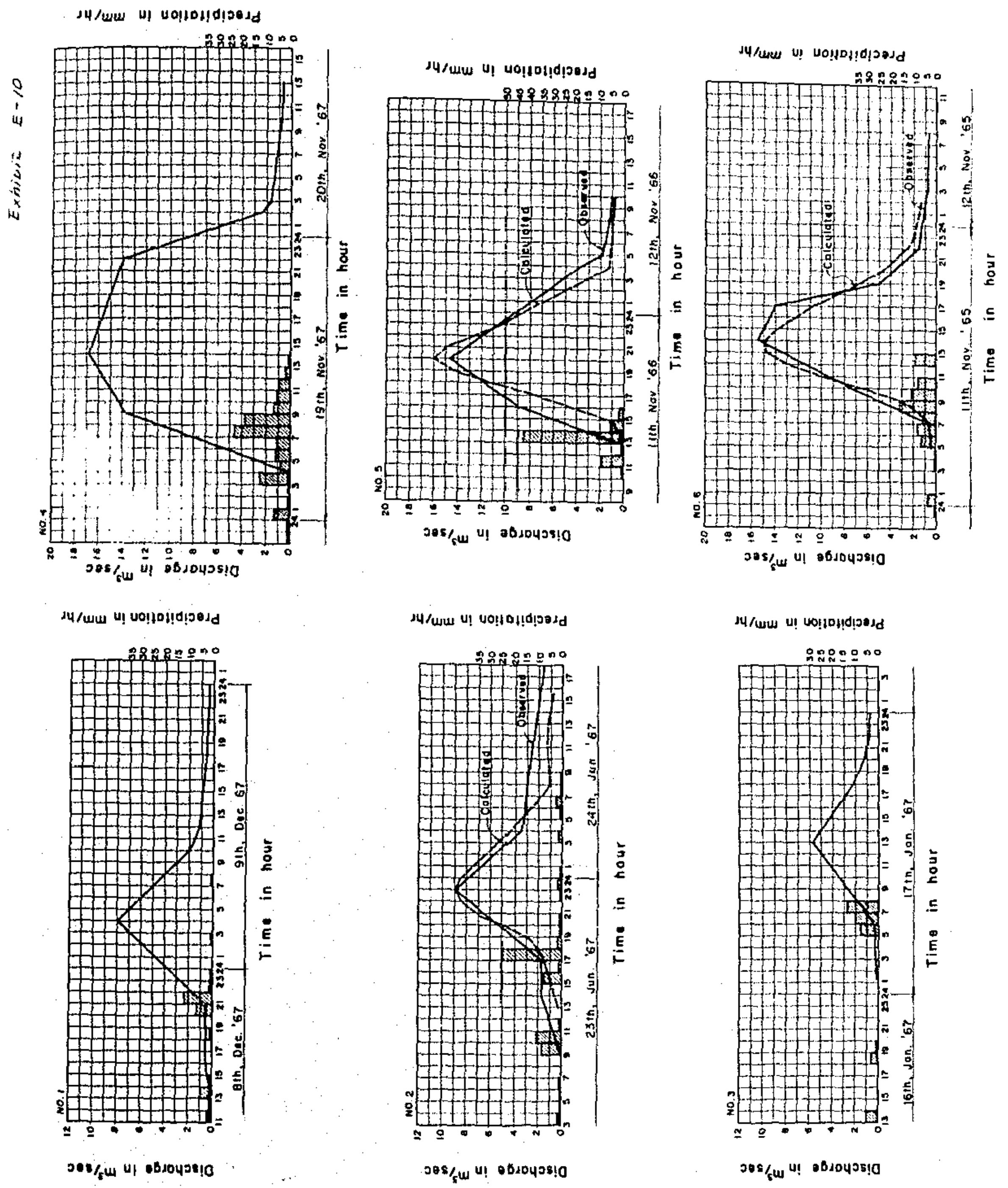
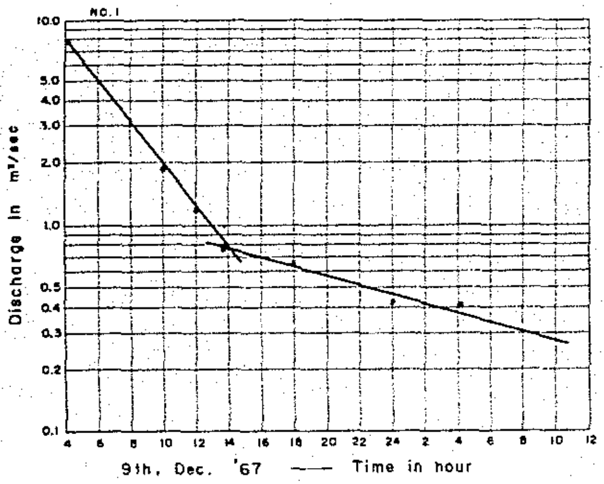
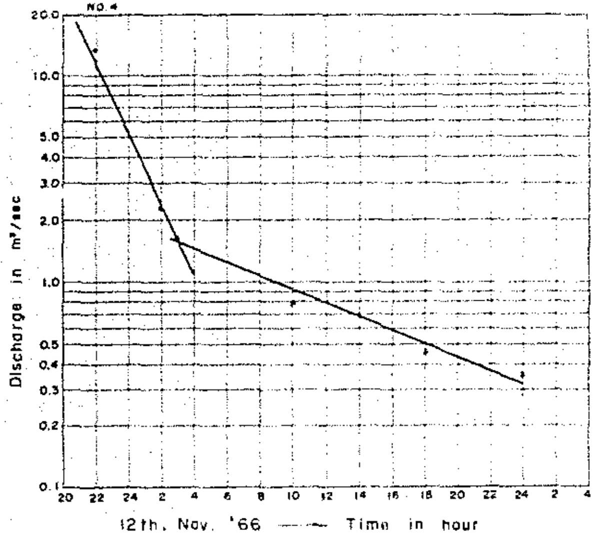
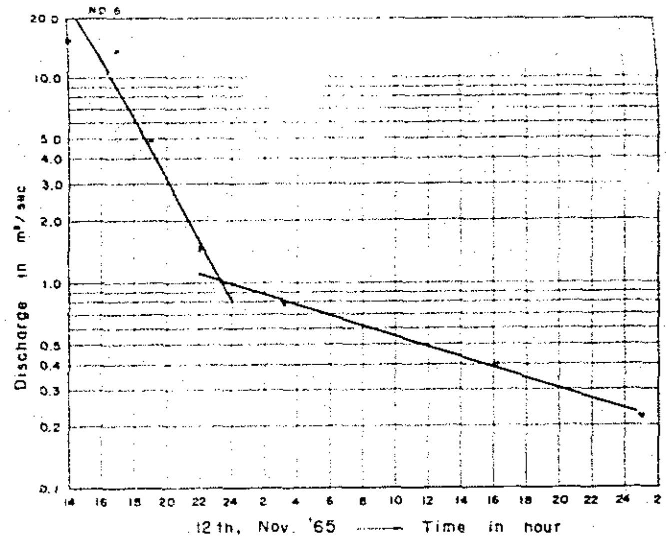


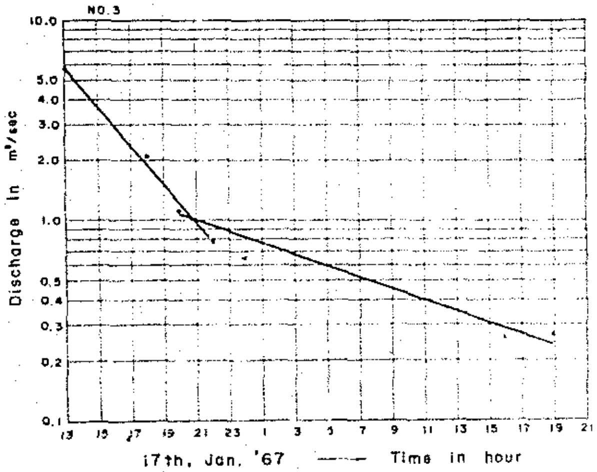
Exhibit E-10
NO. 1
NO. 2
NO. 3
NO. 4
NO. 5
NO. 6
Discharge in m3/sec
Precipitation in mm/hr
Time in hour
Calculated
Observed
8th. Dec. '67
9th. Dec. 67
23th. Jun. '67
24th. Jun. '67
16th. Jan. '67
17th. Jan. '67
19th. Nov. '67
20th. Nov. '67
11th. Nov. '66
12th. Nov. '66
11th. Nov. '65
12th. Nov. '65

Exhibit E-12


NO.1
Discharge in m³/sec
9th, Dec. '67 —— Time in hour


NO.4
Discharge in m³/sec
12th, Nov. '66 —— Time in hour


NO.6
Discharge in m³/sec
12th, Nov. '65 —— Time in hour


NO.3
Discharge in m³/sec
17th, Jan. '67 —— Time in hour

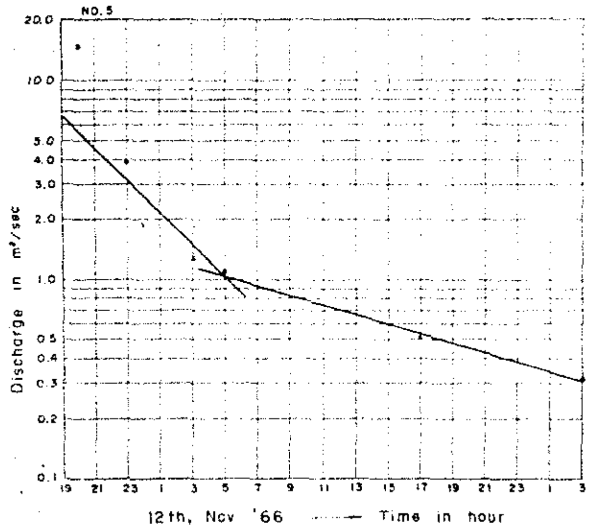
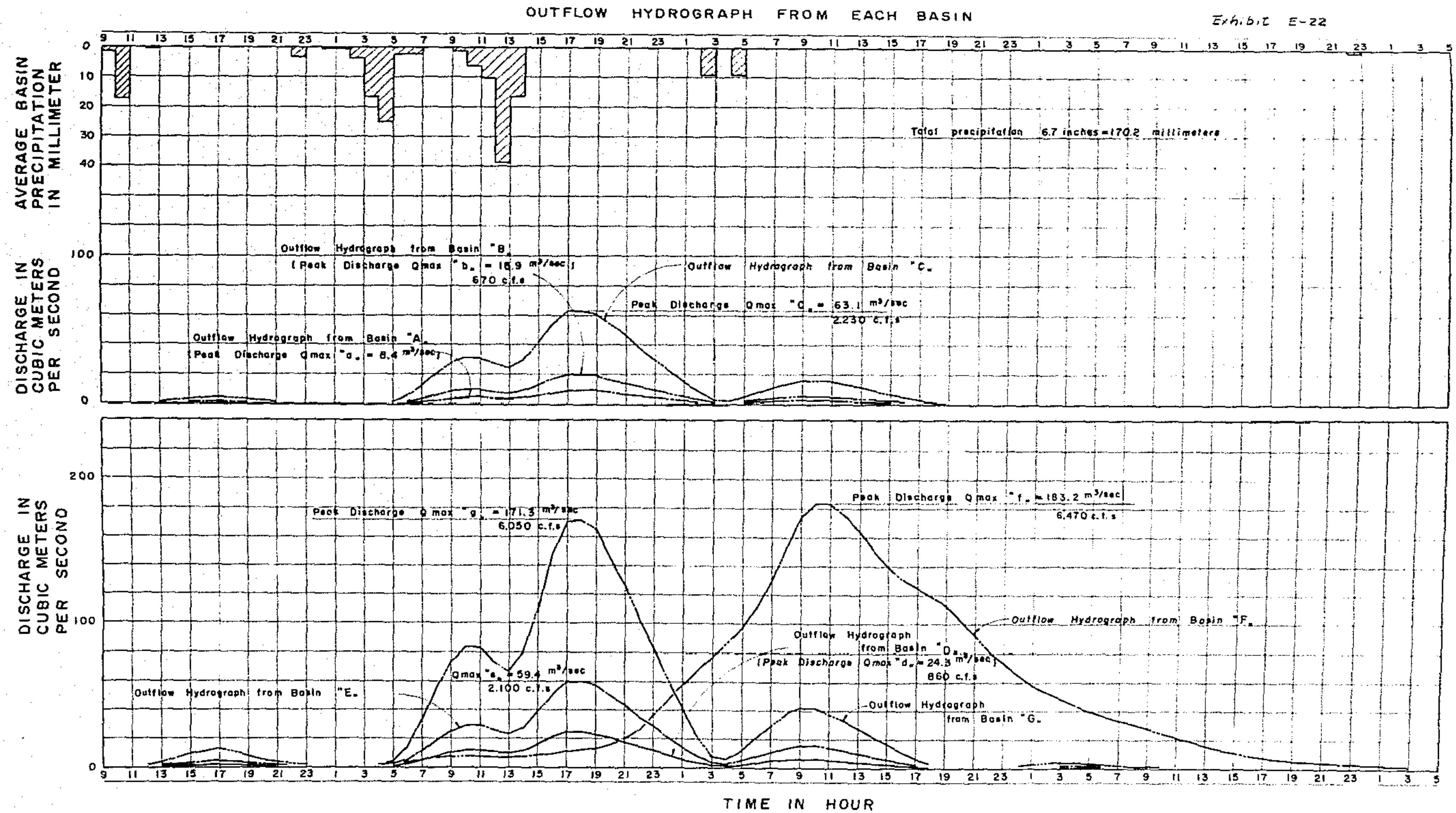

NO.5
Discharge in m³/sec
12th, Nov '66 —— Time in hour

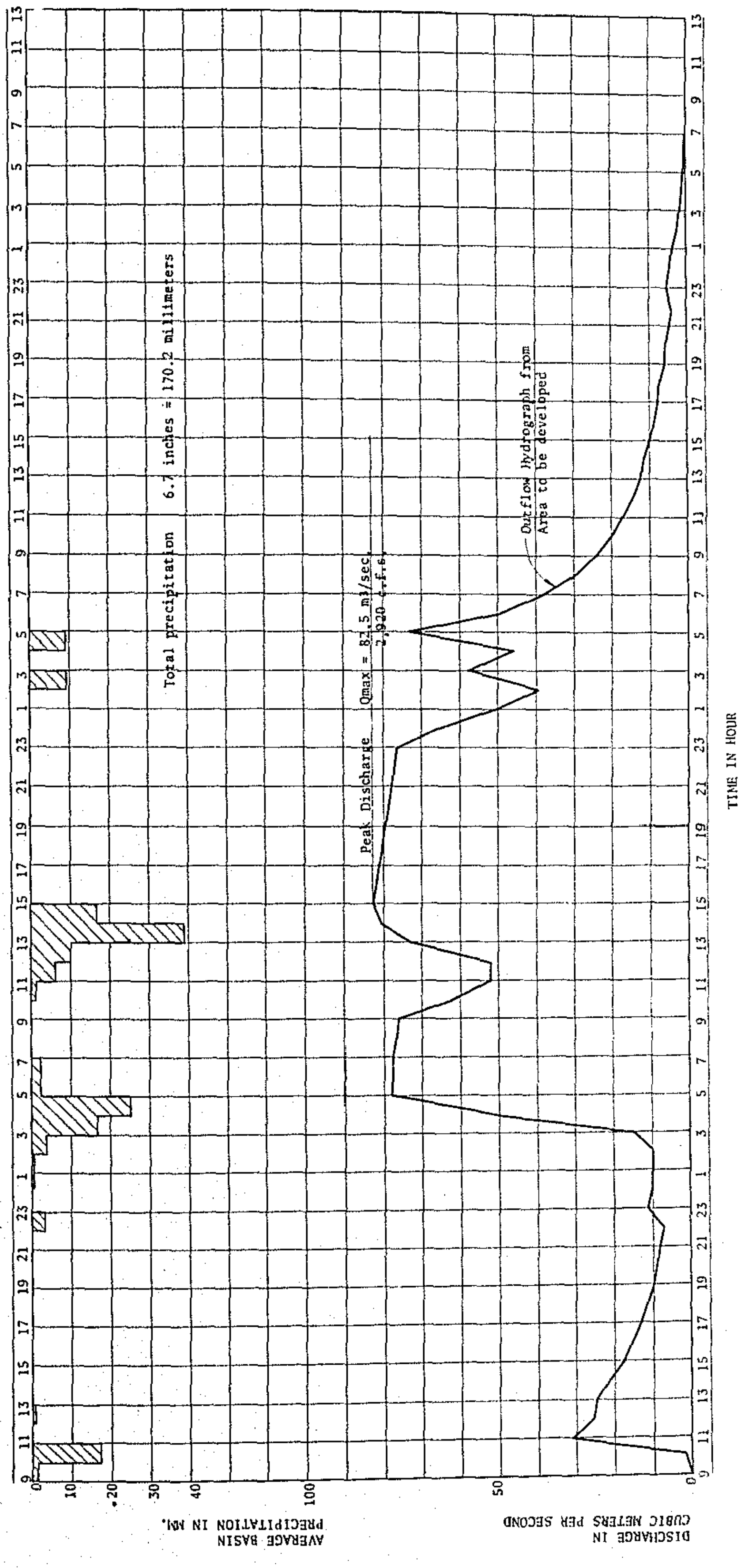
Exhibit E-22



OUTFLOW HYDROGRAPH FROM EACH BASIN
AVERAGE BASIN PRECIPITATION IN MILLIMETER
DISCHARGE IN CUBIC METERS PER SECOND
Total precipitation 6.7 inches=170.2 millimeters
Outflow Hydrograph from Basin "B"
(Peak Discharge Qmax "b" = 18.9 m³/sec)
670 c.f.s
Outflow Hydrograph from Basin "C"
Peak Discharge Qmax "C" = 63.1 m³/sec
2,230 c.f.s
Outflow Hydrograph from Basin "A"
(Peak Discharge Qmax "a" = 8.4 m³/sec)
Peak Discharge Q max "g" = 171.3 m³/sec
6,050 c.f.s
Peak Discharge Q max "f" = 183.2 m³/sec
6,470 c.f.s
Outflow Hydrograph from Basin "F"
Outflow Hydrograph
from Basin "D"
(Peak Discharge Qmax "d" = 24.3 m³/sec)
860 c.f.s
Qmax "e" = 59.4 m³/sec
2,100 c.f.s
Outflow Hydrograph from Basin "E"
Outflow Hydrograph
from Basin "G"
TIME IN HOUR

Exhibit E-25

OUTFLOW HYDROGRAPH FROM AREA TO BE DEVELOPED



Appendix F

Drainage Layout

Appendix F

Drainage Layout

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Appendix F

Drainage Layout

General

In the present development project, the irrigation and drainage are correlated in their functions, and the Nariva Swamp closely relating to the drainage scheme includes 6,200 acres of the lands at lower elevation than the mean sea level, 98.1 feet (T.G.R.) of Cocos Bay facing the Atlantic Ocean. This lower area shall not be developed as the agricultural lands due to impossibility of the gravity drainage by peat zones developing in the area, but shall be utilized as the regulating reservoir of the excess water from the project area and its watershed in order to drain off to Cocos Bay.

The drainage scheme includes two aspects; the one is to drain excess water in the irrigable area and the adjacent watershed, and the other to drain off the water in the regulating reservoir to Cocos Bay by the gravity method in utilization of the tide. The runoff from nearly 86 percent of the watershed shall be stored in the Cocal Reservoir for the irrigation water of the irrigable area in the dry season.

Criteria of Drainage Layout

It is an important problem to determine the objective flood for the drainage scheme. Generally, the selection of this objective flood shall be made synthetically in consideration of seriousty of flood, security of drainage systems and other intagible factors. The seriousty of flood in this case can be represented by the damage potential, and security by the yearly excess probability. And intangible factors include security of people's life and stability of public sentiment. The present irrigable area shall be newly exploited and its objective area ratio to the watershed is comparatively small by 4 to 6. From this view point, the criteria for the drainage scheme shall be taken in the same manner with 10 year rainfall probability as the small scale reclamation criteria in Japan.

Foundamentally, the drainage scheme in the agricultural lands has been made in a way that some inundation is obligated to remain in the irrigable area, and this comes from mainly economical reason.

As for inundation damage to the paddy, its growth stage, inundation depth and water quality have various influence to the paddy plant. Generally, however, two or three days inundation is harmless to the paddy plants, excepting paddy growth period as following; (1) immediately after transplantation, (2) early tillering stage, (3) maturing stage.

Allowable inundation depth and duration to the paddy plants in the flood are shown as follows, inciting the Japanese instances; one or two days inundation with water depth under one foot is allowable to the paddy plants in paddling stage and young head-forming stage, and two or three days with water depth under two feet is allowable in head-sprouting stage, flood water during the paddy cultivation in the wet season. Consequently, in consideration of the fact in Japan, the criteria of the drainage scheme shall be decided on the allowable limitation to the paddy plants, that the maximum allowable inundation depth is one foot from the lowest fields surface and the inundation duration is for three days in maximum.

The schematized rainfall in the drainage program shall be taken at three successive days in 10 year probability.

Drainage System

The drainage system is roughly divided into three; the one is drainage of the surface flow from the watershed adjacent to the irrigable area, another is drainage of water in the irrigable area and the other is drainage of these water to Cocos Bay. The each drainage area and the schematized drainage system shall be shown in Table F-1.

Table F-1 Watershed Divisions and Drainage Systems

Divisions	Area		Existing River	Schematized Drainage System
(A)	1.85 sq.miles	(1.3%)		L'Ebrauche Cut → Cocos Bay
(B)	4.17 sq.miles	(2.9%)	Petite Poule Cut	Turure Cut → Nariva Regulating Reservoir → Cocos Bay
(C)	13.90 sq.miles	(9.8%)	Cuche, Conque River	Nariva Regulating Reservoir → Cocos Bay
(D)	5.33 sq.miles	(3.8%)	Jagroma Cut	
(E)	13.05 sq.miles	(9.2%)	Charuma River	
(F)	65.60 sq.miles	(46.6%)	Navet River	
(G)	37.64 sq.miles	(26.6%)	Anho River	
Sub-Total	141.54 sq.miles	(100%)		
Area to be irrigated	22.05 sq.miles			
Total	163.59 sq.miles			

Drainage Systems of Each Watershed

The drainage system from the watersheds shall be ramified into divisions A, B and C and other watersheds from D to G, in consideration of the present land use, river route conditions. (Refer to exhibit D-1).

(A) Watershed

The division (a) of the watersheds occupies about 1.3 percent of the total watersheds in the long rectangular. There are no rivers and creeks in this watershed. The flood in the watershed shall be drained off to Cocos Bay on the Atlantic Ocean after being caught by L'Ebranche Cut, which shall conduct the water to L'Ebranche River Mouth from the barrage at the north end of the Nariva Regulating Reservoir.

(B) and (C) Watersheds

The watershed divisions (B) and (C) account for 13 percent of the total watersheds and the areas at the foot of the Central Range are rather well-developed for the villages and plantations. The rivers in the watersheds show considerably clear and regular route shapes. Floods to these divisions shall be cut off by an intercepting drain, the Turure Cut, running along the border line of the estate at about 110 foot elevation (T.G.R.) and drained off to Cocos Bay through L'Ebranche Cut and the river mouth after being conducted to the Nariva Regulating Reservoir.

(D) - (G) Watersheds

These watersheds consist of areas of 86 percent of the total watersheds and mostly are covered with unexploited woods. The river routes in the watersheds present unclear and irregular shapes and their discharge capacities are insufficient to drain floods. Especially, around the areas at elevation 110 feet (T.G.R.), transitional portion from the hilly lands to the swamp areas, rivers show only their traces and the floods come covering the wide areas. The floods to the watersehds shall be stored in the Cocal Reservoir surrounding by the low banks, the crests of which are to be used as the main road in the project area. Then, the water shall be conducted to the Nariva Regulating Reservoir through the Cocal Cut at the point of Bush Bush, to flow down to Cocos Bay from L'Ebranche River after being regulated by the barrages.

Drainage System of Area to be irrigated

Rainfall in the irrigable area will be conducted to the Nariva Regulating Reservoir through drainage systems after storing for a while in the fields by the drainage control notches on the ridges, and then will flow down to Cocos Bay through L'Ebranche River after being regulated by the barrage.

Drainage into Cocos Bay

Excess water from the watersheds and the irrigable area shall be drained off to Cocos Bay through L'Ebranche River, which is at the northern edge of the project area and which is flowing into from other watersheds adjacent to the project area. This system shall be taken from consideration of the base-flow for the protection of the river mouth. The cross-section of L'Ebranche River Mouth will be enlarged in its width by the confluent of the discharge from the project area.

Composition of Hydrograph

A hydrograph on each river basin shall be composed from the hydrographs of each watershed and irrigable area which are obtained in the section "Runoff Analysis" (Appendix E).

Hydrograph for Cocal Reservoir

Hydrographs for divisions of watersheds (D) - (G) of which all rivers are running into the Cocal Reservoir, shall be composed and shown on Exhibit F-1. (Refer to Exhibit E-22). In this case, the peak inflow to the reservoir will be 4,443.2 cubic feet per second or 267.4 cubic meter per second.

Hydrograph in Cocal Cut

The hydrograph shows that inflow to the Cocal Reservoir shall be accomodated for flood control by draining surcharge from the spillway gates (N. The surcharge of a designed discharge is to be drained, by gravity, by letting it flow down over the tops of gates), and that thus, peak discharge shall be cut off and conducted to the Nariva Regulating Reservoir through the Cocal Cut.

The inflow for a certain period in a reservoir is equal to the sum of the outflow at an outlet of the reservoir for same period and change of the stored water. In this situation, continuity condition flood control action by the reservoir is expressed by the following formula.

$$\left(\frac{I_1 + I_2}{2}\right)\Delta t = \left(\frac{Q_1 + Q_2}{2}\right) t + \Delta s$$

Where I_1 and I_2 are inflows at the begining and the end of the unit time, Q_1 and Q_2 are outflow at the begining and the end of the unit time, and S_1 and S_2 are stored water at the begining and the end of the unit time.

$$\Delta S = S_2 - S_1$$

There are various decisive methods of the above formula, and now the Kubo's Method, schematized method widely used in Japan, shall be taken herein.

The size of the cross-section of the spillways gives influence to the peak outflow from the Cocal Reservoir and the water level of the reservoir, and their relation based on Kubo's Method, schematized method, shall be shown on Exhibit F-2. In the assumption that the highest water level in the reservoir is fixed at 121.4 feet (T.G.R.) in consideration of influence by inundation to the windbelts and private estates around there, the overflow width of the spillways will be fixed at 150 feet and the peak outflow from the reservoir 3,531.5 cubic feet per second or 11 cubic meter per second. Since the Cocal Cut shall be used as the spillways from the reservoir, the size of the cross-section of the spillways shall be determined by the designed discharge of the spillways.

Table F-2 **Tidal Information on Nariva Estuary**

(Cocos Bay)

Position: Lat. 10° 24' N
Long 61° 02' W

Description	Average heights (ft) D.L (ft) (By Tide Table)	Average heights (ft) T.G.R (ft) (By Tide Table)	Nariva River Mouth (by Government of T & T)
Mean higher high water (Heights at spring near the solstices)	4.4	100.3	100.0
Mean higher high water	3.9	99.8	99.5
Mean lower high water	3.5	99.4	99.1
Mean sea level	2.5	98.4	98.1
Mean higher low water	1.6	97.5	97.2
Mean lower low water	1.1	97.0	96.7
Mean lower low water (Heights at spring near the solstices)	0.5	96.4	96.1

Hydrograph in Nariva Regulating Reservoir

The inflow to the Nariva Regulating Reservoir comes down from the Cocal Cut, the project area and watershed divisions B and C, and a synthesized hydrograph of their hydrographs shall be shown on Exhibit F-3. Peak inflow to the Nariva Regulating Reservoir can be found as 6,847.5 cubic feet per second or 193.9 cubic meter per second.

Layout of Barrage Section

The opening width of the barrage shall be determined to suffice the designed drainage criterion by the combination of the application of the hydrograph of the Nariva Regulating Reservoir with tidal conditions outside the barrage.

Tidal Curve

Tidal conditions outside the barrage in Cocos Bay is shown in Table F-2. The mean tidal curve is usually adopted as a tidal curve outside the barrage. Herein, the highest mean spring tide of elevation nearly 99.5 feet and the lowest mean neap tide of elevation 96.7 feet shall be adopted for the data of the tidal curve at the Nariva Estuary, and the tidal curve outside the barrage is shown on Exhibit F-3, by using a sine curve of which the cycle is 12 hours, as a tidal curve outside the barrage.

Barrage Width

The highest point of the tidal curve on Exhibit F-3 shall be synthesized with the peak flood discharge to obtain the open width of the barrage at 50 feet, and the result is shown on same Exhibit F-3. Exhibit F-3 clarifies that the inundation duration is about 33 hours and the maximum inundation depth is 0.6 feet. These figures fall on those in the criteria of the drainage scheme explained before.

Inundation influence to rice plants under these conditions varies with growing stage of the rice plants, but little harmful influence can be assumed empirically. Maize and Soybean will not be affected harmfully by the inundation if they are cultivated at some high land in the project area.

Finally, the barrage opening width shall be decided at 50 feet. Furthermore, the base level of the barrages shall be 88 feet (T.G.R) in consideration of the vegetation conditons for mangroves and river bed elevation of L'Ebranche River. In this case, the peak outflow from the barrages will be 9,181.8 cubic feet per second or 260 cubic meter per second.

Layout of L'Ebranche Cut

Size of L'Ebranche Cut is decided depending on the hydrograph of L'Ebranche River and the inundation water level in the Nariva Regulating Reservoir and the tidal level.

Hydrograph in L'Ebranche River

A hydrograph of L'Ebnrache River is obtained by multiplying the values in the discharge hydrograph of the Pure River by a watershed ratio, and shown on Exhibit F-4. Peak discharge of the said river can be estimated therefrom as 2,270.7 cubic feet per second or 64.3 cubic meter per second.

Hydrograph in L'Ebranche Cut

A hydrograph of L'Ebranche cut is plotted by synthisizing the discharge hydrograph of the watershed division A, and that of L'Ebranche River and of the barrage, and it is shown on Exhibit F-4. The peak discharge of L'Ebranche Cut can be estimated therefrom as 9,782.2 cubic feet per second.

Section of L'Ebranche Cut

Drainage capacity of L'Ebranche Cut is related to the time intensity of the discharge, to the water level in the Nariva Regulating Reservoir and to the change of the tidal level outside the barrage. The Canal width of L'Ebranche Cut at the peak tide of Cocos Bay is obtained from Exhibit F-3, and F-4, and shown in Table F-4.

Table F-3 Width of L'Ebranch Cut

Tidal Level outside Barrage	Drainage qauntity against tidal Level	Differance[1/] of Water Level	Water Depth	Water-surface[2/] Slope	Canal width of L'Ebranche Cut
feet	ft^3/sec	feet	feet		feet
EL 96.7	95.40	2.72	8.7	1/2,530	280
96.9	97.80	2.61	8.9	1/2,640	280
97.4	97.40	2.16	9.4	1/3,190	280
98.1	81.70	1.49	10.1	1/4,630	250
98.8	76.20	0.74	10.8	1/8,900	290

The necessary canal width of L'Ebranche Cut may be determined as 290 feet from the above Table F-4. The base level of the canal shall be determined as 88 feet (T.G.R.) in consideration on the vegetation condition of mangroves, the present river bed level of L'Ebranche River. The revetment shall be executed with sheet piles on both banks. (Refer to Exhibit F-5)

The results of synthesis of hydrographs for each watershed and for each construction site are presented on bloc in Table F-5.

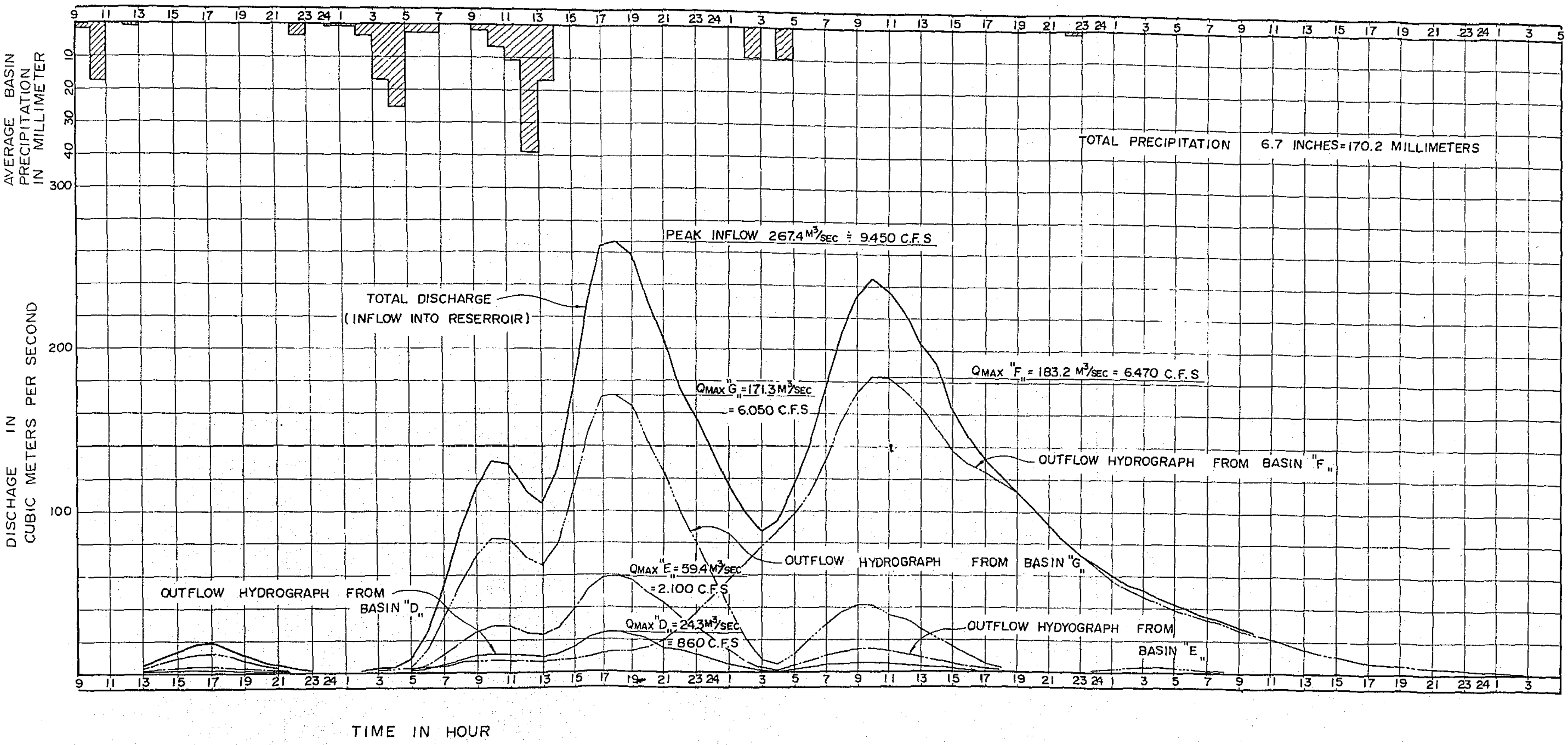
1/ Difference between the hydrographed outflow level of the barrage and the tidal level outside the barrage.

2/ The water level differences divided by distances between the barrage and L'Ebranche River Mouth.

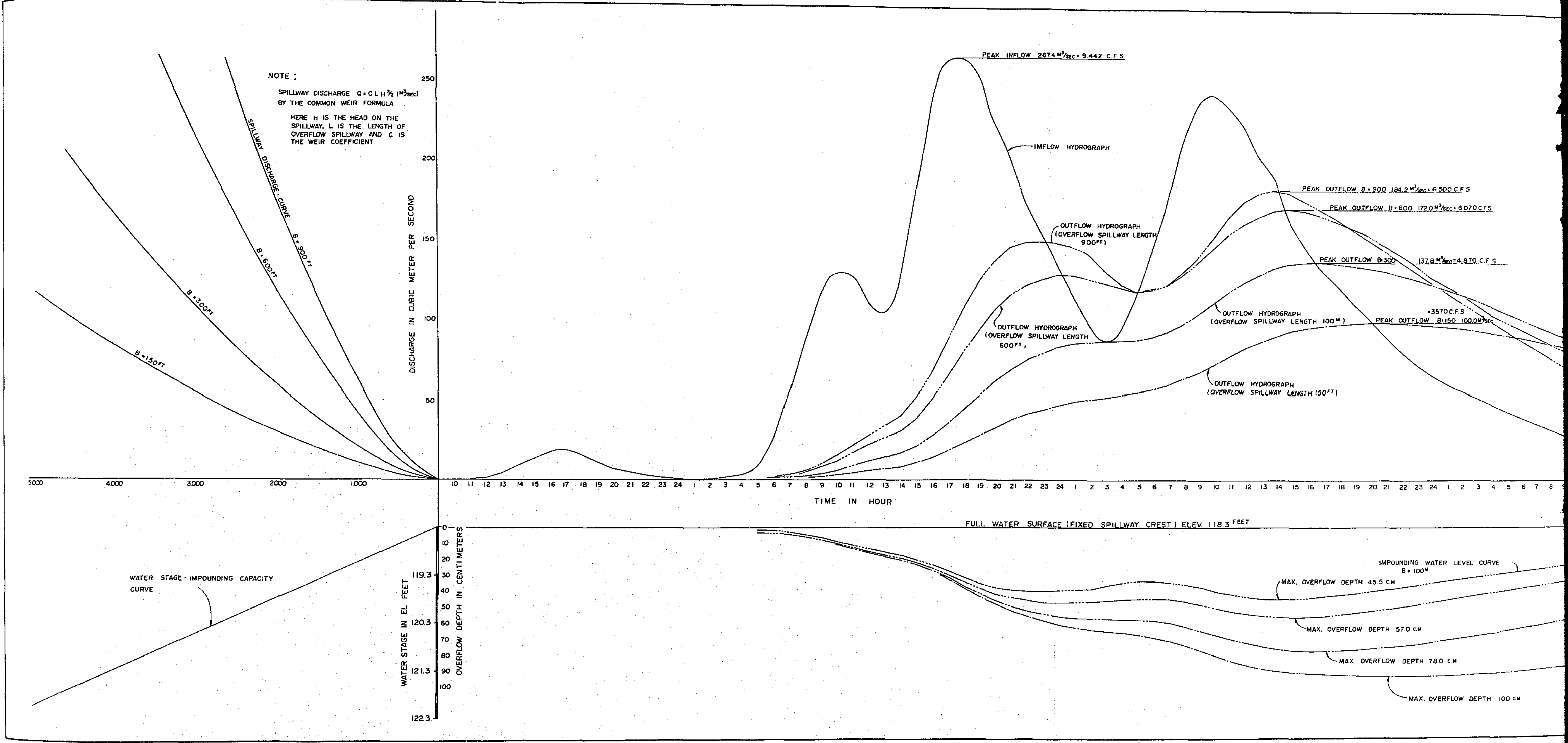
Table F-4 Maximum Outflow Discharge from Each Basin

Basin Division	A	B	C	D	E	F	G	Development area	L'Ebranche River Basin
Basin Area 1/	1.85	4.17	13.90	5.33	13.05	65.60	37.64	17.18	14.13
Maximum Discharge of Each Drainage Basins	296.6	667.4	2,228.4	858.1	2,097.7	6,469.7	6,049.4	2,913.5	2,270.7
Discharge at confluence considering time lag	70.6	643.7	2,228.4	858.1	2,097.7	437.9	6,049.4	2,775.7	529.7
Maximum Discharge of Each Drainage Systems		Turure Cut 2,871.1			Cocal Reservoir 9,443.1 (Cocal Cut 3,531.5)				
Discharge at junction of drainage system considering time lag		2,871.1			1,200.7				
		Nariva Regulating Reservoir 6,847.5 (Barrage Capacity 9,181.8)							
				L'Ebranche Cut 9,782.2					

Note: 1/ Unit of Basin area is square miles.

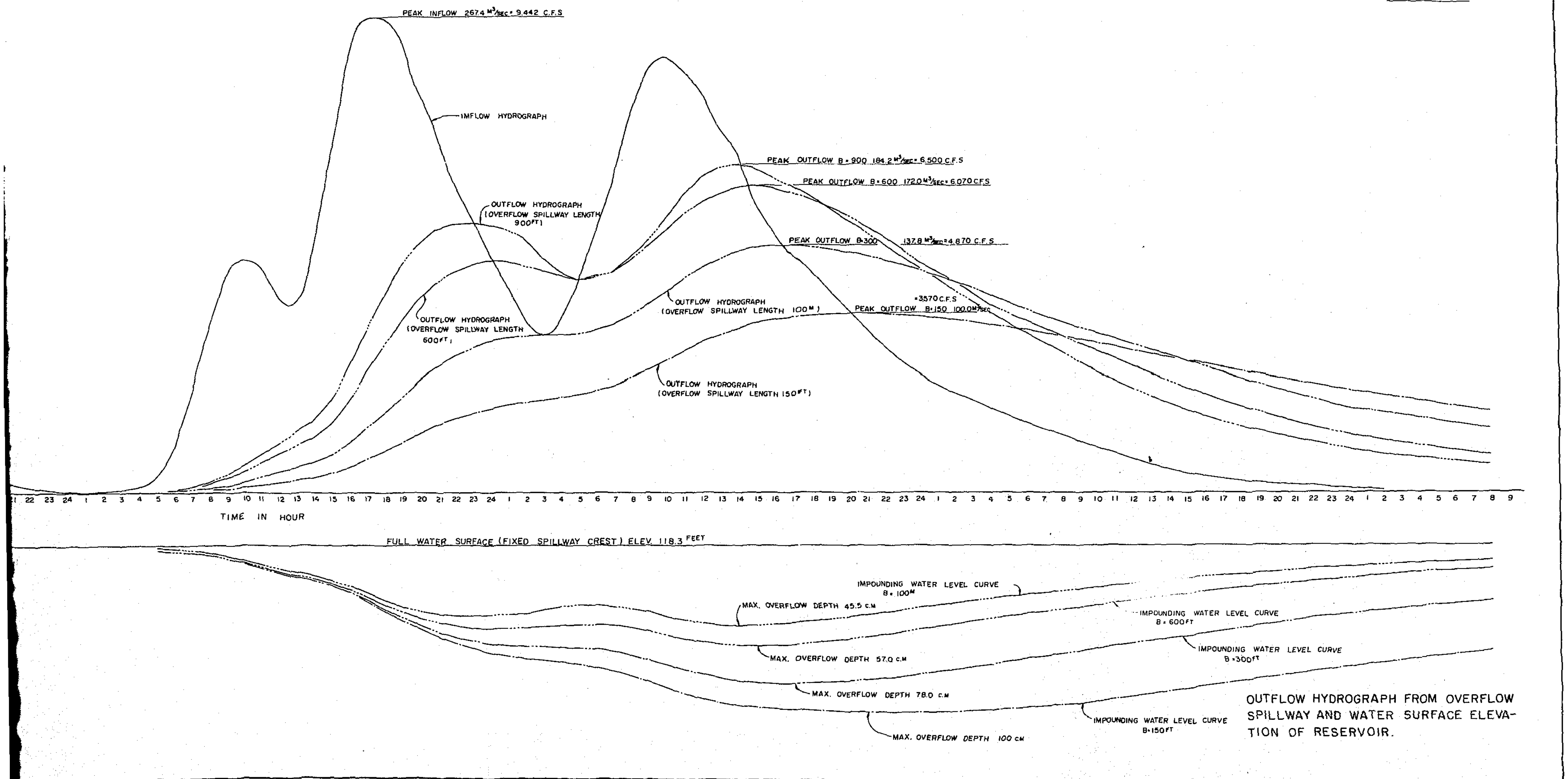


COMPOSITION OF HYDROGRAPH AT COCAL RESERVOIR



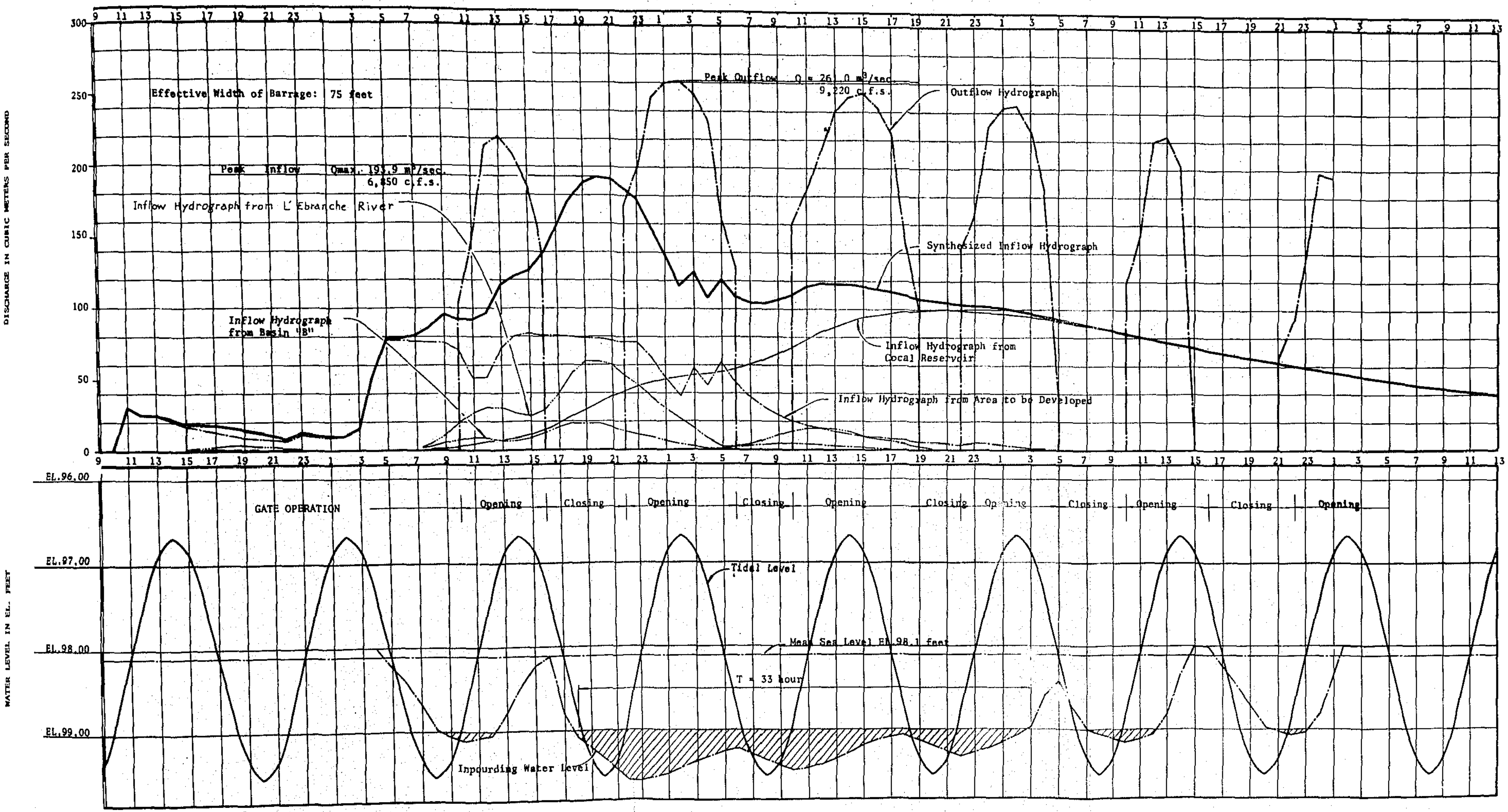
NOTE ;
SPILLWAY DISCHARGE Q = C L H3/2 (M3/SEC) BY THE COMMON WEIR FORMULA
HERE H IS THE HEAD ON THE SPILLWAY, L IS THE LENGTH OF OVERFLOW SPILLWAY AND C IS THE WEIR COEFFICIENT
SPILLWAY DISCHARGE CURVE
B = 900 FT
B = 600 FT
B = 300 FT
B = 150 FT
DISCHARGE IN CUBIC METER PER SECOND
PEAK INFLOW 267.4 M3/SEC = 9.442 C.F.S
IMFLOW HYDROGRAPH
PEAK OUTFLOW B = 900 184.2 M3/SEC = 6.500 C.F.S
PEAK OUTFLOW B = 600 172.0 M3/SEC = 6.070 C.F.S
OUTFLOW HYDROGRAPH (OVERFLOW SPILLWAY LENGTH 900 FT)
PEAK OUTFLOW B = 300 137.8 M3/SEC = 4.870 C.F.S
OUTFLOW HYDROGRAPH (OVERFLOW SPILLWAY LENGTH 600 FT)
OUTFLOW HYDROGRAPH (OVERFLOW SPILLWAY LENGTH 100 M)
PEAK OUTFLOW B = 150 100.0 M3/SEC = 3570 C.F.S
OUTFLOW HYDROGRAPH (OVERFLOW SPILLWAY LENGTH 150 FT)
TIME IN HOUR
FULL WATER SURFACE (FIXED SPILLWAY CREST) ELEV. 118.3 FEET
WATER STAGE - IMPOUNDING CAPACITY CURVE
WATER STAGE IN EL FEET
OVERFLOW DEPTH IN CENTIMETERS
IMPOUNDING WATER LEVEL CURVE B = 100 M
MAX. OVERFLOW DEPTH 45.5 CM
MAX. OVERFLOW DEPTH 57.0 CM
MAX. OVERFLOW DEPTH 78.0 CM
MAX. OVERFLOW DEPTH 100 CM

EXHIBIT F - 2



OUTFLOW HYDROGRAPH FROM OVERFLOW SPILLWAY AND WATER SURFACE ELEVATION OF RESERVOIR.

HYDROGRAPH AT BARRAGE SITE



OUTFLOW HYDROGRAPH IN L'EBRANCHE CUT

Exhibit F-4

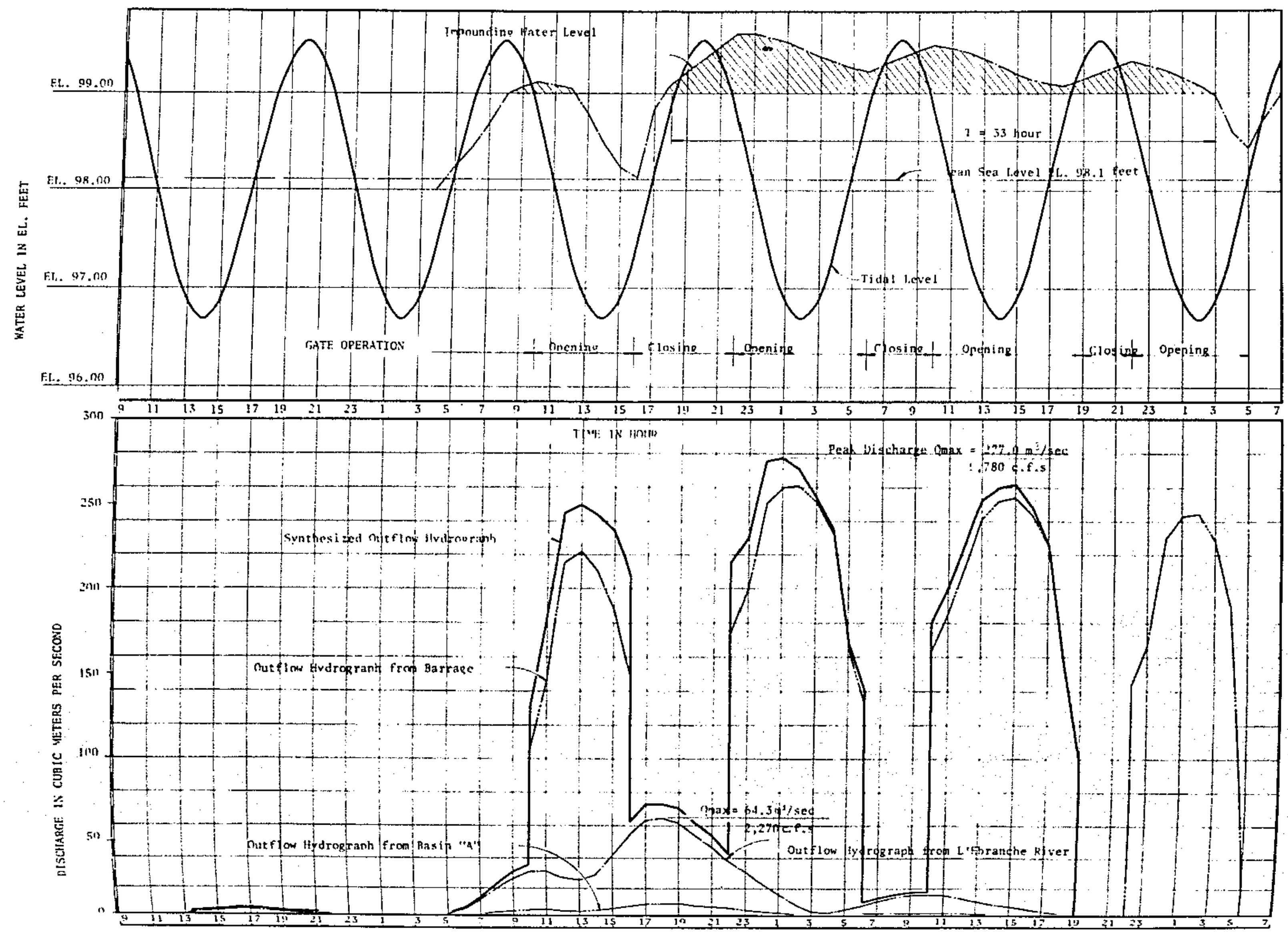
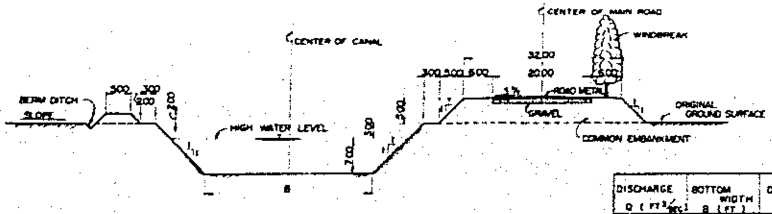
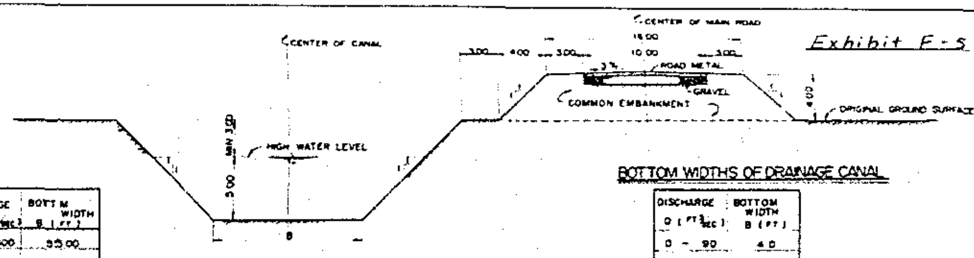


Exhibit F-5



TURURE CUT SECTION



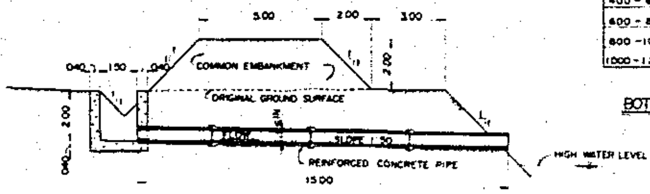
MAIN DRAINAGE CANAL SECTION

BOTTOM WIDTHS OF DRAINAGE CANAL

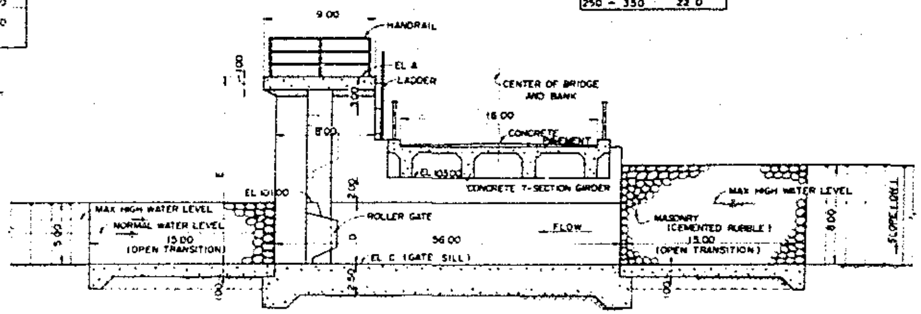
DISCHARGE Q (FT³/SEC)	BOTTOM WIDTH B (FT)
0 - 90	4.0
90 - 160	9.0
160 - 250	15.0
250 - 350	22.0

BOTTOM WIDTHS OF TURURE CUT

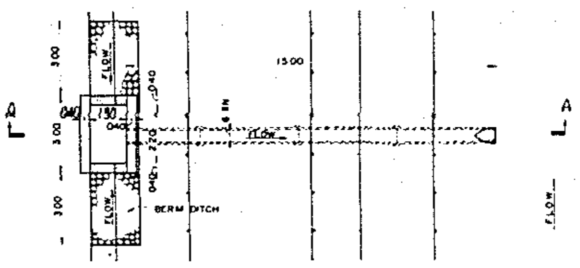
DISCHARGE Q (FT³/SEC)	BOTTOM WIDTH B (FT)	DISCHARGE Q (FT³/SEC)	BOTTOM WIDTH B (FT)
0 - 200	6.00	1200 - 1400	55.00
200 - 400	15.00	1400 - 1600	63.00
400 - 600	23.00	1600 - 1800	71.00
600 - 800	31.00	1800 - 2000	79.00
800 - 1000	40.00	2000 - 2230	88.00
1000 - 1200	47.00		



SECTION A-A



SECTION B-B



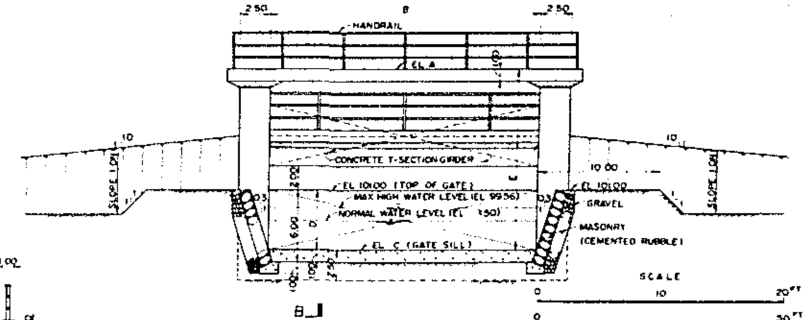
PLAN

BERM INLET

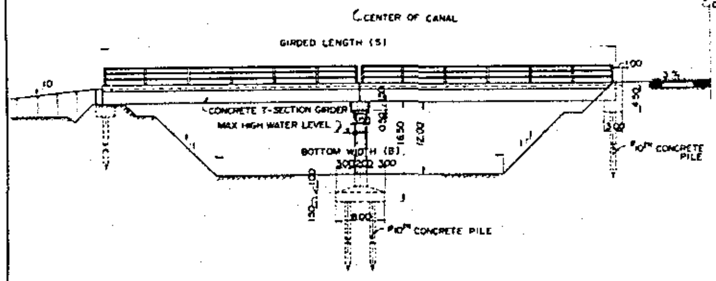
NOTE: A BERM INLET SHOULD BE PLACED PER 500 FT

DIMENSIONS OF SLUICEWAY

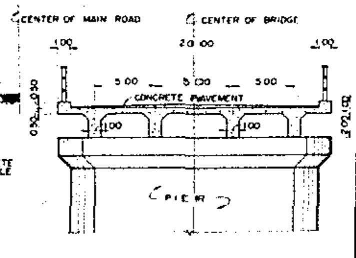
NAME OF DRAINAGE CANAL	A (FT)	B (FT)	C (FT)	D (FT)	F (FT)
NO 1 DRAINAGE CANAL	116.5	4.0	90.5	10.5	26.0
NO 2 DRAINAGE CANAL	113.5	15.0	93.5	7.5	20.0
NO 3 DRAINAGE CANAL	110.5	22.0	96.5	4.5	14.0
NO 4 DRAINAGE CANAL	111.0	22.0	96.0	5.0	15.0
NO 5 DRAINAGE CANAL	111.0	22.0	96.0	5.0	15.0



ELEVATION OF SLUICEWAY



TYPICAL SECTION OF BRIDGE



SUPERSTRUCTURE OF BRIDGE

TYPE OF FARM BRIDGE	B (FT)	S (FT)	NUMBER OF SPAN	NUMBER OF BUTTRESS	NUMBER OF PIER
I	6.0	42.0 × 1	1	2	—
II	28.0	32.0 × 2	2	2	1
III	38.0	42.0 × 2	2	2	1
IV	70.0	32.0 × 2 42.0 × 1	3	2	2
V	90.0	42.0 × 3	3	2	2

DIMENSIONS OF BRIDGE

OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN

THE NARNA SWAMP AGRICULTURAL DEVELOPMENT PROJECT

PRELIMINARY DESIGN OF MAIN DRAINAGE CANALS

SANYU CONSULTANTS INTERNATIONAL, INC.

SUBMITTED	DATE
APPROVED	DRAWING NO

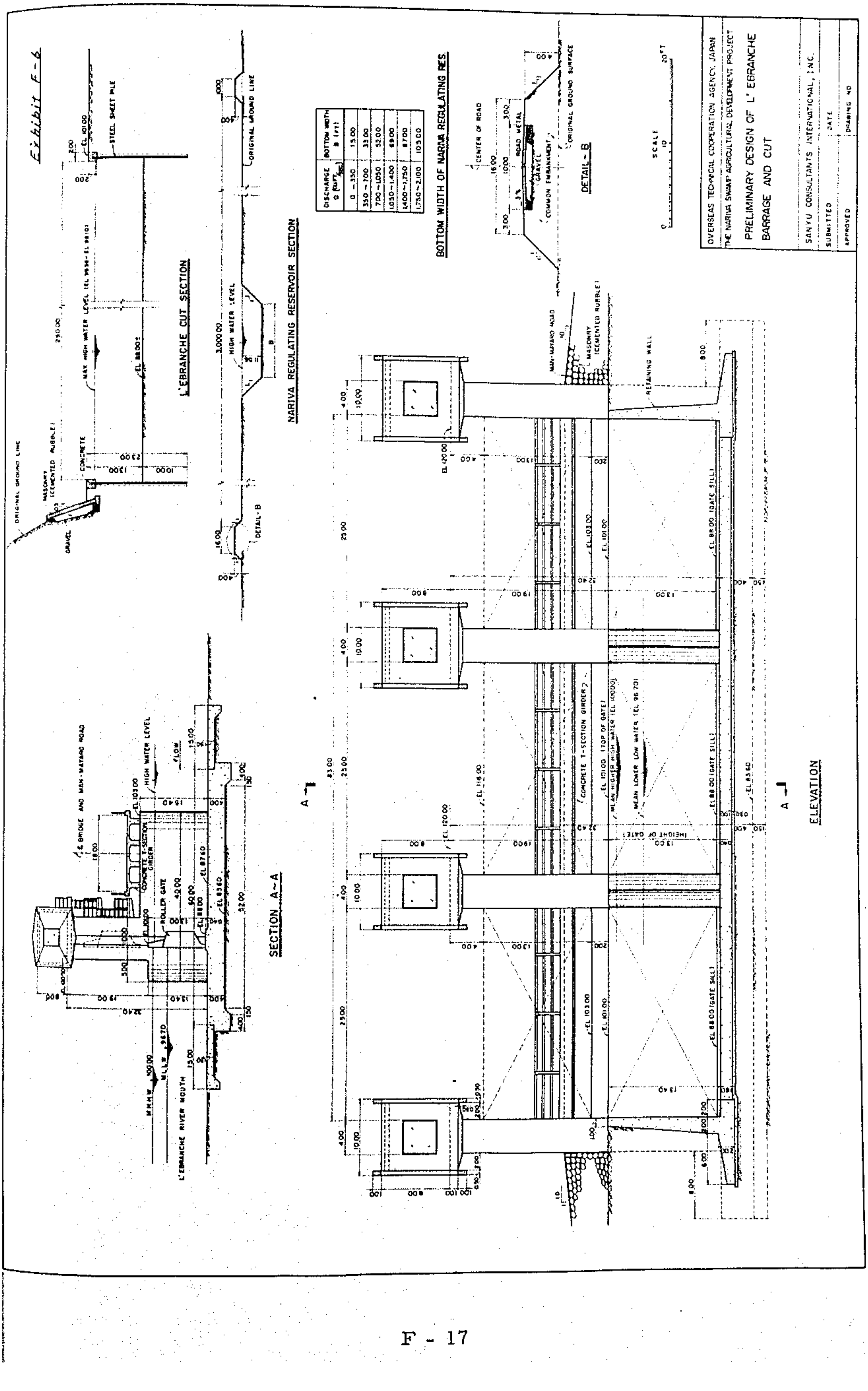


Exhibit F-6
L'EBRANCHE CUT SECTION
NARIVA REGULATING RESERVOIR SECTION
BOTTOM WIDTH OF NARIVA REGULATING RES.
DETAIL - B
SCALE
SECTION A-A
ELEVATION
OVERSEAS TECHNICAL COOPERATION AGENCY, JAPAN
THE NARIVA SWAMP AGRICULTURAL DEVELOPMENT PROJECT
PRELIMINARY DESIGN OF L' EBRANCHE
BARRAGE AND CUT
SANYU CONSULTANTS INTERNATIONAL, INC.
SUBMITTED
APPROVED
DATE
DRAWING NO

Appendix G

Estuary Works

Appendix G

Estuary Works

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Appendix G

Estuary Works

Coastal and Estuary Condition

The island of Trinidad is situated at Longitude 61° - 62° West and Latitude 10° - 11° North, and at the southern tip of where the Atlantic Ocean and the Caribbean Sea are bounded, and the west coast faces Venezuela having Gulf of Paria in between. Therefore, the waves surrounding this island could be classified into three large categories, that is, the Gulf of Paria, the Atlantic Ocean, and the Caribbean Sea. The wave generated in Gulf of Paria may be calculated from the wind and the marine topography, whether deep or shallow. For the waves at north, east and south coast, it would be advisable to base on the off-shore which has a less irregularity by location considering the length of the coast. And from this off-shore wave, the wave at the proposed construction site of the shore will be calculated by considering the particularity of the location.

The waves discussed hereinafter are statistically analyzed based on the following reference material "Ocean Wave Statistics" 1/ and "Hindcast Wave statistics for Atlantic Coast of Trinidad and Tobago" 2/. As an intermediate case, the outline of the wave at the east coast will be discussed. The observation years of the reference data are nine years and two years respectively, and by putting the variation of the coastal phenomena into account, the design wave will indicate that of a ten year probability.

Table G-1 Design wave of the off shore wave (10-year probability)

Significant Wave Height:	6.5 m (22 feet)
Significant Wave Period:	16 - 20 Sac.
Significant Wave Direction:	NE - E

1/ National Physical Laboratory, Ocean Wave Statistics, London: Her Majesty's Stationery Office, 1967.

2/ C.A.W. Deane, Hindcast Wave Statistics for Atlantic Coast of Trinidad and Tobago, Port of Spain: University of the West Indies, 1960.

As the off-shore wave to find out the coastal drift sand and the characteristics of the beach over a long period, the following wave should be referred to , as it carries the most abundant amount of wave energy; (Wave represented by maximum (fH^2T), f: Frequency of recurrence. H: Wave height. T: Periodic time)

Table G-2 Maximum Energy Wave (Off-shore Wave)

Significant Wave Height:	2.0 m (7 feet)
Significant Wave Period:	6.5 sec
Significant Wave Direction:	NE

In case when the construction site is within the wave breaker zone, the greatest wave that may occur in this site will be determined by the water depth and the periodicity of the wave. Therefore, the periodic wave which has the greatest height among the periodicity of the off-shore wave may be used as the design wave. This may be obtained from the calculation by applying the Breaker Index by the United States of America Beach Erosion Board[1/], and the research data of Iversen[2/] and Nakanura[3/].

According to the isolated wave theory, the wave height (breaker) Hb that may occur in water depth h may be represented by Hb = 0.78 h, regardless of the periodicity. For the gradient of the sea bed greater than 1/30, the Breaker Index may be used, and for those of lenient slope the result of Nakamura's study could be applied. These are shown on Exhibit G-3, G-4 and G-5.

The direction of the wave at the construction spot must be obtained by drawing refraction map by using the direction of the off-shore wave and the periodicity.

1/ M. A. Mason, "The Transformation of Waves in Shallow Water", (Paper read at 1st Conference on Coastal Engineering, 1951)

2/ H. W. Iversen, "Waves and Breakers in Shoaling Water", (Paper read at 1st Conference on Coastal Engineering, 1951).

3/ M. Nakamura and H. Shiraishi, "Wave Decaying due to Breaking," (Paper read at 10th conference on Coastal Engineering, 1966).

THE FLOW AT THE COAST

As to the ocean current, a strong Gulg current flows toward North-West in the off-shore of the North and East coast.

The general flow conditions are as given in Table 3.

Table G-3. Gulf current in the off-shore of Trinidad

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
North Coast	0.8	1.1	1.0	2.0	1.2	1.2	1.1	1.0	1.2	1.1	1.0	1.2
	WNW	WNW	WNW	NW	W	WNW	NW	W	W	W	W	WNW
East Coast	1.5	1.2	1.0	2.0	1.5	1.2	1.0	1.1	1.2	1.1	1.0	1.5
	NW	NW	NWN	N	NW	NW	N	NW	NW	NW	NWN	NWN

However, the most important current data for the shore construction is on the nearshore current. This current is affected by the incident direction of the wave.

As Cocos Bay and Mayaro Bay in the east coast, violent breaker zone is formulated along the shore line as the beach is shallow to a great distance from the shore (Shoaling beach). From the aerial observation made at the beginning of our survey, we have found almost no longshore (littoral) current to be noteworthy and we merely observed rip current an an interval of 500 - 600 meter (appreximately 1/3 mile). However, assuming from the distribution of wave direction, it is considered that there exists a longshore current moving south.

SEA LEVEL

Tidal information for Port of Spain, Gaspar Grande, Point Lisas, Point Fortin, Bonasse Pier, Herine Bay, Guayaguayare Bay, the Nariva River, and Las Cuevas Bay are given in the Tide Table.

G-4 provides the analytical result of the survey records at the Nariva estuary, in 1967 and 1968[1/].

1/ "River Stage Hydrographs of Nariva River", Government of Trinidad and Tobago, 1969.

Table G-4 Tidal information on Nariva Estuary (Cocos Bay)

Position: Lat. 10°24' N Long 61°02' W

Description	Average Heights (ft) D.L.(ft) (By Tide Table)	T.G.R.(ft)	Nariva River Mouth (By Government of T.&T.)
Mean higher high water (Heights at spring near the solstices)	4.4	100.3	100.0
Mean ghigher high water	3.9	99.8	99.5
Mean lower high water	3.5	99.4	99.1
Mean sea level	2.5	98.4	98.1
Mean higher low water	1.6	97.5	97.2
Mean lower low water	1.1	97.0	96.7
Mean lower low water (Heights at spring near the solstices)	0.5	96.4	96.1

Seasonal changes in mean level (ft)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0.0	-0.1	-0.2	-0.2	-0.2	-0.2	-0.1	0	+0.2	+0.3	+0.3	+0.2

At this stage, the fact that an attention has to be paid is the sea level at shore rise by the shoreward current created by the wave where there is an extreme breaker zone, such as in Cocos Bay and Mayaro Bay. The result pertaining to the phenomena is insufficient, but, according to Nakamura's study[1/] , the following equation may be introduced.

$$\frac{\eta}{hb} = \sqrt{1 + \frac{32K}{3} \cdot \frac{Hb}{gT^2}} - 1$$

$$K = 3 - 5 \div 4$$

1/ M. Nakamura and H. Shiraishi, "Hydraulic Charter of Breaker", (Proclamated at 15th Conference on Castal Engineering in Japan.)

Where	η	:	Increased level of the sea
	Hb, hb	:	Height of the broken wave Depth of the broken wave
	g	:	Gravity Acceleration
	T	:	Periodicity of the wave

DRIFT SAND

The bed materials of the coast is fine sand. Thereby, the gradient of the sea bottom near the shore has a gentle slope of approximately 1/40 - 1/70. Case being as such, there is a great movement of driftsand toward off-shore, and there is a tendency to form an equilibrium gradient by carrying the sand towards off-shore or near-shore depending upon the deformation of the wave. The drift sand towards the shore is judged by the incident direction of the wave. Judging from the wave as indicated in Table G-2, the sand drifting south in the east coast is rather predominating. Cocos Bay and Mayaro Bay form an extremely gentle beach slope, but yet, the beach erosion is still advancing gradually.

Now, it is considered that a construction to prevent the breaking height of the wave is the simplest and most adequate way, and this structure should be of a permeable material, so that the striking wave will be absorbed when in contact.

Discharge characteristic of Nariva Estuary

Discharge observation

The river cross section at the Bailey Bridge is as illustrated on Exhibit G-8, and on Exhibit G-9 the result of the discharge observation. According to Exhibit G-9, it seems that there is a base flow of about 9 m^3/sec (320 cusec), but this is considered to be on account of an influence by the diurnal inequality. The diurnal inequality at observation dates are given in Table G-5.

Table G-5 Observed Sea Level

4th April	H.W.	3.6 fet	
	L.W.	1.1	
5th April	H.W.	3.9	Observation Period
	L.W.	0.4	
	H.W.	3.4	

Discharge analysis for Nariva Swamp by mathematical model

The following method is a simplified method for analysis, but the discharge at the Nariva estuary by the tide will be calculated by this method.

(1) Assume that the variation of the sea level and water level in the swamp may be represented by sine curve.

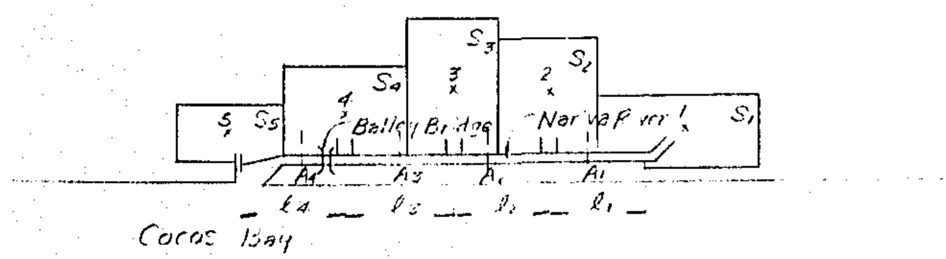
(2) The variation of the water level will be represented by a typical point in the controlled water surface.

(3) Nariva swamp will be divided into tidal water surface as illustrated on Exhibit 10. by the aero-photograph, the contour of the topographical map, and the distribution of the mangrove.

Note: The lands where there is a dense growth of mangroves, the ground is found within three feet below the high and low tide level.

(4) The discharge coefficient C for inflow and outflow water to and from the divided water surfaces, are corrected by the observation data previously given under paragraph 5-(a), as a friction loss of the channel. Table G-6. illustrates the Mathematical Model of Nariva Swamp.

Exhibit G-10



Nariva Swamp Mathematical Model

Table G-6 The Values for the Mathematical Model of Nariva Swamp

Division	Length of the river (1)	Control area (2)	Flow area of the river (A)	Discharge Coefficient $(C)=\alpha\sqrt{h^{4/3}/2gn^2\ell}$	α
1	1300 m	$15.91 \times 10^6 m^2$	40 m^2	0.13	0.6
2	1200	3.76	90	0.17	0.6
3	1300	6.80	200	0.20	0.6
4	220	6.89	210	0.16	0.6
5	-	6.46	20	0.42	0.6

Note: h: water depth

g: gravity acceleration

n: Roughness coefficient

α: Correction factor derived from field observation

From the premise of previously stated (1) - (3), the oscillation of the typical point of the divided area (ξ') and the quantity of water inflowing and outflowing to and from the divided area q, may be obtained from the following formula, when the oscillation for the water level fluctuation of the water outside of the divided area is ξ,

$$\xi' = K\left[\left\{1 + 2\left(\frac{\xi}{K}\right)^2\right\}^{1/2} - 1\right]^{1/2}$$

$$K = \frac{1}{\sqrt{2}}\left(\frac{ATCBg^{1/2}}{2s}\right)^2$$

$$B = \frac{\Gamma(\frac{3}{4})\,\Gamma(\frac{1}{2})}{\pi\Gamma(5/4)} = 0.76 \quad , \quad \bar{q} = \frac{2S\xi'}{T}$$

$$q = \frac{\bar{q}}{\beta}\,\mathrm{Sin.}^{1/2}\,\frac{2\pi}{T}(t + \delta), \qquad \delta = \frac{T}{4} - \frac{T}{2\pi}\,\mathrm{Cos.}^{-1}\frac{\xi'}{\xi}$$

Where: T: Tide cycle $\bar{q}$: Mean discharge per hour into divided area.

$\Gamma(\ )$: Gamma Function

By applying the above formulae to the water surface (area) 1-4 repeatedly, the tidal range of the open sea and the oscillation and discharge of each divided area may be obtained.

Exhibit G-11 illustrates the relationship between the peak flow (discharge) at the Nariva (Mita) bridge and the river mouth, and the tidal range of the open sea. The corresponding calculated value at the observation period has been plotted on Exhibit G-9.

The sand moved by tractive force may be calculated by using Exhibit G-11. To judge from Exhibit G-11 as to whether the river mouth could be kept open, it is considered that the river mouth could surely be maintained by the tidal flow. This fact is very important and it is the basic requirement for the phase development plan of the Nariva swamp project.

The conclusions obtained from the studies on the features of the coast and the Nariva Esturary are shown as followings.

1. The coast line of Cocos Bay has a violent wave breaker zone, and the movement of the sand is extremely great. It bears scouring tendency, but as a whole it may be considered to be stabilized. In order to maintain the river mouth as such by preventing the drift of sand at a certain spot of the coast line, it would be necessary to have a constant flow to flush the sand, or to construct a large training jetty.

2. During the dry season, the present status of the estuary is maintained by the tidal discharge which is given under Exhibit G-11. Furthermore, 40 to 50 years ago, the water of the Nariva Swamp was drained through the Nariva and Doubloon River, but at present the Doubloon River is completely closed by sedimentation and merely leaves a trace of the water level to identify that there was once a river in the area. Therefore, it may be considered that this fact substantiates the discharge characteristics of the Nariva area, that is, two estuaries are difficult to be maintained.

Estuary Works

Base Flow

The lower Nariva Swamp area has an elevation about 98.5 feet (T.G.R.) and is lower than the high tidal level. Consequently, the construction of barrage is indispensable in shutting out the high tide to protect the area. Since the high tide is shut out with the barrage, the estuary shall be necessarily maintained without the same high tide as at present is seen, but only with base flow. The discharge possibility in the dry season shall be studied on the further discharge analysis and water utilization scheme, but it has to be assumed that the estuary will be kept without discharge for a long time in the dry season.

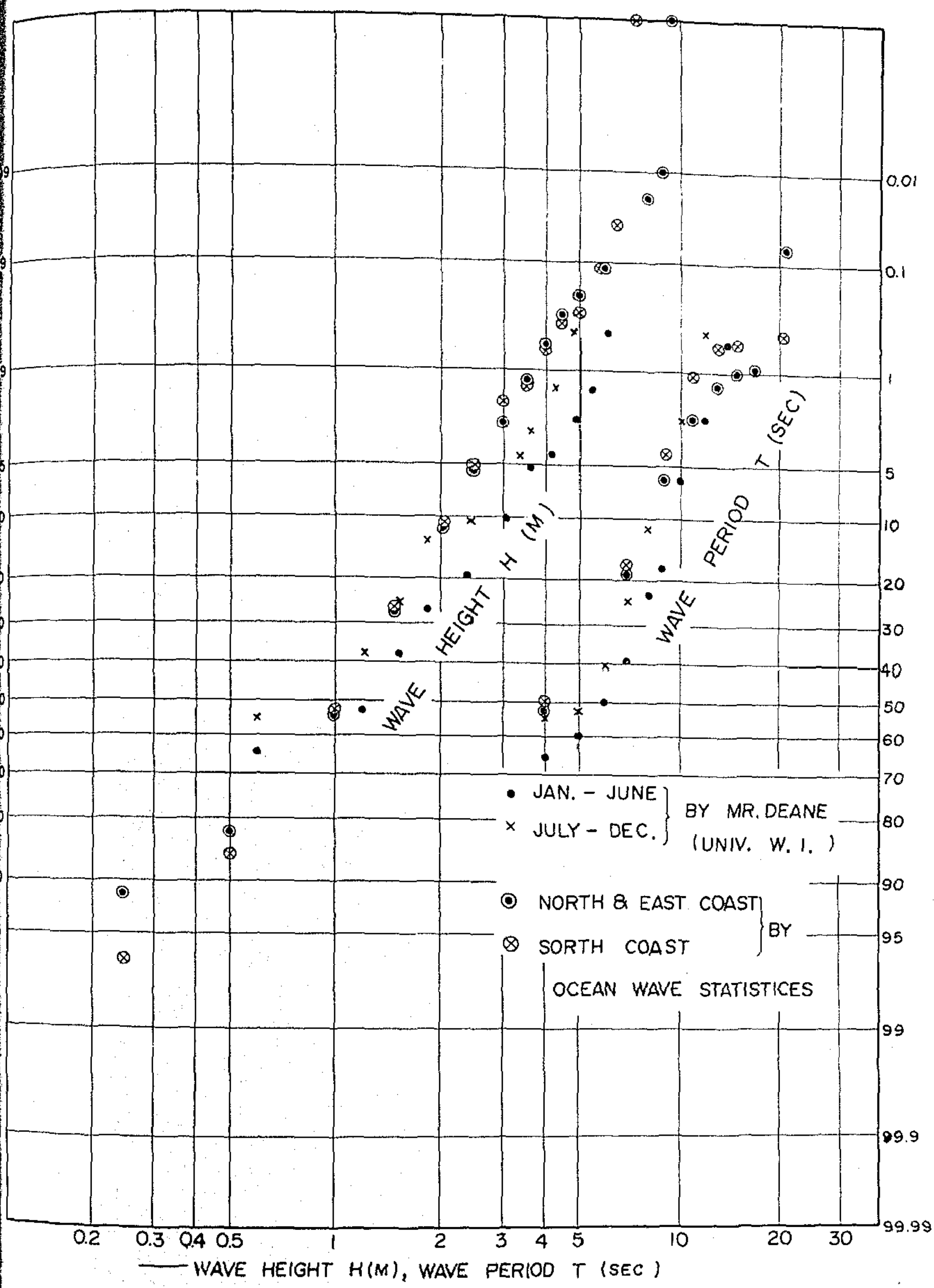
Estuary Location

To make a scheme for maintenance of the Nariva Estuary apart from the above mentioned conditions, it is required that a training jetty is constructed with the necessary river cross-section for maintenance of the estuary capable of draining the flood water in the assumption of the absence of discharge in the rainy season. The construction is theoretically expected to be made at the northern tip of Cocos Bay in consideration of the prevailing direction of the drift sand and the training jetty on the left (facing the downstream) shall be constructed long enough and the right bank shall be not so long as the left one, to protect the estuary from waves and drift sand being carried there.

In meeting these requirements, however fortunately, there is a natural training jetty projecting out into the sea at the northern tip of Cocos Bay, where L'Ebranche Estuary opens under the protection of the banks. L'Ebranche River has an independent basine, so that the estuary of the river is to be maintained regardless of whether or not the Nariva Swamp Development is accomplished. If the estuary of the river is used for both of L'Ebranche River and the project area drainage, it is enough utilizable only with a certain consideration of the preventive works for erosion by increasing discharge from the confluences. The excess water from watershed and the project area shall be drained off into the Nariva Regulating Reservoir, at the lowest plain, along the Nariva River for the temporary storage, and then they shall be removed from the reservoir to the ocean by gravity after controlled by the barrage. Under the circumstances, there exist no definite objections in making a plan on L'Ebranche Estuary as a new estuary, and on the contrary, it will be possible to make a useful estuary plan for the development of the area.

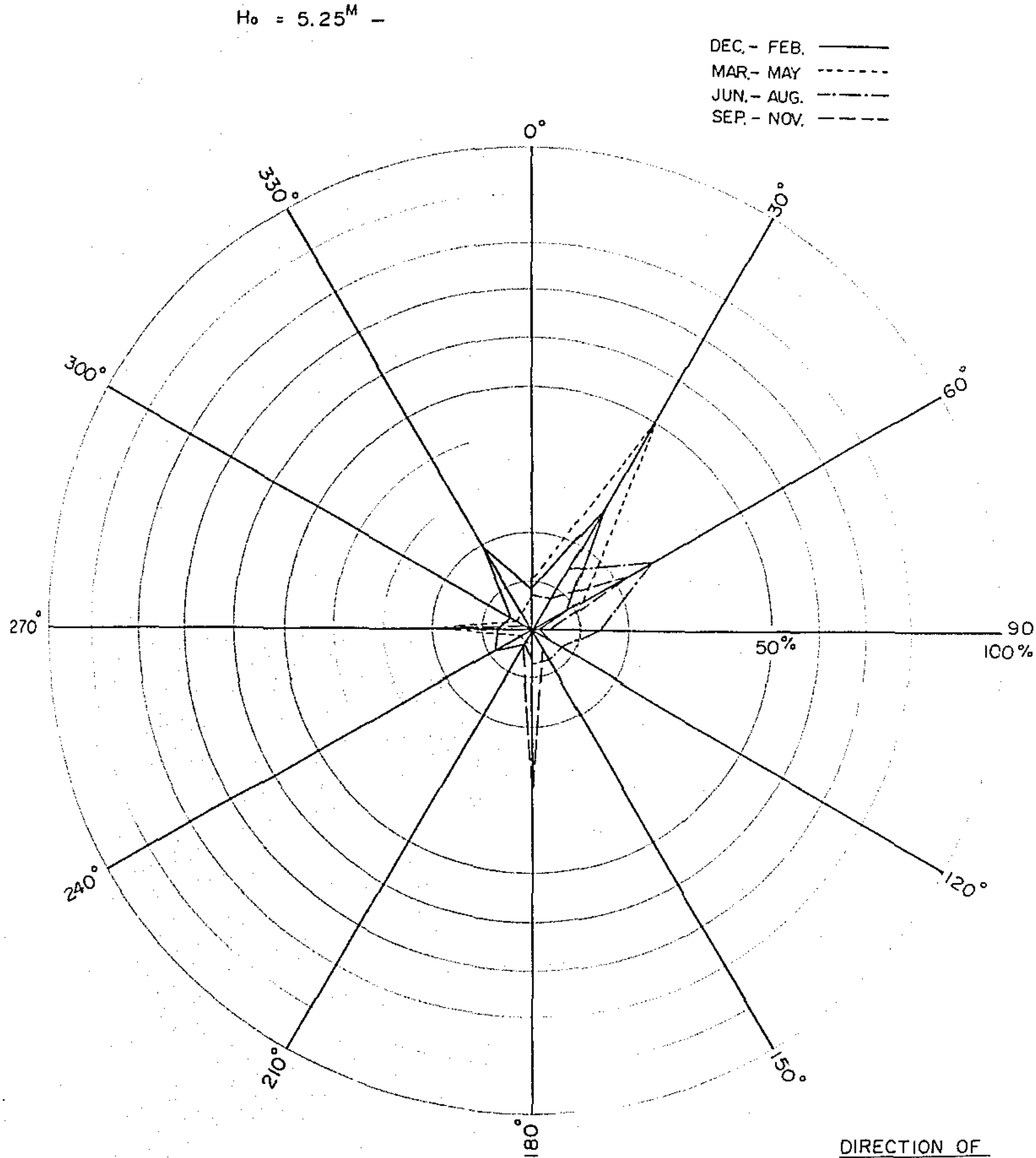
Estuary Structure

There is no much need for special construction of various estuary structures, but only for widening of the hydraulic cross-section of the flows in confluences of discharges from the areas relating to the project area and for executing the bank protecting works.



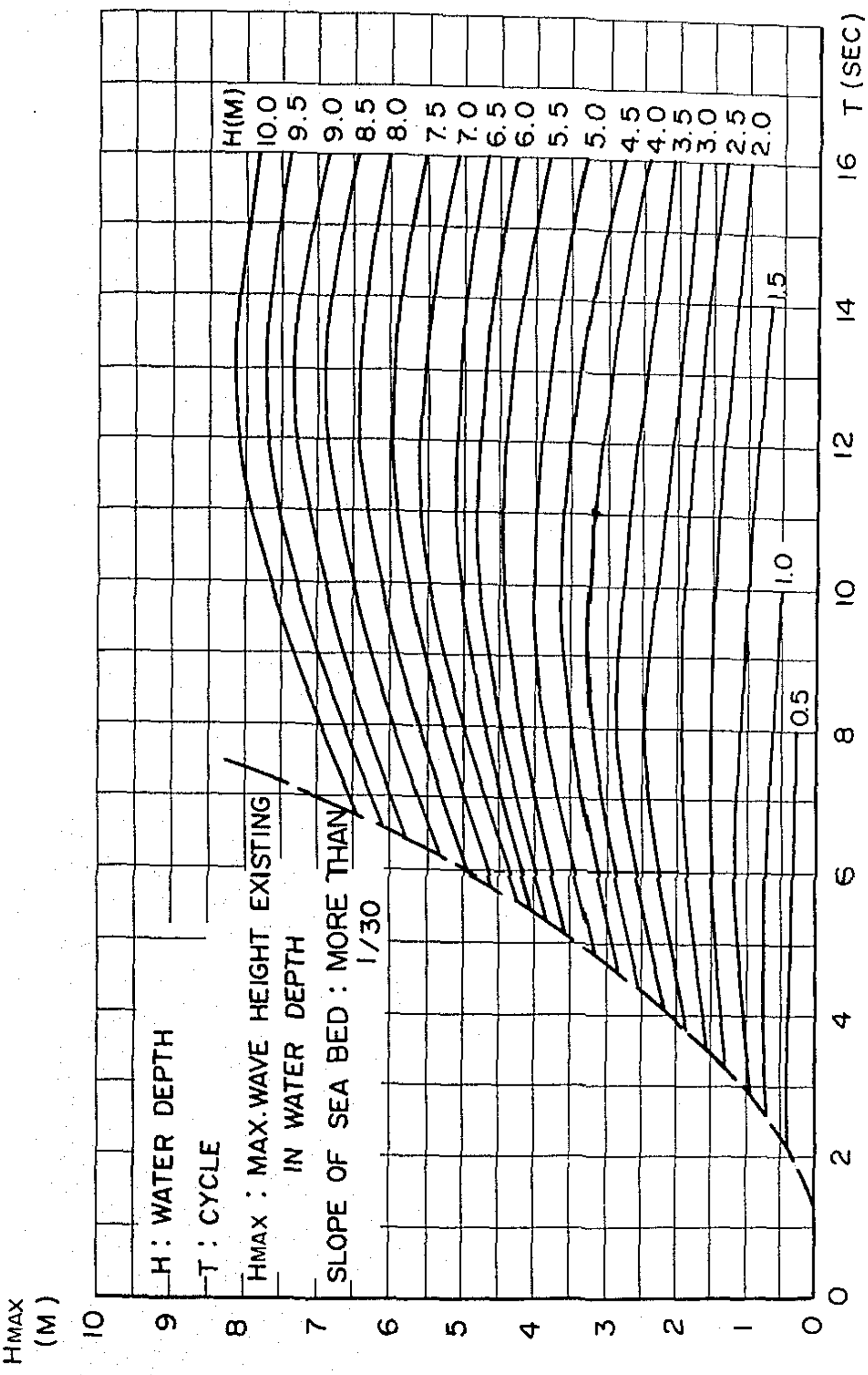
STATISTICAL ANALYSIS FOR OFFING WAVE

EXHIBIT G - 2



DIRECTION OF

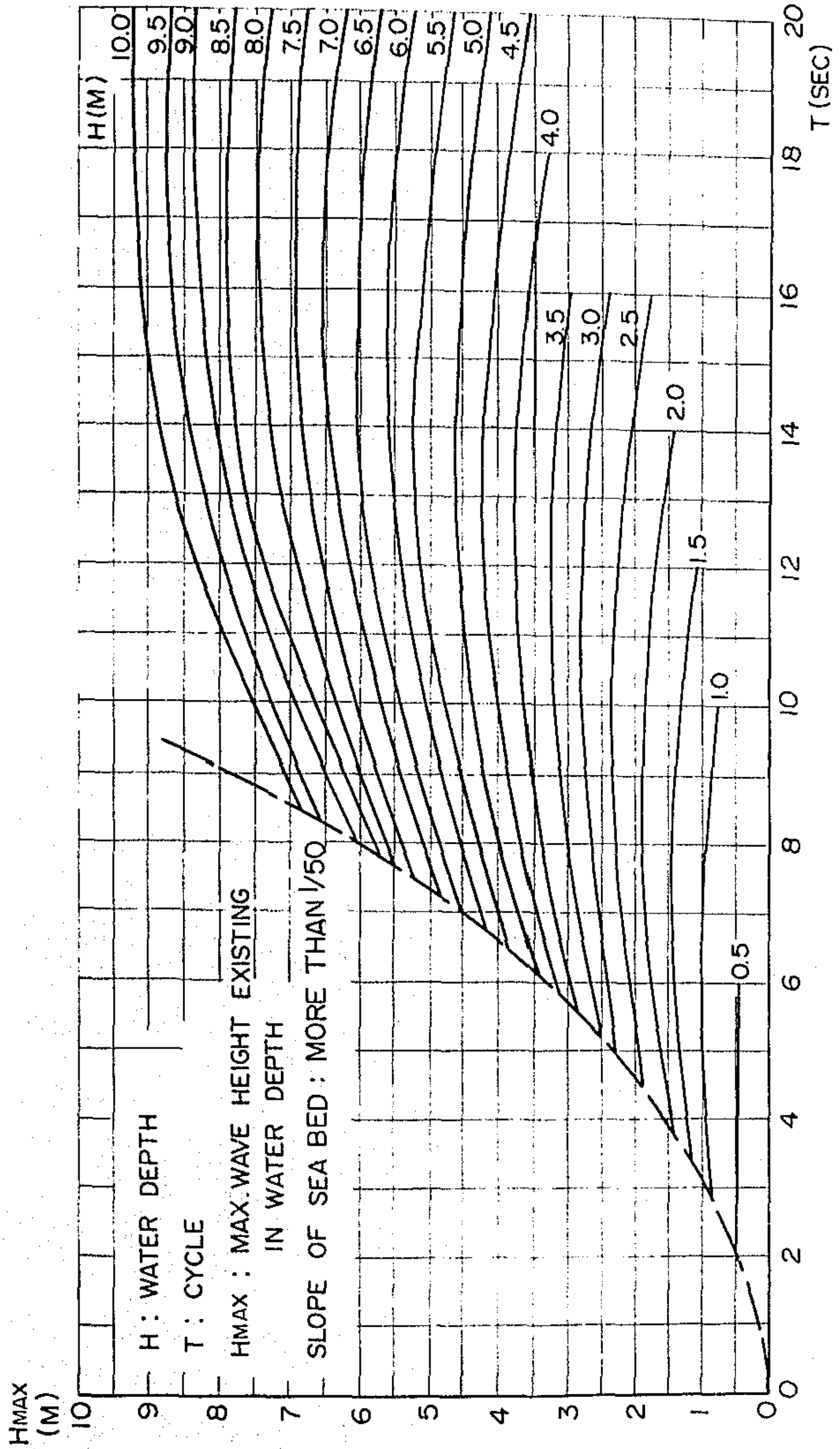
OFFING WAVE



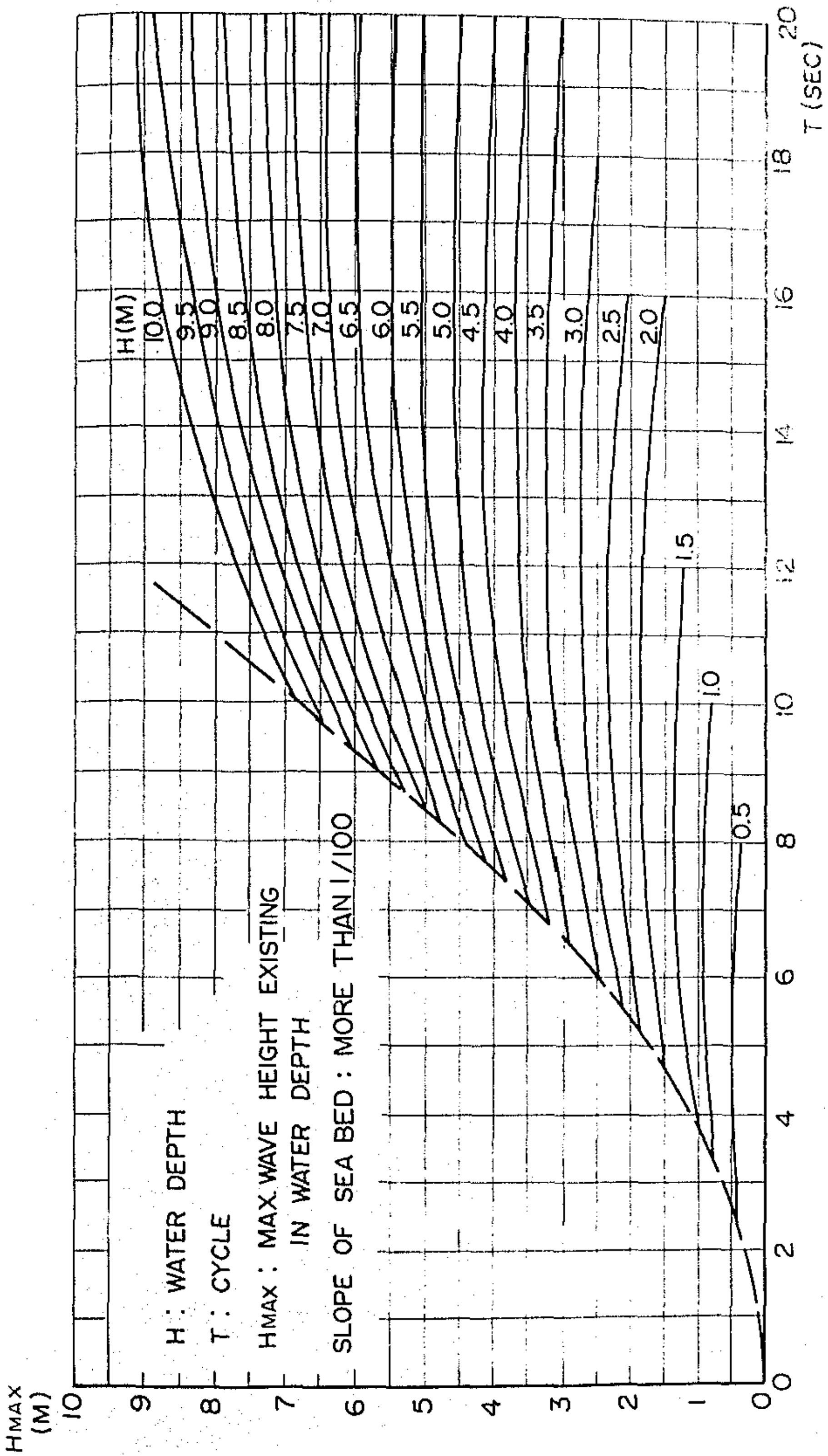
MAX. WAVE HEIGHT HMAX (M) EXISTING

IN WATER DEPTH H(M)-SLOPE OF SEA BED,

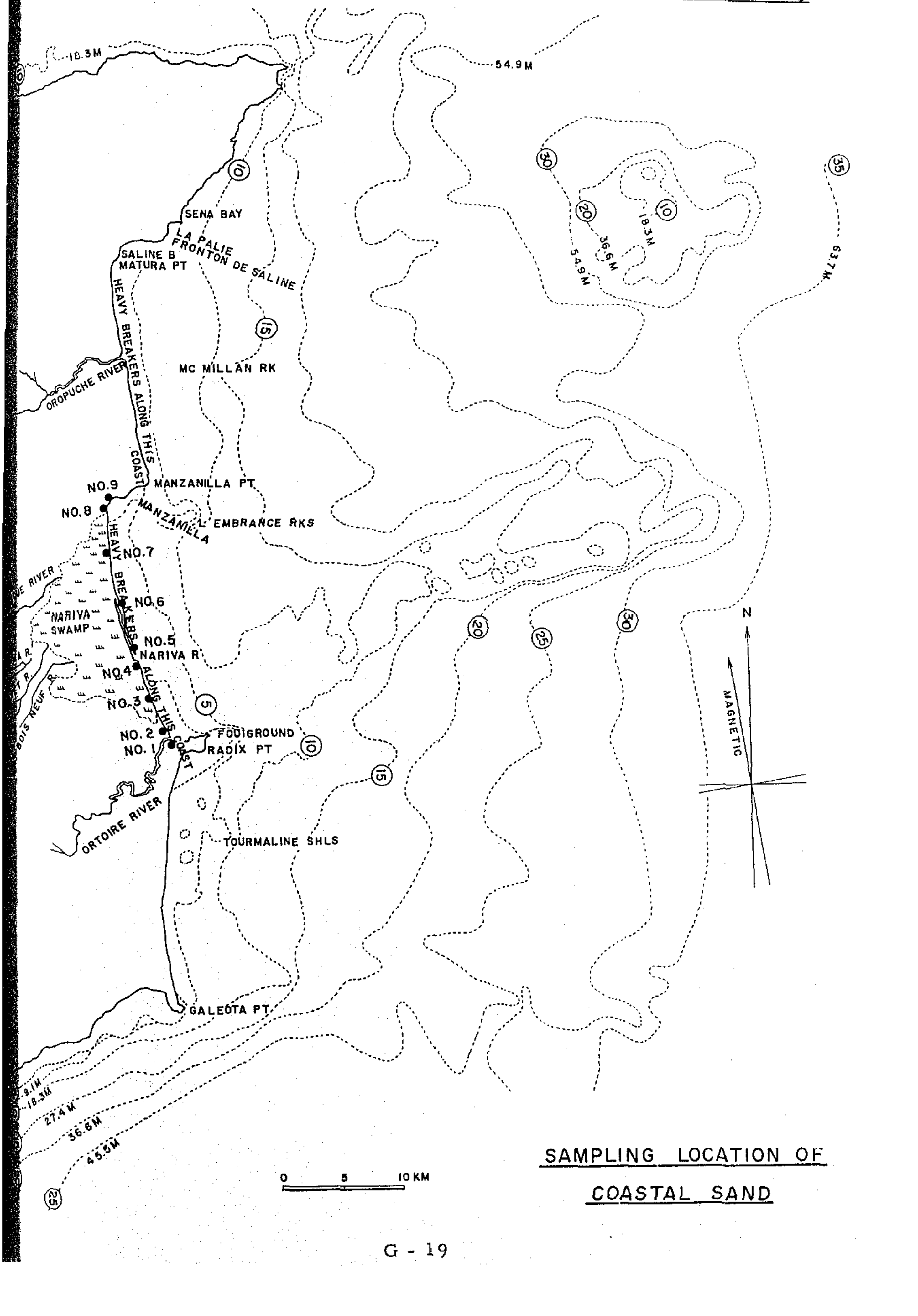
MORE THAN 1/30



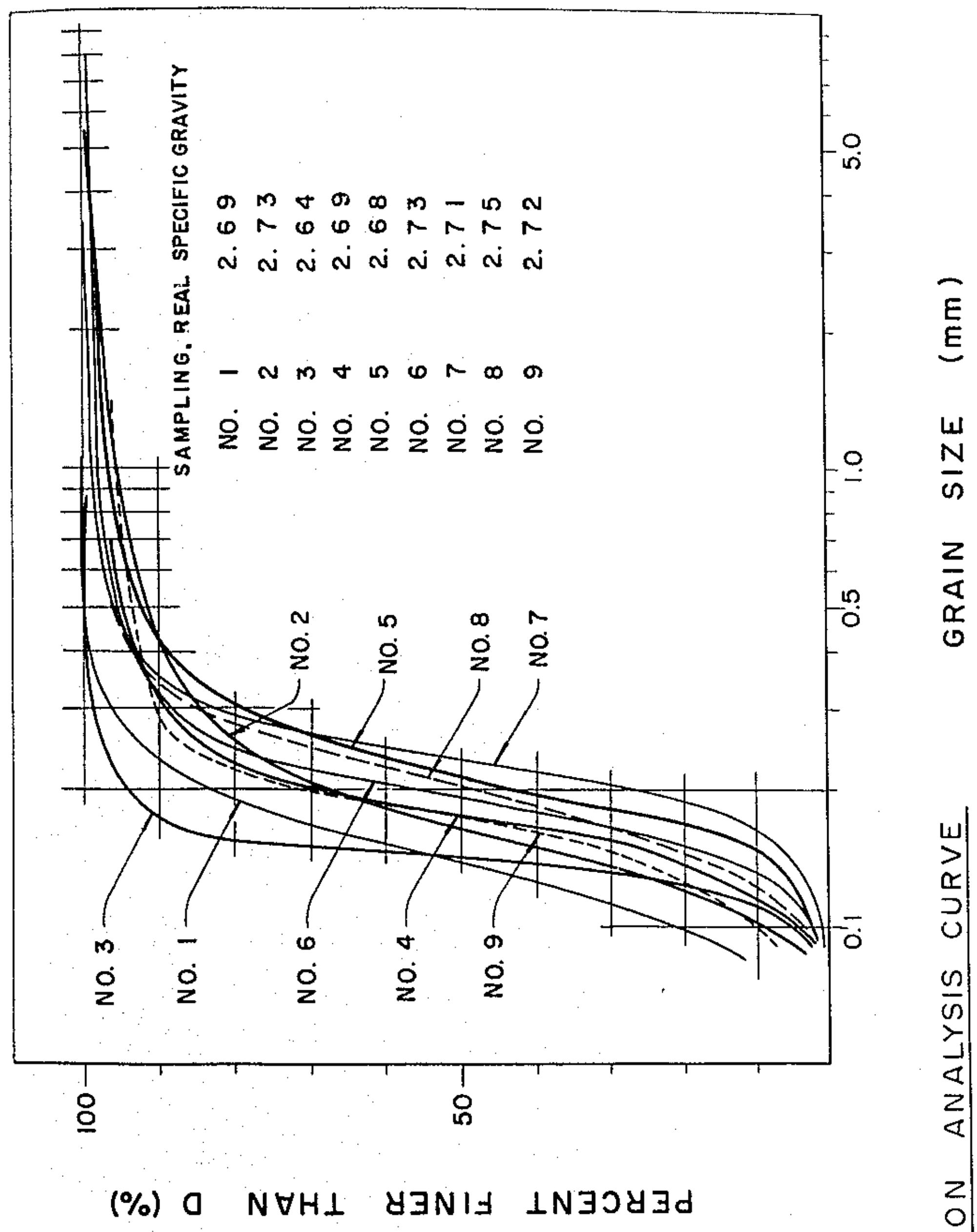
MAX. WAVE HEIGHT HMAX (M) EXISTING IN WATER DEPTH H(M)-SLOPE OF SEA BED, MORE THAN 1/50



MAX. WAVE HEIGHT HMAX (M) EXISTING IN WATER DEPTH H(M)-SLOPE OF SEA BED, MORE THAN 1/100

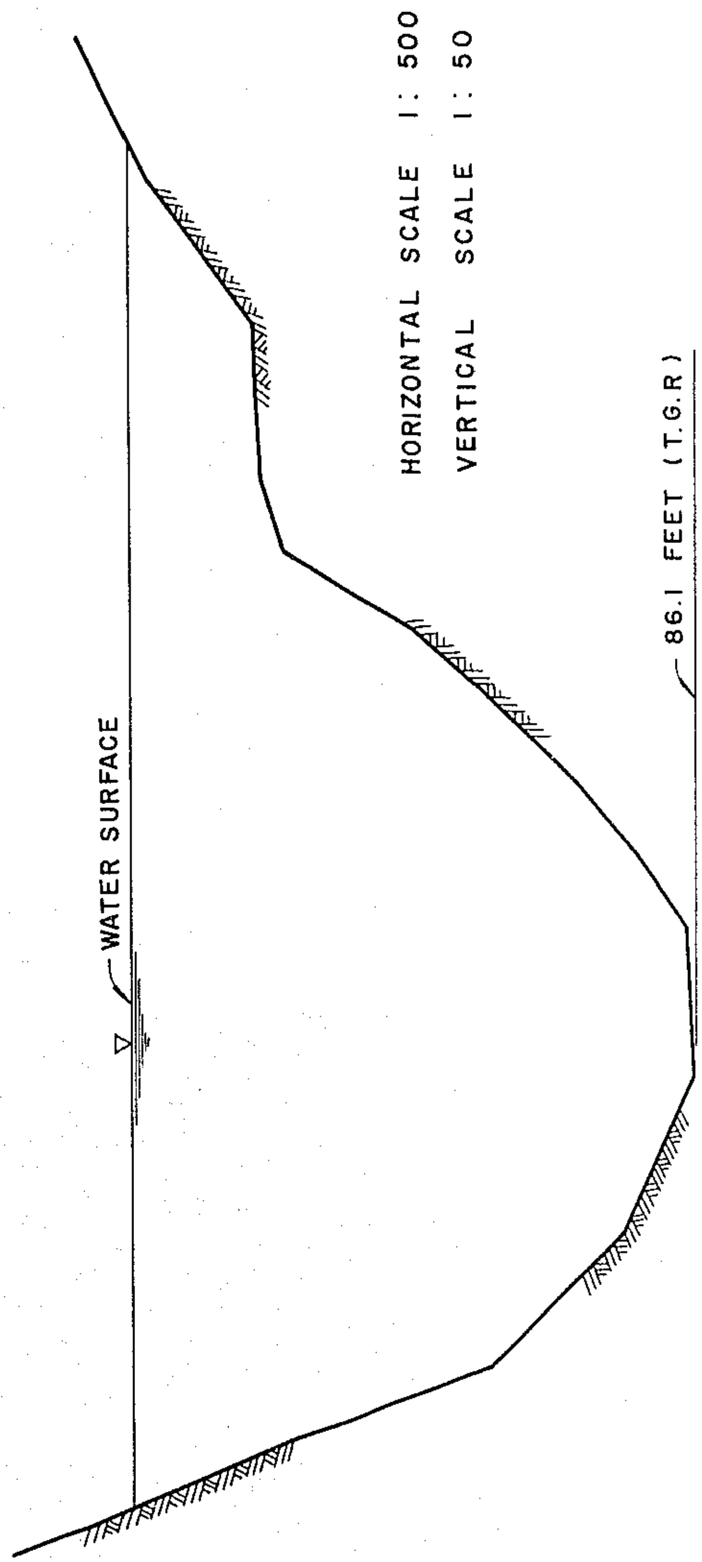


SAMPLING LOCATION OF COASTAL SAND



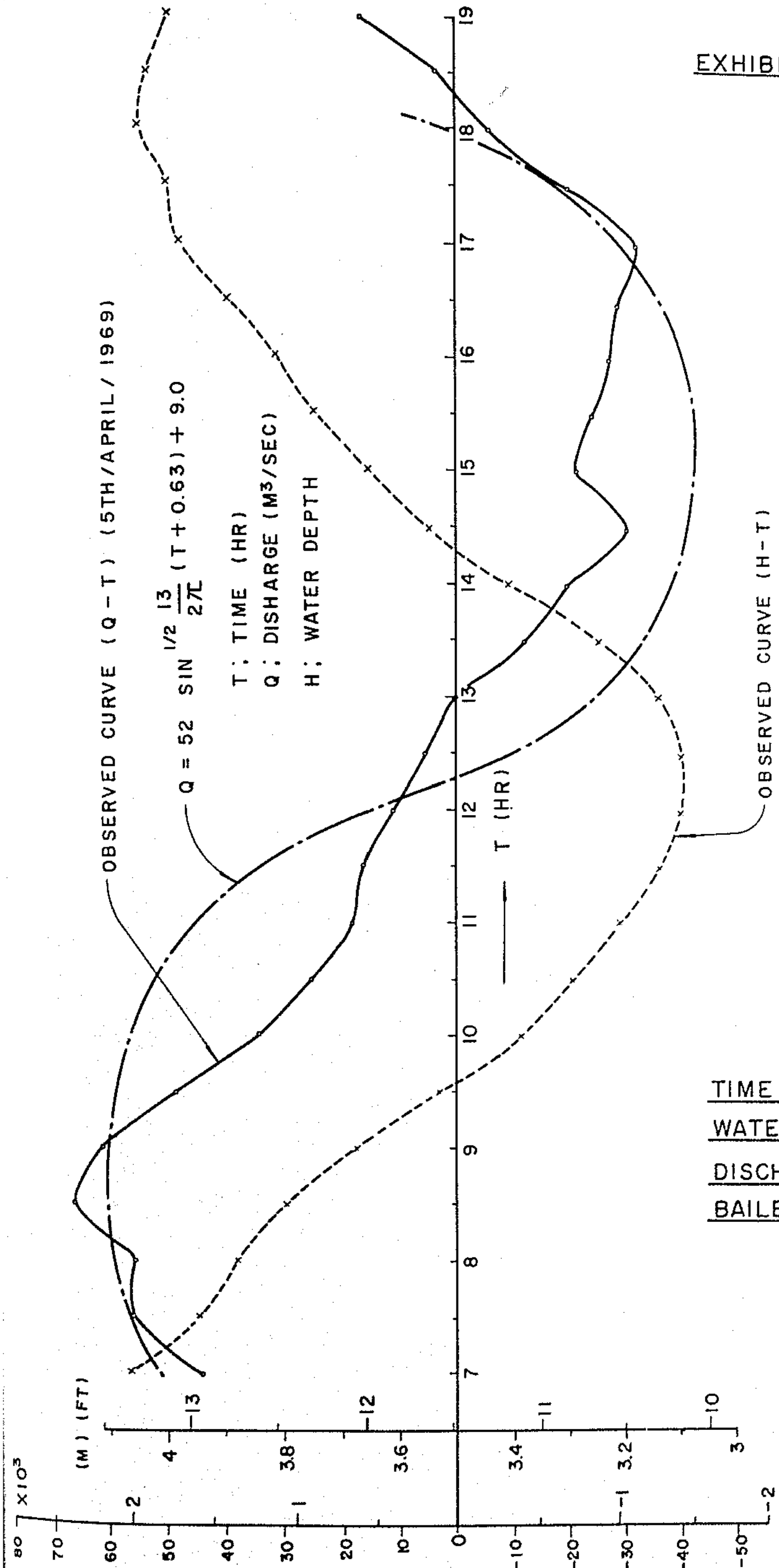
GRADATION ANALYSIS CURVE
OF COASTAL SAND

EXHIBIT G-8



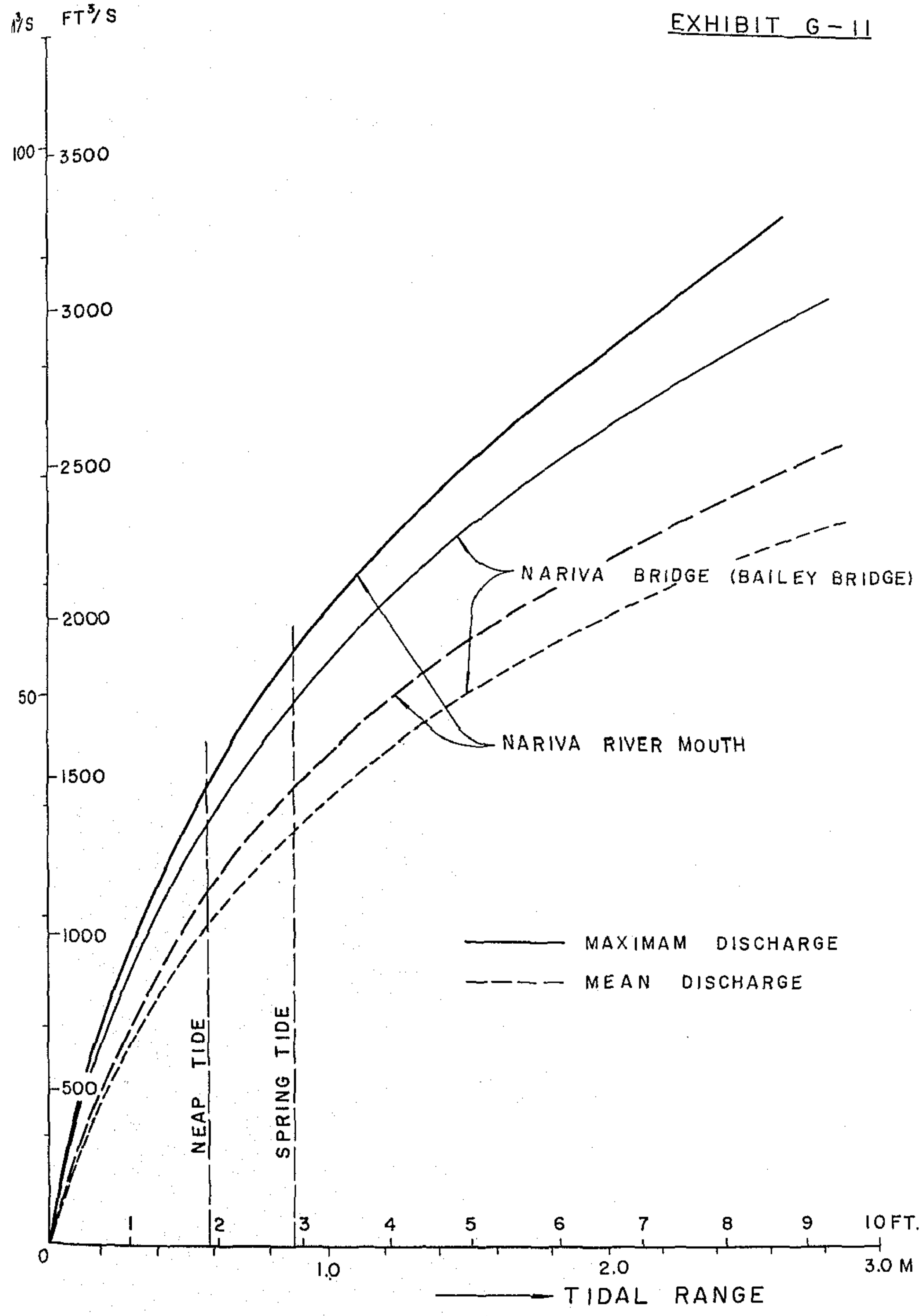
SECTION OF NARIVA RIVER AT BAILEY BRIDGE

EXHIBIT G-9



TIME VARIATION OF WATER LEVEL AND DISCHARGE AT BAILEY BRIDGE

EXHIBIT G-11



TIDAL RANGE ON OFF SHORE AND DISHARGE OF NARIVA RIVER.

Appendix H

Water Requirement

Appendix H

Water Requirement

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Appendix H

Water Requirement

Estimation of Evapotranspiration

The irrigation water requirements includes evapotranspiration and percoration. There are various methods in evapotranspiration calculation, such as Blaney-Criddle's, Thorthwaite's, Penman's and so forth. The Penman's method shall be taken herein for estimation in consideration of high humidity oceanic climate in the project area. From a result of the method monthly water consumption shall be determined for the total upland irrigation.

Penman Requirement

$$Et = \frac{\Delta H + 0.27Ea}{\Delta + 0.27}$$

Here; $H = Ra\ (1 - r)(0.18 + 0.5\ h/N) - \sigma Ta^4(0.56 - 0.92\sqrt{ed})$
$\times\ (0.10 + 0.90\ h/N)$

$$Ea = 0.35(e_a - e_d)(1 + 0.0098\ U_2)$$

H: Daily heat budget at surface in mm H_2O/day

RA: Mean monthly extra terrestrial radiation in mm H_2O/day

γ: Refection coefficient of surface

h: Actual duration of bright sunshine

N: Maximum possible duration of bright sunshine

σ: Boltymann constant

e_d: Saturation vapor pressure at mean dew point in mm Hg (i.e. actual vapor pressure in the air)

E_a: Evaporation in mm H_2O/day

e_a: Saturation vapor pressure at mean air temperature in mm Hg

U_2: Mean wind speed at 2 meter above the ground in miles/day $U_2 = (\frac{\log 66}{\log h})U_1$

U_1: Measured wind speed in miles per day at height h in feet

E_t: Evapotranspiration in mm H_2O/day

Δ: Slope of saturated vapor pressure curve of air at absolute temperature Ta in °F mm Hg/°F

Meteorological Data

Evapotranspiration is calculated by Penman formula in preparation of the meteorological data such as mean temperature, mean humidity, wind speed and maximum possible duration of bright sunshine, and these data are tabulated respectively in Table D-3, D-4 and H-2. The keynotes of these data are shown intensively in Table H-1.

Table H-1 Meteorological Data

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Mean temperature	77	77	78	79	79	79	78	76	79	79	78	77	78
Mean Humidity	63	58	57	56	62	71	72	72	71	70	71	68	66
Maximum Possible Duration of Bright Sunshine	359.7	330.1	373.0	369.5	389.5	368.2	392.8	385.0	366.8	370.7	351.4	359.0	368.0
Actual duration of Bright Sunshine	273.0	220.7	261.7	204.1	203.3	192.1	240.5	180.6	172.4	231.9	277.1	273.4	227.6
Wind Speed	5.9	5.8	6.8	7.8	7.7	7.6	6.7	5.0	4.0	4.3	4.6	4.5	5.1

NB: Source of the above data

Mean temperature : Data observed at Navet Reservoir Damsite No.3-8 in 1968.

Mean Humidity : Data observed at Piarco Airport. Refer to Table D-4.

Maximum Possible Duration of Bright Sunshine : Refer to Table H-2

Actual duration of Bright Sunshine : Data observed at Navet Reservoir Damsite No. 3-8 in 1968.

Wind Speed : Refer to Table D-3.

The seasonal evapotranspiration is estimated by the Penman's Formula on the basis of the above data. Table H-3 shows a process of this calculation and its result. For further references, the result obtained by the Thornthwaite's Method is shown in Table H-4.

The records of monthly fluctuation of evapotranspiration in green crops were observed at the Unviersity of West Indies, and the data are shown in Exhibit E-1 in comparison with the results obtained by the Penman's and Thornthwaite's Methods.

Determination of Water Requirements

Monthly water requirements (monthly water consumption) of the green crops is equivalent to an amount of evapotranspiration shown in Table H-3. Water requirements of paddy fields shall be estimated in addition of percolation to the above evapotranspiration. Percolation shall be estimated at 0.2 inches per day in consideration of the soil conditions in the project area.

Furthermore, water requirements for puddling, which is to be carried out at the end of May and November, can be calculated on the basis of the following assumption.

Thickness of top soil	30 cm
Porosity	40 %
Submergence depth after puddling	5 cm

Therefore, the puddling water requirements will be 7.8 inches in depth from the following calculation.

(30 cm x 0.4) + 50 xm + allowance 30 cm + 20 cm or 7.87 inches

Table H-6 shows the proposed cropping pattern with the water requirement per unit area (Refer to Table H-5). And Table H-7 shows the weighted irrigation requirement per unit area in consideration of the proposed cropping land ratio.

Determination of Basic Precipitation

Determination of Basic Year

In the project area and its watershed, there exist six gauging stations, among which Newland Estate Biche Gauging Station (3-1) keeps the observation records for 39 years, from 1930 to 1968. The calculation for probable rainfall in the dry season (January - April) can be made anu shown on Exhibit H-2. From the said Exhibit, 1961 with probable rainfall of 1/8 non-exceedence shall be determined as the basic irrigation year in the area.

Schematic Rainfall

Correlation among Gauging Stations

Table H-8 shows the correlation of rainfall data between Newlands Estate Biche (3-1), Gauging Station and other five gauging stations located in the project area and their basins.

Table H-8 Correlation with Newland Estate Biche (3-1)

Station	Correlation formula	Correlation coefficience
Plum Mitan Rice Scheme (3-2)	Y=0.98x -8.79	0.94
	Y=0.85x +0.84	0.77
Cocal Estate Mauzanilla (3-7)	Y=0.44x +29.66	0.65
	Y=0.82x -2.45	0.97
Navet Dam site (3-8)	Y=0.66x +18.21	0.83
	Y=0.84x -1.80	0.77
Navet Preabyterian School (3-9)	non-correlation	
Bush Bush Camp	Y=0.74x +9.46	0.93
	Y=0.80x +1.15	0.76

NB: Correlation equations in the upper part shows the correlation in the wet season, and those in the lower part in the dry season.

Table H-8 clarifies that there is no correlation of the rainfall records between Presbyterian School (3-9) and Newlands Estate Biche (3-1), which are taken as the selected location for determination of the bsic year for the project.

Divided Area

The arable alnds, 54.73 square miles shall be selected from the total project area for calculation of mean proposed rainfall on the total project area. To calculate the designed rainfall on each basin, 54.73 square miles shall be ramified by using the Thiessen Meghod, on the basis of the data recorded at the five stations excluding Navet Presbyterian School which has no correlation with those of Newland Estate Biche. And the division of the area is shown on Exhibit H-3.

Design Rainfall

From the divided areas by the Thiessen's Method and the rainfall data of gauging stations representing each bloc, the weighted mean value cen be calculated for the designed rainfall for the total project area. In these calculations, however, no observation records are available about the rainfall at Bush Bush Camp (3-14) for a period, January to April, and the same for a period, January to May at Plum Mitan Rice Scheme (3-2). Such being the case, for these data at two gauging stations, monthly rainfall shall be estimated on the basis of the aforementioned correlation equations.

Effective Rainfall

Effective rainfall shall be considered for two objectives, green crop and rice crop. Effective rainfall for green crops is estimated in application of graphs used by American bureau of Reclamation and the result is shown on Exhibit H-4. On the other hand, effective rainfall for rice crop shall be estimated on the basis of 70 percent of effective rainfall of the monthly mean rainfall. This is the empirical value of effective rainfall for the paddy fields. These data are shown in Table H-10 and H-11 together with the summerized one in Table H-9.

Table H-9 Effective Rainfall for Field Crops and Paddy

Crops	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Upland crops	3.67	0.88	2.20	1.36	1.88	4.07	4.07	4.07	4.07	4.07	4.07	2.87	37.28
Paddy crops	3.30	0.62	1.67	0.99	1.41	5.35	7.72	5.22	7.97	9.37	9.72	2.63	55.97

Net Irrigation Requirements

Net irrigation requirements can be estimated in subtraction of effective rainfall from irrigation requirements and is shown in Table H-12.

Water Requirements

Necessary irrigation water can be estimated by the following equation in consideration of net irrigation requirements irrigation efficiency and conveyance loss.

$$I.W.R. = \frac{N.I.R.}{E(1 - Loss)}$$

Where $I.W.R.$ is necessary irrigation water in inch unit.
$N.I.R.$ is net irrigation requirement in inch unit.
E is irrigation efficiency and $Loss$ is conveyance loss.

The necessary irrigation water is shown in Table H-12 in the result of estimation with 0.65 as a irrigation efficiency E and 0.15 as conveyance loss.

Table H-2

Maximum Possible Duration of Blight Sunshine, in hour

Date	Sunset (1)	Sunrise (2)	(1)-(2) = (3)	(3) x No. of Interval	Probable Maximum Sunshine Hours
				Days	hr min.
Jan. 1 - 10	17 50	6 17	11 33	10	110 330
11 - 20	17 56	6 20	11 36	10	110 360
21 - 30	18 01	6 22	11 39	10	110 390
31	18 05	6 22	11 43	1	11 43
Total					$341^{hr}1,124^{min.} = 359^{hr}\ 44^{min.}$
Feb. 1 - 9	18 05	6 22	11 43	9	99 387
10 - 19	18 08	6 21	11 47	10	110 470
20 - 28	18 10	6 18	11 52	9	99 468
Total					$308^{hr}1,325^{min.} = 330^{hr}\ 5^{min.}$
Mar. 1 -	18 10	6 18	11 52	1	11 52
2 - 11	18 11	6 14	11 57	10	110 570
12 - 21	18 11	6 09	12 02	10	120 20
22 - 31	18 11	6 03	12 08	10	120 80
Total					$361^{hr}722^{min.} = 373^{hr}\ 2^{min.}$
Apr. 1 - 10	18 11	5 57	12 14	10	120 140
11 - 20	18 11	5 52	12 19	10	120 190
21 - 30	18 11	5 47	12 24	10	120 240
Total					$360^{hr}570^{min.} = 369^{hr}\ 30^{min.}$
May 1 - 10	18 12	5 42	12 30	10	120 300
11 - 20	18 13	5 39	12 34	10	120 340
21 - 30	18 15	5 38	12 37	10	120 370
31	18 18	5 37	12 41	1	12 41
Total					$372^{hr}1,051^{min.} = 389^{hr}\ 31^{min.}$
Jun. 1 - 9	18 18	5 37	12 41	9	108 369
10 - 19	18 21	5 40	12 41	10	108 369
20 - 29	18 23	5 40	12 43	10	120 430
30	18 25	5 42	12 43	1	12 43
Total					$348^{hr}1,211^{min.} = 368^{hr}\ 11^{min.}$

Date	Sunset (1)	Sunrise (2)	(1)-(2) = (3)	(3) x No. of Interval	Probable Maximum Sunshine Hours
				Days	hr min.
July 1 - 9	18.25	5 42	12.43	9	108 387
10 - 19	18 26	5 45	12 41	10	120 410
20 - 29	18 25	5 47	12 38	10	120 380
30 - 31	18 24	5 49	12 35	2	24 70
Total					$372^{hr}1,247^{min.} = 392^{hr}\ 47^{min.}$
Aug. 1 - 8	18 24	5 49	13 35	8	104 280
9 - 18	18 21	5 50	12 31	10	120 310
19 - 28	18 16	5 51	12 25	10	120 250
29 - 31	18 11	5 51	12 20	3	36 60
Total					$370^{hr}\ 900^{min.} = 385^{hr}\ 0^{min.}$
Sep. 1 - 7	18 11	5 51	12 20	7	84 140
8 - 17	18 05	5 50	12 15	10	120 150
18 - 27	17 59	5 49	12 10	10	120 100
28 - 30	17 53	5 48	12 05	3	36 15
Total					$360^{hr}\ 405^{min.} = 366^{hr}\ 45^{min.}$
Oct. 1 - 7	17 53	5 48	12 05	7	84 35
8 - 17	17 47	5 48	11 59	10	110 590
18 - 27	17 42	5 48	11 54	10	110 540
28 - 31	17 38	5 49	11 49	4	44 196
Total					$348^{hr}1,361^{min.} = 370^{hr}\ 41^{min.}$
Nov. 1 - 6	17 38	5 49	11 49	6	66 294
7 - 16	17 36	5 52	11 44	10	110 440
17 - 26	17 35	5 55	11 40	10	110 400
27 - 30	17 36	5 59	11 37	4	44 148
Total					$330^{hr}1,282^{min.} = 351^{hr}\ 22^{min.}$
Dec. 1 - 6	17 36	5 59	11 37	6	66 222
7 - 16	17 39	6 04	11 35	10	110 350
17 - 26	17 43	6 09	11 34	10	110 340
27 - 31	17 48	6 14	11 34	5	55 170
Total					$341^{hr}1,082^{min.} = 359^{hr}\ 2^{min.}$

Table H-3

Evapo-Transpiration by Penman Method

		Item / Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Average	Remarks
Date	1.	Mean Temperature (°F)	77	77	78	79	79	79	78	76	79	79	78	77	936	78	Depends on the data observed at Navet Reservoi
	2.	Mean Relative Humidity (%)	63	58	57	56	62	71	72	72	71	70	71	68	791	66	Refer to Table-
	3.	Maximum Possible Duration of Bright Sunshine N (hr)	359.7	330.1	373.0	369.5	389.5	368.2	392.8	385.0	366.8	370.7	351.4	359.0	4,415.7	368.0	Refer to Table-
	4.	Actual Duration of Bright Sunshine n (hr)	238.7	224.0	251.1	243.0	244.9	195.0	213.9	213.9	198.0	210.8	201.0	210.8	2,645.1	220.4	Refer to Table-
	5.	Ratio of Bright Sunshine (n/N) x 100 (%)	66.4	67.9	67.3	65.8	62.9	53.0	54.5	55.6	54.0	56.9	57.2	58.7	7,202	60.0	
	6.	Windspeed U_1 (mile/hr)	5.8	6.8	7.8	7.7	7.6	6.7	5.0	4.0	4.3	4.6	4.5	5.1	69.9	5.8	Refer to Table-
	7.	Windspeed U_2 (mile/hr)	3.1	3.7	4.2	4.2	4.1	3.6	2.7	2.2	2.3	2.5	2.4	2.8	37.8	3.2	$U_2 = \left(\frac{\log 6.6}{\log 33} \right) \times U_1 = 0.54\ U_1$
	8.	Windspeed U_2 (mile/day)	74.4	88.8	100.8	100.8	98.4	86.4	64.8	52.8	55.2	60.0	57.6	67.2	917.2	76.4	
	9.	Radiation Rate R_A (mm H_2O/day)	12.8	13.9	14.8	15.2	15.0	14.8	14.8	15.0	14.9	14.1	13.1	12.4	170.8	14.2	Obtain from the related table in Penman Equati
	10.	Reflection Coefficient (r x 100) (%)	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0			Reflection coefficient is determined to be 25 following references developed by Monteith in Pasture : 25.2 % Sugar beat : 25.5 % Alfalfa : 25.2 % White potato : 27.0 Wheat : 27.4 %
Solving Expression { $R_A(1 - r)(0.18 + 0.55\ n/N)$ }	11.	1 - r	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75			
	12.	0.55 x (n/N)	0.37	0.37	0.37	0.36	0.35	0.29	0.30	0.31	0.30	0.31	0.31	0.32			
	13.	0.18 + (12)	0.55	0.55	0.55	0.54	0.53	0.47	0.48	0.49	0.48	0.49	0.49	0.50			
	14.	(9) x (11) x (13)	5.28	5.73	6.11	6.16	5.96	5.22	5.33	5.51	5.36	5.18	4.81	4.65			
Solving Expression; { $\sigma Ta^4(0.56 - 0.092\sqrt{e_d})(0.10 + 0.90\ n/N)$ }	15.	Saturation Vapor Pressure e_a (mmHg)	24	24	25	25	25	25	25	24	25	25	25	24	296	24.7	Obtain from the related table in Penman Equati
	16.	Actual Vapor Pressure in the Air e_d = (15) x (2) (mmHg)	15.12	13.92	14.25	14.00	15.50	17.75	18.00	17.28	17.75	17.50	17.75	16.32	195.14	16.26	
	17.	$\sqrt{e_d} = \sqrt{(16)}$	3.89	3.73	3.77	3.74	3.94	4.21	4.24	4.16	4.21	4.18	4.21	4.04			
	18.	σTa^4	15.90	15.90	16.00	16.12	16.12	16.12	16.00	15.78	16.12	16.12	16.00	15.90			Obtain from the related table in Penman Equati
	19.	$0.092\sqrt{e_d}$ = 0.092 x (17)	0.36	0.34	0.35	0.34	0.36	0.39	0.39	0.39	0.39	0.38	0.39	0.37			
	20.	$0.56 - 0.092\sqrt{e_d}$ = 0.56 - (19)	0.20	0.22	0.21	0.22	0.20	0.17	0.17	0.17	0.17	0.18	0.17	0.19			
	21.	0.90 x (n/N)	0.60	0.61	0.61	0.59	0.57	0.48	0.49	0.50	0.49	0.51	0.51	0.53			
	22.	0.10 + 0.90(n/N) = 0.10 + (21)	0.70	0.71	0.71	0.69	0.67	0.58	0.59	0.60	0.59	0.61	0.61	0.63			
	23.	(18) x (20) x (22)	2.23	2.48	2.39	2.45	2.16	1.59	1.60	1.61	1.62	1.77	1.66	1.90			
Solving for H	24.	H = (14) - (23)	3.05	3.25	3.72	3.71	3.80	3.63	3.73	3.90	3.74	3.41	3.15	2.75			
Solving Expression; $Ea = 0.35(e_a - e_d)(1 + 0.0098U_2)$	25.	$e_a - e_d$ = (15) - (16) (mmHg)	8.88	10.08	10.75	11.00	9.50	7.25	7.00	6.72	7.25	7.50	7.25	7.68			
	26.	$0.35(e_a - e_d)$ = 0.35 x (25)	3.11	3.53	3.76	3.85	3.33	2.54	2.45	2.35	2.54	2.63	2.54	2.69			
	27.	0.0098 U_2 = 0.0098 x (8)	0.73	0.87	0.99	0.99	0.96	0.85	0.64	0.52	0.54	0.59	0.56	0.66			
	28.	1 + 0.0098 U_2 = 1 + (27)	1.73	1.87	1.99	1.99	1.96	1.85	1.64	1.52	1.54	1.59	1.56	1.66			
	29.	Daily Evaporation Ea = (26) x (28) (mm/day)	5.38	6.60	7.48	7.66	6.53	4.70	4.02	3.57	3.91	4.18	3.96	4.47	62.46	5.21	
Solving Expression; $Et = \frac{\Delta H + 0.27Ea}{\Delta + 0.27}$	30.	Slope of Saturated Vapor Pressure Curve of Air at Absolute Temperature Ta in °F Δ (mmHg/°F)	0.79	0.79	0.80	0.80	0.80	0.80	0.80	0.78	0.80	0.80	0.80	0.79			
	31.	ΔH = (24) x (30)	2.41	2.57	2.98	2.97	3.04	2.90	2.98	3.12	2.99	2.73	2.52	2.17			
	32.	0.27Ea = 0.27 x (29)	1.45	1.78	2.02	2.07	1.76	1.27	1.09	0.96	1.06	1.13	1.07	1.21			
	33.	ΔH + 0.27Ea = (31) + (32)	3.86	4.35	5.00	5.04	4.80	4.17	4.07	4.08	4.05	3.86	3.59	3.38			
	34.	Δ + 0.27 = 0.27 + (30)	1.06	1.06	1.07	1.07	1.07	1.07	1.07	1.05	1.07	1.07	1.07	1.06			
	35.	Daily Evapo-Transpiration Et = (33)/(34) (mm/day)	3.64	4.10	4.67	4.71	4.49	3.90	3.80	3.89	3.79	3.61	3.36	3.19	47.15	3.93	
	36.	Monthly Evapo-Transpiration Et (inch/month)	4.44	4.52	5.70	5.56	5.48	4.61	4.64	4.75	4.48	4.41	3.97	3.89	56.45	4.70	
	37.	Et/Ea (35)/(29)	0.68	0.62	0.62	0.61	0.69	0.83	0.95	1.09	0.97	0.86	0.85	0.71	8.48	0.71	

Table H-3

po-Transpiration by Penman Method

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Average	Remarks
	77	77	78	79	79	79	78	76	79	79	78	77	936	78	Depends on the data observed at Navet Reservoir Damsite No.3.8 in 1968
	63	58	57	56	62	71	72	72	71	70	71	68	791	66	Refer to Table-
ht Sunshine N (hr)	359.7	330.1	373.0	369.5	389.5	368.2	392.8	385.0	366.8	370.7	351.4	359.0	4,415.7	368.0	Refer to Table-
e n (hr)	238.7	224.0	251.1	243.0	244.9	195.0	213.9	213.9	198.0	210.8	201.0	210.8	2,645.1	220.4	Refer to Table-
100 (%)	66.4	67.9	67.3	65.8	62.9	53.0	54.5	55.6	54.0	56.9	57.2	58.7	7,202	60.0	
	5.8	6.8	7.8	7.7	7.6	6.7	5.0	4.0	4.3	4.6	4.5	5.1	69.9	5.8	Refer to Table-
	3.1	3.7	4.2	4.2	4.1	3.6	2.7	2.2	2.3	2.5	2.4	2.8	37.8	3.2	$U_2 = (\frac{\log 6.6}{\log 33}) \times U_1 = 0.54\ U_1$
	74.4	88.8	100.8	100.8	98.4	86.4	64.8	52.8	55.2	60.0	57.6	67.2	917.2	76.4	
	12.8	13.9	14.8	15.2	15.0	14.8	14.8	15.0	14.9	14.1	13.1	12.4	170.8	14.2	Obtain from the related table in Penman Equation
(%)	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0			Reflection coefficient is determined to be 25 per cent depending on the
	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75			following references developed by Monteith in 1956.
	0.37	0.37	0.37	0.36	0.35	0.29	0.30	0.31	0.30	0.31	0.31	0.32			Pasture : 25.2 % Sugar beat : 25.5 %
	0.55	0.55	0.55	0.54	0.53	0.47	0.48	0.49	0.48	0.49	0.49	0.50			Alfalfa : 25.2 % White potato : 27.0 %
	5.28	5.73	6.11	6.16	5.96	5.22	5.33	5.51	5.36	5.18	4.81	4.65			Wheat : 27.4 %
(mmHg)	24	24	25	25	25	25	25	24	25	25	25	24	296	24.7	Obtain from the related table in Penman Equation
e_d = (15) x (2) (mmHg)	15.12	13.92	14.25	14.00	15.50	17.75	18.00	17.28	17.75	17.50	17.75	16.32	195.14	16.26	
	3.89	3.73	3.77	3.74	3.94	4.21	4.24	4.16	4.21	4.18	4.21	4.04			
	15.90	15.90	16.00	16.12	16.12	16.12	16.00	15.78	16.12	16.12	16.00	15.90			Obtain from the related table in Penman Equation
	0.36	0.34	0.35	0.34	0.36	0.39	0.39	0.39	0.39	0.38	0.39	0.37			
	0.20	0.22	0.21	0.22	0.20	0.17	0.17	0.17	0.17	0.18	0.17	0.19			
	0.60	0.61	0.61	0.59	0.57	0.48	0.49	0.50	0.49	0.51	0.51	0.53			
	0.70	0.71	0.71	0.69	0.67	0.58	0.59	0.60	0.59	0.61	0.61	0.63			
	2.23	2.48	2.39	2.45	2.16	1.59	1.60	1.61	1.62	1.77	1.66	1.90			
	3.05	3.25	3.72	3.71	3.80	3.63	3.73	3.90	3.74	3.41	3.15	2.75			
	8.88	10.08	10.75	11.00	9.50	7.25	7.00	6.72	7.25	7.50	7.25	7.68			
	3.11	3.53	3.76	3.85	3.33	2.54	2.45	2.35	2.54	2.63	2.54	2.69			
	0.73	0.87	0.99	0.99	0.96	0.85	0.64	0.52	0.54	0.59	0.56	0.66			
	1.73	1.87	1.99	1.99	1.96	1.85	1.64	1.52	1.54	1.59	1.56	1.66			
) (mm/day)	5.38	6.60	7.48	7.66	6.53	4.70	4.02	3.57	3.91	4.18	3.96	4.47	62.46	5.21	
Curve of Air Δ (mmHg/°F)	0.79	0.79	0.80	0.80	0.80	0.80	0.80	0.78	0.80	0.80	0.80	0.79			
	2.41	2.57	2.98	2.97	3.04	2.90	2.98	3.12	2.99	2.73	2.52	2.17			
	1.45	1.78	2.02	2.07	1.76	1.27	1.09	0.96	1.06	1.13	1.07	1.21			
	3.86	4.35	5.00	5.04	4.80	4.17	4.07	4.08	4.05	3.86	3.59	3.38			
	1.06	1.06	1.07	1.07	1.07	1.07	1.07	1.05	1.07	1.07	1.07	1.06			
3)/(34) (mm/day)	3.64	4.10	4.67	4.71	4.49	3.90	3.80	3.89	3.79	3.61	3.36	3.19	47.15	3.93	
nch/month)	4.44	4.52	5.70	5.56	5.48	4.61	4.64	4.75	4.48	4.41	3.97	3.89	56.45	4.70	
	0.68	0.62	0.62	0.61	0.69	0.83	0.95	1.09	0.97	0.86	0.85	0.71	8.48	0.71	

Table H-4

Evapo-transpiration by Thornthwaite Method

Description	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
(1) Monthly Mean Temperature, T (°C)	25.0	25.0	25.6	26.1	26.1	26.1	25.6	24.4	26.1	26.1	25.5	25.0	
(2) Monthly Head Index Valves, I	11.44	11.44	11.85	12.21	12.21	12.21	11.85	11.02	12.21	12.21	11.85	11.44	141.94
(3) Potential Monthly Evapo-transpiration, P.E.T. (cm/month)	9.3	9.3	9.9	10.5	10.5	10.5	9.9	8.7	10.5	10.5	9.9	9.3	118.8
(4) Correction Factor corresponding to Latitude and Month	1.00	0.91	1.03	1.03	1.08	1.06	1.08	1.07	1.02	1.02	0.98	0.99	
(5) Actual Potential Monthly Evapo-transpiration (cm/month)	9.30	8.46	10.20	10.82	11.34	11.13	10.69	9.31	10.71	10.71	9.70	9.21	121.58
(inch/month)	3.61	3.33	4.02	4.26	4.46	4.38	4.21	3.67	4.22	4.22	3.82	3.63	47.83

Note:
(1) Monthly mean temperature depends upon the data observed at Navet Reservoir Damsite No.3.8 in 1968.

(2) Monthly heat index values corresponding to monthly mean temperature are taken from the figure related to Thornthwaite Method.

(3) Potential monthly evapo-transpiration is taken from the nomograph corresponding to the mean temperature for that month.

(4) Factor corresponding to the latitude of the station and the month under consideration is taken from the table.

(5) Actual potential evapo-transpiration is obtained by multipling the above factor (4) by the potential monthly evapo-transpiration (3).

Table H-5

Proposed Cropping Pattern and Rotation System

Crops	May	Jun.	Jul.	Aug.	ep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Paddy			(Cropping ratio 100%)					Cropping ratio (50%)				
Soybeans									(Cropping ratio 25%)			
Maize									(Cropping ratio 25%)			

Note: ----- Transplanting of paddy rice

Table H-6

Irrigation Requirement, in inches

Crops	First Crops						Second Crops					
	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Paddy	7.87	10.61	10.84	10.95	10.48		7.87	10.09	10.64	10.12	11.90	
Soybeans								2.64	4.44	4.52	5.70	1.85
Maize								2.64	4.44	4.52	5.70	1.85

Note: The figures indicated in the above table are derived from the Table H-5 except for the irrigation requirement of paddy, which is estimated by adding the percolation rates of 0.2 inch per day to the evapo-transpiration rates indicated in the Table H-5.

Table H-7

Weighted Irrigation Requirement, in inch

Crops	Cropping Ratio		First Crops							Second Crops							Total
	First Crops	Second Crops	May	Jun.	Jul.	Aug.	Sep.	Oct.	Sub-Total	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Sub-Total	
Paddy	100	50	7.87	10.61	10.84	10.95	10.48		50.75	3.94	5.05	5.32	5.06	5.95		25.32	76.07
Soybeans		25									0.66	1.11	1.13	1.43	0.46	4.79	4.79
Maize		25									0.66	1.11	1.13	1.43	0.46	4.79	4.79
Total	100	100	7.87	10.61	10.84	10.95	10.48		50.75	3.94	6.37	7.54	7.32	8.81	0.92	34.90	85.65

Note: The figures indicated in the above table are calculated by multipling the cropping ratio indicated in Table H-7.

Puddling water requirement is estimated to be 7.87 inch depending upon the assumption denoted previously.

Table H-10

Estimation of Monthly Effective Precipitation of Upland Fields by Weighted Average Method in 1961

Name of Block	Area divided by Thiessen Method, A (sq.mile)		Dry Season				Rainy Season								Total	Remarks
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.			
		R_1= 5.12	0.96	2.64	1.53	2.54	10.08	13.15	7.98	11.12	12.64	13.65	4.60		86.01	R_1 (inch)
3-1	A = 12.45	EP_1= 3.81	0.92	2.40	1.47	2.32	4.07	4.07	4.07	4.07	4.07	4.07	3.63		38.97	
		47.43	11.45	29.88	18.30	28.88	50.67	50.67	50.67	50.67	50.67	50.67	45.19		485.15	$A_1 x EP_1$ (sq.mile-inch)
		R_2=*4.78	*0.90	*2.45	*1.42	*2.49	6.37	10.52	8.39	13.59	16.01	15.04	4.69		86.65	R_2
3-2	A_2 = 10.84	EP_2= 3.71	0.89	2.25	1.37	2.28	4.07	4.07	4.07	4.07	4.07	4.07	3.68		38.60	
		40.22	9.65	24.39	14.85	24.72	44.12	44.12	44.12	44.12	44.12	44.12	39.89		418.44	A_2 x EP_2
		R_3= 2.66	0.66	0.62	0.97	1.66	6.63	9.67	6.52	7.43	9.06	11.10	2.90		59.88	R_3
3-7	A_3 = 2.17	EP_3= 2.41	0.65	0.61	0.93	1.56	4.07	4.07	4.07	4.07	4.07	4.07	2.61		33.19	
		5.77	1.41	1.32	2.02	3.39	8.83	8.83	8.83	8.83	8.83	8.83	5.66		72.55	A_3 x EP_3
		R_4=*4.68	*0.88	*2.40	*1.39	1.66	7.15	10.42	6.96	10.97	13.06	13.78	3.11		76.41	R_4
3-14	A_4 = 29.27	EP_4= 3.67	0.87	2.22	1.34	1.57	4.07	4.07	4.07	4.07	4.07	4.07	2.26		36.35	
		107.42	25.46	64.98	39.22	45.95	119.13	119.13	119.13	119.13	119.13	119.13	66.15		1,063.96	A_4 x EP_4
Total	54.73	200.84	47.97	120.57	74.39	102.94	222.75	222.75	222.75	222.75	222.75	222.75	156.89		2,040.10	ΣAi x EPi
Monthly Effective Precipitation, in inch		3.67	0.88	2.20	1.36	1.88	4.07	4.07	4.07	4.07	4.07	4.07	2.87		37.28	ΣAi x EPi/ΣA

Note: Monthly effective precipitation (EP) is obtained from Exhibit H-4 and also the values asterisked is obtained by using the correlation equations.

Table H-11

Estimation of Monthly Effective Mean Precipitation of Paddy Fields by Weighted Average Method in 1961

Name of Block	Area divided by Thiessen Method, A (sq.mile)	Dry Season				Rainy Season								Total	Remarks
		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.		
3-1	A_1 = 12.45	R_1= 5.12	0.96	2.64	1.53	2.54	10.08	13.15	7.98	11.12	12.64	13.65	4.60	86.01	R_1 (inch)
		63.74	11.95	32.87	19.05	31.62	125.50	163.72	99.35	138.44	157.37	169.94	57.27	1,070.82	$R_1 \times A_1$ (sq.mile-inch)
3-2	A_2 = 10.84	R_2=*4.78	*0,90	*2.45	*1.42	*2.49	6.37	10.52	8.39	13.59	16.01	15.04	4.69	86.65	R_2
		51.82	9.76	26.56	15.39	26.99	69.05	114.04	90.95	147.32	173.55	163.03	50.84	939.30	$R_2 \times A_2$
3-7	A_3 = 2.17	R_3= 2.66	0.66	0.62	0.97	1.66	6.63	9.67	6.52	7.43	9.06	11.10	2.90	59.88	R_3
		5.77	1.43	1.35	2.10	3.60	14.39	20.98	14.15	16.12	19.66	24.09	6.29	129.93	$R_3 \times A_3$
3-14	A_4 = 29.27	R_4=*4.68	*0.88	*2.40	*1.39	1.66	7.15	10.42	6.96	10.97	13.06	13.78	3.11	76.46	R_4
		136.98	25.76	70.25	40.69	48.59	209.28	304.99	203.72	321.09	382.27	403.34	91.02	2,237.98	$R_4 \times A_4$
Total	54.73	258.31	48.90	131.03	77.23	110.80	418.22	603.73	408.17	622.97	732.85	760.40	205.42	4,378.03	$\Sigma Ri \times Ai$ (sq.mile-inch)
Monthly Mean Precipitation, in inch		4.72	0.89	2.39	1.41	2.02	7.64	11.03	7.46	11.38	13.39	13.89	3.75	79.97	$\Sigma Ri \times Ai/\Sigma Ai$
Monthly Effective Mean Precipitation, in inch		3.30	0.62	1.67	0.99	1.41	5.35	7.72	5.22	7.97	9.37	9.72	2.63	55.97	Rm (inch)

Note: R_1, R_2, R_3 and R_4 are monthly precipitation value observed at each precipitation station, 3-1, 3-2, 3-7, 3-14 respectively except for the values with an asterisk. The values asterisked is obtained by using the correlation equations.

Monthly effective mean precipitation is estimated by making assumption that the ratio of monthly effective mean precipitation to total monthly mean precipitation is 70 per cent.

Table H-12

Estimation of Net Irrigation Requirement and Irrigation Water Requirement in 1961

Unit : inch

Description	First Crops						Second Crops							Total
	Jun.	Jul.	Aug.	Sep.	Oct.	Sub-Total	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Sub-Total	
Irrigation Requirement (A)	7.87	10.84	10.95	10.48	10.61	50.75		1.38	4.44	4.52	5.70	3.72	19.76	70.51
Monthly Effective Precipitation (B)	5.35	7.72	5.22	7.97	9.37	35.63		2.87	3.67	0.88	2.20	1.36	10.61	46.24
Net Irrigation Requirement (C)	2.52	3.12	5.73	2.51	1.24	15.12		-	0.77	3.64	3.50	2.36	10.64	25.76
Irrigation Water Requirement														
Farm Head Gate Requirement (D)	3.88	4.80	8.82	3.86	1.91	23.27		-	1.18	5.60	5.38	3.63	16.37	39.64
Diversion Requirement (E)	4.56	5.65	10.38	4.54	2.25	27.38		-	1.39	6.59	6.33	4.27	19.27	46.65

Note: Irrigation Requirement (A) : see Table

Monthly Effective Precipitation (B) : see Table for upland fields and Table for paddy fields

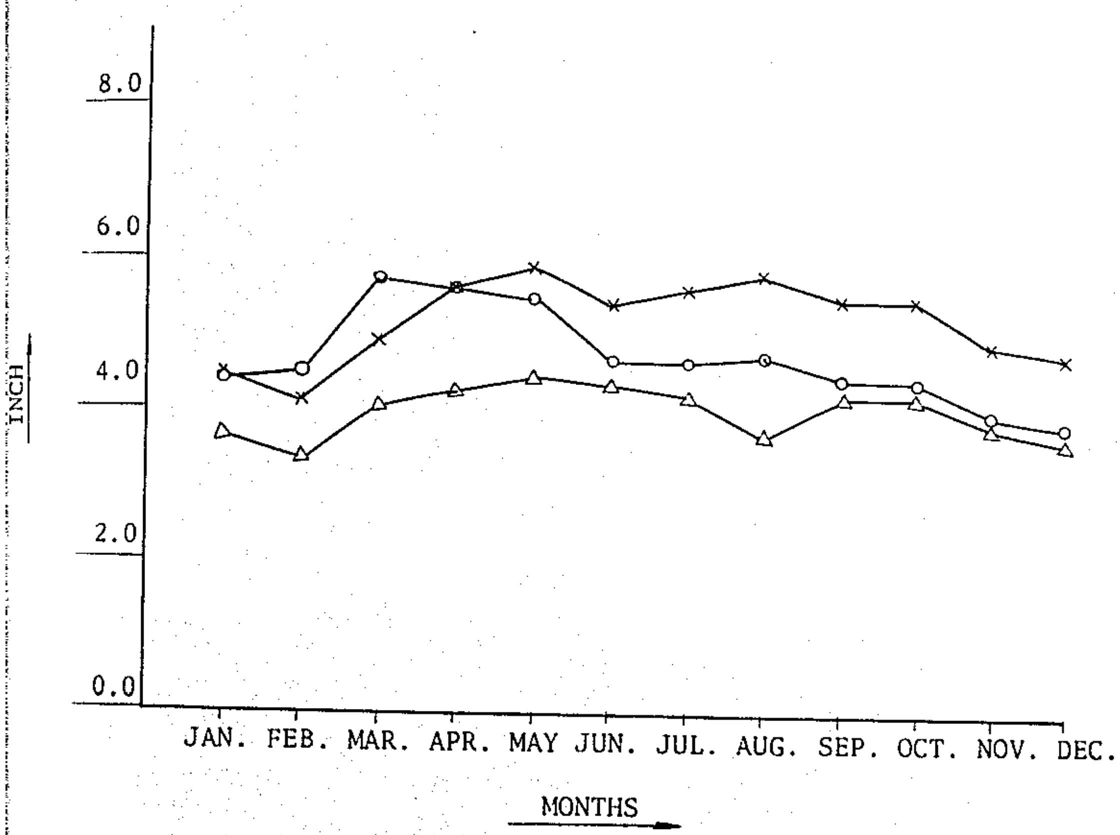
Net Irrigation Requirement (C) : (A) - (B)

Irrigation Water Requirement

Farm Head Gate Requirement (D) : (C)/0.65 0.65 : Irrigation Efficiency

Diversion Requirement (E) : (D)/1 - 0.15 0.15 : Conveyance Loss

Exhibit H-1



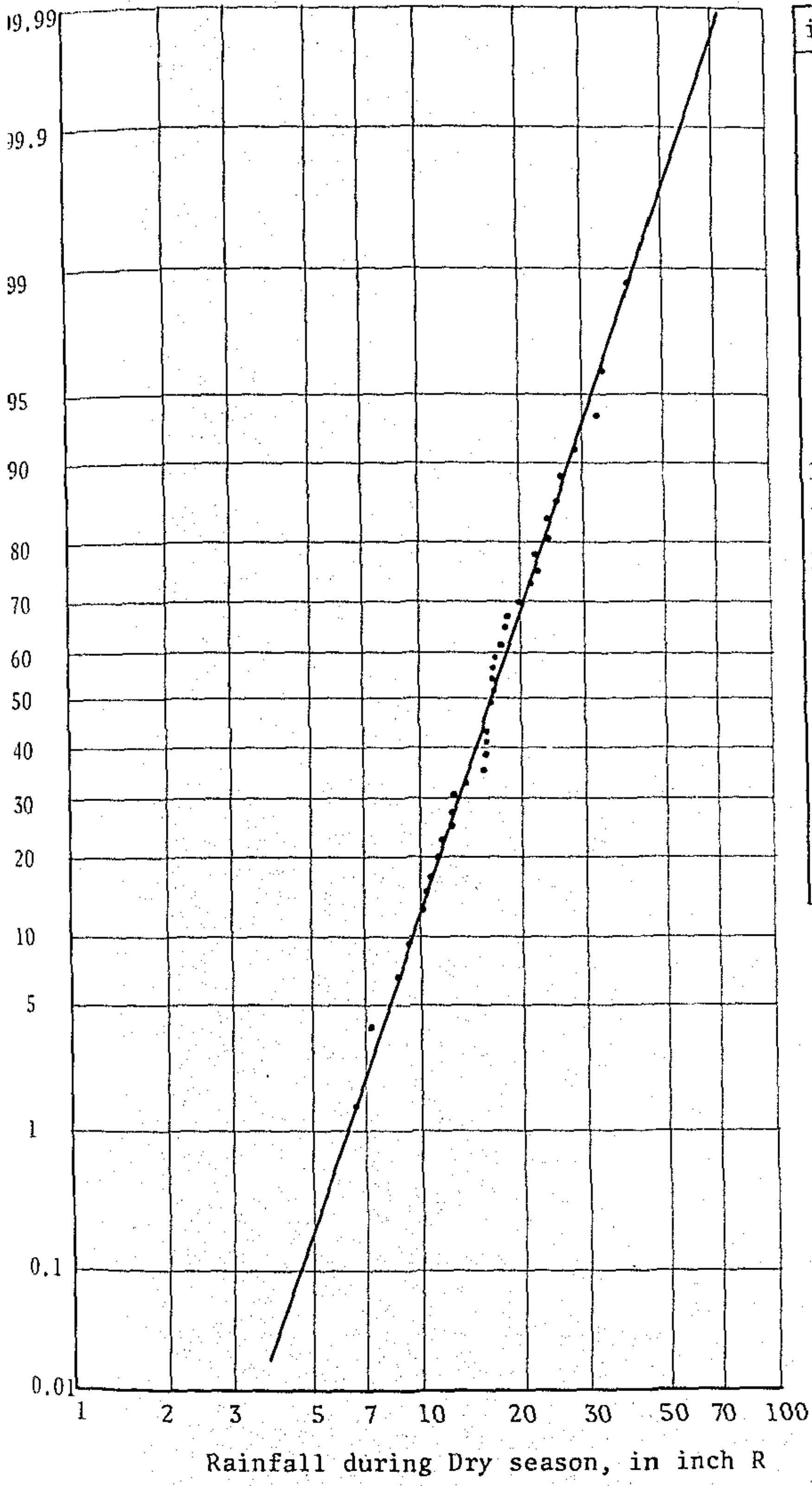
REMARKS

—o— CALCULATED VALUE BY PENMAN METHOD

—△— CALCULATED VALUE BY THORNWAITE METHOD

—×— DEVIDED FROM MR. SMITH (1966)
(SOURCE: "THE SCOPE FOR MECHANISATION OF VEGETABLE PRODUCTION IN ARANJUEZ TRINIDAD" PAGE 71)

MONTHLY VARIATION OF EVAPO-TRANSPIRATION

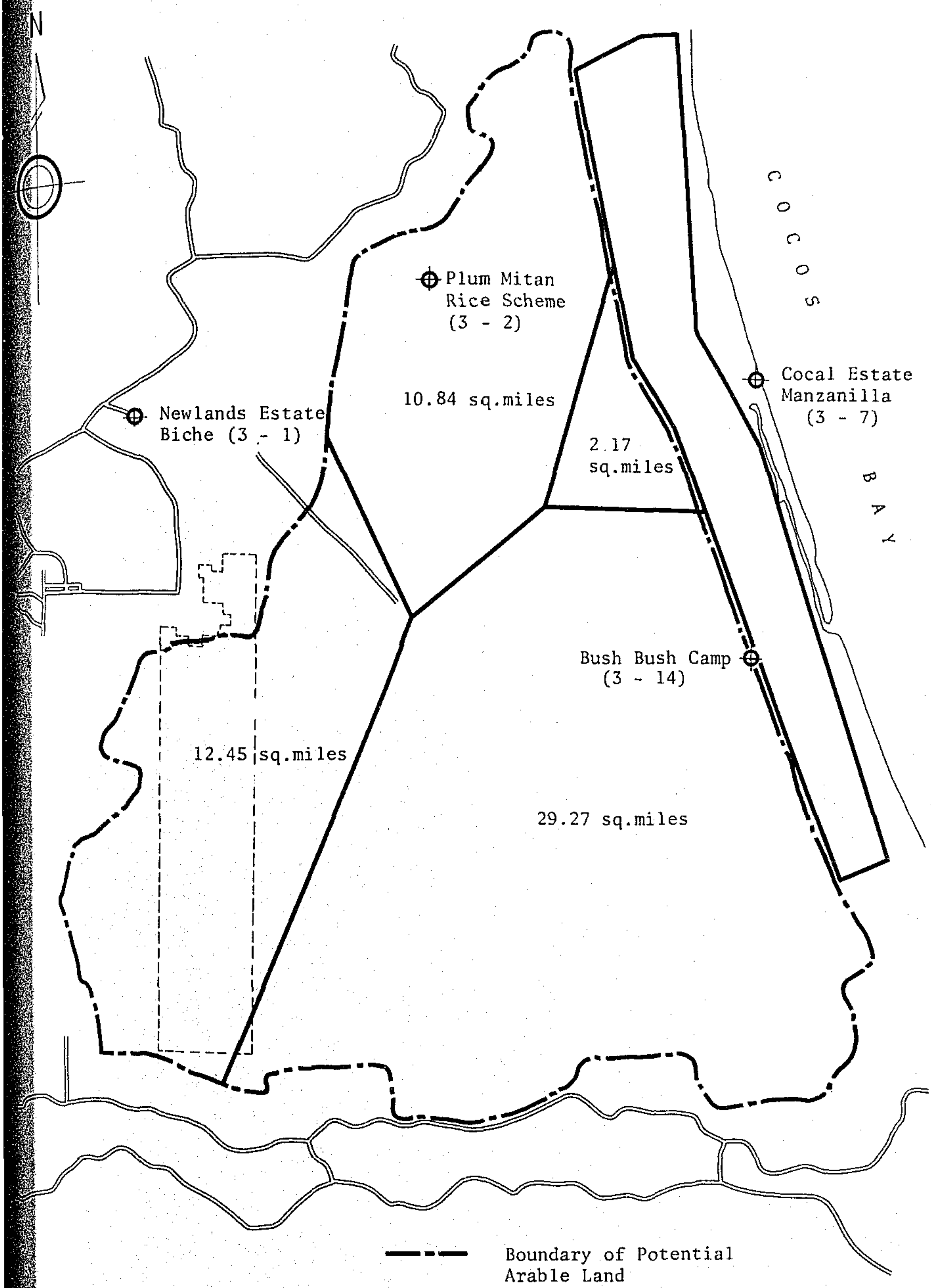


i	R	year	i	R	Year
1	6.68	'31	20	16.83	'60
2	7.29	'42	21	16.89	'57
3	8.73	'59	22	16.93	'64
4	9.40	'52	23	16.95	'39
5	10.25	'61	24	17.72	'54
6	10.34	'40	25	18.18	'67
7	10.94	'66	26	18.41	'63
8	11.42	'35	27	20.59	'58
9	12.19	'62	28	21.46	'56
10	12.79	'49	29	22.44	'53
11	12.88	'41	30	22.45	'37
12	13.09	'46	31	23.94	'68
13	14.17	'34	32	24.12	'33
14	15.72	'44	33	25.73	'48
15	16.05	'65	34	26.72	'43
16	16.09	'30	35	28.53	'32
17	16.22	'47	36	33.85	'38
18	16.32	'36	37	34.60	'50
19	16.67	'55	38	41.60	'51

i: Order from Minimum

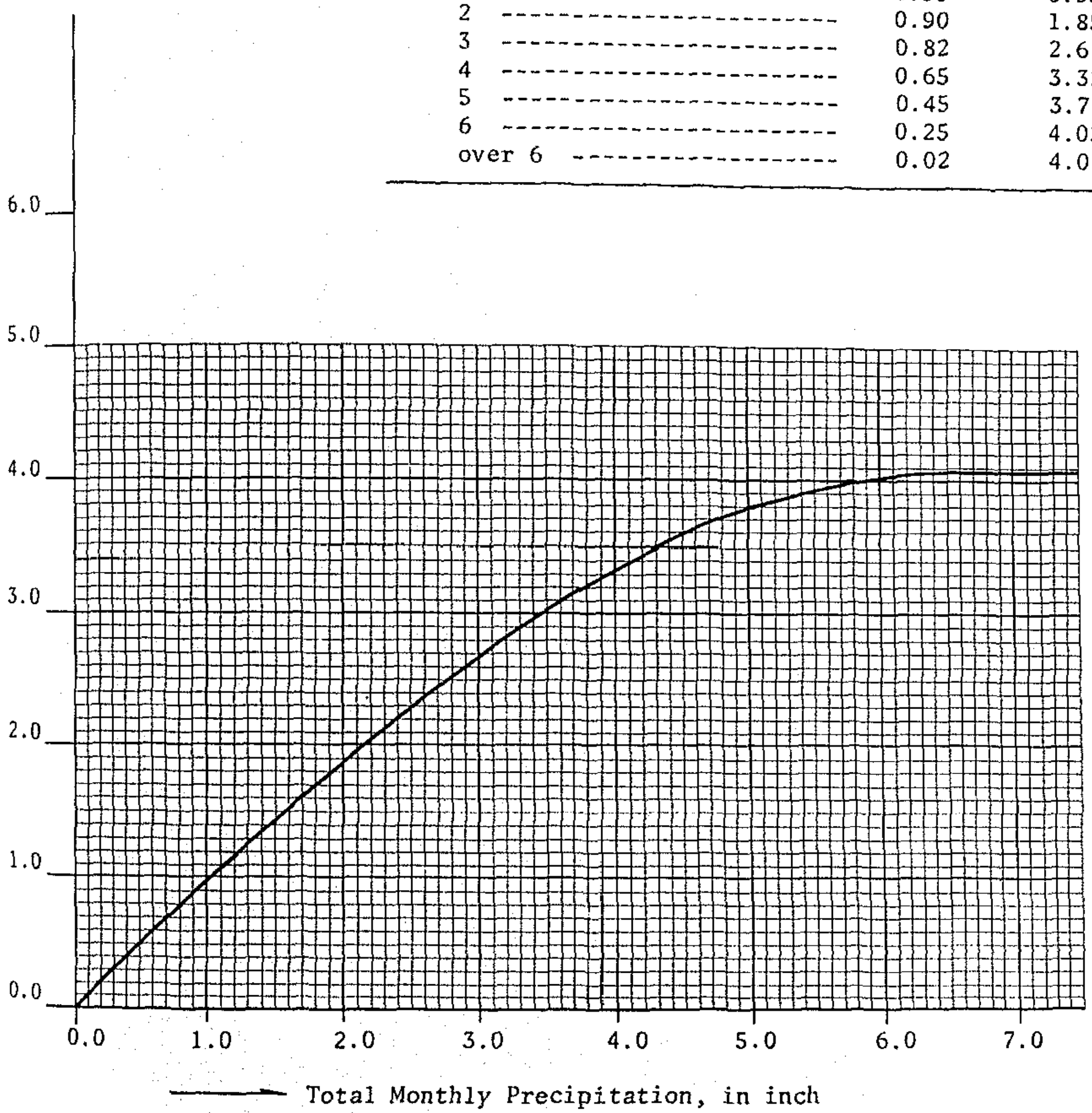
R: Rainfall in inch

Non-Exceeding Probability of Dry Season Rainfall by Harzen Paper at New Land Estate Biche



Divided Area by Thissen Method

Total Monthly Precipitation that might occure, in inch	Monthly Rainfall considered Effective, in inches	
	Part of Each inch Increment	Accumulated Total
1	0.95	0.95
2	0.90	1.85
3	0.82	2.67
4	0.65	3.32
5	0.45	3.77
6	0.25	4.02
over 6	0.02	4.07



* Souse: Federal Soil Conservation Service, Agricultural Research Service and Bureau of Reclamation Agencies

Appendix I

Irrigation Layout

Appendix I

Irrigation Layout

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Appendix I

Irrigation layout

General

Water requirement for the irrigable area in the basic year for irrigation planning (1961) is about 61,000 acre-feet (see Table I-6). For the storage of the water, it would be the most economical to construct a low reservoir around Bois Neuf, at the transitional portion of the downstream of the Navet Anho River, of which elevation is higher than the irrigable area due to the employment of a gravity irrigation system and where the flood water at the flood season is easily caught. The crest of this dike will be utilized for a main road in the irrigable area.

The storage capacity of the reservoir is correlated with the water requirement of cropping pattern in the irrigable area. But the water surface of the reservoir should be designed to be less than 120 feet in elevation in order to prevent submersion of private estate, poor drainage and destruction of wind belt behind the Nariva Swamp area. Upon completion of the reservoir, about 86% of watershed area will be regulated for drainage of the excess water from the watershed during the rainy season, by selection of the construction site of the reservoir along elevation of 110 feet between the Jagroma Cut and Bois Neuf and hilly zone linking with Bois Neuf and Bush Bush.

Determination of reservoir capacity

The storage capacity of the reservoir should be determined upon calculation of water balance of the reservoir every ten days in the basic year 1961 for Irrigation Planning.

Inflow to Reservoir

The quantity of inflow to the reservoir is obtained by a calculation on multiplying an effective rainfall by a watershed area.

Calculation of rainfall in the basic year of irrigation

The rainfall gauging stations stand at the Navet Reservoir Damsite (3-8), Navet Presbyterian School (3-9), Newland Estate Biche (3-1) and Bush Bush Camp, all of which are in the watershed area (D, E, F & G) around the reservoir. From calculation of an averaged design rainfall in the whole watershed area, the rainfall observed in Navet Presbyterian School is excluded due to non-correlation with Newland Estate Biche (see Appendix H). The daily rainfall in the basic year for irrigation (1961) were not observed for a full year at the Navet Reservoir Damsite and for dry season at Bush Bush Camp. Therefore, from the correlation with the data of Newland Estate Biche, the total precipitation during the rainy and dry seasons are obtained. Then the data for the Navet Reservoir damsite are substituted with the 10-day discharge data assumed from the discharge rate by season of Newland estate with the total precipitation. The sphere of each rainfall gauging station observatory is shown in Table I-1, and the watershed area is devided, based upon "Thiessen method".

Table I-1 Dividing the Basin of Cocal Reservoir by Thiessen's Method

	Basin area	Percent
Newland Estate Biche	27.30 sq.mile	22.4 %
Navet Reservoir Damsite	56.68	46.6
Bush Bush Camp	37.64	31.0
Total	121.62	100.0

Table I-2 and Exhibit I-1 show an average rainfall of the whole watershed area corresponding to the above division.

Determination of runoff coefficient

An average monthly runoff coefficient is obtained by a calculation on the records of the year 1961-1966 observed in the Navet Reservoir discharge gauging station (3-2). Table I-3 and Exhibit I-1 show monthly mean runoff coefficient on the basis of observation records (Trinidard Water Resources Survey, Interim Report No.1). There are most of the years when the discharge is not perceived during March and April as shown clearly in Table I-3.

The basic year for irrigation planning is a drought year, which occurs in a probability of 1 to 8 years, and mean rainfall amounts up to 2.14 inches during March and 1.24 inches during April, so that the runoff ciefficient can be regarded as zero. The runoff coefficients of other months are obtained from the calculation and rounding up on the basis of an average monthly value of rinfall as shown in Table I-4.

Table I-4 Mean Monthly Average Run-off Coefficients

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
Run-off Coeffi-cients	21.0	14.0	0	0	10.0	34.0	42.0	28.0	28.0	38.0	26.0	43.0

Note: An annual mean runoff coefficient is 30.6 percent.

Calculation of inflow

An effective rainfall is obtained by multiplying mean rainfalls per 10 days in the watershed area by runoff coefficients as shown in Table I-2. The inflow is obtained by multiplying an effective rainfall by 121.62 square miles of the watershed area as shown in Table I-5.

Irrigation water requirement

Required irrigation water for the development scheme is obtained by multiplying 13.5 acres of cultivated land by diversion requirement (e) as shown in Table H-14 of Appendix H. In case monthly water requirement is connected to 10 days water requirement, a day ratio is used. The calculation process is shown in Table I-6.

Reservoir Capacity

Net Reservoir Capacity

Net water capacity of reservoir is determined to be equal to the maximum shortage of amount of the water by reducing irrigation water requirement from inflow amount in reservoir as shown in Table I-5. The calculation process is shown in Table I-6. From this table the net water capacity of reservoir is estimated at 26,600 acre-feet for the cropping pattern required in the development scheme.

Water loss from Reservoir

The water loss of reservoir is considered to be evaporation from the water surface and percolation from the foundation of dike.

Water surface evaporation: The water surface evaporation of the reservoir is obtained from the calculation on the base of evaporation per unit area and reservoir surface area.

To obtain the evaporation per unit water surface area, it is presented on when the actual values gauged at the Navet Reservoir Damsite from May 1967 (estimated values of A type evaporation) and values obtained from the calculation by "Perman Formula" in Table H-6 of Appendix H. It is shown on Exhibit I-2. The totaled value obtained from "Penman Formula" is 20.22 inches during the dry season (from January to April) which is a little larger than the gauged value 19.35 inches, and represents and intermediate value of actual values recorded during the wet season (from May to December) of the years, 1967 and 1968. As shown clearly in Table I-6, shortage of irrigation water occurs between the first part of February and the end of May of the following year. Therefore, as the evaporation values used for the determination of the storage capacity of the reservoir, the value obtained by "Penman Formula" used for determination of paddy irrigation water requirement. Assuming that the storage amount of nearly three fifth of 26,600 acre-feet of net storage capacity of reservoir is an average reservoir surface area (Ao), Ao is estimated at approximately 3,450 acres from Exhibit I-3 (storage water level, Surface area, and water quantity amount). The evaporation is estimated at 25.70 inches (approximately 2.1 feet) between the first part of February and the end of May of next year as shown in Exhibit I-2. Therefore, the whole evaporation is: 3,000 acres x 2.1 feet = 6,200 acre-feet.

Leakage

The dike of reservoir should be built up of impervious heavy clay distributed around the reservoir with uniformality. The cross section of the dike should be designed to be broad enough for the main road in the project area, and the creep length is to be extended, decreasing leakage.

On the other hand, the foundation of dime is composed of heavy clay, the permeability coefficient of which is 10^{-7} feet/sec at the depth of 5feet below the ground surface. Therefore, the leakage through the dike is considered small and is assumed to be 3 percent of net water storage capacity and the evaporation, and hence the leakage is calculated as follows: 32,800 acre-feet x 0.03 = 1,000 acre-feet.

Sediments

Almost of the watershed area "A" (121.62 sq.miles) on reservoir is covered with heavy clay, where limestone and tuff are hereabouts distributed. Therefore, it is naturally considered that the sediment discharge is estimated to be most distributed, in view of the topography. However, the watershed area is, as a whole, flat plain and covered with thick forest, and hence vegitation conditions is very favourable. An average annual rainfall amounts up to 77.9 inches, but the runoff ratio is only about 30 percent. The actual record is not, at present, available for sediment, the discharge of which is emperically accounted for 340 cu.yd/year/sq.mile (100 m^2/year/km^2).

The analysis year is for sediments is assumed 50 years as long as for economic analysis years.

Sediment: 340 cu.yd/yr./sq.mile x 50 yr x 121.62 sq.mile
= 2,067,540 cu.yd
= 1,282 acre-feet (approximately 1,300 acre-feet)

Reservoir capacity

On the basis of the aforementioned calculation, the factors, which shall determin the reservoir capacity corresponded with the proposed cropping pattern in the scheme development, are shown as follows:

Net water storage capacity	V_1 = 26,600 acre-feet
Evaporation of water surface of reservoir	V_2 = 6,200 acre-feet

Leakage from reservoir V_3 = 1,000 acre-feet

Effective water storage: $V_e = V_1 + V_2 + V_3$ = 33,800 acre-feet

Sediments V_4 = 1,300 acre-feet

The Reservoir Capacity is obtained sediments and effective water storage of reservoir.

A total of water storage: $V_T = V_e + V_4$ = 35,100 acre-feet

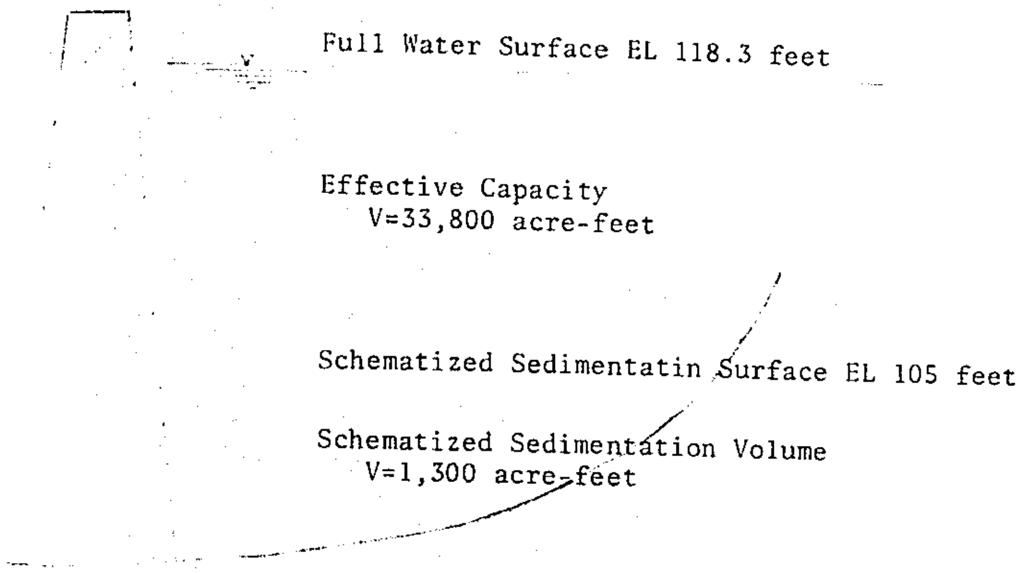
The water level at the peak storage based on the total of water storage is 118.3 feet (T.G.R.) as shown on Exhibit I-3. The reservoir capacity is generally, subject to the cropping pattern. In review of the imports of agricultural products and the marketing system in this country, according to the cropping patterns 3 cases are proposed, and the water storages of reservoir is 3 cases are shown as follows.

	Case I Cropping Pattern		Case II Cropping Pattern		Case III Cropping Pattern	
	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season
	M. 50% S. 50%	P. 100%	M.25%,S.25% P.50%	P.100%	P.100%	P.100%
	acre-feet		acre-feet		acre-feet	
Net Reservoir Capacity	13,000		26,600		40,600	
Evaporation	6,000		6,200		10,000	
Percolation	600		1,000		1,300	
Effective Capacity	19,600		33,800		51,900	
Sedimentation	1,300		1,300		1,300	
Total Capacity	20,900		35,100		53,200	

Note: 1. Case II shows the cropping pattern of the planned development.

2. M: Maize, S: Soybean and P: Paddy

The reservoir in the development scheme, with its elements are ellust-rated below:



The sediment is believed to be loaded, levelled at the lowest portion of the bottom of reservoir. But the sediment shows, in fact, a tendency to be loaded around the area, through which river water flows into the reservoir.

Layout of dam body

The crest of the 'Cocal' Reservoir is planned to be utilized for main road in the irrigable area. Therefore it should be considered upon determination of the size of dam body.

Dam type

Heavy clay prospected to be the foundation of dam is of the seepage coefficient of N x 10^{-7} feet/sec at the depth of 5 feet below the ground, so that there is no need of drawing up a particular design for ground seepage and pumping action. In case of heavy clay, the seepage resistivity is about 20 times per foot.

Also this heavy clay soil of which penetration registance is 20 times per foot, has a full characteristics of prevention capacity of leakage and strengthness for supporting the dam, necessary for the foundation of low dam. There are various types of dams. The most economic material is heavy clay of antiseepage action, which is only the available material around dam site. Accordingly the dam shall determined of a homogeneous type of "Earth Dam".

Standard section

Based on the design cropping pattern of the development scheme, the height of the dam with the crest is determined with the addition of free-board and wind wave-geight to the design flood level which is the water level of 1.2-time as much as flood water passing through a spillway in probability of 1 to 100 Major elements concerned with the height of crest are as follows:

Full water level of reservoir	118.3 feet (T.G.R.)
Estimated flood level of reservoir	121.4 feet (T.G.R.)
Wind wave-height (including the width of wave)	3.9 feet
Free-board	0.8 feet

The crest-height of dam is, therefore, 126.3 feet (T.G.R.)

In case of adoption of a homogeneous type of earth dam, the embankment slope should be a comparatively gentle slope in order to keep enough stability against the slip, according to the relations of pore pressure and shearing strength; 3 to 1 in the upperstream and 2.5 to 1 in the downstream. Main road in consideration of linking with roads in the irrigable area shall be arranged on the tip of the slope at the downstream, in order to make the dam body stabler on taking an advantage of counterweight action of the backfill. The standard cross-section of the Cocal r-servoir on the basis of the size of the dam body is shown in Exhibit I-4. The sizes of dam body according to 3 cases of the cropping patters are as follows.

	Case I Cropping Pattern		Case II Cropping Pattern		Case II Cropping Pattern	
	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season
	M. 50% S. 50%	P.100%	M.25%,S.25% P.50%	P.100%	P.100%	P.100%
	acre-feet		acre-feet		acre-feet	
Total Capacity	20,900		35,100		53,200	
Full Water Level	115.2 feet(T.G.R.)		118.3 feet(T.G.R.)		121.9 feet(T.G.R.)	
High Water Level	118.3 "		121.4 "		125.0 "	
Dam Crest	123.2 "		126.3 "		129.9 "	

Layout spillway

In consideration of connection to the Nariva Regulation Reservoir, the condition of topography and draining of flood water to Cocos Bay in the process of the 1st development, the spillway should be established on the hilly land of Bush Bush by excavation so as to be led to the present mouth of the Nariva river.

Schematic flood for spillway

As the flood water for the spillway, a 20 percent increase on the 100 years probability is to be adopted, based on the standard by the International Big Dam Conference. For the calculation for the schematic flood, Unit Hydrograph of Chapter II, Drainage and rainfall records of Newland Estate Biche is used.

Daily rainfall of Newland Estate Biche in a probability of 1 to 10	5.62 inches
Schematic daily rainfall for spillway (1.2 x daily rainfall in a probability of 1 to 10)	10.20 x 1.2 = 12.24 inches
Ratio of schematic daily rainfall for spillway to daily rainfall of Newland Estate Biche in a probability of 1 to 10.	12.24 ÷ 5.62 = 2.178

Peak discharge of the Cocal Reservoir on the basis of daily rainfall in a probability of 1 to 10 years — 9,443.1 ft^3/sec.

Schematic peak discharge for apillway
$9,443.1 \times 2.178 = 20,564.9$ ft^3/sec approx. 20,600 ft^3/sec.

Standard section

Spillway, which is of a overflow spillway with 4 flap gates of a 50-feet span, is 114.0 feet (T.G.R.) in height and 209 feet in width. The design flood water (3,531.5 ft /sec of flood in a probability of 1 to 10 years) in the drainage scheme can be discharged by overflowing those flap gates. The flap gates overturn automatically in excess of 121.4 feet (T.G.R.) of high-water level of reservoir. The design flood water for spillway can be discharged at the water level of 121.4 feet (T.G.R.) in a completely overturned position of the flap gates. The discharged water overflowing spillway is introduced into the Nariva Regulating Reservoir though a rabi and monsoon section of a open canal of a 520-feet-wide. Exhibit I-5 shows the design of a sizable spillway according to the above standards.

Conveyance system

A shortage of irrigation water should be filled up in the irrigation area from the Cocal reservoir. Major facilities are the outlets of Jagroma, Bois Neuf and Ortoire introducing water to the Plum Mitan Irrigation Canal, Bois Neuf Irrigation Canal and Ortoire Irrigation Canal from the Cocal reservoir. The size of each outlet and canal for irrigation are different according to the sphere areas. The structure and its cross-section of irrigation canal and outlet are shown in Exhibit I-4.

Water quality

The problem of water quality should be studied on drawing up an irrigation plan of the Nariva area. It is of the utmost importance to decide whether or not the present water quality is suitable for irrigation water. The current survey was made on salinity, electric conductivity and pH-value as shown in Table I-7. The water quality of this area was divided into 3 kinds: (1) River water inflowing into the swamp area from the moutainous area; (2) Water logged in the area; and (3) the water of L'Ebranche river and the Nariva river facing Cocos Bay. Since the survey was made from the middle to the end of dry season (March 24, 1969 to April 13, 1969), the rivers connected to the swamp area were in a shortage condition of the water and the logged water in the area was considered condenced so that concentration of salinity and total salinity concentration, which is closely related to electric conductivity, are at the peak. and also it is assimed that the water was less than the average in L'Ebranche River and the Nariva River which have their mouths on Cocos Bay. Therefore, it is easy to regard the survey result as the one on the most severe condition, in view of the water quality.

River water inflowing into Nariva swamp

From the Cuche River (W-1), the Canque River (W-3), the Navet River (W-7) and the Bois Neuf River (W-8), 4 in all as representatives of rivers of which waters inflow from the mountainous are into the swamp area, the water was sampled. The results of the survey are as follows:

	Midstream of the Cuche River	Downstream of the Canque River	Downstream of the Navet River	Upperstream of the Neuf River
Salinity	300-440 ppm	350-460 ppm	270 ppm	250 ppm
Electric conductivity	μv/cm 1,300 - 1,800	μv/cm 1,500-1,900	1,200 μv/cm	1,100 μv/cm
pH-value	6.6	7.1	-	-

The river water inflowing from mountainous area into swamp area is concluded to be suitable for irrigation, from the above data.

Existing logged water within Nariva swamp

Logged water was surveyed at Jagroma (W-2), along the Keranham Road (W-5, W-6) in the waterway of Plum Mitan (W-9, W-10) and Dabllon Bason (W-13). The results of the survey are as follows;

	Jagroma	Plum Mitan	Dabblon
Salinity	1,150-1,600 ppm	320-500 ppm	720 ppm
Electric conductivity	3,300-4,000 μv/cm	1,400-2,000 μv/cm	2,800 μv/cm
pH-value	-	6.4-7.0	7.1

Judging from the above values, the logged water has almost no problem except for water quality showing salinity of 1,150-1,600 ppm at the road side trench of the Kerananham Road eastsouth of Nariva swamp area. Such being the case crops, which are weak in the antisalinity, should be provided with fresh water for field irrigation during dry season, in order that the crops may not be damaged by salinity.

River water draining into the Cocos Bay

The Nariva and the L'Ebranche river are only the two rivers that are flowing into the Cocos Bay. The survey was made on water quality at 4 places of the downstream (W-4) and the midstream (W-14) of the Nariva river and also the midstream (W-11) and the L'Ebranche river mouth (W-12). The results of the survey of the Nariva river are as follows.

	Midstream of the Nariva river (W-4)	Downstream of the Nariva river (W-14)
Salinity	10,000 ppm	13,000 ppm
Electric conductivity	20,000 μv/cm	25,000 μv/cm

In consideration of the vegitation condition of mangrove, around 4.4 miles from the Cocos Bay is considered effected by the tide. The present water quality of the Nariva river is not suitable for irrigation water. On the other hand the results of the survey of the L'Ebranche river are as follows.

	Midstream of the L'Ebranche river (W-11) (A point intersected at eastern main road)	L'Ebranche river mouth (W-12)
Salinity	11,500 ppm	13,000 ppm
Electric conductivity	22,000 μv/cm	25,000 μv/cm
pH-value	7.5	7.9

The midstream and the mouth of the L'Ebranche river clearly show the feature of a tidal compartment. Flesh water of the upperstream of the L'Ebranche river would be introduced into the Nariva area in consideration of utilization of the river water for irrigation.

However, consideration on the problems of construction costof waterway and the decreased river water of the L'Ebranche would make introduction of fresh water into Nariva area unreasonable. After all, the river water of the L'Ebranche and the Nariva rivers is not suitable for utilization of irrigation water. The survey period was so short that the survey was not made on micro-element of chemical components such as boron, magnesium, manganese and calcium. The next survey will clarify the elements of these chemical components.

Agricultural community plan

By the development of the Nariva swamp area, large-sized agricultural land will be reclamated, where many settlers are engaged in agricultural and new villages will be borne. The establishment plan of village, therefore, should be made in anticipation of a long-term agricultural development of the Nariva swamp area.

General plan

The development stage of the Nariva area is divided into the 1st and the 2nd stages. The project area of the 1st stage is a relatively high-lying area along Plum Mitan northwest of the Nariva and a central village is placed. The new village shall be provided with a function of a control center. The community plan includes production, administration, education, purchasing, culture, recreation, for the purpose of which besides of the housing plot, the land of 150 acres for the central village and 100 acres for ordinary villages should be secured. According to the spheres of cultivation land, one village should be established around Bois Neuf and the other one in the irrigable area.

Facilities and equipments

Agricultural production and public facilities which are to be provided for a model village and 2 ordinary villages on the basis of the community plan are as follows:

		Central village houses	ordinary villages 2 houses per village	Total houses
Farming household	House with vegetable garden	200	200	640
Agricultural production facilities	Warehouse of farm machinery	7	7	21
	Agricultural cooperative	1	1	3
	Warehouse of agricultural cooperative	1	1	3
	Rice center	1	1	3
	Motor pool	1	-	1
	Distributing facility	1	1	3
	Agricultural pilot farm	1	-	1
Education	Primary school	1	1	3
Purchasing center	Shop	10	10	30
Administration	village office	1	-	1
Culture	Assembly hall	1	1	3
Health and welfare	Clinic	1	-	1
Recreation center	Park	1	-	1
	Athletic ground	1	1	3
Public facilities	Water supply facility	1	1	3
	Distribution center	1	1	3
	Village road	1	1	3
Religious center	Church	2	2	6
	Grave yard	1	1	3

Farm houses

In view of an enviromental improvement of village life and an effective utilization of public facilities, developed village, farm houses should be grouped, separated from cultivation land and agricultural production facilites. Farm house is a type of high-standing base with a 0.5-acre housing lot.

Warehouse of farm machinery

1 unit includes agricultural machinery and implement for 450 - 500 acres farming and the warehouse of farm machinery should be provided for 30 to 40 farm houses for a storage of farm machinery and implements, covering 5,380 sq.feet per floor space.

Workshop of farm machinery

The workshop of farm machinery should be provided for a central village for repair and maintenance of farm machinery.

Rice center

Drying, cleaning and packing of rice, hulled rice storage, and packing and storing of Maize and soybean are to be conducted. The rice center, which should be established, according to the following seale in every ordinary village, should deal with the whole production of the village.

Floor space		14,200 sq. feet
Selectors of raw materials	3.0 ton/hour	2 units
Dryer for unhulled rice	2.4 ton/12-hour	3 units
Container for storage of unhulled rice	20 x 20 x 17 feet	15 pcs.
Ventilation equipment		1 unit
Rice polishing machinery	2 ton/12-hour	2 units
Belt convayer		1 units
Scale		1 units
Electric equipment		1 units

The scales of facilities are based on the following calculation.

° Production quantity of paddy rice

Annual production quantity:	3,650 ha x 4.0 ton/ha = 14,600 ton
Annual consumption of farming household:	640 farming households x 10 persons per household x 0.17 ton = 1,088 ton
Seedrice:	3,650 ha x 0.15 ton = 548 tons
Loss of paddy rice in farm land:	14,600 x 0.02 = 292 tons
Possession of paddy rice per farming household:	1,088 + 548 + 292 = 1,928 tons

Annual rice storage is 50% of the whole production quantity deducted from the possession of paddy rice of farming household.

(14,600-1,928)1/2 = 6,336 tons

6,336 x 1/3 - 2,112 tons per village

° Capacity of rice dryer

Number of days receiving paddy rice:	70 days
Production quantity per village:	12,672 x 1/3 = 4,224 tons
Received quantity per day:	4,224 x 1/70 = 60.3 tons

° Capacity of rice polishing machinery

Production quantity is precessed within 6 months.

4,224 ton x 1/24days x 6 months ..... Approx. 30 tons per day

° Storage of unhulled rice

Unhulled rice should be stored in a wooden-made container (6m x 6m x 5.5m) with iron sheet plated.

3,000 x 1/(6x5.5) = 90 m 15 sets

° Floor space of rice center

Space for container for storage of unhulled rice	6 pcs. x 90 m = 540 m^2
Space for rice dryer	300 m^2

Space for rice polishing machinery	100 m^2
Other space	300 m^2
Office space	80 m^2
Total	1,320 m^2 (approx. 14,200 sq.feet)

Agricultural Experimental Station

Agricultural Experimental station shall conduct experiment, research, guidance in services on crops specified in the Nariva area, (rice, maize and soybean) soils, fertilizer, disease, insect and cultivation machines.
For these, the following land and building are to be provided.

Water supply

Trunk distribution water pipe should be installed from the end of the existing water supply pipe line to the central and ordinal village though Plum Mitan, from which the pipe lines are to be diverted to individual houses and facilites.

Extension of main water distribution pipe line: 10 miles
Extension of sub water distribution pipe line: 6 miles

will be necessary.

Power distribution line

Power, of which the distribution has already been installed on the road from Nanzanilla to Mayaro, should be transmitted by branched lines to flood gate, agricultural production facility and village for the industrial and domestic utilization.

Extension of main power distribution line: approx. 10 miles

Village roads

Village roads should be paved with pitch, which is a special product of this country, from main road of the planned development area to each facility and farm house of villages. Paved roads should be net 10 feet in width with an extension of approximately 5 miles.

Cost

The construction cost of an agricultural cooperative facilities established in villages are as follows. The public facilities, which are anywhere essential to the settlement of farmers, are not included in the irrigation project cost, but financed by the Budget of the Government.

Farm house	T.T.$26,000 per farm house	640 farm houses	T.T.$1,664,000
Warehouse for farm machinery and implements	15,000 per warehouse	21 warehouses	315,000
Rice center	400,000 per units	3 units	1,200,000
Warehouse	15,000 per warehouse	3 warehouses	45,000
Building of motor-pool		1 builidng	30,000
Building of motor-facility		1 building	30,000
Building of agricultural pilot farm		1 building	200,000
		Total:	3,484,000

The construction cost of rice center per unit with ground space was estimated as follows;

Builidng of rice center	14,200 sq. feet	T.T.$ 79,200
Rice polishing machinery (30 tons)	1 units	55,000
Dryer for unhulled rice (30 tons)	3 units	36,000
Container for storage of unhulled rice	15 units	150,000
Ventilation equipment	1 units	10,000
Machinery for selecting raw materials (3.0 ton/hour)	2 units	10,000
Automatic scale	1 unit	15,000
Belt convayer	1 unit	4,000
Power & electric facilities	1 unit	38,600
	Total:	T.T.$397,800
	approx.	T.T.$400,000

Table I-2

Mean Precipitation during each 10 days

	Newland Estate Biche Precipitation inches	Ratio (%)	22.4% inches	Bush Bush Camp Precipitation inches	31.0% inches	Navet Reservoir Damsite Precipitation inches	46.6% inches	Mean Precipitation inches
Jan. 1-10	0.94	9.2	0.21	0.86	0.27	0.63	0.29	0.77
11-20	0.78	7.6	0.17	0.71	0.22	0.52	0.24	0.63
21-31	3.40	33.2	0.76	3.11	0.96	2.26	1.05	2.77
Sub-total	5.12	50.0		4.68		3.41		4.17
Feb. 1-10	0.29	2.8	0.06	0.26	0.08	0.19	0.09	0.23
11-20	0.38	3.8	0.09	0.36	0.11	0.26	0.12	0.32
21-28	0.29	2.8	0.06	0.26	0.08	0.19	0.09	0.23
Sub-total	0.96	9.4		0.88		0.64		0.78
Mar. 1-10	1.44	14.0	0.32	1.31	0.41	0.96	0.45	1.18
11-20	0.02	0.2	0.00	0.02	0.01	0.01	0.00	0.01
21-31	1.18	11.5	0.26	1.07	0.33	0.78	0.36	0.95
Sub-total	2.64	25.7		2.40		1.75		2.14
Apr. 1-10	0.95	9.3	0.21	0.87	0.27	0.63	0.29	0.77
11-20	0.23	2.2	0.05	0.20	0.06	0.15	0.07	0.18
21-30	0.35	3.4	0.08	0.32	0.10	0.23	0.11	0.29
Sub-total	1.53	14.9		1.39		1.01		1.24
Total	10.25	100.0		9.35		6.81		8.33
May 1-10	0.21	0.3	0.05	0.07	0.02	0.20	0.09	0.16
11-20	0.18	0.2	0.04	0.18	0.06	0.14	0.07	0.17
21-31	2.15	2.9	0.48	1.41	0.44	1.98	0.92	1.84
Sub-total	2.54	3.4		1.66		2.32		2.17
June 1-10	5.34	7.0	1.20	2.51	0.78	4.77	2.22	4.20
11-20	2.76	3.6	0.62	2.77	0.86	2.46	1.15	2.63
21-30	1.98	2.6	0.44	1.87	0.58	1.77	0.82	1.84
Sub-total	10.08	13.2		7.15		9.00		8.67
July 1-10	5.35	7.1	1.20	5.14	1.59	4.84	2.26	5.05
11-20	6.46	8.5	1.45	3.12	0.97	5.80	2.70	5.12
21-31	1.34	1.8	0.30	2.16	0.67	1.23	0.57	1.54
Sub-total	13.15	17.4		10.42		11.87		11.71
Aug. 1-10	4.50	5.9	1.01	3.47	1.08	4.02	1.87	3.96
11-20	1.56	2.1	0.35	1.71	0.53	1.43	0.67	1.55
21-31	1.92	2.5	0.43	1.78	0.55	1.71	0.80	1.78
Sub-total	7.98	10.5		6.96		7.16		7.29
Sep. 1-10	6.51	8.6	1.44	6.39	1.98	5.87	2.74	6.16
11-20	3.13	4.1	0.70	2.35	0.73	2.80	1.30	2.73
21-30	1.48	2.0	0.33	2.23	0.69	1.36	0.63	1.65
Sub-total	11.12	14.7		10.97		10.03		10.54
Oct. 1-10	4.16	5.5	0.93	2.90	0.90	3.75	1.75	3.58
11-20	3.07	4.1	0.69	1.81	0.56	2.80	1.30	2.55
21-31	5.41	7.1	1.21	8.35	2.59	4.84	2.26	6.06
Sub-total	12.64	16.7		13.06		11.39		12.19
Nov. 1-10	1.90	2.5	0.43	2.08	0.64	1.70	0.79	1.86
11-20	0.96	1.3	0.22	0.76	0.24	0.89	0.41	0.87
21-30	10.79	14.2	2.42	10.94	3.39	9.69	4.52	10.33
Sub-total	13.65	18.0		13.78		12.28		13.06
Dec. 1-10	2.76	3.6	0.62	1.83	0.57	2.45	1.14	2.33
11-20	0.59	0.8	0.13	0.77	0.24	0.55	0.26	0.63
21-31	1.25	1.7	0.28	0.51	0.16	1.16	0.54	0.98
Sub-total	4.60	6.1		3.11		4.16		3.94
Total	75.76	100.0		67.11		68.21		69.57
Grand Total	86.01			75.31		75.02		77.90

Table I-3

Runoff Ratio (Navet Reservoir)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1961	4.73	1.39	1.88	0.75	2.30	9.68	13.75	6.21	12.83	13.19	7.90	4.06	78.64
	0.52	0.28	Nil	Nil	0.59	0.91	4.17	Nil	7.13	6.10	1.82	1.22	22.74
1962	3.34	3.90	0.33	2.33	3.31	11.18	12.87	11.55	6.60	5.37	9.53	8.52	78.83
	0.61	0.10	Nil	Nil	Nil	2.70	4.20	5.36	1.10	1.94	0.80	2.80	19.01
1963	3.80	2.80	2.50	2.24	11.37	12.24	10.43	7.61	14.87	1.31	9.84	6.95	85.96
	1.40	0.64	Nil	0.37	2.40	3.60	5.30	0.98	2.00	0.24	3.20	3.20	23.33
1964	3.75	1.96	1.08	5.86	4.45	19.54	5.33	6.40	13.38	16.88	7.85	12.00	108.48
	0.63	0.95	0.17	0.34	0.13	7.83	8.75	Nil	5.00	7.30	4.80	5.30	40.60
1965	8.27	3.05	1.88	1.19	8.23	14.16	9.00	10.85	7.89	11.70	13.24	9.19	98.65
	1.98	0.66	Nil	0.06	0.44	5.16	3.78	4.34	1.52	2.47	4.41	4.36	29.18
1966	2.18	1.87	0.87	1.33	5.28	26.88	12.34	6.97	13.05	9.85	15.15	8.18	103.95
	0.46	0.13	0.12	Nil	Nil	12.20	4.96	3.45	2.42	4.87	1.70	4.34	34.65
Total	26.07	14.77	8.51	13.70	34.94	93.68	73.72	47.59	68.62	58.30	63.51	48.90	554.51
	5.60	2.16	0.29	0.77	3.56	32.40	31.16	14.13	19.17	22.32	16.73	21.22	169.51
Mean	4.35	2.50	1.42	2.28	5.82	15.61	12.29	8.27	11.44	9.72	10.59	8.15	
	0.93	0.36	0.05	0.13	0.59	5.40	5.19	2.36	3.20	3.72	2.79	3.54	
Mean Runoff Ratio	21.4	14.4	3.5	5.7	10.1	34.6	42.2	28.1	28.0	38.3	26.3	43.4	30.6
Determined Runoff Ratio	21.0	14.0	0	0	10.0	34.0	42.0	28.0	28.0	38.0	26.0	43.0	

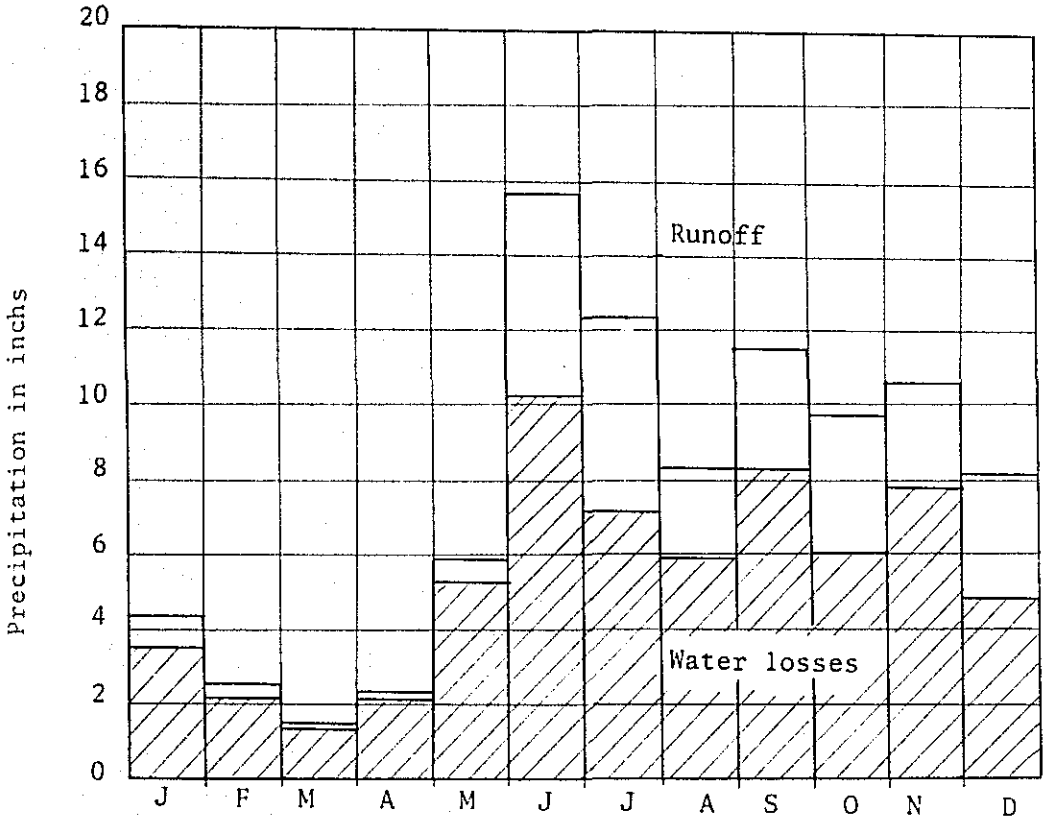
Table I-5

Estimate of Inflow

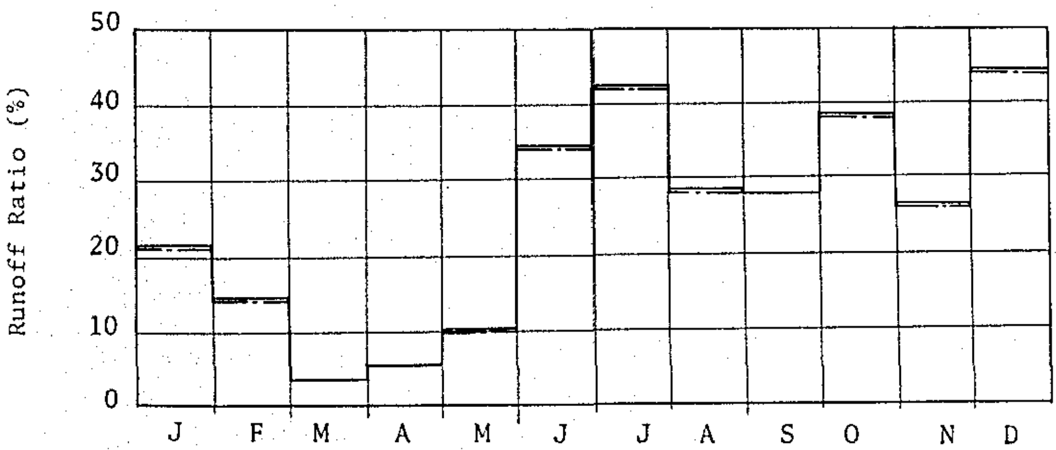
		Mean Precipitation	Runoff Ratio	Effective Precipitation	Inflow
		inches	%	inches	acre-feet
Jan.	1-10	0.77		0.16	1,039
	11-20	0.63	21.0	0.13	844
	21-31	2.77		0.58	3,767
Feb.	1-10	0.23		0.03	195
	11-20	0.32	14.0	0.04	260
	20-28	0.23		0.03	195
Mar.	1-10	1.18		0.0	
	11-20	0.01	0	0.0	
	21-31	0.95		0.0	
Apr.	1-10	0.77		0.0	
	11-20	0.18	0	0.0	
	21-30	0.29		0.0	
May	1-10	0.16		0.02	130
	11-20	0.17	10.0	0.02	130
	21-31	1.84		0.18	1,169
June	1-10	4.20		1.43	9,289
	11-20	2.63	34.0	0.89	5,781
	21-30	1.84		0.63	4,092
July	1-10	5.05		2.12	13,771
	11-20	5.12	42.0	2.15	13,965
	21-31	1.54		0.65	4,222
Aug.	1-10	3.96		1.11	7,210
	11-20	1.55	28.0	0.43	2,793
	21-31	1.78		0.50	3,248
Sep.	1-10	6.16		1.72	11,172
	11-20	2.73	28.0	0.76	4,937
	21-30	1.65		0.46	2,988
Oct.	1-10	3.58		1.36	8,834
	11-20	2.55	38.0	0.97	6,301
	21-31	6.06		2.30	14,940
Nov.	1-10	1.86		0.48	3,118
	11-20	0.87	26.0	0.23	1,494
	21-30	10.33		2.69	17,473
Dec.	1-10	2.33		1.00	6,496
	11-20	0.63	43.0	0.27	1,754
	21-31	0.98		0.42	2,728
Total		77.90		23.76	154,335

Table I-6 Estimate of Net Reservoir Capacity

		(1) Inflow (acre-feet)	(2) Irrigation Water Requirement					(1)-(2) (acre-feet)	Cumulative value (acre-feet)
			Fields		Paddy		Total Requirement		
			Effective Precipitation (inches)	Water Requirement (acre-feet)	Effective Precipitation (inches)	Water Requirement (acre-feet)	(acre-feet)		
					Paddy	100%			
May	1-10	130						130	-18,445
	11-20	130			5.96	4,499	4,479	-4,349	-22,794
	21-31	1,169			6.55	4,923	4,923	-3,754	-26.548
June	1-10	9,289			3.17	2,383	2,383	6,906	∓26,600
	11-20	5,781			3.17	2,383	2,383	3,398	
	21-30	4,092			3.18	2,390	2,390	1,702	
July	1-10	13,771			1.82	1,368	1,368	12,403	
	11-20	13,965			1.82	1,368	1,368	12,597	
	21-31	4,222			2.01	1,511	1,511	2,711	
Aug.	1-10	7,210			3.35	2,518	2,518	4,698	
	11-20	2,793			3.35	2,518	2,518	275	
	21-31	3,248			3.68	2,766	2,766	482	
Sep.	1-10	11,172			1.51	1,135	1,135	10,037	
	11-20	4,937			1.51	1,135	1,135	3,802	
	21-30	2,988			1.52	1,142	1,142	1,846	
Oct.	1-10	8,834						8,834	
	11-20	6,301			Harvest Time			6,301	
	21-31	14,940						14,940	
Nov.	1-10	3,118	Maize	25%	Paddy	50%		3,118	
	11-20	1,494	Soybean	25%	1.26	473	473	1,021	
	21-30	17,473			1.26	473	473	17,000	
Dec.	1-10	6,496			4.36	1,638	1,638	4,858	
	11-20	1,754	0.60	225	4.36	1,638	1,863	- 109	
	21-31	2,728	0.67	252	4.79	1,800	2,052	676	
Jan.	1-10	1,039	0.45	169	4.28	1,608	1,777	- 738	
	11-20	844	0.45	169	4.28	1,608	1,777	- 933	
	21-31	3,767	0.49	184	4.72	1,774	1,958	1,809	
Feb.	1-10	195	2.35	883	6.14	2,307	3,190	-2,995	-2,995
	11-20	260	2.35	883	6.14	2,307	3,190	-2,930	-5,925
	21-28	195	1.89	710	4.92	1,845	2,555	-2,360	-8,285
Mar.	1-10		2.04	767	5.97	2,243	3,010	-3,010	-11,295
	11-20		2.04	767	5.97	2,243	3,010	-3,010	-14,305
	21-31		2.25	846	6.58	2,473	3,319	-3,319	-17,624
Apr.	1-10		2.53	951			951	-951	-18,575
	11-20		Harvest Time					0	-18,575
	21-30							0	-18,575
Total		154,335					60,724		

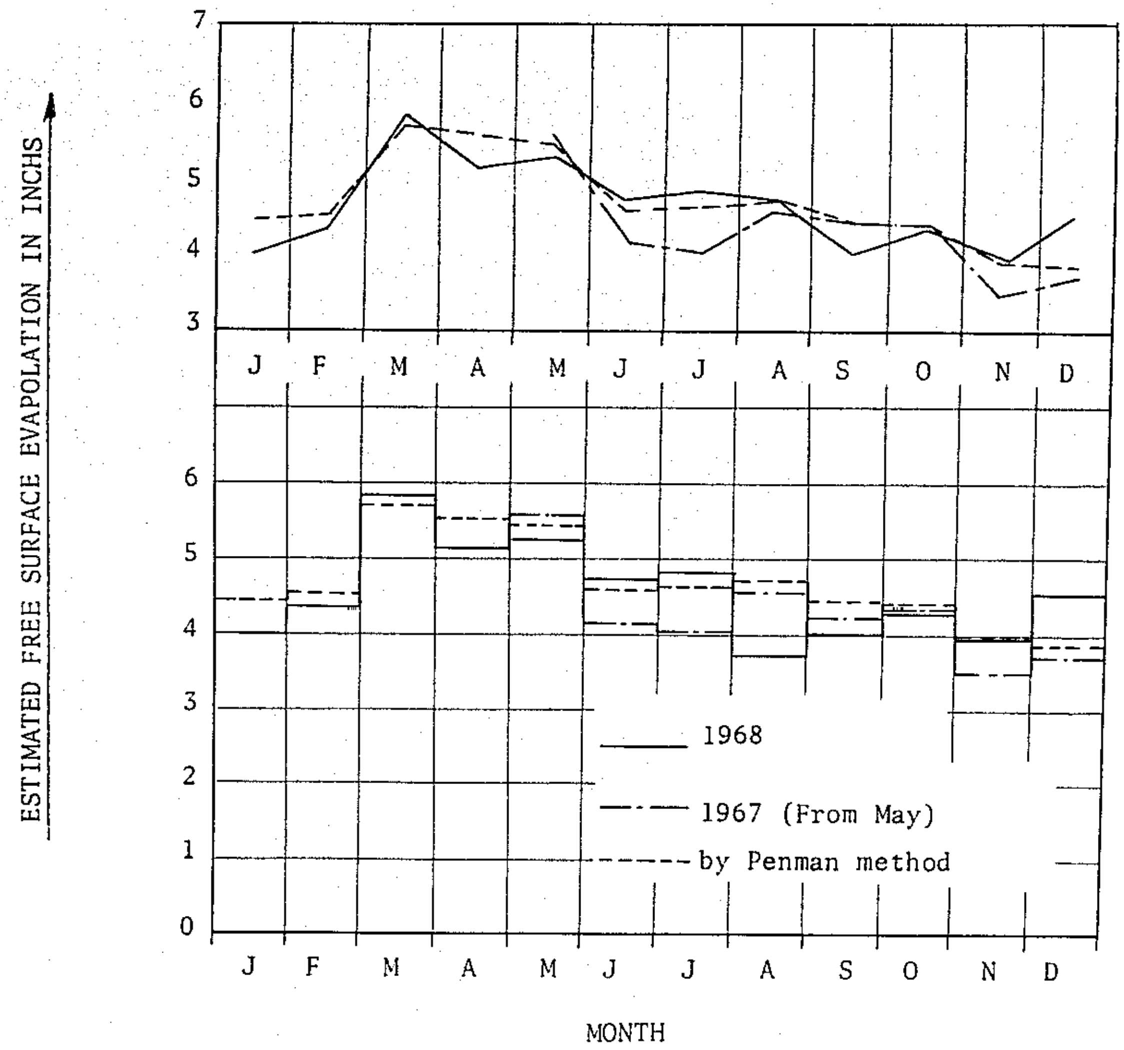


MEAN MONTHLY PRECIPITATION AND RUN OFF
AT STATION 3.2 NAVET RESERVOIR



MEAN MONTHLY RUNOFF RATIO

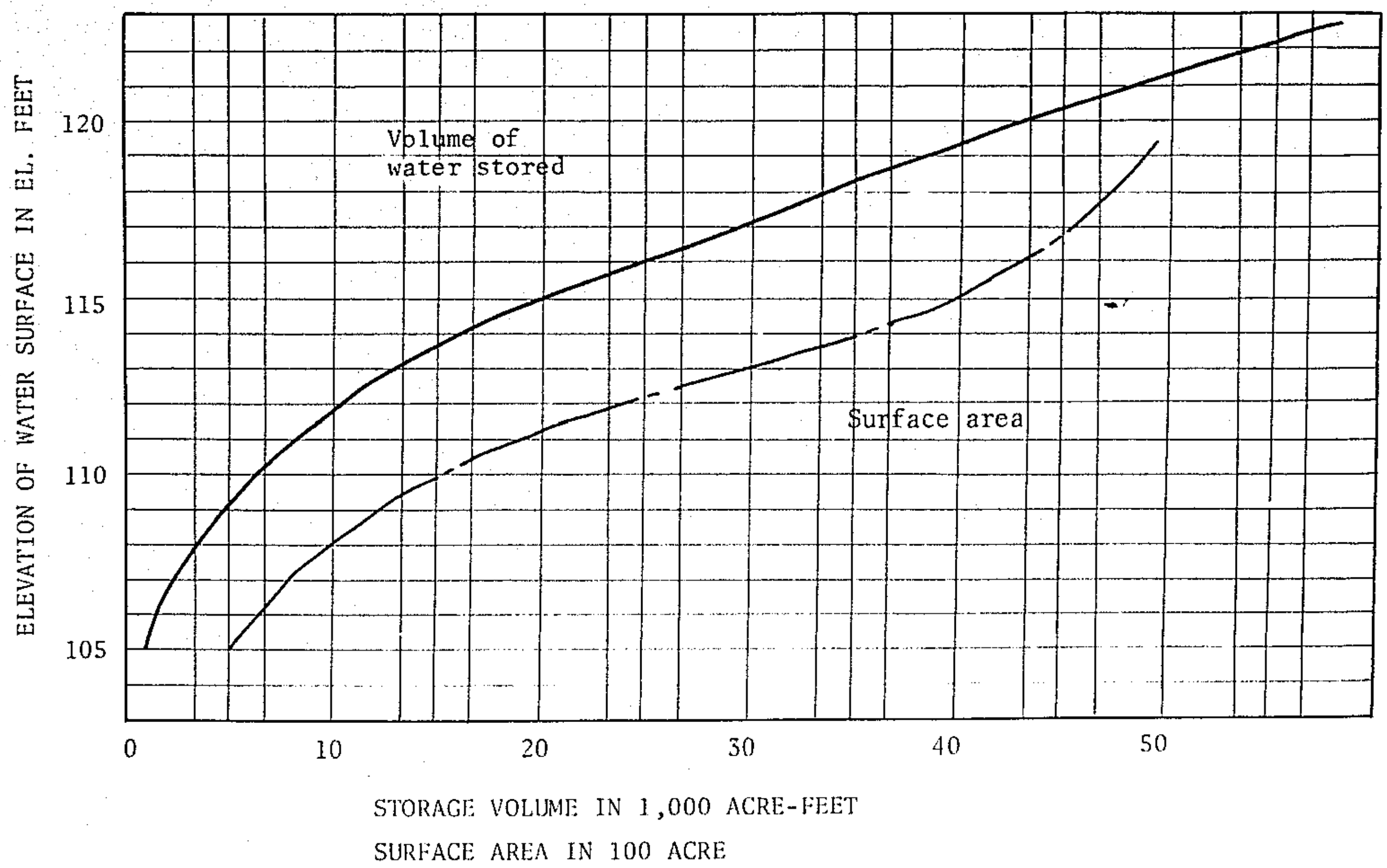
Mean Monthly Runoff Ratio



Month	From Report 1967	From Report 1968	By Penman Method
Jan.		4.00	4.44
Feb.		4.36	4.52
Mar.		5.82	5.70
Apr.		5.17	5.56
May	5.61	5.30	5.48
Jun.	4.20	4.73	4.61
Jul.	4.07	4.85	4.64
Aug.	4.60	3.76	4.75
Sep.	4.29	4.09	4.48
Oct.	4.43	4.33	4.41
Nov.	3.51	3.97	3.95
Dec.	3.72	4.55	3.89

ESTIMATE OF FREE SURFACE EVAPORATION

Exhibit I-3



Surface Area of A Reservoir and Volume of Water Storage

Appendix J

Geology and Foundation

Appendix J

Geology and Foundation

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Appendix J

Geology and Foundation

Geological Outline

The northern half of the Nariva area is a central uplift area being composed of relatively old formations of the Cretaceous and Paleogene of Tertiary Systems. The north-western side is covered by moderately lower member of the Paleogene.

The southern half of the area forms a very flat low land, inwhere the Nariva Swamp spreads out.

Many rivers and streams pour into the swamp through watershed area of said geological systems. The watershed area consists of relatively old formations; the Cuche Member of the Cretaceous System, the Paint-A-Pierre Member of the Paleogene-Eocene and the Brasso Member of the Neogene. The Nariva Member of the Oligocene forms the low hilly land in the western area. Relatively young formations, so-called the Lengua and Cruse Members of the Miocene compose slanting hilly land in the southern area. Along the Cocos Bay, sandbank extends, in the form of spit, to the south-north direction and prevents drainage from the inland area. At the inside of sandbank, flat alluvial plain developes consisting of muddy deposits which are cultivated by the rivers flowing through the mountainous land behind the Nariva Swamp. The alluvial plain located close to the sandbank is under worse drainage condition as the ground surface of the plain is around the sea level. A part of the swamp forms tidal compartment.

Foundation Investigations

At the points shown in Exhibit J-1, the geological investigations were made to clarify condition of foundation of major structures for the project. Permeability and penetration tests and undisturbed sampling were performed on the five bore-holes. Three test pits were digged and a series of soil test was carried out on the samples from the pits.

Subsurface Exploration

To grasp the condition of foundation of the major structures, five boreholes of 175 ft in total lengths were drilled. Permeability and standard penetration tests were made together with the coring in each hole. The permeability and penetration resistance (N-value) are listed in Table J-1. The depth taken, color and classification of samples from the holes are shown in Table J-2. Table J-3 shows physical properties of samples from the holes. Table J-4 is physical properties of samples taken from the Hole No.2 by shelby sampling tube. Exhibit J-2 shows the result of grain-size analysis on the samples from the Hole Nos. 1, 2 and 5.

The drilling and sampling for the subsurface exploration were carried out by the Drainage Department of the Ministry of Works. The soil tests were performed by the University of West Indies.

Surface Exploration

For the surface exploration, soil samples were taken from three test pits of 1.64 ft (0.50 m) deep each. Table J-5 shows the result of physical tests; grain-size analysis, specific gravity, and moisture content, made by the University of West Indies.

Table J-1

Geological Log of Bore Hole

All borings are plotted to a scale of 1" = 8 ft. Date: May 1969

No.1

		N-Value
0	Med Br Sand	11
4.5	Med Grey Sand	16
7.0	Med Grey Sand & Shells	21, 17
14.0	Coarse Grey Sand Large Gravel	17, 21
17.0	Very Hard Grey Clay Fine Sand Little Silt	60/4, 60/6, 60/5, 60/6, 70/6, 60/4, 60/6
50.0		

Tried For Sample at 14' & 15'
No Sample Due to Large Gravel

Drove 18' Casing Very Hard
Driving

No.2

		N-Value
0	Stiff Br Clay Trace of Sand	8, 6
8.5	Stiff Br Grey Clay	13
14.5	Soft Med Grey Clay Trace of Sand & Silt	5
20.0	Med Grey Sand	50, 30, 33, 27
33.0		

4'-6'	Shelby	No.1	2"x24"
9'-11'		No.2	2"x24"
14'-16'		No.3	2"x24"
19'-21'		No.4	2"x24"

16' Water Level

5'	15 Minutes	3"	$2.2x10^{-6}$cm/sec
10'	15 "	4"	$3.0x10^{-6}$ "
15'	15 "	5"	$3.7x10^{-6}$ "
20'	15 "	6"	$4.4x10^{-6}$ "

No.3

		N-Value
0	Soft Med Grey Br Clay	4
3.0		2, 3, 2, 3, 4
16.0		

No Water in Borehole But
Clay Damp

Permeability

No.1 Hole

5' No Water
Fill Hole with Water

	15 Minutes	1.5'	$9.6x10^{-5}$cm/sec
10'10	"	1"	
15	"	2"	$1.2x10^{-5}$ "
15'10	"	2"	
15	"	3"	$1.2x10^{-5}$ "
20'15	"	4"	$1.6x10^{-5}$ "
25'15	"	6"	$2.4x10^{-5}$ "
30'15	"	7"	$2.8x10^{-5}$ "
35'15	"	5"	$2.0x10^{-5}$ "
40'15	"	4"	$1.6x10^{-5}$ "
45'15	"	5"	$2.0x10^{-5}$ "
50'15	"	5"	$2.0x10^{-5}$ "

After Completing Boring Water
Stayed at Top of Hole for 3 Hrs
Water Level 3' After 16 Hrs.

Classifications are made by visual inspection.

Water levels (WL). Figure indicates time of reading (hours) after completion of boring. Water levels indicated are those observed when borings were made, or as noted. Porosity of the soil strata, variations of rainfall, site topography, etc., may cause changes in these levels.

Figures in right hand column indicate number of blows required to drive 2" O.D. sampling pipe one foot, using 140-lb. weight falling 30 inches.

Total Footage 119
Foreman BASANTA
Classification by F SCHEID
Sheet 1 of 2

Table J-1

Geological Log of Bore Hole (cont'd)

All borings are plotted to a scale of 1" = 8 feet.

Date: May 1969

No.4

Depth (ft)	Description	N-Value
0 – 8.0	Med Br Clay	5, 4, 6
8.0 – 21.0	Soft Grey Clay	2, 4, 4
21.0 – 26.0	Stiff Grey & Br Clay Trace of Sand	27, 31

Dry Hole No Water

No.5

Depth (ft)	Description	N-Value
0 – 8.0	Med Br Sand	12, 10, 12
8.0 – 13.0	Med Coarse Grey Sand & Shells	10
13.0 – 18.0	Coarse Med Grey Sand & Shells	16
18.0 – 22.0	Med Br Sand & Shells	10
22.0 – 38.0	Fine & Med Br Grey Sand & Shells	16, 14, 15
38.0 – 42.0	Fine to Coarse Grey Sand	17
42.0 – 48.0	Med to Fine Grey Sand	16
48.0 – 50.0	Fine Grey Sand	18

Had to Drive 49 Casing Due to Sand

Permeability

No.5 Hole

5'	10	Minutes	1'-8"	
	15	"	2'-6"	1.4x10⁻⁴cm/sec
10'	10	"	4'-6"	
	15	"	4'-6"	unpermeable
15'	10	"	4'-6"	
	15	"	4'-6"	unpermeable
20'	5	"	3'-6"	
	10	"	3'-8"	
	15	"	3'-8"	1.1x10⁻⁵cm/sec
25'	10	"	2'-2"	
	15	"	2'-2"	unpermeable
30'	10	"	3'-0"	
	15	"	3'-6"	6.8x10⁻⁵cm/sec
35'	5	"	3'-0"	
	10	"	4'-0"	
	15	"	4'-6"	1.0x10⁻⁴cm/sec
40'	10	"	4'-0"	
	15	"	4'-6"	6.8x10⁻⁵cm/sec
45'	5	"	2'-0"	
	10	"	3'-0"	
	15	"	4'-6"	
	18	"	4'-6"	1.4x10⁻⁴cm/sec
50'	5	"	2'-0"	
	10	"	3'-0"	
	15	"	4'-0"	
	17	"	4'-6"	
	20	"	5'-6"	
	23	"	5'-6"	

Water Level In Hole 5'-6" Pulled 5'-6"

Pulled Casing to 20 Water Level was 5'-6"
" " " 15 " " 3'-2"
" " " 10 " " 3'-2"
All Casing Out of Hole " " at 3'-2"

Classifications are made by visual inspection.

Water levels (WL). Figure indicates time of reading (hours) after completion of boring. Water levels indicated are those observed when borings were made, or as noted. Porosity of the soil strata, variations of rainfall, site topography, etc., may cause changes in these levels.

Figures in right hand column indicate number of blows required to drive 2" O.D. sampling pipe one foot, using 140-lb. weight falling 30 inches.

Total Footage 76
Foreman ST CLAIR
Classification by F SCHEID
Sheet 2 of 2

Table J-2

Split Spoon Samples - Sample Identification and Descriptions

Hole No.	Sample No.	Depth	Description
1	1	2' - 3'	moist light brown uniform fine sand
1	2	4' - 5'	moist light brown uniform fine sand
1	3	6' - 7'	wet grey uniform very fine sand
1	4	9' - 10'	wet grey uniform very fine sand
1	5	19'-19'-4"	dark grey silty clay (disturbed)
1	6	24'-24'-6"	hard dark grey dry silty clay
1	7	29'-29'-5"	hard dark grey dry silty clay
1	8	34'-34'-6"	hard dark grey dry silty clay
1	9	39'-39'-6"	hard dark grey dry silty clay
1	10	44'-44'-4"	hard dark grey dry silty clay
1	11	49'-6"-50	hard dark grey dry silty clay
2	1	2' - 3'	Stiff light brown clay
2	2	6' - 7'	stiff clay light grey with brown mottlings
2	3	11' - 12'	stiff clay light grey with grave sommlings
2	4	16' - 17'	dark grey organic clay
2	5	21' - 22'	light grey uniform very fine sand
2	6	24' - 25'	light grey uniform very fine sand with inclusions of black uniform very fine sand.
2	7	29' - 30'	light grey uniform fine sand with pieces of shale
2	8	32' - 33'	light grey uniform fine sand with occasional piece of shale
3	1	2' - 3'	light grey clay with rust brown inclusions
3	2	4' - 5'	light grey clay with rust brown inclusions
3	3	6' - 7'	soft grey clay with rust brown inclusions
3	4	9' - 10'	soft grey clay with rust brown inclusions
3	5		grey and rust brown clay

Table J-2

Split Spoon Samples - Sample Identification and Descriptions (cont'd)

Hole No.	Sample No.	Depth	Description
4	1	2' - 3'	rust brown and mottling grey clay
4	2	4' - 5'	rust brown and mottling grey clay
4	3	6' - 7'	rust brown and mottling grey clay
4	4	9' - 10'	soft grey and brown clay
4	5	14' - 15'	soft grey and brown clay
4	6	19' - 20'	soft grey and brown clay
4	7	23' - 24'	light grey clay with purple inclusions
4	8	25' - 26'	light grey clay with purple inclusions
5	1	2' - 3'	grey and brown uniform fine sand
5	2	4' - 5'	grey brown uniform fine sand
5	3	6' - 7'	grey brown uniform fine sand (wet)
5	4	9' - 10'	dark grey organic fine sand with small shells
5	5	14' - 15'	dark grey organic fine sand with small shells
5	6	19' - 20'	grey uniform fine sand trace of shells
5	7	24' - 25'	grey uniform fine sand trace of shells
5	8	29' - 30'	grey brown fine sand, trace of silt, occasional shell
5	9	34' - 35'	grey brown uniform fine sand trace of silt
5	10	39' - 40'	grey brown very fine silty sand, trace of shells
5	11	44' - 45'	grey brown very fine silty sand, trace of shells
5	12		very fine brown silty sand trace of clay

Table J-3

Splits Spoon Samples - Soil Tests

Hole No.	Sample No.	Depth	Water Content %	Liquid Limit %	Plastic Limit %	Plasticity Index %
1	6	24'-24'6	12.2	37.4	17.1	20.3
1	7	29'-29'-5"	10.4			
1	9	39'-39'6"	10.4	38.1	20.5	17.6
1	10	44'-44'-4"	10.9			
1	11	49'-6"-50'	10.6	38.6	22.2	16.4
2	1	2'-3'	22.1	51.7	22.8	28.9
2	2	6'-7'	27.9			
2	3	11'-12'	23.3	72.5	32.1	40.4
2	4	16'-17'	68.3	84.4	49.4	35.0
2	5	21'-22'	21.4			
2	6	24'-25'	24.2			
2	7	29'-30'	16.3			
2	8	32'-33'	20.5			
3	1	2'-3'	36.8			
3	2	4'-5'	38.1	91.1	37.6	53.5
3	3	6'-7'	42.2			
3	4	9'-10'	46.8	89.2	41.8	47.4
3	5		29.2	49.3	23.1	26.2
4	1	2'-3'	30.1			
4	2	4'-5'	23.4			
4	3	6'-7'	26.1	67.1	29.1	38.0
4	4	9'-10'	33.5			
4	5	14'-15'	26.3	74.7	23.2	51.5
4	6	19'-20'	27.0			
4	7	23'-24'	17.9			
4	8	25'-26'	13.8	30.4	13.6	16.3
5	12		22.2	Non Plastic		

Table J-4

Shelby Tube Samples - Soil Test

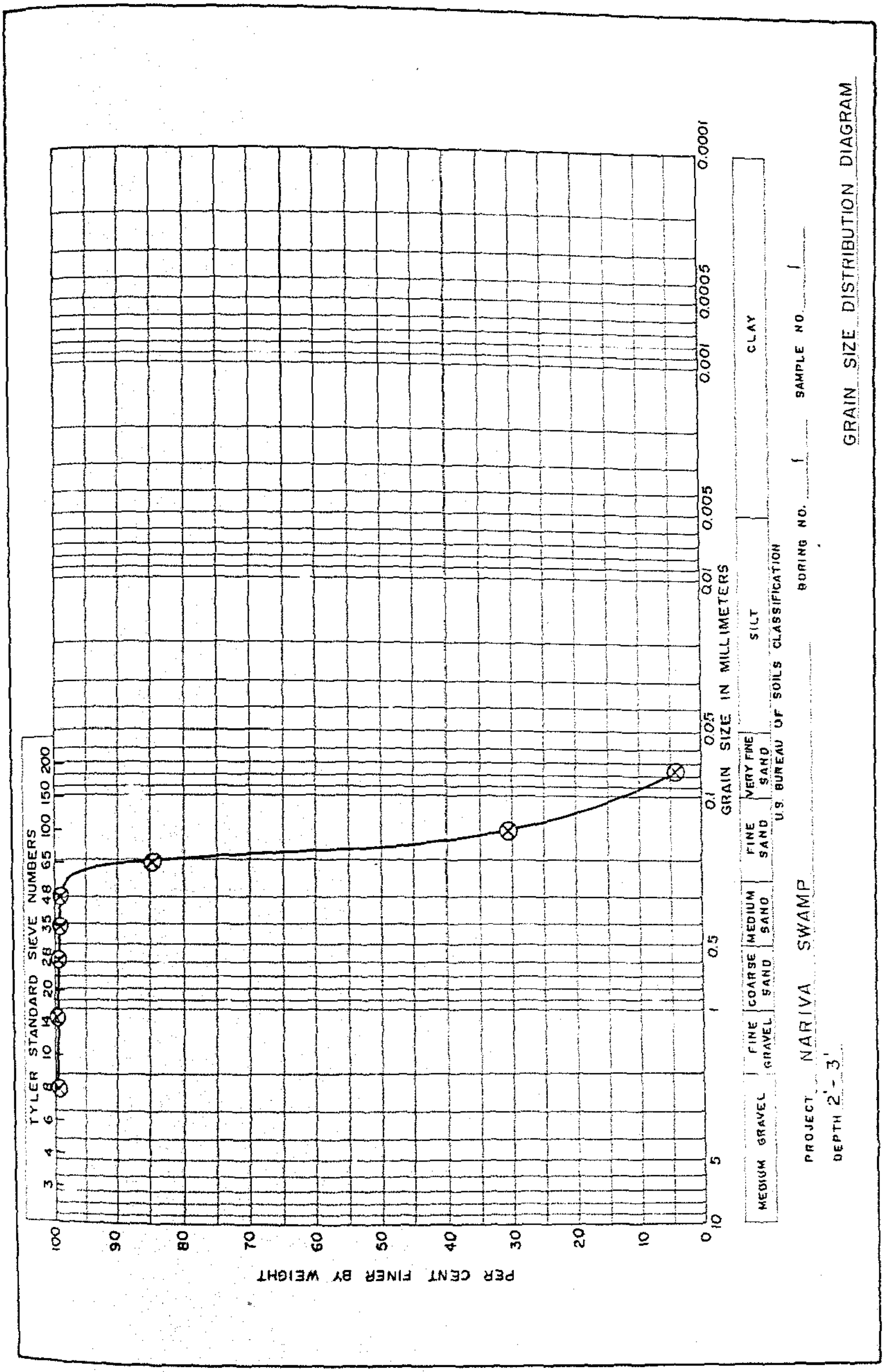
Hole No.	Sample No.	Depth	Water Content %	Liquid Limit %	Plastic Limit %	Plasticity Index	Dry Density lbs/sq.ft	Unconfined Compressive Strength Undisturbed lbs/sq.in	Unconfined Compressive Strength % Strain	Unconfined Compressive Strength Remoulded lbs/sq.in	Description
2	1	4'-6'	21.9	65.5	28.4	37.1	91.5	98.0	8.9	17.2	Moist Very Stiff Grey Brown Mottled Clay.
2	2	9'-11'	20.3	58.8	36.5	22.3	90.9	78.5	16.0	44.7	Moist Very Stiff Rust Brown & Grey Mottled Clay.
2	3	14'-16'	35.9	60.5	21.1	39.4	73.2	46.0	12.0	13.3	Wet Medium Light Grey Clay, Organic Spots.
2	4	19'-21'	32.0	-	-	-	-	-	-	-	Light Grey Soft highly Organic Clay Changing to Grey Fine Sand. (Middle to Test)

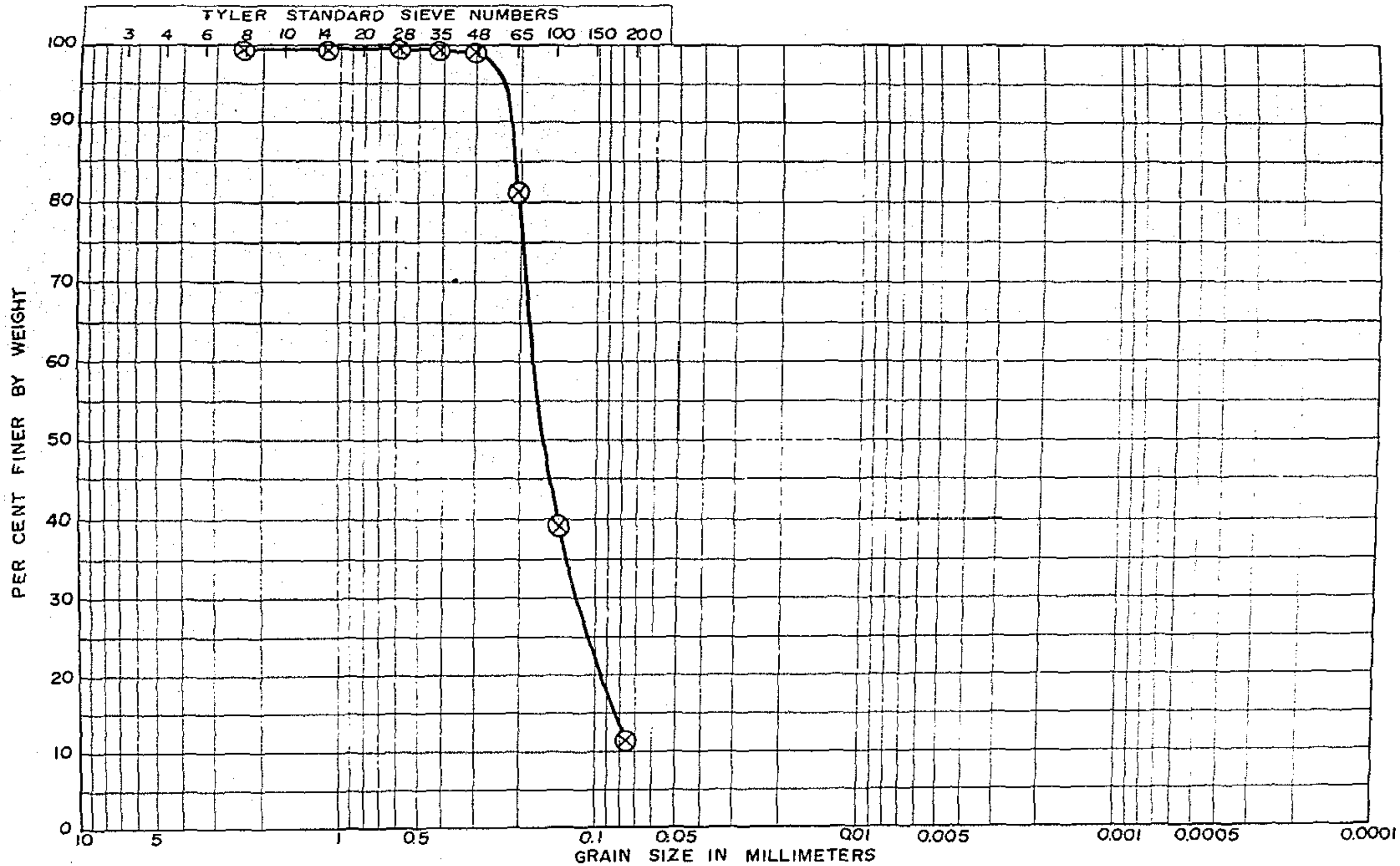
Table J-5

Test Pits - Soil Test

Sampling point		Sampling depth	Gradation analysis			Real specific gravity	Apparent specific gravity	Porosity	Field moisture %	Wilting point P.F=3.7	Moisture equivalent 2.7	Field capacity P.F=1.5
			Fine sand	Silt	Clay							
		m										
No.2 upper	1	0.25	Trace	15	84	2.64) 2.65	-	-	76.3) 74.5	25.1	52.5) 52.5	100.0) 98.0
"	2	0.25	Trace	15	84	2.66	-	-	72.7		52.4	96.0
No.2 lower	1	0.50	Trace	15	84	2.67) 2.70	-	-	83.6) 82.2	24.0	53.0) 53.6	104.0) 103.4
"	2	0.50	Trace	15	84	2.73	-	-	80.8		54.1	102.9
No.4 upper	1	0.25	5	11	84	2.69) 2.72	-	-	38.3) 37.3	26.3	48.6) 48.5	90.9) 90.4
"	2	0.25	7	13	80	2.74	-	-	36.3		48.3	89.9
No.4 lower	1	0.50	3	17	80	2.70) 2.71	-	-	41.1) 43.3	28.1	50.2) 50.5	94.5) 90.8
"	2	0.50	5	13	82	2.72	-	-	45.5		50.7	87.0
No.6 upper	1	0.25	5	13	82	2.61) 2.61	-	-	75.2) 76.8	27.8	54.7) 54.9	100.9) 107.4
"	2	0.25	5	13	82	2.60	-	-	78.5		55.0	113.9
No.6 lower	1	0.50	7	11	82	2.59) 2.61	-	-	79.5) 80.8	26.4	57.9) 57.8	107.8) 110.3
"	2	0.50	6	12	82	2.62	-	-	82.1		57.7	112.5
No.2 1)		0.15		-		2.55	0.81	68.2	83.8	-	-	-
No.6 1)		0.15		-		2.42	0.70	71.1	93.0	-	-	-

1) By undisturbed sampling


GRAIN SIZE DISTRIBUTION DIAGRAM
TYLER STANDARD SIEVE NUMBERS
3 4 6 8 10 14 20 28 35 48 65 100 150 200
PER CENT FINER BY WEIGHT
100 90 80 70 60 50 40 30 20 10 0
10 5 1 0.5 0.1 0.05 0.01 0.005 0.001 0.0005 0.0001
GRAIN SIZE IN MILLIMETERS
MEDIUM GRAVEL
FINE GRAVEL
COARSE SAND
MEDIUM SAND
FINE SAND
VERY FINE SAND
SILT
CLAY
U.S. BUREAU OF SOILS CLASSIFICATION
PROJECT NARIVA SWAMP
BORING NO. 1
SAMPLE NO. 1
DEPTH 2'-3'



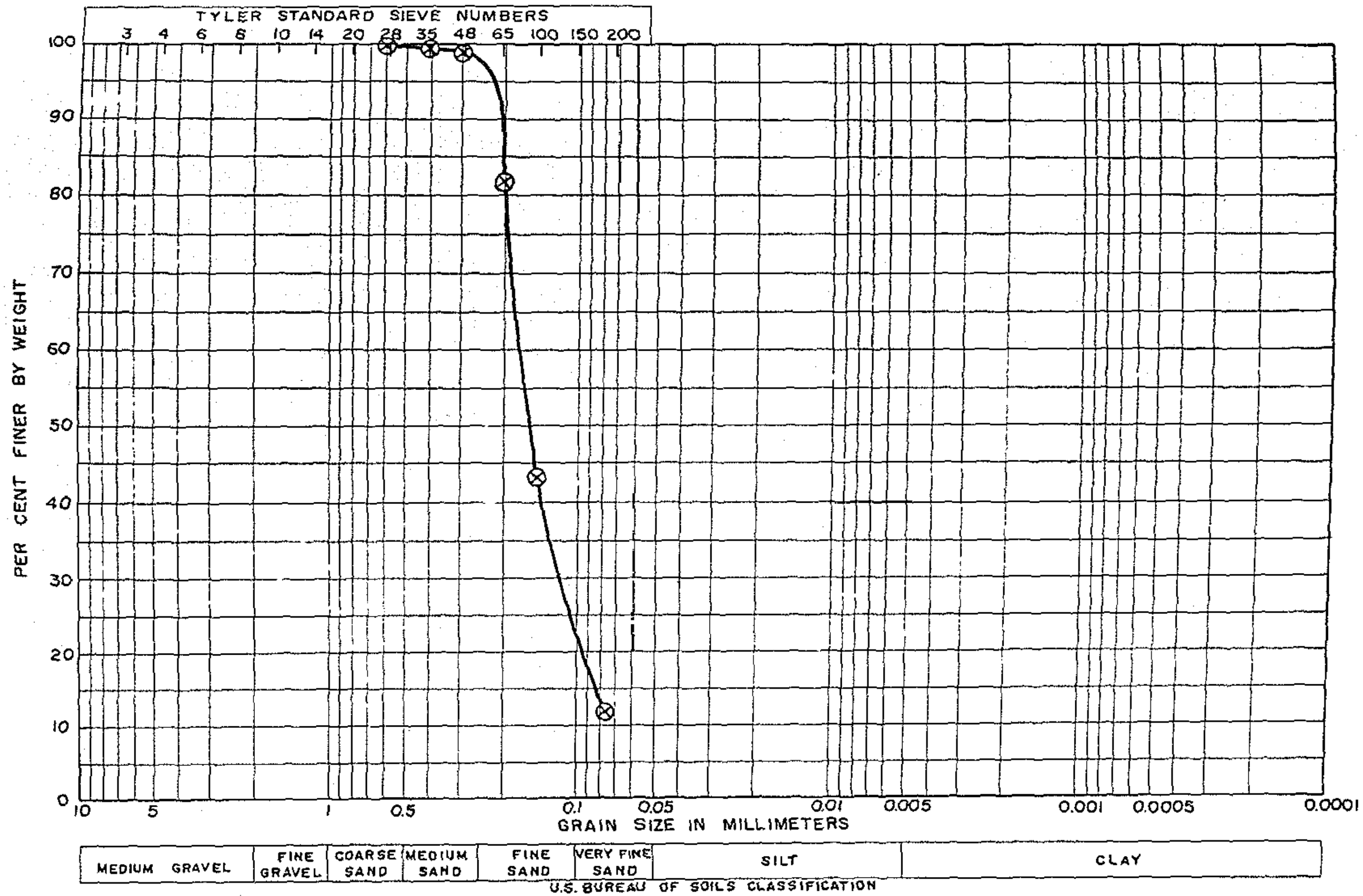
MEDIUM GRAVEL	FINE GRAVEL	COARSE SAND	MEDIUM SAND	FINE SAND	VERY FINE SAND	SILT	CLAY

U.S. BUREAU OF SOILS CLASSIFICATION

PROJECT NARIVA SWAMP BORING NO. 1 SAMPLE NO. 3

DEPTH 6'-7'

GRAIN SIZE DISTRIBUTION DIAGRAM (CONT' D)

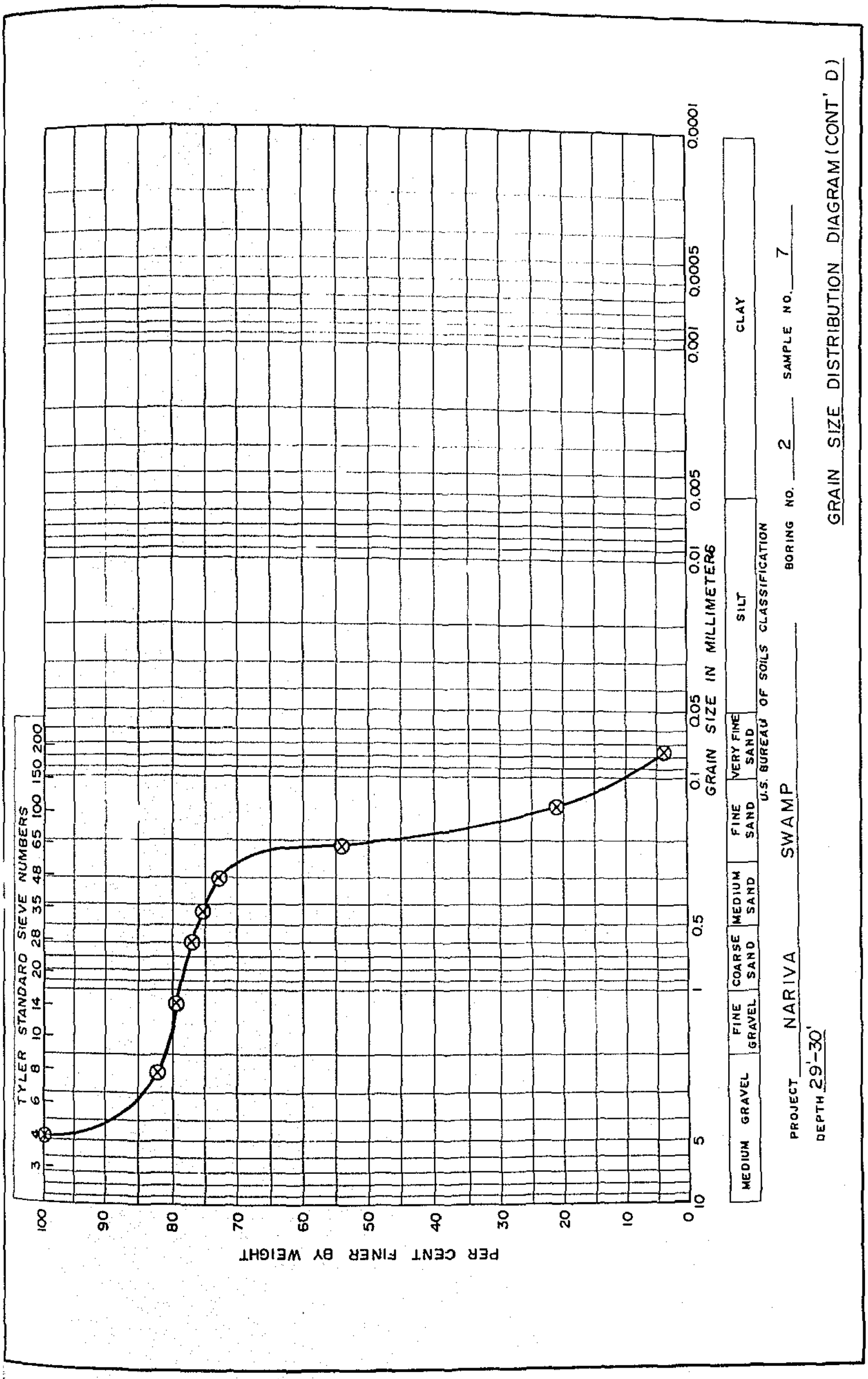


PROJECT NARIVA SWAMP

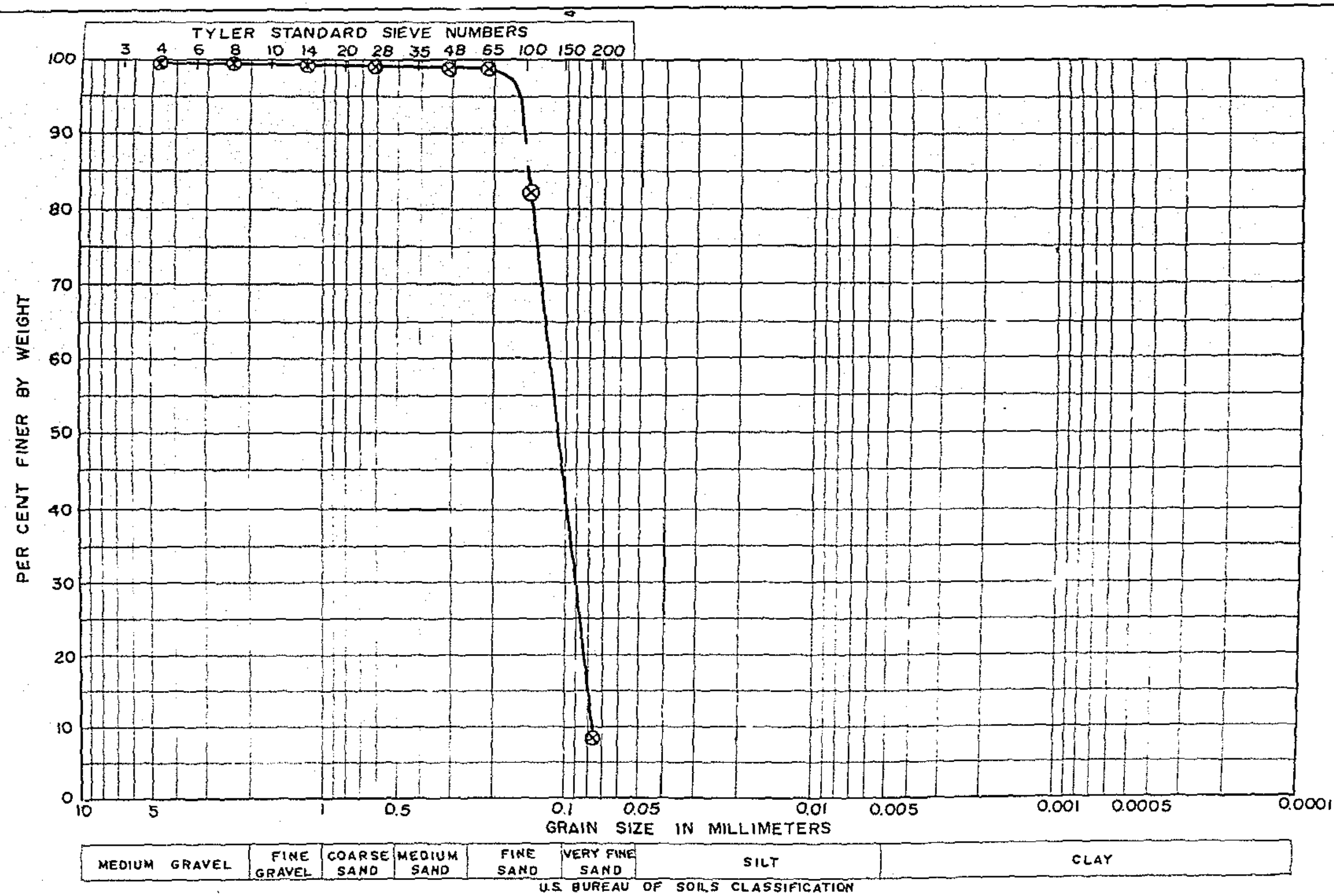
BORING NO. 2 SAMPLE NO. 5

DEPTH 21'-22'

GRAIN SIZE DISTRIBUTION DIAGRAM (CONT' D)



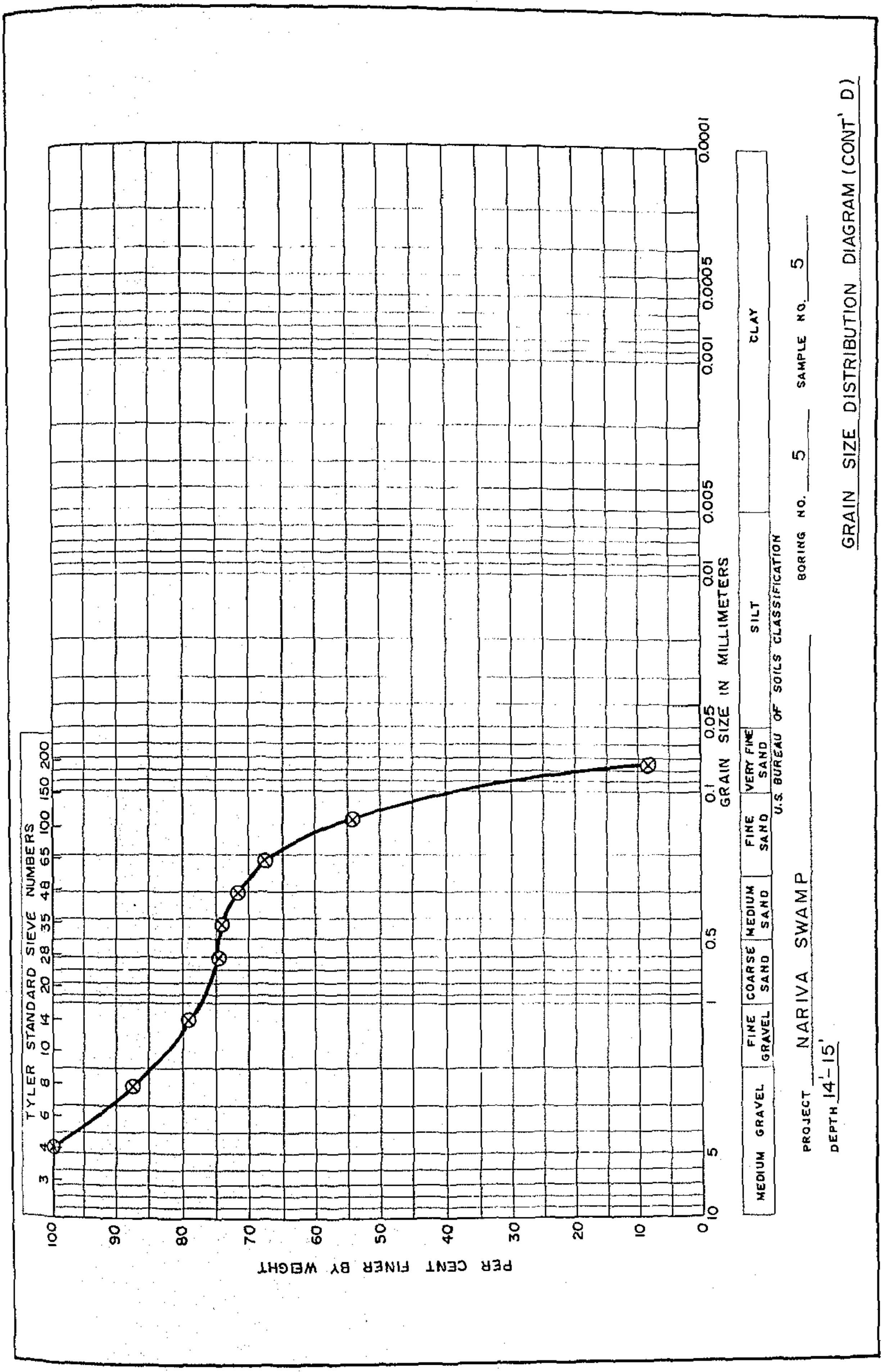
GRAIN SIZE DISTRIBUTION DIAGRAM (CONT' D)



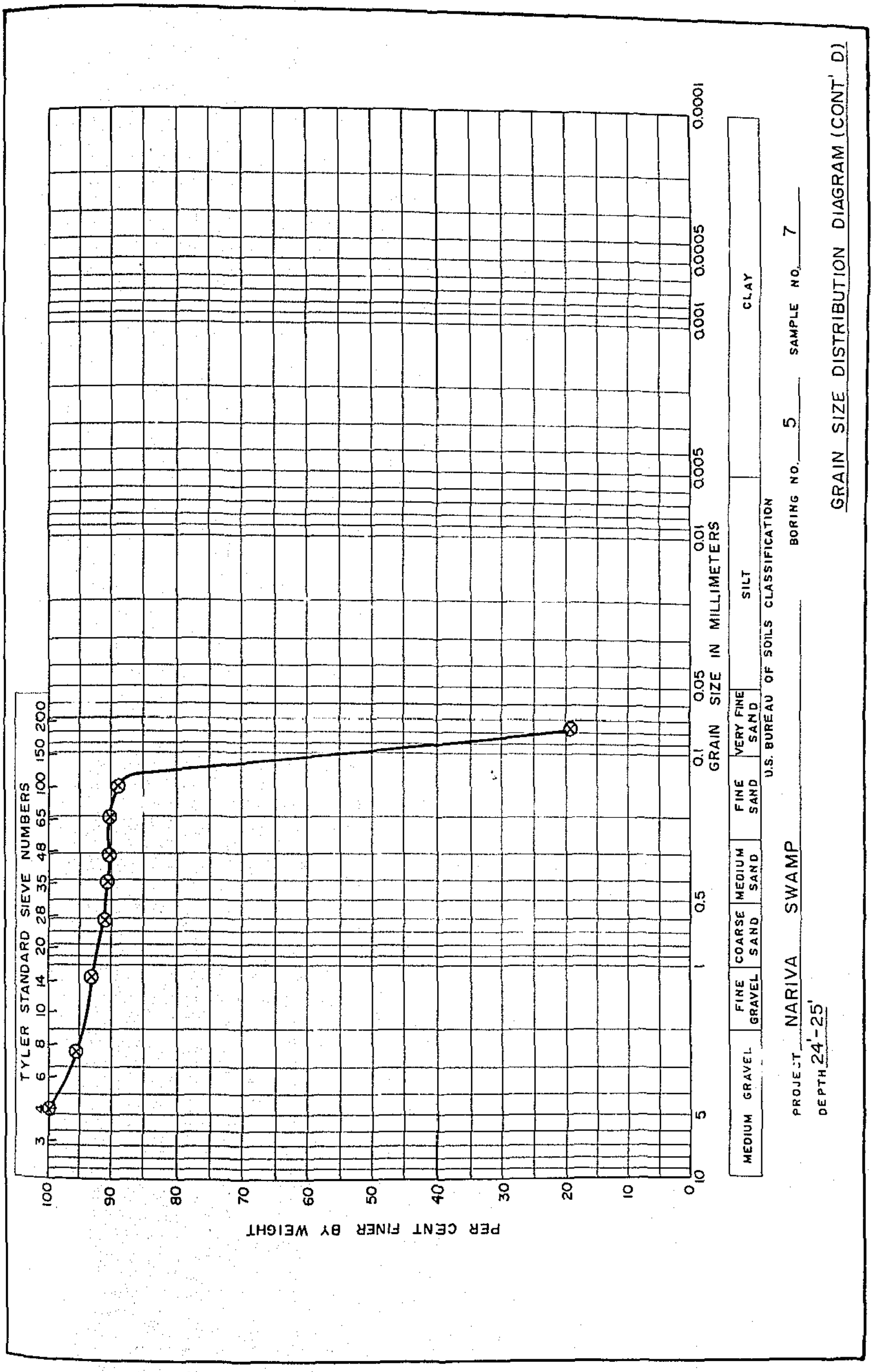
PROJECT NARIVA SWAMP BORING NO. 5 SAMPLE NO. 2

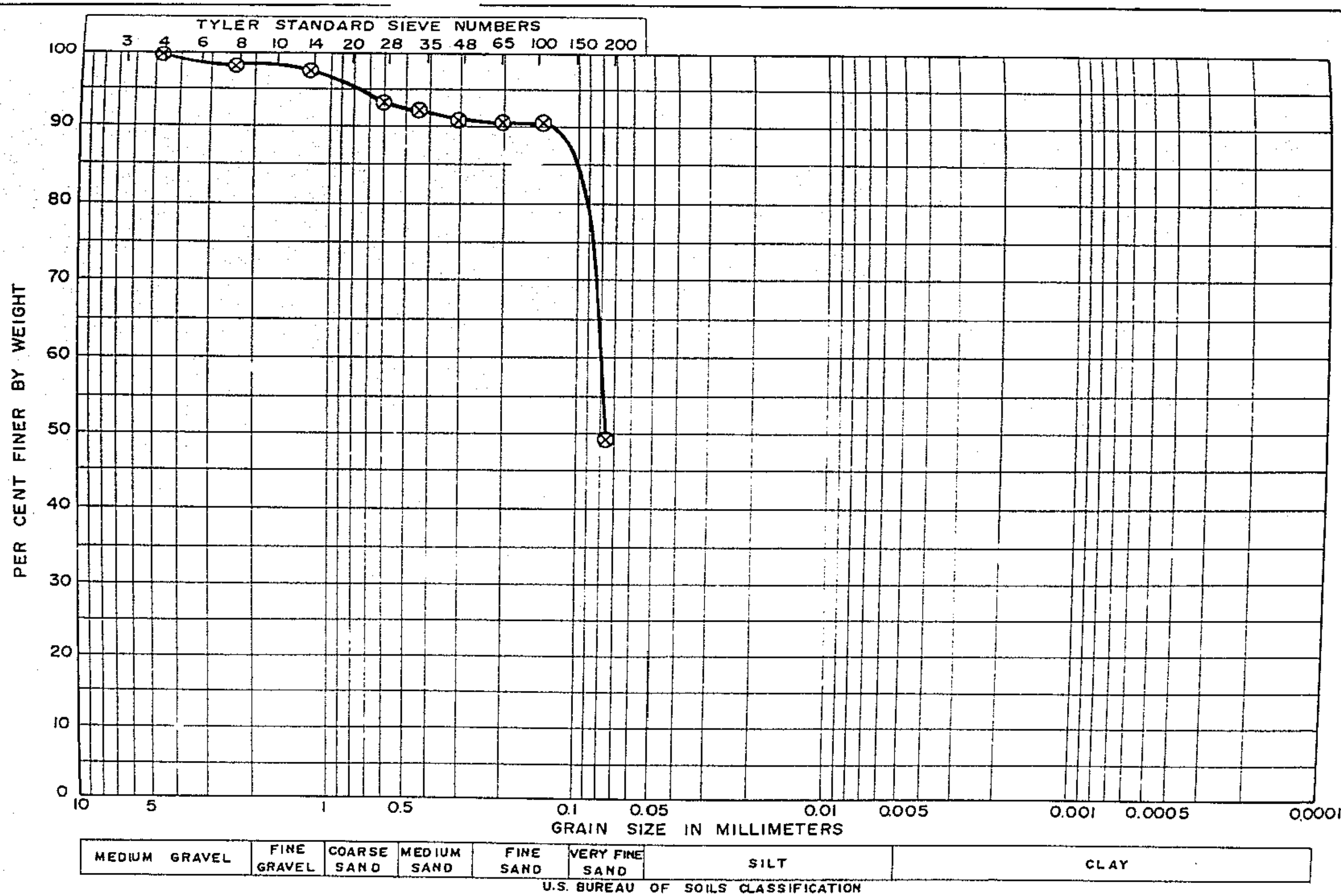
DEPTH 4'- 5'

GRAIN SIZE DISTRIBUTION DIAGRAM (CONT'D)



GRAIN SIZE DISTRIBUTION DIAGRAM (CONT' D)


GRAIN SIZE DISTRIBUTION DIAGRAM (CONT'D)
TYLER STANDARD SIEVE NUMBERS
3 4 6 8 10 14 20 28 35 48 65 100 150 200
GRAIN SIZE IN MILLIMETERS
10 5 1 0.5 0.1 0.05 0.01 0.005 0.001 0.0005 0.0001
PER CENT FINER BY WEIGHT
100 90 80 70 60 50 40 30 20 10 0
MEDIUM GRAVEL
FINE GRAVEL
COARSE SAND
MEDIUM SAND
FINE SAND
VERY FINE SAND
SILT
CLAY
U.S. BUREAU OF SOILS CLASSIFICATION
PROJECT NARIVA SWAMP
DEPTH 24'-25'
BORING NO. 5
SAMPLE NO. 7



PROJECT NARIVA SWAMP

BORING NO. 5 SAMPLE NO. 11

DEPTH 44'-45'

GRAIN SIZE DISTRIBUTION DIAGRAM (CONT' D)

Appendix K

Project Costs

Appendix K

Project Costs

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Appendix K

Project Cost

General

In the contents of Appendix K, construction cost and operation & maintenance costs are calculated on the basis of the planned development. Each cost is described in the classification of a foreign exchange currency component and local currency every stage in the process of the project construction. The calculation of each cost depends upon basic data of construction materials, machinery and recent wage in this country.

Basic Data

The calculation of the project construction cost depends upon basic data of wage and construction materials on the basis of the fact-findings made by Inter-American Development Bank, October 1968 and April, 1969. Construction machinery should be imported on terms of C.I.F. price of April, 1969. The basic data was shown in Table K-1.

Construction Cost

Interest during a period of the project construction works is not included in a total of construction cost. Table K-2 and K-3 shows stage-wised construction cost in the process of the project construction works. Table K-4 shows the breakdown of each structure of stage-wised construction cost.

Construction Cost in TT$1,000	
1st stage	TT$5,100
2nd stage	9,170
Total:	TT$14,270

Construction cost is involved in the scale of Cocal Reservoir based on cropping pattern. Projected cropping pattern is case II as is shown below.

	Cropping Pattern				Total Reservoir Capacity	Dam Volume	Dam Construction Cost	Project Construction Cost
	Rainy Season Paddy	Dry Season Paddy	Dry Season Maize	Dry Season Soybean	acre-feet	yd³	$	$
Case I	100%	-	50%	50%	20,900	1,174,000	1,371,800	15,584,000
Case II	100%	50%	25%	25%	35,100	1,761,000	1,960,080	16,314,000
Case III	100%	100%	-	-	53,200	2,348,000	4,200,000	19,114,000

Foreign Exchange Requirement

A foreign exchange component is used for the purchase of construction machinery and materials in the project construction works. Construction cost shall be covered by local currency and a foreign exchange component as shown in Table K-5 and K-6.

Unit: T.T.$1,000

	Local currency	Foreign exchange currency component	Total cost
1st stage	$ 2,830	$ 2,270	$ 5,100
2nd stage	4,800	4,370	9,170
Total	$ 7,630	$ 6,640	$14,270

Operation and Maintenance Costs

The cooperative organization should be in charge of the operation of the planned development, the maintenance and management of the project facilities. The costs such as repair and sweeping of large-sized Cocal Reservoir and Nariva Regulating Reservoir by machinery, maintenance of irrigation and drainage canals by manpower and annual cost of gate to be amortized over 25 years are included in the operation and maintenance cost.

Table K-1

Basic Data for Cost Estimate

Wages	Local Currency (per Day)	U.S. Dollar (Average)	Remarks
Construction Helper	6.25 - 6.61	3.21	Inter-American Bank Data
Mason 1st Class	7.69 - 8.05	3.70	- ditto -
2nd Class	7.21 - 7.57	3.93	- ditto -
Foreman	8.91 - 11.01	4.98	- ditto -
Driver grade I	7.21 - 7.57	3.70	- ditto -
grade II	6.77 - 7.13	3.47	- ditto -
Bull-dozer Operator			
Heavy	8.35 - 10.35		
Med.	7.21 - 8.13	4.03	- ditto -
Light	6.77 - 7.57		
Welder grade I	7.69 - 8.05	3.81	- ditto -
grade II	7.21 - 7.57		
Carpenter 1st Class	7.69 - 8.05	3.93	- ditto -
2nd Class	7.21 - 7.57	3.70	- ditto -

Materials	Local Currency	U.S. Dollar	Remarks
Portland Cement (Ton)	50.60	25.30	Inter-American Bank Data Local
Steel Reinforcing Rods (Ton)	430.00	215.00	Import
Fabric Reinforcement (Ton)	492.80	246.40	Import
Ready Mixed Concrete			
$1:1\frac{1}{2}:3$ (Cub.yd)	32.20		Ministry of Works in Trinidad Local
1:2:4 (Cub.yd)	29.60		- ditto -
1:3:6 (Cub.yd)	26.20		- ditto -

Aggregates

Gravel for Road Base	(Cub. yd)	6.50	Ministry of Works in Trinidad Local
Gradel Gravel for Concrete	(Cub.yd)	8.50	- ditto -
Sharp Sand for Concrete	(Cub.yd)	8.50	- ditto -
Gasoline Regular	(Gallon)	0.56	April 1969 in Trinidad Local
Extra	(Gallon)	0.73	- ditto -
Diesel oil	(Gallon)	0.31	- ditto -
Lublication oil	(4 gall. Tin)	5.56	- ditto -

Local Currency	U.S. Dollar	Remarks
Timber		
Rough Mora (2" x 4" x 1ft)	0.20	April 1969 in Trinidad Local
Dressed Mora (2" x 4" x 1ft)	0.40	- ditto -
Water Quay (bd. foot)	0.30	- ditto -
Green Heart (bd. foot)	0.50	Import

Machines

Shovel (0.6 m^3 Buckets)	29,000	(CIF Port of Spain)	Import
Bulldozer (17 ton Operating Weight)	25,000	(do)	- do -
Dozer Shovel (1.5 m^3 Buckets)	25,000	(do)	- do -
Motor Grader (11.5 ton Operating weight)	23,000	(do)	- do -
Road Roller (Tandem Type)	9,500	(do)	- do -
Jamping Roller (Double Drum Type)	4,000	(do)	- do -
Dump Trucks (6 Ton Capacity)	7,000	(do)	- do -
Servicing Truck	4,000	(do)	- do -
Inspection Car	3,000	(do)	- do -

Table K-2

Construction Costs at 1st Stage

ITEM	UNIT PRICE	AMOUNT	TOTAL COST
Temporary Road	$ 1,390/100 FT	15,000 FT	208,500
No.2 D. Canal	$ 840/100	3,200	26,880
No.3 D. Canal	$ 950/100	3,100	29,450
No.4 D. Canal	$ 950/100	3,700	35,150
Turure Cut	$ 13,980/500	1,500	41,940
Cocal Reservoir	$ 5,160/100	38,000	1,960,800
Spillway	$ 500,000/each	1	500,000
Outlet Works	$ 15,000/each	4	60,000
Cocal Cut	$ 4,650/100	11,500	534,750
Plum Mitan I. Canal	$ 140/100	9,800	13,720
Bois Neuf I. Canal	$ 1,110/100	6,800	75,480
Ortoire I. Canal	$ 100/100	19,700	19,700
No.3 D. Canal	$ 950/100	7,900	75,050
No.4 D. Canal	$ 950/100	7,000	66,500
No.5 D. Canal	$ 950/100	7,200	68,400
Lateral Canals & Others	$ 161/acre	2,250 acres	362,250
Sub-total			$4,078,570
Contingencies (10%)			407,857
Engineering & Administration			611,785
Total			$5,098,212

Rounded to T.T.$ 5,100,000

Table K-3

Construction Costs at 2nd Stage

ITEM	UNIT PRICE	AMOUNT	TOTAL COST
Nariva Regulating Res.	$ 3,290/100 FT	52,500 FT	1,727,250
L'Ebranche Barrage		1	270,000
L'Ebranche Cut	$35,390/100	7,200	2,548,080
Closing of Nariva River		1	15,000
Turure Cut	$13,980/500	28,000	782,880
No.1 D. Canal	$ 740/100	5,700	42,180
No.2 D. Canal	$ 840/100	9,700	81,480
No.3 D. Canal	$ 950/100	10,100	95,950
No.4 D. Canal	$ 950/100	10,700	101,650
No.5 D. Canal	$ 950/100	10,500	99,750
Sluice Ways	$30,000/each	5	150,000
Bridges	$ 8,000/each	9	72,000
Plum Mitan I. Canal	$ 140/100	5,700	7,980
Bois Neuf I. Canal	$ 1,110/100	24,400	270,840
Lateral Canal & Others	$ 161/acre	6,173 acres	993,853
Land Expropriation		1	12,000
Diversion Road	$ 1,390/100	4,400	61,160
Sub-total			$7,332,053
Contingencies (10%)			733,205
Engineering & Administration (15%)			1,099,807
Total			$9,165,065
	Rounded to	T.T.$	9,170,000

Table K-4

Basic Data for Each Stage Costs

Main Road (per 100 feet)

ITEM	AMOUNT	UNIT	UNITPRICE	COST
Excavation by Bulldozer	851	yd^3	50 ¢	425.50
Embankment of Road	481	yd^2	15 ¢	72.15
Road Metal, Tran and Place	222	yd^2	$ 3.00	666.00
Gravel, Trans, and Place	74	yd^3	$ 3.00	222.00
Total				$1,385.65
Rounded to				$1,390.00

No. 2 D. Canal (per 100 feet)

ITEM	AMOUNT	UNIT	UNITPRICE	COST
Weeding and Uprooting	277	yd^2	15 ¢	41.55
Excavation by Dragline	503	yd^3	60 ¢	301.80
Embankment of Road	303	yd^2	15 ¢	45.45
Road Metal Trans and Place	111	yd^2	$ 3.00	333.00
Gravel, Trans and Place	37	yd^3	$ 3.00	111.00
Total				$832.00
Rounded to				$840.00

No. 3 D. Canal (per 100 feet)

ITEM	AMOUNT	UNIT	UNITPRICE	COST
Weeding and Uprooting	344	yd^2	15 ¢	51.60
Excavation by Dragline	681	yd^3	60 ¢	408.60
Embankment of Road	303	yd^2	15 ¢	45.45
Road Metal, Trans and Place	111	yd^2	$ 3.00	333.00
Gravel, Trans and Place	37	yd^3	$ 3.00	111.00
Total				$949.65
Rounded to				$950.00

Turure Cut (per 500 feet)

ITEM	AMOUNT	UNIT	UNITPRICE	COST
Weeding and Uprooting	344	yd^2	15 ¢	51.60
Excavation by Dragline	681	yd^3	60 ¢	408.60
Embankment of Road	303	yd^2	15 ¢	45.45

Basic Data for Each Stage Costs

ITEM	AMOUNT	UNIT	UNITPRICE	COST
Sub-Total				$ 7,387.95
Road Metal, Trans and Place	1,111	yd^2	$ 3.00	3,333.00
Gravel, Trans and Place	370	yd^3	$ 3.00	1,110.00
Berm Inlet	1		$500.00/each	500.00
Sub-Total				$12,330.95
Temporary Work	$7,387.95 x 5%			369.39
Total				$12,700.34
Overhead	$12,700.34 x 10%			1,270.03
Grand Total				$13,970.37
Rounded to				$13,980.00

Cocal Reservoir (per 100 feet)

ITEM	AMOUNT	UNIT	UNITPRICE	COST
Weeding and Uprooting	1,435	yd^2	15 ¢	215.25
Excavation by Bulldozer	4,174	yd^3	50 ¢	2,087.00
Embankment of Dike	3,495	yd^2	25 ¢	873.75
Embankment of Road	638	yd^3	15 ¢	95.70
Sub-Total				$3,271.70
Road Metal, Trans and Place	222	yd^2	$ 3.00	666.00
Gravel, Trans and Place	74	yd^3	$ 3.00	222.00
Total				$4,159.70
Temporary Work	$ 3,271.70 x 10%			327.17
Total				$4,486.87

Overhead	$ 4,486.87 x 15%			673.13
Grand Total				$5,159.90
Rounded to				$5,160.00

Cocal Cut (per 100 feet)

ITEM	AMOUNT	UNIT	UNITPRICE	COST
Weeding and Uprooting	2,444	yd^2	15 ¢	366.60
Excavation by Bulldozer	5,366	yd^3	50 ¢	2,683.00
Embankment of Dike	4,169	yd^2	15 ¢	625.35
Sub-Total				$3,674.95
Temporary Work	$3,674.95 x 10%			367.49
Total				$4,042.22
Overhead	$4,042.22 x 15%			606.36
Grand Total				$4,648.80
Rounded to				$4,650.00

Plum Mitan Canal (per 100 feet)

ITEM	AMOUNT	UNIT	UNITPRICE	COST
Weeding and Uprooting	138	yd^2	15 ¢	20.70
Excavation by Dragline	133	yd^3	60 ¢	79.80
Embankment of Dike	237	yd^2	15 ¢	35.55
Total				136.05
Rounded to				$140.00

Bois Neuf I. Canal (per 100 feet)

ITEM	AMOUNT	UNIT	UNITPRICE	COST
Weeding and Uprooting	155	yd^2	15 ¢	23.25
Excavation by Dragline	166	yd^3	60 ¢	99.60
Embankment of Road	600	yd^2	15 ¢	90.00
Road Metal Trans and Place	222	yd^2	$ 3.00	666.00
Gravel, Trans, and Place	74	yd^3	$ 3.00	222.00

Total				$ 1,100.85
Rounded to				$ 1,100.00

Ortoire I. Canal (per 100 feet)

ITEM	AMOUNT	UNIT	UNITPRICE	COST
Weeding and Uprooting	122	yd^2	15 ¢	18.30
Excavation Dragline	103	yd^3	60 ¢	61.80
Embankment of Dike	122	yd^2	15 ¢	18.30
Total				$98.40
Rounded to				$100.00

Lateral Canal and Others (per 48 acres)

Lateral Canal				
Weeding and Uprooting	4,106	yd^2	15 ¢	615.90
Excavation by Dragline	2,346	yd^3	60 ¢	1,407.60
Embankment of Dike	2,845	yd^2	15 ¢	426.75
Sub-Total				2,450.25
Farm Road				
Excavation by Bulldozer	1,173	yd^3	50 ¢	586.50
Embankment of Road	1,201	yd^2	15 ¢	180.15
Road Metal, Trans and Place	440	yd^2	$ 3.00	1,320.00
Gravel Trans, and Place	146	yd^3	$ 3.00	438.00
Sub-Total				2,524.65
Pipe Culverts and Check Gates				1,600.00
Farm Bridges	$300.00/each x $\frac{1}{5}$			60.00
Borders				
Excavation by Bulldozer	586	yd^3	50 ¢	293.00
Embankment of Border	2,816	yd^2	15 ¢	422.40
Sub-Total				715.40
Total				$7,350.30

Overhead	$ 7,350.30 x 5%		367.51
Grand Total			$7,717.81
Rounded to			$7,728.00
Per acre	7,728.00/48 acres		$ 161.00

Nariva Regulating Reservoir (per 100 feet)

ITEM	AMOUNT	UNIT	UNITPRICE	COST
Excavation by Bulldozer	4,672	yd^3	50 ¢	2,336.00
Embankment of Dike	540	yd^2	15 ¢	81.00
Sub-Total				$2,417.00
Road Metal Trans and Place	111	yd^2	$ 3.00	333.00
Gravel Trans and Place	37	yd^3	$ 3.00	111.00

ITEM	AMOUNT	UNIT	UNITPRICE	COST
Sub-Total				$2,861.00
Temporary Work	$2,417.00 x 5%			120.85
Total				$2,981.85
Overhead	$2,981.85 x 10%			298.18
Grand Total				$3,280.03
Rounded to				$3,290.00

L'Ebranche Cut (per 100 feet)

ITEM	AMOUNT	UNIT	UNITPRICE	COST
Excavation by Suction Dredge	6,982	yd^3	50 ¢	3,491.00
Steel Sheet Pile	66.7	yd	$ 300.00	20,010.00
Concrete	33.8	yd^3	$ 50.00	1,690.00
Masonry Cemented with Rubble	138.9	yd^2	$ 20.00	2,778.00
Sub-Total				$27,969.00
Temporary Work	$27,969.00 x 10%			2,796.90
Total				$30,765.90
Overhead	$30,765.90 x 15%			$ 4,614.88
Grand Total				$35,380.78
Rounded to				$35,390.00

No.1 D. Canal (per 100 feet)

ITEM	AMOUNT	UNIT	UNITPRICE	COST
Weeding and Uprooting	222	yd^2	15 ¢	33.30
Excavation by Dragline	355	yd^3	60 ¢	213.00
Embankment of Road	303	yd^2	15 ¢	45.45
Sub-Total				\$291.75
Road Metal, Trans and Place	111	yd^2	\$ 3.00	333.00
Gravel Trans and Place	37	yd^3	\$ 3.00	111.00
Sub-Total				\$444.00
Grand Total				\$735.75
Rounded to				\$740.00

Table K-5

Foreign Exchange Requirement at 1st Stage

Item	Local Currency Thousands of T.T.$	Foreign Currency Thousands of T.T.$	Total Cost Thousands of T.T.$
Cocal Reservoir	1,560.08	400	1,960.08
Spillway	473	27	500
Outlet Works	36	24	60
Cocal Cut	214.75	320	534.75
Temporary Road	48.50	160	208.50
Irrigation & Drainage Canals	12.27	440	452.27
Lateral Canals & Others	2.25	360	362.25
Sub-Total	2,346.85	1,731	4,077.85
Contingencies (10%)	234,685	173.1	407.785
Engineeering (15%)	244,670	367.007	611.677
Total	2,826,205	2,271.107	5,097.312
Rounded to	2,830	2,270	5,100

Table K-6

Foreign Exchange Requirement at 2nd Stage

Item	Local Currency Thousands of T.T.$	Foreign Currency Thousands of T.T.$	Total Cost Thousands of T.T.$
Nariva Regulating Reservoir	1,407.25	320	1,727.25
L'Ebranche Cut	578,08	1,970	2,548.08
Irrigation & Drainage Canals	1,002.87	640	1,642.87
Lateral Canals & Others	633.853	360	993.853
L'Ebranche Barrage	221.00	49	270.00
Sluice ways	124.00	26	150.00
Sub-Total	3,967.053	3,365	9,332.053
Contingencies (10%)	396.705	336.50	733.205
Engineering (15%)	439,922	659,885	1,099,807
Total	4,803,680	4,361,385	9,165,065
Rounded to	4,800	4,370	9,170

Table K-7

Operation and Maintenance Costs

Operation Costs

Operation List	No. of Personnel	Rates of Month	Rates of Year
Super intendent	1	500	6,000
Chief Water Master	1	350	4,200
Ditch Riders	10	250	30,000
Clerks	4	250	12,000
Telephone Operators	1	180	2,160
Foremen	2	250	6,000
Equipment Operators	4	180	8,640
Mechanics	2	180	4,320
Laborers	15	150	27,000
Total	40		T.T.$100,320

Maintenance Costs

1st Stage Gates	$\$5.50/yd^2 \times 160yd^2$	$ 880.00
Cocal Reservoir		$1,200.00
Sub-Total		$2,080.00
2nd Stage Gates	$\$5.50/yd^2 \times 160yd^2$	$ 880.00
Nariva Regulating Reservoir		$1,200.00
Sub-Total		$2,080.00
Total		$4,160.00

Operation and Maintenance Costs

Operation Costs	$ 100,320.00
Maintenance Costs	$ 4,160.00
Total	$ 104,480.00
Rounded to	$ 105,000.00

Appendix L

Project Agricultural Economy

Appendix L

Project Agricultural Economy

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Appendix L

Projected Agricultural Economy

Type of Development

The Nariva Swamp agricultural development project selects the Nariva Swamp area and the hilly land nearly 62,000 acres located at the central-eastern part of Trinidad as the object of the development, and the main purpose is to develop agricultural condition. About 26,500 acres excluding the private estate and the lease of the Crown Land will be the object of the development. So to speak, the low-lying swamp area, where much of land has not been utilized due to an inundation during the rainy season, should be converted into a arable land, covering about 11,000 acres, on the basis of a drainage plan (Drainage system is utilized for irrigation during the dry season.) The southern hilly land next to the Nariva Swamp area is a rolling land covered with forests, covering about 15,500 acres, of which about 7,400 acres should be reclamed in an attempt to carry out a large-scaled livestock production.

In regard to the aspect of livestock production, any detailed topographical map and other data are not available for the planning. Detailed development plan could not be, therefore, prepared, but in consideration of present status and future prospects of the domestic production and the import quota of livestock in Trinidad and Tobago, beef cattle breeding is planned to be conducted and managed by a few estates, as a large scaled livestock management. 500 acres of the Nariva swamp area developed by the Plum Mitan Rice Scheme (1,200 acres of initially developed land has decreased to 500 acres due to the lowered-function of drainage canal facilities) are being only utilized for the temporary cultivation of paddy rice during the rainy season and watermelon during the dry season by about 300 farming households under the Government's lease of land. Upon completion of irrigation and drainage canal facilities in the Nariva Swamp area, net about 9,000 acres of land will be utilized for arable land, the settlers of which will be selected from among current farmers upon reexamination of their qualifications for the settlement in the project area.

Qualified farmers selected throughout the country will settle in the rest of project area. The Government should take necessary steps for the settlers in the project area. Paddy should be cultivated on 100% of the whole project area during the rainy season, and also during the dry season paddy and field crops (maize and soybean) should be cultivated on a half area for each. Actual result of cultivation of such crops has not been almost recorded. Therefore, cooperative is necessary to demonstrate a trial cultivation method and helf the settlers of the project area in agricultural techniques.

Farm Managing Scale

For the determination of farm managing scale, the first is that the income of farmers should be increased as high as that of urban people. The second element is that large-sized machinery such as tractor (60HP), combine (with a 14-feet-wide cicling breadth) and so forth should be introduced and utilized. Upon introduction of such large-sized farm machinery, however, a set of farm machinery should not be utilized by a single farm household, but by 30 to 40 farm households in number. In view of such conditions, farm managing scale is determined as that of 14 acre per farm household. 14 acres is divided into two, 2 and 12 acres on the assumption that irrigation should be practised in each area. As for the foreign field 12 acres shall be for the cultivation of paddy, maize and soybean and 2 acres shall be for homestead located in the village, and innitially cropping pattern of 2 acres area shall be the same as that of the foreign paddy. In future, in the domestic field, intensive farming of vegitable etc. shall be conducted. For reference, farm size in other project works is shown in Table L-1.

Table L-1 Farm sizes of other projects

	Farm size
Crown Land Project in Trinidad and Tobago	
Dairying (Full Development)	20 acres
Tree crops (Full Development)	10
Pisayambo Project in Equador	12-86
Guiana, Settlement in Polder	15

Cropping Pattern

Exhibit L-1 shows cropping pattern and proportion following the attainment of the agricultural development scheme. The following conditions are considered on the determination of crops.

1) To raise agricultural benefit most effectively upon completion of irrigation and drainage project in the Nariva Swamp area
2) To be the substitutes for imported foods, that is, be less self-suppliable.
3) To meet natural conditions of climate, topography, soil and so forth
4) To reduce production costs for the application of large-sized farm machinery
5) To be farmed under cooperative activities

In view of the above conditions, paddy should be cultivated on the whole project area during the wet season by the completion of drainage project and by the fulfilment of supplemental water by irrigation project. On the other hand, irrigation water requirement varies from the cropping ratio of the whole project area during the dry season. Therefore, the capacity of the Cocal Reservoir is necessitated to be changed. On final determination of cropping proportions, it is necessary to compare fluctuation of the dam construction costs according to cropping proportion with investment efficiency or B/C Ratio varying according to the benefit or fluctuation of yields, as shown in Table L-2. According to this table, B/C ratio of case III is the highest. However, the full water level of dam in case III will reach higher than in other two cases, so that, private estates behind the Nariva Swamp area will be submerged by water. Furthermore, the compensation cost is not exactly estimated in this case. And in addition to many technical difficultues, there are many uncalculable factors unfaourable for the adoption of case III, though B/C ratio is seemed to be higher than that of other cases. Therefore, in this report, the cropping proportion of case II is adopted. That is, double cropping of paddy rice should be conducted in the stage I of agricultural development scheme. After completion of stage II, the cropping intensity of paddy rice should be 100% during the rainy season, and during the dry season the cropping intensity of paddy rice, maize and soybean should be 50%, 25% each.

Projected Yields

The yields of paddy rice, maize and soybean which are primarily adopted in agricultural department and beef cattle which is adopted in livestock department of the Nariva Swmap Agricultural and livestock yields, enough data of the project area and its surroundings are not easily obtainable and therefore, Table L-4 shows only the whole data of agriclutral and livestock yields in Trinidad and Tobago.

Table L-3 Projected Yields

Paddy	3,570 lbs/acre	(4,000 kg/ha)
Maize	3,000 lbs/acre	(3,360 kg/ha)
Soybean	1,700 lbs/acre	(1,900 kg/ha)
Beef Cattle	174 lbs/acre	

Table L-4 List of the Data for Yields

Paddy	A Survey of Rice Industry	Aug. 1953
	Rice Growing in Trinidad	Jun. 1949
	Rice Industry in Trinidad	May 1949
Soybean	The Prospects for Soybean Production in Trinidad and Tobago	Jun. 1968
	A Note on the Cultivation of Soybeans and Groundnuts with Special Reference to Trinidad and Tobago	
Maize	The Prospects for Soybean Production in Trinidad and Tobago	Jun. 1968
	Methods for the Production of Food Crops in Trinidad and Tobago, Corn	1968
Beef	The Star Farm - Texaco in Agriculture	1968

In case of the determination of the projected yeild in agricultural department on the basis of the above data, the available data of paddy rice yield is too old, only to be referred. Therefore, the final determination was made on the same basis of the projected yield of irrigation and drainage facilities as in other countries, and of actual results performed in other agricultural development projects in Southeast Asia, Guiana and Surinam. To obtain the projected yields, the experiments and research is necessary to be carried out. As for the projected yields of maize and soybean were determined on the basis of "The Prospects for Soybean Production in Trinidad and Tobago, (June, 1968)", which is a report of research by the University of the West Indies. Except for apprehension of the short period of the research, according to the report, the yields of both maize and soybean are recorded conservative. The yields mentioned in the report are employed in the agricultural development project.

Prices of Agricultural Products

Table L-5 shows the prices of agricultural and livestock products in the Nariva Swamp agricultural development project.

Table L-5 Prices of Agricultural Products

Agricultural Products	Prices TT$/100lbs.	(TT$/100 kg)
Paddy	13.60	18.00
Soybean	6.00	13.23
Maize	3.50	7.72
Beef Cattle	65.00	143.30

The determination of the above unit prices was made on the base of C.I.F. price of imported agricultural products in Trinidad and Tobago. The unit price of paddy rice was calculated on multiplying 0.6 of rice cleaning charges by C.I.F. price which is obtained by the calculation using a weighted mean of quantity and amount of imported paddy rice in 1966, 1967 and 1968. According to the table of "Supported or Stabilized Prices to Producers for Paddy in 1965/66" presented in "The State of Food and Agriculture 1966" issued by F.A.O., the price of paddy rice in Trinidad and Tobago is US$9.00 per 100 kg, which corresponds to the figure of Table L-5.

The price of maize is TT$0.0562 per pound on C.I.F. price in 1966, 1967 and 1968, on the basis of which producers' received prices are anticipated for 70% of C.I.F. price (TT$0.0393 per pound). However, in recent years, C.I.F. price of maize is downward trend, so that the price of maize is fixed at TT$0.035 per pound.

The import statistics of soybean as well as paddy rice and maize is not available. According to "The Prospect for Soybean Production in Trinidad and Tobago", soybean cake and meal of 10 million pounds worth about TT$1 million was imported in 1965, and therefore C.I.F. price of soybean was obtained on the basis of weight exchange of this imported soybean cake and meal. According to an actual attainment of processing soybean into soybean cake and meal, 750 kg. of soybean cake and meal is processed from 1,000 kg of soybean. Accordingly, 10 million pounds of imported soybean cake and bean are equivalent to 6,048,000 kg of soybean. C.I.F price of soybean is, by this calculation method, estimated at TT$0.1653 per kg, and further, producers received price is fixed at TT$6.00 per 100 pounds (TT$0.1323 per kg) in anticipation of 80% of C.I.F. price.

At a foreign exchange rate of the prices of maize and soybean, the prices ofmaize are US$1.37 per 56 pounds and soybean US$2.54 per 60 pounds, the prices of which are nearly as same as wholesale prices at the delivery of Chicago (Table L-6, 1962-1966) according to "Production Year Book" of FAO.

Table L-6 Wholesale Price of Maize and Soybean in Chicago

	Maize (Yellow No.3 of U.S.A.)	Soybean (Yellow No.2 of U.S.A)
1962	1.19 US$/56 lbs	2.54 US$/60 lbs
1963	1.20 "	2.74 "
1964	1.26 "	2.82 "
1965	1.27 "	2.63 "
1966	1.37 "	2.93 "

The determination of meat prices was based on imported meat prices. As shown in Table A-8, the unit prices of fresh frozen meat (11) and preserved meat not canned, (012) are fixed at TT$65 per 100 pounds.

Specification of the Total Project Area

Table L-7 shows the contents of the Nariva Swamp agricultural development project area. According to the same table, the project areas amount up to about 62,000 acres, about 26,500 acres of which is a new development objective area. Among about 26,500 acres, irrigable area and livestock production area are about 11,000 acres and about 16,500 acres (actual reclamation land area is 7,400 acres), respectively.

Agricultural Production and Gross Value of Total Production

Table L-8 shows agricultural production and gross value of total production following the completion of agricultural development plan.

Production Cost

Crop (Paddy Rice, Maize and Soybean)

Table L-9, L-10 and L-11 show production costs of paddy rice, maize and soybean, which will be cultivated on the irrigable area of the development project. Table L-12 shows basic data for the determination of the production costs. Most important element for the determination of the production costs depends upon cropping pattern with an introduction of large-sized farm machinery. The farm management is carried out by farmers settled in the irrigable area, where large-scale cropping system is adopted with the cooperative utilization of large-sized farm machinery. Cultivation land area 450 to 500 acres will be reasonablly covered by 30 to 40 farming households. The estimation of working efficiency is made on the standard of 450 acres of cultivation land area.

The utilization cost of machinery per hectar was obtained by a calculation on the standard of cultivation land area (450 acres) and aforementioned cropping proportion. Table L-13 shows various types of farm machinery and their working efficiency in consideration of a characteristics of the irrigable area. Table L-14 shows the relations between number of available machinery and its life years according to Table L-13. Table L-15, L-16, L-17 show the calculation standards of fixed cost and variable cost, fixed cost and annual total cost per ha, respectively according to Table L-14. The cost of farm machinery, which are mentioned in production cost of Table L-9, L-10 and L-11, is estimated with the addition of costs of various types of working machinery according to cropping pattern and proportion. The production cost of paddy rice, maize and soybean is 75%, 12.5% and 12.5% respectively.

The cost of corn attachement of combine is estimated on the assumption that a set of combine will be utilized by 2 collaborative bodies possessing 900 acres of cultivation land area.

Beef Cattle Farming

The diary farming of Crown Land is based on the data of "Cattle Ranches" of "Farm Costs and Return" (U.S.D.A. Economic Research Service) of 1968. Annual total cost of beef cattle raising estimated at TT$90 per acre on a ratio of 1 acre to 1 head.

Net Income and Farming Family Income

Net Income

Net income of farming household is obtained by deducting production cost from a gross value of total production and is one of the most important elements affecting economic feasibility of the development project. In case of development project for only agriculture, the net income of farming household is only involved in benefit upon an actual economic calculation (B/C Ratio, Internal Rate of Return and so forth).
Table L-18 shows annual per capita net income per ha in the project.

Farming Family Income

Farming family income, which is obtained from deducting production cost paid in cash from a gross value of total production, is a decisive factor of the living standard of farming household. Various kinds of amortization costs and water charge (O&M cost) should be paid from farming family income, which is obtained by adding net income, capital interest and management cost to family labour charge for crop production. Table L-19 shows farming family annual income per hectar. Beef cattle raising is operated and managed by each estate.

Table L-2

Cropping Proportion and B/C Ratio

(Interest Rate 7% Period of the Analysis 50 Years)

	Cropping Proportion				Total Installation Costs TT$	Full Benefit TT$	Annual Cost TT$	Annual Benefit TT$	B/C Ratio
	Rainy Season	Dry Season							
	Paddy	Paddy	Maize	Soybean					
Case I (per ha.)	100%	-	50%	50%	15,584,000 (4,270)	1,416,200 (388)	1,154,306 (316)	993,508 (272)	0.86
Case II (per ha.)	100%	50%	25%	25%	16,314,000 (4,470)	1,846,900 (506)	1,217,320 (334)	1,295,658 (355)	1.06
Case III (per ha.)	100%	100%	-	-	19,114,000 (5,237)	2,277,600 (624)	1,458,870 (400)	1,597,808 (438)	1.10

Table L-7

Break-down of Total Project Area

Item	Acre
Total Project Area	62,000
Area under New Development	26,500
Gross Area under Irrigation	11,000
Gross Area for Livestock Farming	15,500
Others	35,500
Cocal Reservoir	4,200
Nariva Regulating Reservoir	6,400
Lease & Windbelt Reserve, etc.	4,900
Private Land, Estate & Others	20,000

Item	Stage I Acre	Stage II Acre	Total Area
Gross Irrigable Area	3,550	7,450	11,000
Main Structures	400	830	1,230
Site for Village	150	200	350
Land for Domestic House	100	220	320
Agricultural Research Station	100	-	100
Net Cultivated Area	2,800	6,200	9,000

Item	Acre
Gross Area for Livestock Farming	15,500
Road, Structures & Others	8,100
Net Operating Acre	7,400

Table L-8

Agricultural Production and Gross Value of Total Production

Crop

Crop	Area Acres	Yield Lbs/acre	Production 1,000 lbs.	Unit Price TT¢/lb.	Gross Value of Total Production TT$
Stage I					
Paddy	4,260	3,570	15,208.2	8.16	1,240,990
Maize	710	3,000	2,130.0	3.50	74,550
Soybean	710	1,700	1,207.0	6.00	72,420
Sub-total	5,680				1,387,960
Stage II					
Paddy	9,270	3,570	33,093.9	8.16	2,700,460
Maize	1,545	3,000	4,635.0	3.50	162,250
Soybean	1,545	1,700	2,626.5	6.00	157,590
Sub-total	12,360				3,020,300
Total Area					
Paddy	13,530	3,570	48,302.1	8.16	3,941,450
Maize	2,255	3,000	6,765.0	3.50	236,800
Soybean	2,255	1,700	3,833.5	6.00	230,010
Grand Total	18,040				4,408,260

Beef Cattle

Item	Head	Yield Lbs/head	Production 1,000 Lbs.	Unit Price TT¢/Lb.	Gross Value of Total Production TT$
Beef Cattle	7,400	226	1,968.4	65.00	1,279,460

Table L-9

Production Costs per Hectare (Estimate) TT$

Crop: Paddy
Yield: 4,000 kg

Unit Price of Products: 18.00 ¢/kg
Gross Value of Total Production: 720.00 TT$

				(Family Labour)
Nursery Operations	35.00			
Preparation of Nursery, Sowing Seed			10.00	10.00
Watering Nursery			25.00	25.00
Field Operations	170.04			
Land Preparation		44.58		
Ploughing			7.35	
Harrowing			4.50	
Puddling			6.53	
Fertilizing			26.20	25.00
Transplanting		49.00		
Uprooting Nursery			10.00	10.00
Transplanting			30.00	30.00
Supplying			9.00	9.00
Maintenance		29.91		
Cultivating			4.28	
Hoeing			14.43	10.00
Plant Protecting			11.20	10.00
Harvesting		46.55		
Combine			36.55	10.00
Transporting			10.00	5.00
Materials	153.00			
Fertilizer		98.00		
Sulphate of Ammonium(21%) 300kg			30.00	
Triple Super Phosphate(45%) 200kg			50.00	
Sulphate of Potash(50%) 100kg			18.00	
Seed 100kg @20¢		20.00		
Plant Protection		35.00		
Others	18.55			10.00
Rent	7.41			
Repair & Maintenance	-			
Taxes	-			
Total	384.00			

Table L-9

Production Costs per Hectare (Estimate) TT$ (Cont'd)

Interest for Operating Capital (2.5%)	9.60	
Management	14.40	
Grand Total	408.00	154.00
Net Income	312.00	
Net Income Ratio	43.3%	
Farming Family Income	490.00	

Table L-10

Production Costs per Hectare (Estimate) TT$

Crop: Maize — Unit Price of Products: 7.72 ¢/kg
Yield: 3,360 kg — Gross Value of Total Production: 259.40 TT$

				(Family Labour)
Field Operations	90.82			
Land Preparation		18.27		
Ploughing			1.23	
Harrowing			0.75	
Land Levelling			1.09	
Fertilizing			15.20	15.00
Planting		9.80		5.00
Maintenance		21.65		
Cultivating			0.71	
Hoeing			10.74	10.00
Plant Protecting			10.20	10.00
Harvesting		41.10		
Combine (with Corn Attachment)			33.10	10.00
Transporting			8.00	5.00
Materials	70.00			
Seed 50 kg @10¢		5.00		
Fertilizer		45.00		
Sulphate of Ammonium (21%) 300kg			30.00	
Triple Super Phosphate (45%) 60kg			15.00	
Plant Protection		20.00		
Others	15.48			5.00
Rent	3.70			
Repair & Maintenance	-			
Taxes	-			
Total	180.00			
Interest for Operating Capital (2.5%)	4.50			
Management	5.20			
Grand Total	189.70			60.00
Net Income	69.70			
Net Income Ratio	26.9%			
Farming Family Income	139.40			

Table L-11

Production Costs per Hectare (Estimate) TT$

Crop: Soybean
Yield: 1,900 kg

Unit Price of Products: 13.23 ¢/kg
Gross Value of Total Production: 251.40 TT$

				(Family Labour)
Field Operations	72.15			
Land Preparation		18.27		
Ploughing			1.23	
Harrowing			0.75	
Land Levelling			1.09	
Fertilizing			15.20	15.00
Planting		9.80		5.00
Maintenance		21.65		
Cultivating			0.71	
Hoeing			10.74	10.00
Plant Protecting			10.20	10.00
Harvesting		22.43		
Combine			14.43	10.00
Transporting			8.00	5.00
Materials	64.50			
Seed 70 kg @15¢		10.50		
Fertilizer		24.00		
Triple Super Phosphate(45%) 100kg			25.00	
Sulphate of Potash (50%) 50kg			9.00	
Plant Protection		20.00		
Others	19.65			6.00
Rent	3.70			
Repair & Maintenance	-			
Taxes	-			
Total	160.00			
Interest for Operating Capital (2.5%)	4.00			
Management	5.00			
Grand Total	169.00			61.00
Net Income	82.40			
Net Income Ratio	32.8%			
Farming Family Income	152.40			

Table L-12

Basic Data for Estimation of Production Cost

Labour Wages per Day		T.T.$
Tranctor Operator		8.00
Combine Operator		8.00
Farm Labour (male)		5.00
Farm Labour (female)		3.00
Fertilizer Price		
Sulphate of Ammonium	(21%) (kg)	0.10
Triple Super Phosphate	(45%) (kg)	0.25
Sulphate of Potash	(50%) (kg)	0.18
Price of Fuels*		
Petroleum (Light Oil)	(ℓ)	0.06
Lubricating Oil	(ℓ)	0.40
Price of Agricultural Machines & Equipments		
Tractor (MF-165, 60HP)		7,500
Disc Plough (MF-765, 3 Furrow)		1,140
Disc Harrow		1,800
Rotovator		1,630
Planter (Four-Row)		3,300
Sprayer		1,800
Cultivator*		560
Storage Hoe*		940
Combine (MF 400-7)		19,340
Corn Attachment for Above		8,690

* These Prices are estimated from Japanese Prices.

Table L-13

The Agricultural Mechanized System

Agricutlrual Machines and Equipment	Kinds of Work	Types and Sizes	Operating Width	Operating Speed	Theoretical Working Amount	Operating Efficiency in Cultivated Land	Working Amount per Hour	Coefficient for Movement	Working Amount Including Movement	Working Hour per Day	Working Amount per Day	Working Raito	Average Working Amount per Day	Average Working Amount per Hour
	-	-	m	km/hr.	ha./hr.	%	ha./hr.		ha./hr.	hrs.	ha./day	%	ha./day	ha./hr.
Disc Plough	Ploughing	3-Furrow	1.10	5.6	0.62	80	0.53	1.1	0.48	8	3.84	90	3.46	0.43
Disc Harrow	Harrowing	Diam 20"	2.21	5.6	1.24	80	0.99	1.1	0.90	8	7.20	90	6.48	0.81
Rotovator	Levelling	-	2.16	3.2	0.69	85	0.59	1.1	0.54	8	4.32	90	3.89	0.49
	Puddling	-	2.16	4.0	0.86	85	0.73	1.1	0.66	8	5.28	00	4.75	0.59
Planter	Planting	-	2.80	6.4	1.79	55	0.98	1.1	0.89	8	7.12	90	6.41	0.80
Cultivator	Cultivating	MF 920	2.13	4.0	0.85	85	0.72	1.1	0.65	8	5.20	90	4.68	0.59
Storage Hoe	Hoeing	MF Standen	2.80	3.2	0.90	85	0.77	1.1	0.70	8	5.60	90	5.04	0.63
Sprayer	Spraying	-	5.60	6.4	3.58	50	1.79	1.1	1.63	8	13.04	90	11.74	1.47
Combine	Harvesting	MF 400-7	4.20	2.2	0.92	75	0.69	1.1	0.63	8	5.04	80	4.03	0.50
Tractor	General	60 HP	(MF - 165)		-	-	-	-	-	-	-	-	-	-

Table L-14

Useful Lives of Agricultural Machines & Equipment

Agricultural Machines and Equipments	(1) Cultivated Area by Machines per year	(2) Daily Workable Area by Machines	(3) Working Days by Machines per year	(4) Number of Machines	(5) Annual Working Days per Machines	(6) Working Hours per day	(7) Annual Working Hours	(8) Durable Hours	(9) Useful Life
	ha.	ha./day	days	No.	days	hours	hours	hours	years
Disc Plough	364	3.46	106	3	36	8	288	2,000	7
Disc Harrow	364	6.48	57	3	19	8	152	2,000	13
Rotovator	273 91	4.75 3.89	58 24	3	28	8	224	2,000	9
Planter	91	6.41	15	1	15	8	120	1,200	10
Sprayer	728	11.74	63	3	21	8	168	1,500	9
Cultivator	364	4.68	78	2	39	8	312	2,500	8
Steerage Hoe	364	5.04	73	2	37	8	296	2,000	7
Combine	364	4.03	90	2	45	8	360	2,000	6
(Corn Attach.)	(45)	(3.83)	(12)	(1/2)	(24)	(8)	(192)	(1,000)	10
Tractor			474	3	158	8	1,264	12,000	9

Table L-15

The Basic Data for Culculation of Fixed Cost

Agricultural Machines and Equipments	Fixed Cost							Variable Cost	
	Useful Life	Remain-ing Value	Correlation of Total Repair Cost During Use-ful Life	Correlation of Annual Average Re-pair Cost	Correla-tion of Cost for Hanger	Tax (Correla-tion)	Insurance (Correla-tion)	Consump-tion of Fuel Oil	Consump-tion of Lubricating Oil
	yrs.	%	%	%	%	%	%	ℓ/hr.	ℓ/hr.
Disc Plough	7	10	40	5.71	0.85	0.5	0.25	5.00	1.50
Disc Harrow	13	10	40	3.08	1.66	0.5	0.25	3.50	1.05
Rotovator	9	10	50	5.56	0.80	0.5	0.25	4.50	1.35
Planter	10	10	40	4.00	0.95	0.5	0.25	2.00	0.60
Sprayer	9	10	32	3.56	0.39	0.5	0.25	2.00	0.60
Cultivator	8	10	30	3.75	1.00	0.5	0.25	3.50	1.05
Steerage Hoe	7	10	30	4.29	1.00	0.5	0.25	3.50	1.05
Combine	6	10	50	8.33	0.36	0.5	0.25	10.00	3.00
Corn Attachment	10	10	50	5.00	0.36	0.5	0.25	-	-
Tractor	9	10	70	8.75	0.43	0.5	0.25	-	-

Table L-16

Fixed Cost of Agricultural Machines & Equipment
(per year)

(T.T.$)

Agricultural Machines and Equipments	Purchase Price	Remaining Value	Useful Life	Annual Depreciation	Annual Repair and Maintenance	Cost for Hangar	Annual Capital Interest	Tax	Insurance	Total
Disc Plough	1,140	10%	7	147	65	10	38	6	3	269
Disc Harrow	1,800	10	13	125	55	30	59	9	5	283
Rotovator	1,630	10	9	163	91	13	54	8	4	333
Planter	3,300	10	10	297	132	31	109	17	8	594
Sprayer	1,800	10	9	180	64	7	59	9	5	324
Cultivator	560	10	8	63	21	6	18	3	1	112
Steerage Hoe	940	10	7	121	40	9	31	5	2	208
Combine	19,340	10	6	2,901	1,611	70	638	97	48	5,365
Corn Attachment	4,345	10	10	391	218	15	143	22	11	800
Tractor	7,500	10	9	750	656	32	248	38	19	1,743

Table L-17

Total Cost of Agricultural Machines & Equipment per Year

Agricultrual Machines and Equipment	(1) Fixed Cost			(2) Variable Cost			(3)	(4)	(5)	(6)	(7)
	Annual Fixed Cost	Annual Working Hours	Fixed Cost per Hour	Fuel Oil Cost per Hour	Lubri-cating Oil Cost per Hour	Variable Cost per Hour	Operator's Wage (Trac-tor and Combine)	Tractor's Fixed Cost per Hour	Total Cost per Hour	Working Hour per ha.	Total Cost per ha.
	TT$	hrs.	TT$/hr.	TT$/hr.	TT$/hr.	TT$/hr.	TT$/hr.	TT$/hr.	TT$/hr.	hrs./ha.	TT$/ha.
Disc Plough	269	288	0.93	0.30	0.60	0.90	1.00	1.38	4.21	2.33	9.80
Disc Harrow	283	152	1.86	0.21	0.42	0.63	1.00	1.38	4.87	1.23	6.00
Rotovator	333	224	1.49	0.27	0.54	0.81	1.00	1.38	4.68	1.86	8.70
Planter	594	120	4.95	0.12	0.24	0.36	1.00	1.38	7.69	1.25	9.60
Sprayer	324	168	1.93	0.12	0.24	0.36	1.00	1.38	4.67	0.68	3.18
Cultivator	112	312	0.36	0.21	0.42	0.63	1.00	1.38	3.37	1.69	5.70
Steerage Hoe	208	296	0.70	0.21	0.42	0.63	1.00	1.38	3.71	1.59	5.90
Combine	5,365	360	14.90	0.60	1.20	1.80	1.00	-	17.70	2.00	35.40
Corn Attach-ment	800	96	8.33	-	-	-	-	-	9.33	2.00	18.66
Tractor	1,743	1,264	1.38	-	-	-	-	-	-	-	-

Table L-18

Net Income

(T.T.$)

	Gross Value of Total Production per ha./per head	Production Cost per ha. or per head	Net Income per ha. or per head	Cropped Proportion per year	Net Income per ha./per head per year
Crop					
Paddy	720.00	408.00	312.00	1.50	468
Maize	259.40	189.70	69.70	0.25	17
Soybean	251.40	169.00	87.40	0.25	21
Livestock					
Beef Cattle	174.00	122.00	52.00		52

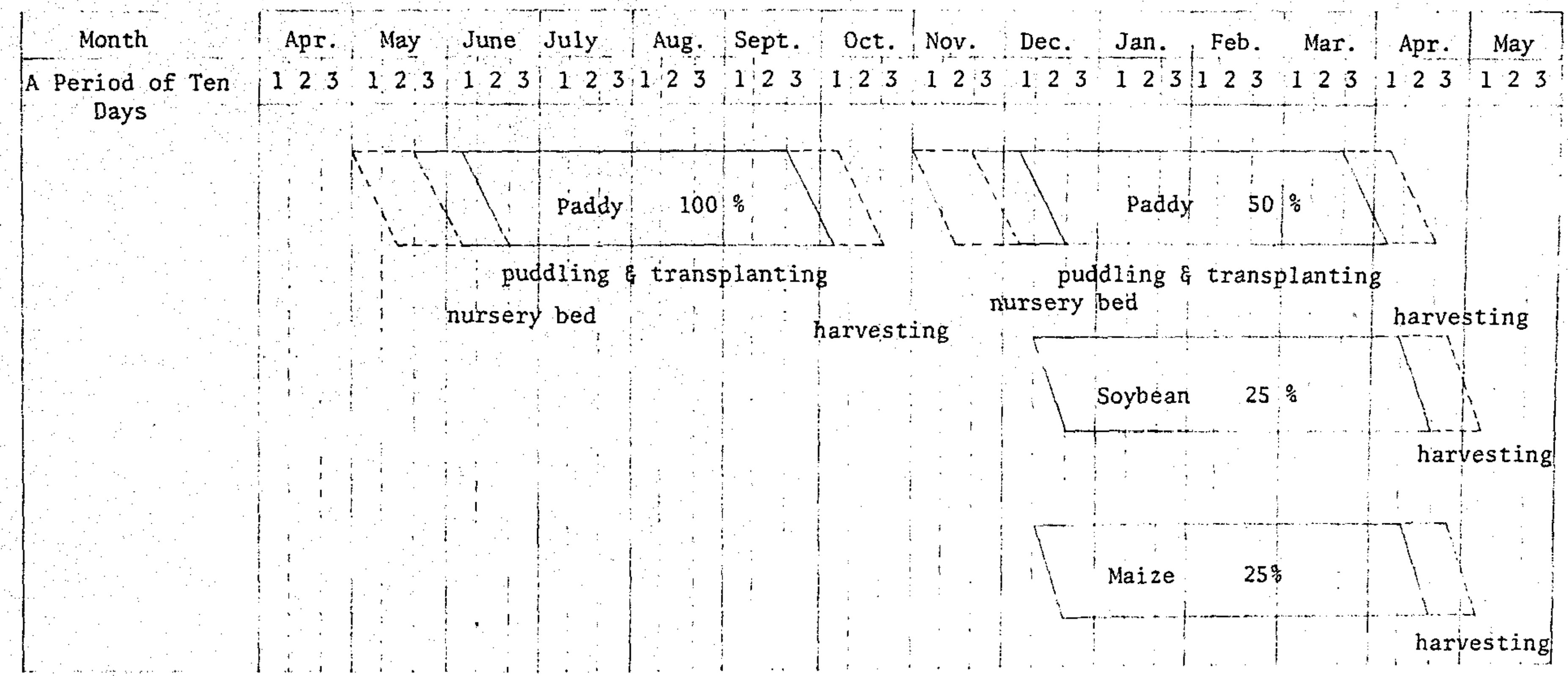
Table L-19

Farming Family Income Under Irrigation

(T.T.$)

Crop	Family Labour per ha.	Net Income per ha.	Capital Interest per ha.	Management Cost per ha.	Farming Family Income/ha.	Cropped Proportion per year	Farming Family Income per ha. per year
Paddy	154.00	312.00	9.60	14.40	490.00	1.50	735
Maize	60.00	69.70	4.50	5.20	139.40	0.25	35
Soybean	61.00	82.40	4.00	5.00	152.40	0.25	38
Total							808

Exhibit L-1



Proposed Cropping Pattern and Cropping Proportion

Appendix M

Project Benefit and Payment Capacity

Appendix M

Project Benefit and Payment Capacity

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Appendix M

Project Benefit and Payment Capacity

Time Flow of Total Project

The Nariva Swamp Agricultural Development Project consists of the irrigation and drainage plan in the swamp area and the land reclamation plan on hilly land south of the swamp area. The irrigation and drainage plan is divided into two stages. Major works of stage I is the Cocal Reservoir construction followed by its minor construction works. After a 5-year construction peiod, net irrigable area will amount up to about 2,800 (1,150 ha). Shortly after completion of the works of stage I, major works of stage II will be started on the construction of the Nariva Regulating Reservoir, L'Ebranche Cut, the Irrigation and Drainage Canals and so forth. With completion of a 5-year construction works of stage II, net irrigable area, about 6,200 acres (2,500 ha), is to be newly added to developed 2,800 acres, (1,150 ha) totalling about 9,000 acres (3,650 ha) in the Nariva Swamp area.

The development of the southern hilly land can be started at any time after completion of the works of stage I. It is mentioned in this report that land reclamation works shall be started shortly after commencement of the works of stage I. About 7,400 acres (3,000 ha) of net operating area shall be developed within a 5-year construction period of hilly land (excluding an existing wind belt under lease) is selected as suitable lands to livestock raising owing to their easiness in reclamation In the course of the land reclamation works, an effort should be made for preservation of shadow trees as much as possible. Exhibit M-1 shows time flow of summarized total plan of the Nariva Swamp Agricultural Development project.

Economic Evaluation

The objective area involved in the irrigation and drainage scheme is the Nariva Swamp, where a relatively high-lying land is temporarily utilized covering 500 acres out of about 1,200 acres developed by Plum Mitan Rice

Scheme. The land utilization does not reach its full development, and to make, it is difficult to reveal the present stage of the land utilization. The existing irrigation and drainage facilities shall be all repaired or renovated in the present development project. The above-mentioned 500 acres with existing facilities is also included in the taken up as an objective area in the present project.

As already mentioned, the development of the swamp area shall be proceeded in 2 stages. Economic analysis was based on the addition of calculated values for each stage. With such a technical method, Exhibit M-2 showing time flow was composed on the basis of cost and benefit at 7% interest rate and a 50-year economic analysis period. The economic yield has a 5-year time lag between stage I and stage II. Annual cost and benefit of each stage are estimated at an incidental time of economic yield in each stage. Each total of annual cost and benefit is estimated in a manner that annual cost and benefit of stage I is added to a component of discounted cost and benefit of stage II in consideration of 5-year time lag.

The development project plan of the swamp area was completed on the basis of each case study. This is mentioned a little in "Cropping Proportion" of Appendix L. The final development project plan was completed in a comparative study of the changes of cost and benefit related to each cropping pattern.

Table M-1-a shows data for a final plan. B/C ratio of Case III is estimated higher than that of case II. As already mentioned, the B/C ratio of case III is the theoretical one, since there are some intangible negative factors such as technical difficulties of project construction, compensation for the submerging lands and the cultivation limited to paddy rice in carrying out the Case III. To solve these matters, more detailed survey should be made for a rather longer period. By this reason, the case II was adopted for the development of the irrigable area in the project. Table M-1-a shows a case of annual cost at 7% interest rate. For reference, Table M-1-b shows annual cost, annual benefit and B/C ratio at 3% and 6% interest rates. Interst rate is one of the most important elements upon calculation of economic analysis. Trinidad and Tobago obtain a long-term loan at 7% interst rate from A.D.B. (the Agricultural Development Bank). The project cost of the Crown Land is also financed at 7% interest rate. That is the reason why 7% interest rate is adopted in the estimation of the project. For reference, the economic analyses were made on the basis of interest rate at 3% and 6%; the former is the rate in soft-lan by the international financing agencies and the latter is the rate of opportunity cost in major countries. The economic analysis period is 50 years including a 5-year straight line lag period to reach the target yields in the divisions of agriculture and livestock.

Annual Benefit

Table M-2-a, b and c show annual benefit and its calculation process. The remarkable point is that the full benefit of the project development will be relatively higher, amounting up to TT$506 per ha (US$253 per ha).

Annual Cost

Table M-3 shows the breakdown of the cost in each case and stage in the irrigation and drainage scheme. Upon calculation of B/C ratio in the same table, it is net land investments that are included in annual cost, and they are construction cost, land improvement cost and O&M cost.

Annual cost was calculated on the basis of net land investment. Annual cost was calculated on an addition of replacement cost, O&M cost, interest during construction period and a total installation cost (construction cost and land improvement cost). Replacement cost was estimated on the renovation cost of steel gate a 25-year life. Most of O&M cost in each case is personnel expenditure, which is proportionated by a ratio of construction cost in each case and stage. As the details of yearly construction investment were not clear, an interest on a total installation cost during construction period was calculated on the assumption that equal amount will be paid annually. Table M-4-a, b and c show annual cost at,3%, 6% and 7% interest rates in the scheme for total area of case II.

Benefit Cost Ratio

B/C ratio is an important element to judge the economic feasibility of the development project. The costs excluding O&M cost and replacement cost are inputs during a relatively short period before the economic result yields. Benefit is an output in a long period after completion of the project. Therefore, in order to compare with these two elements with time lag, the conversions shall be made, on the same time basis, from total input cost to annual equivalent cost and from output benefit to annual equivalent benefit. The result of this comparison is shown clearly in Exhibit M-2. B/C ratio of case II adopted for the development project is shown below.

Benefit Cost Ratio under Irrigation
(Case II)

(TT$)

		Annual Benefit	per ha	Annual Cost	per ha	B/C Ratio
7%	Stage I	508,101	442	527,581	459	0.96
	Stage II	1,104,568	442	967,376	387	1.14
	Total Area	1,295,658	355	1,217,320	334	1.06
6%	Stage I	516,069	449	457,651	398	1.13
	Stage II	1,121,889	449	838,633	335	1.34
	Total Area	1,354,457	371	1,084,361	297	1.25
3%	Stage I	539,309	469	278,757	242	1.93
	Stage II	1,172,411	469	509,283	204	2.30
	Total Area	1,550,631	425	718,064	197	2.16

Internal Rate of Return (Irrigation)

The conception of internal rate of return can be explained as a discount factor (interest rate) which will make the total benefit, in a period analysis of a project, equivalent to the invested total cost for the benefit. In other words, internal rate of return is defined as interest rate to make B/C ratio at 1.

i		0.03	0.04	0.05	0.06	0.07	0.08
Annual Benefit	(per ha.)	425	406	388	371	355	340
Annual Cost	(per ha.)	197	229	262	297	334	371
B/C Ratio		2.16	1.77	1.48	1.25	1.06	0.92

As mentioned in the above list, B/C ratio comes below 1 between 7% and 8% interest rates. According to Exhibit M-3 plotted with the above figures, internal rate of return is 7.4%.

Of land reclamation works (livestocks), detailed topographical map was not available. Therefore, the survey was not made sufficiently, so that the estimation of input and output for livestocks (beef cattle breeding) was obliged to be roughly made. Economic evaluation was conservatively estimated to result in B/C ratio, 1.53, and internal rate of return. 10.1%. which are higher than those of irrigation scheme. As already mentioned in the article of repayment capacity in this report, a large-scaled livestocks operation and management is expected to be established by the estates, if TT$800 per ha is allowed to be invested on the private basis.

This contributes much to the national economy by saving foreign exchange at US$640,462 annually. An initial investment cost of TT$800 per ha (excluding TT$140 of an interest during construction period) amounts up to US$1,200,000 in total, and some subsidies to the scheme are considered to be given by the Government.

Rapid increase of domestic pork production and its price reduction is, at present, advancing. The countermeasure for this situation should be taken in future prospect of the substitution of pork for beef and decrease of import beef. Full consideration should be taken for this matter in the future.

Benefit cost ratio is 3.06 in case of 3% interest rate, 1.79 in case of 6% interest rate, 1.53 in case of 7% interest rate and 1.01 in case of 10% interest rate. The calculation basis of each cost and benefit in case of 7% interest rate is mentioned in this report.

Table M-9 and 10 show the calculation basis of each cost and benefit in other interest rates.

Special loan was not considered because repayment is made by estates' own capital. Repayment will be possible under the conditions of 10% annual interest rate over 17 years including a 5-year grace period. Internal rate of return is estimated at 10.1% according to the figures below mentioned and Exhibit M-4.

i		0.03	0.05	0.06	0.07	0.08	0.10	0.11
Annual Benefit	(per ha)	120.5	117.1	115.3	113.5	111.7	108.2	106.1
Annual Cost	(per ha)	39.4	55.3	64.4	74.1	84.5	106.9	118.8
B/C Ratio		3.06	2.12	1.79	1.53	1.32	1.01	0.89

Payment Capacity and Payment Schedule

Payment Capacity

Of TT$14,270,000 of a total of project cost of irrigation and drainage scheme, US$3,320,000 of a foreign exchange currency component is financed on a soft-loan by the international financing agencies, and the rest is disbursement from the budget of the Government. TT$2,044,000 for land improvement cost and TT$3,484,000 for cooperative facilities cost are financed by the Agricultural Development Bank.

Agricultural machinery cooperatively operated by farmers is all of foreign make. The cost of farm machinery, which reaches up to US$955,000 in total, is expected to be financed on a soft-loan by the international financing agencies. Each portion of repayment for mechanization and co-operative facilities is deducted upon determination of agricultural production cost of farm gate price. The repayment, which should be made from farming family income is borne by an annual amortization of land improvement, water facilities and M&O cost. Out of farming family income, TT$4,524/household, the percentage of savings amount depends upon the extent of living expense according to propriate standards of living. The data of this matter were not available in Trinidad and Tobago. In this connection the survey was made in Japan to result that 20% of the income is saved by the farming family which can pay living expenses out of its net agricultural income. In the case, therefore, this 20% of savings rate is adopted for the savings account of farming family in Trinidad and Tobago.

Out of the possible savings amount, the amount to be allocated for amortization of debt is viewed to be maximum at 40% of the income in consideration of the primary purpose of savings such as increaseing of capital and raising of the standards of living. Upon calculation of repayment capacity, savings amount is TT$65 per ha and TT$362 per household. By this, 70% of land improvement cost is a debt of farming household. (30% is supplemented by family labour force.) The amortization is TT$49 per ha and TT$276 per household. TT$16 per ha and TT$90 per household are an amount to be paid for M&O cost as water charge. M&O cost is TT$29 per ha and TT$162 per household. The half of M&O cost is only paid. The rest half should be borne by the subsidies of the Government or its direct collection of water charge. The local currency of construction cost should be an expenditure by annual budget of the Government as already mentioned. Such being the case, it is impossible to collect annual amortization (US$223,171/ 3,650 ha = US$61/ha Maximum annual amortization amount) from farmers on a foreign exchange component loaned by international financing agencies. Therefore, the foreign exchange component of annual amortization should be an expenditure by the budget of the Government as detailed in the following article.

Payment Schedule

Repayment of farming household is mentioned in the previous article. The repayment of local currency to the Agricultural Development Bank from the cooperative and foreign exchange to the international financing agencies from the Government is mentioned as follows.

Local Currency

As shown in Table M-5 and M-6, local currency covers the repayment of a loan for cooperative facilities and land improvement costs. (7% interest rate over 17 years with a 5-year grace period is included in the repayment amount.)

	Loan	Repayment Amount	Annual Repayment Amount (maximum years)
Associated cost	TT$3,484,000	6,604,972	438,636
Land improvement	2,044,000	3,875,000	257,340
Total:	TT$5,528,000	10,479,972	695,976

Land improvement is made by farmers' labour force and "Repayment Schedule" of the above article is made on the basis that 70% of the relative cost shall be loaned to the famers. As the said "Repayment Schedule" is drawn up for the cooperative, land improvement will be not made by all farmers' labour force. Repayment amount was estimated with allowance on the assumption that full amount of loan will be financed. The repay of farmers is dealt with by the cooperative, which the repayment will be made to the Agricultural Development Bank. Associated cost is collected as the charges of the use of cooperative facilities from farmers by the cooperative. The associated cost will be paid to the Agricultural Development Bank.

Foreign Exchange

46.5% of construction cost and the cost of farm machinery is financed on a soft-loan in foreign exchange. (Construction cost is at 3% interest rate over 25 years including a 25-year grace period. Mechanization cost is at 3% interest rate over 17 years including a 5-year grace period.)

	Loan	Repayment	Per Annum
Construction cost	US$3,320,000	4,712,420	157,080
Mechanization cost	1,016,250	1,376,056	62,500

Mechanization cost is collected by the cooperative as the charge (included in production cost) of the use of farm machinery. The collected charges will be paid to the international financing agencies through the Agricultural Development Bank. A foreign exchange component of constructio cost should be paid annually by the budget of the Government as shown in Table M-7. An average annual amount of the repayment is US$157,080, which is only 10% of US$2,243,836 of foreign exchange saving amount required for domestic production of the substitutes for the imported goods (Maximum amortization year: the 11th year to the 25th year). The Nariva Swamp agricultural development project is, therefore, advantageous from the national economic standpoint.

Foreign Exchange Saving Amount
(After completion of the project works)

	Imports (1966)		Ratio of Substitutes for Imported Goods		Foreign Exchange Saving Amount
Paddy rice	TT$9,292,000	x	41.5%	=	3,856,180
Maize	3,946,000	x	10.2%	=	402,492
Soybean	1,000,000	x	22.9%	=	229,000
	Sub-total:				4,487,672
Meat	7,156,000	x	17.9%	=	1,280,924
	Grand-Total			=	5,768,596

Note: The ratio of agricultural production to the imports in the project is as follows:

Paddy rice	41.5%
Maize	10.2%
Soybean	22.9%
Meat	17.9%

The estimated foreign exchange saving amount for irrigation and livestock developments amounts annually up to TT$4,487,677 (US$2,243,836) and TT$1,280,924 (US$640,462), respectively.

Table M-1-a

Benefit Cost Ratio by Cases and Stages (Irrigation)

i = 7%		Construction Costs	Land Improvement Costs	Total Insallation Costs	Full Benefit	Annual Cost	Annual Benefit	B/C Ratio
CASE I	Stage I 1,150 ha.	4,370,000 3,800	644,000 560	5,014,000 4,360	446,200 388	462,428 402	389,611 339	0.84
1st Crop: Paddy 100%	Stage II 2,500 ha.	9,170,000 3,668	1,400,000 560	10,570,000 4,228	970,000 388	970,376 388	846,981 339	0.87
2nd Crop: Field Crop 100%	Total 3,650 ha.	13,540,000 3,710	2,044,000 560	15,584,000 4,270	1,416,200 388	1,154,306 316	993,508 272	0.86
CASE II	Stage I 1,150 ha.	5,100,000 4,435	644,000 560	5,744,000 4,995	581,900 506	527,581 459	508,101 442	0.96
1st Crop: Paddy 100%	Stage II 2,500 ha.	9,170,000 3,668	1,400,000 560	10,570,000 4,228	1,265,000 506	967,376 387	1,104,568 442	1.14
2nd Crop: Paddy 50% Field Crop 50%	Total 3,650 ha.	14,270,000 3,910	2,044,000 560	16,314,000 4,470	1,846,900 506	1,217,320 334	1,295,658 355	1.06
CASE III	Stage I 1,150 ha.	7,900,000 6,870	644,000 560	8,544,000 7,430	717,600 624	776,974 676	626,591 545	0.81
1st Crop: Paddy 100%	Stage II 2,500 ha.	9,170,000 3,668	1,400,000 560	10,570,000 4,228	1,560,000 624	956,376 383	1,362,155 545	1.42
2nd Crop: Paddy 100%	Total 3,650 ha.	17,070,000 4,677	2,044,000 560	19,114,000 5,237	2,277,600 624	1,458,870 400	1,597,808 438	1.10

(Note) Total is estimated by adding Stage II discounted 5 years at same i (7%) to Stage I.

Table M-1-b

Benefit Cost Ratio by Cases & Stages at 3%, 6% Interest Rate (Irrigation)

(T.T.$)

		Interest Rate: 3%			Interest Rate: 6%		
		Annual Cost	Annual Benefit	B/C Ratio	Annual Cost	Annual Benefit	B/C Ratio
CASE I	Stage I 1,150 ha.	245,254 213	413,541 360	1.69	401,393 349	395,721 344	0.99
1st Crop: Paddy 100%	Stage II 2,500 ha.	512,283 205	899,003 360	1.75	841,633 337	860,263 344	1.02
2nd Crop: Field Crop 100%	Total 3,650 ha.	687,149 188	1,189,021 326	1.73	1,030,345 282	1,038,596 285	1.01
CASE II	Stage I 1,150 ha.	278,757 242	539,309 469	1.93	457,651 398	516,069 449	1.13
1st Crop: Paddy 100%	Stage II 2,500 ha.	509,283 204	1,172,411 469	2.30	838,633 335	1,121,889 449	1.34
2nd Crop: Paddy 50% Field Crop 50%	Total 3,650 ha.	718,064 197	1,550,631 425	2.16	1,084,361 297	1,354,457 371	1.25
CASE III	Stage I 1,150 ha.	406,756 354	655,077 578	1.64	672,927 585	636,417 553	0.95
1st Crop: Paddy 100%	Stage II 2,500 ha.	498,283 199	1,445,819 578	2.90	827,633 331	1,383,516 553	1.67
2nd Crop: Paddy 100%	Total 3,650 ha.	836,575 229	1,912,240 487	2.29	1,291,417 354	1,670,319 458	1.29

Table M-2-a

Annual Benefit (TT$)
(Irrigation)

(Case II)

Interest Rate: 3%
Period of the Analysis: 50 yrs.

	Stage I (1,150 ha)	Stage II (2,500 ha)	Total (3,650 ha)
(1) Annual Net Income (Full Benefit)	581,900	1,265,000	1,673,089
Straight line lag			
(2) Annual Increase (1) x 1/5	116,380	253,000	334,618
(3) Present Worth (2) x 13.4684	1,567,452	3,407,505	4,506,766
(4) Amortized for 50 years (3) x 0.03887	60,927	132,450	175,178
Complete lag			
(5) Present Worth at beginning of 6th year (1) x 24.519	14,267,606	31,016,535	41,022,469
(6) Present Worth at beginning of 1st year (5) x 0.8626	12,307,237	26,754,863	35,385,982
(7) Equivalent annual 50 years (6) x 0.03887	478,382	1,039,961	1,375,453
(8) Equivalent annual Benefit for straight line lag period	60,927	132,450	175,178
Total Annual Benefit	539,309	1,172,411	1,550,631
-ditto- per hectare	469	469	425

Note: (Total) = (Stage I) + (Stage II) x 0.8626

Table M-2-b

Annual Benefit (TT$)
(Irrigation)

(Case II)

Interest Rate: 6%

Period of the Analysis: 50 yrs.

	Stage I (1,150 ha)	Stage II (2,500 ha)	Total (3,650 ha)
(1) Annual Net Income (Full Benefit)	581,900	1,265,000	1,527,235
Straight line lag			
(2) Annual Increase (1) x 1/5	116,380	253,000	305,447
(3) Present Worth (2) x 12.1469	1,413,650	3,073,166	3,710,234
(4) Amortized for 50 years (3) x 0.06344	89,682	194,962	235,377
Complete lag			
(5) Present Worth at beginning of 6th year (1) x 15.456	8,993,846	19,551,840	23,604,944
(6) Present Worth at beginning of 1st year (5) x 0.7473	6,721,101	14,611,090	17,639,975
(7) Equivalent annual 50 years (6) x 0.06344	426,387	926,927	1,119,080
(8) Equivalent annual Benefit for straight line lag period	89,682	194,962	235,377
Total Annual Benefit	516,069	1,121,889	1,354,457
-ditto- per hectare	449	449	371

Note: (Total) = (Stage I) + (Stage II) x 0.7473

Table M-2-c

Annual Benefit (TT$)
(Irrigation)

(Case II)

Interest Rate: 7%

Period of the Analysis: 50 yrs.

	Stage I (1,150 ha)	Stage II (2,500 ha)	Total (3,650 ha)
(1) Annual Net Income (Full Benefit)	581,900	1,265,000	1,483,845
Straight line lag			
(2) Annual Increase (1) x 1/5	116,380	253,000	296,769
(3) Present Worth (2) x 11.7469	1,367,104	2,971,966	3,486,115
(4) Amortized for 50 years (3) x 0.07246	99,060	215,349	252,604
Complete lag			
(5) Present Worth at beginning of 6th year (1) x 13.606	7,917,331	17,211,590	20,189,195
(6) Present Worth at beginning of 1st year (5) x 0.7130	5,645,057	12,271,864	14,394,896
(7) Equivalent annual 50 years (6) x 0.07246	409,041	889,219	1,043,054
(8) Equivalent annual Benefit for straight line lag period (4)	99,060	215,349	252,604
Total Annual Benefit	508,101	1,104,568	1,295,658
-ditto- per hectare	442	442	355

Note: (Total) - (Stage I) + (Stage II) x 0.713

Table M-3

Specification of Costs for the Nariva Project
(Irrigation)

(TT$)

		Stage I		Stage II		Total Area	
		1,150 ha		2,500 ha		3,650 ha	
		TT$	per ha	TT$	per ha	TT$	per ha
I. Investment Costs							
1) Construction Cost	Case I	4,370,000	3,800	9,170,000	3,668	13,540,000	3,710
	Case II	5,100,000	4,435	9,170,000	3,668	14,270,000	3,910
	Case III	7,900,000	6,870	9,170,000	3,668	17,070,000	4,667
2) Land Improvement Cost Case I,II,III		644,000	560	1,400,000	560	2,044,000	560
3) Total Installation Costs[1)+2)]	Case I	5,014,000	4,360	10,570,000	4,228	15,584,000	4,270
	Case II	5,744,000	4,995	10,570,000	4,228	16,314,000	4,470
	Case III	8,544,000	7,430	10,570,000	4,228	19,114,000	5,237
4) Replacement Cost Case I,II,III		40,000	35	33,000	13	73,000	20
II. O & M Cost	Case I	35,000	30	70,000	28	105,000	29
	Case II	38,000	30	67,000	27	105,000	29
	Case III	49,000	43	56,000	22	105,000	29
III. Associated Costs							
a) Production Facilities							
1) Agr. Machine Pool		105,000	91	210,000	84	315,000	86
2) Rice Center		400,000	348	800,000	320	1,200,000	329
3) Store House		15,000	13	30,000	12	45,000	12
4) Motor Pool		60,000	52	-	-	60,000	16
5) Agr. Reserch Station		200,000	174	-	-	200,000	55
Sub-Total		780,000	678	1,040,000	416	1,820,000	498
b) Others							
1) Domestic House		520,000	452	1,144,000	458	1,664,000	456
Total [a) + b)]		1,300,000	1,130	2,184,000	874	3,484,000	954

Table M-4-a

Annual Cost (TT$)
(Irrigation)

(Case II)

Interest Rate: 3%

Period of the Analysis: 50 yrs.

	Stage I (1,150 ha)	Stage II (2,500 ha)	Total (3,650 ha)
Estimated installation cost and initial investment:			
(1) Total installation cost	5,744,000	10,570,000	14,861,682
(2) Interest during construction (1) x 1/2 x 0.03 x 5	430,800	792,750	1,114,626
(3) Total initial investment (1) + (2)	6,174,800	11,362,750	15,976,308
Annual Cost:			
(4) Operation & Maintenance Cost	38,000	67,000	95,794
(5) Amortization of investment Cost (3) x 0.03887	240,014	441,670	620,999
(6) Price of Replacement	40,000	33,000	68,466
(7) Replacement Cost (6) x 0.4776 x 0.03887	743	613	1,271
Grand Total Cost	278,757	509,283	718,064
-ditto- per ha.	242	204	197

Note: (Total) = (Stage I) + (Stage II) x 0.8626

Table M-4-b

Annual Cost (TT$)
(Irrigation)

(Case II)

Interest Rate: 6%

Period of the Analysis: 50 yrs.

	Stage I (1,150 ha)	Stage II (2,500 ha)	Total (3,650 ha)
Estimated installation Cost and initial investment:			
(1) Total installation cost	5,744,000	10,570,000	13,642,961
(2) Interest during construction (1) x 1/2 x 0.06 x 5	861,600	1,585,500	2,046,444
(3) Total initial investment (1) + (2)	6,605,600	12,155,500	15,689,405
Annual Cost:			
(4) Operation & Maintenance Cost	38,000	67,000	88,069
(5) Amortization of investment Cost (3) x 0.06344	419,059	771,145	995,336
(6) Price of Replacement	40,000	33,000	64,661
(7) Replacement Cost (6) x 0.2330 x 0.06344	591	488	956
Grand Total	457,651	883,633	1,084,361
-ditto- per ha.	398	335	297

Note: (Total) = (Stage I) + (Stage II) x 0.7473

Table M-4-c

Annual Cost (TT$)
(Irrigation)

(Case II)

Interest Rate: 7%

Period of the Analysis: 50 yrs.

	Stage I (1,150 ha)	Stage II (2,500 ha)	Total (3,650 ha)
Estimated installation Cost and initial investment:			
(1) Total installation cost	5,744,000	10,570,000	13,280,410
(2) Interest during construction (1) x 1/2 x 0.07 x 5	1,005,200	1,849,750	2,324,072
(3) Total initial investment (1) + (2)	6,749,200	12,419,750	15,604,482
Annual Cost:			
(4) Operation & Maintenance cost	38,000	67,000	85,771
(5) Amortization of investment cost (3) x 0.07246	489,047	899,935	1,130,701
(6) Price of replacement	40,000	33,000	63,529
(7) Replacement cost (6) x 0.1842 x 0.07246	534	440	848
Grand Total	527,581	967,375	1,217,320
-ditto- per ha.	459	387	v 334

Note: (Total) = (Stage I) + (Stage II) x 0.713

Table M-5

Repayment Schedule for L.C. (TT$)
(Associated Cost)

Interest Rate: 7%
Repayment: 17 yrs. (incld. 5yrs-grace)

Year	Loan			Repayment		
	Stage I	Stage II	Total	Stage I	Stage II	Total
1						
2						
3						
4						
5	1,300,000		1,300,000	45,500		45,500
6				91,000		91,000
7				91,000		91,000
8				91,000		91,000
9				91,000		91,000
10		2,184,400	2,184,000	91,000	76,440	167,440
11				163,670	152,880	316,550
12				163,670	152,880	316,550
13				163,670	152,880	316,550
14				163,670	152,880	316,550
15				163,670	152,880	316,550
16				163,670	274,966	438,636
17				163,670	274,966	438,636
18				163,670	274,966	438,636
19				163,670	274,966	438,636
20				163,670	274,966	438,636
21				163,670	274,966	438,636
22				163,670	274,966	438,636
23					274,966	274,966
24					274,966	274,966
25					274,966	274,966
26					274,966	274,966
27					274,966	274,966
Total	1,300,000	2,184,000	3,484,000	2,464,540	4,140,432	6,604,972

Table M-6

Repayment Schedule for L.C. (TT$)
(Land Improvement Cost)

Interest Rate: 7%
Repayment: 17 yrs. (includ. 5yrs-grace)

Year	Loan			Repayment		
	Stage I	Stage II	Total	Stage I	Stage II	Total
1						
2						
3						
4						
5	644,000		644,000	22,540		22,540
6				45,080		45,080
7				45,080		45,080
9				45,080		45,080
10		1,400,000	1,400,000	45,080	49,000	94,080
11				81,080	98,000	179,080
12				81,080	98,000	179,080
13				81,080	98,000	179,080
14				81,080	98,000	179,080
15				81,080	98,000	179,080
16				81,080	176,260	257,340
17				81,080	176,260	257,340
18				81,080	176,260	257,340
19				81,080	176,260	257,340
20				81,080	176,260	257,340
21				81,080	176,260	257,340
22				81,080	176,260	257,340
23					176,260	176,260
24					176,260	176,260
25					176,260	176,260
26					176,260	176,260
27					176,260	176,260
Total	644,000	1,400,000	2,044,000	1,220,900	2,654,120	3,875,020

Table M-7

Repayment Schedule for F.E. (US$)
(Construction Cost)

Interest Rate: 3%
Repayment: 25 yrs. (includ. 5yrs-grace)

Year	Loan			Repayment		
	Stage I	Stage II	Total	Stage I	Stage II	Total
1	227,000		227,000	3,405		3,405
2	227,000		227,000	10,215		10,215
3	227,000		227,000	17,025		17,025
4	227,000		227,000	23,835		23,835
5	227,000		227,000	30,645		30,645
6		437,000	437,000	76,295	6,555	82,850
7		437,000	437,000	76,295	19,665	95,960
8		437,000	437,000	76,295	32,775	109,070
9		437,000	437,000	76,295	45,885	122,180
10		437,000	437,000	76,295	58,995	135,290
11				76,295	146,876	223,171
12				76,295	146,876	223,171
13				76,295	146,876	223,171
14				76,295	146,876	223,171
15				76,295	146,876	223,171
16				76,295	146,876	223,171
17				76,295	146,876	223,171
18				76,295	146,876	223,171
19				76,295	146,876	223,171
20				76,295	146,876	223,171
21				76,295	146,876	223,171
22				76,295	146,876	223,171
23				76,295	146,876	223,171
24				76,295	146,876	223,171
25				76,295	146,876	223,171
26					146,876	146,876
27					146,876	146,876
28					146,876	146,876
29					146,876	146,876
30					146,876	146,876
Total	1,135,000	2,185,000	3,320,000	1,611,025	3,101,395	4,712,420

Table M-8

Repayment Schedule for F.E. (US$)
(Mechanization Costs)

Interest Rate: 3%
Repayment: 17 yrs. (includ. 5yrs-grace)

Year	Loan			Repayment		
	Stage I	Stage II	Total	Stage I	Stage II	Total
1						
2						
3						
4						
5						
6	320,000		320,000	9,600		9,600
7				9,600		9,600
8				9,600		9,600
9				9,600		9,600
10				9,600		9,600
11		635,000	635,000	32,147	19,050	51,197
12				32,147	19,050	51,197
13				32,147	19,050	51,197
14				32,147	19,050	51,197
15				32,147	19,050	51,197
16				32,147	63,792	95,939
17				32,147	63,792	95,939
18				32,147	63,792	95,939
19				32,147	63,792	95,939
20				32,147	63,792	95,939
21				32,147	63,792	95,939
22				32,147	63,792	95,939
23					63,792	63,792
24					63,792	63,792
25					63,792	63,792
26					63,792	63,792
27					63,792	63,792
Total	320,000	635,000	955,000	433,764	860,754	1,294,518

Table M-9

Annual Benefit (TT$ per hectare)
(Beef Cattle Farms)

Period of the Analysis: 50 yrs

Interest Rate: i

	3%	6%	7%	10%
(1) Annual Net Income (Full Benefit)	130.0	130.0	130.0	130.0
Straight line lag				
(2) Annual Increase (1) x 1/5	26.0	26.0	26.0	26.0
(3) Present Worth (2) x $\sum_{k=1}^{5} \frac{k}{(1+i)^k}$ 1/	350.2	315.8	305.4	277.0
(4) Amortized for 50 yrs. (3) x $\left[\sum_{k=1}^{50} \frac{1}{(1+i)^k} \right]^{-1}$ 2/	13.6	20.0	22.1	27.9
Complete lag				
(5) Present Worth at beginning of 6th year (1) x $\sum_{k=1}^{45} \frac{1}{(1+i)^k}$ 3/	3,187.5	2,009.3	1,768.8	1,282.2
(6) Present Worth at beginning of 1st year (5) x $\frac{1}{(1+i)^5}$ 4/	2,749.5	1,510.5	1,261.1	796.1
(7) Equivalent annual 50 years (6) x $\left[\sum_{k=1}^{50} \frac{1}{(1+i)^k} \right]^{-1}$	106.9	95.3	91.4	80.3
(8) Total Annual Benefit (4) + (7)	120.5	115.3	113.5	108.2

Note: 1/ Uniformly Increasing Annual Series - Present Worth Factor
2/ Capital Recovery Factor
3/ Uniform Series - Present Worth Factor
4/ Single Payment - Present Worth Factor

Table M-10

Annual Cost (TT$ per hectare)
(Beef Cattle Farming)

Period of the Analysis: 50 yrs.

	Interest Rate: i			
	3%	6%	7%	10%
Estimated installation cost and initial investment:				
(1) Total installation cost	800.0	800.0	800.0	800.0
(2) Interest during construction period (1) x 1/2 x i x 5	60.0	120.0	140.0	200.0
(3) Total initial investment (1) + (2)	860.0	920.0	940.0	1,000.0
Annual Cost:				
(4) Operation & Maintenance cost	6.0	6.0	6.0	6.0
(5) Amortization of investment cost (3) x $\left(\sum_{n=1}^{50} \frac{1}{(1+i)^n} \right)^{-1}$ *	33.4	58.4	68.1	100.9
(6) Replacement Cost	-	-	-	-
Grand Total Cost	39.4	64.4	74.4	106.9

Note: * Capital Recovery Factor

Time Flow of Total Project

Exhibit M-1

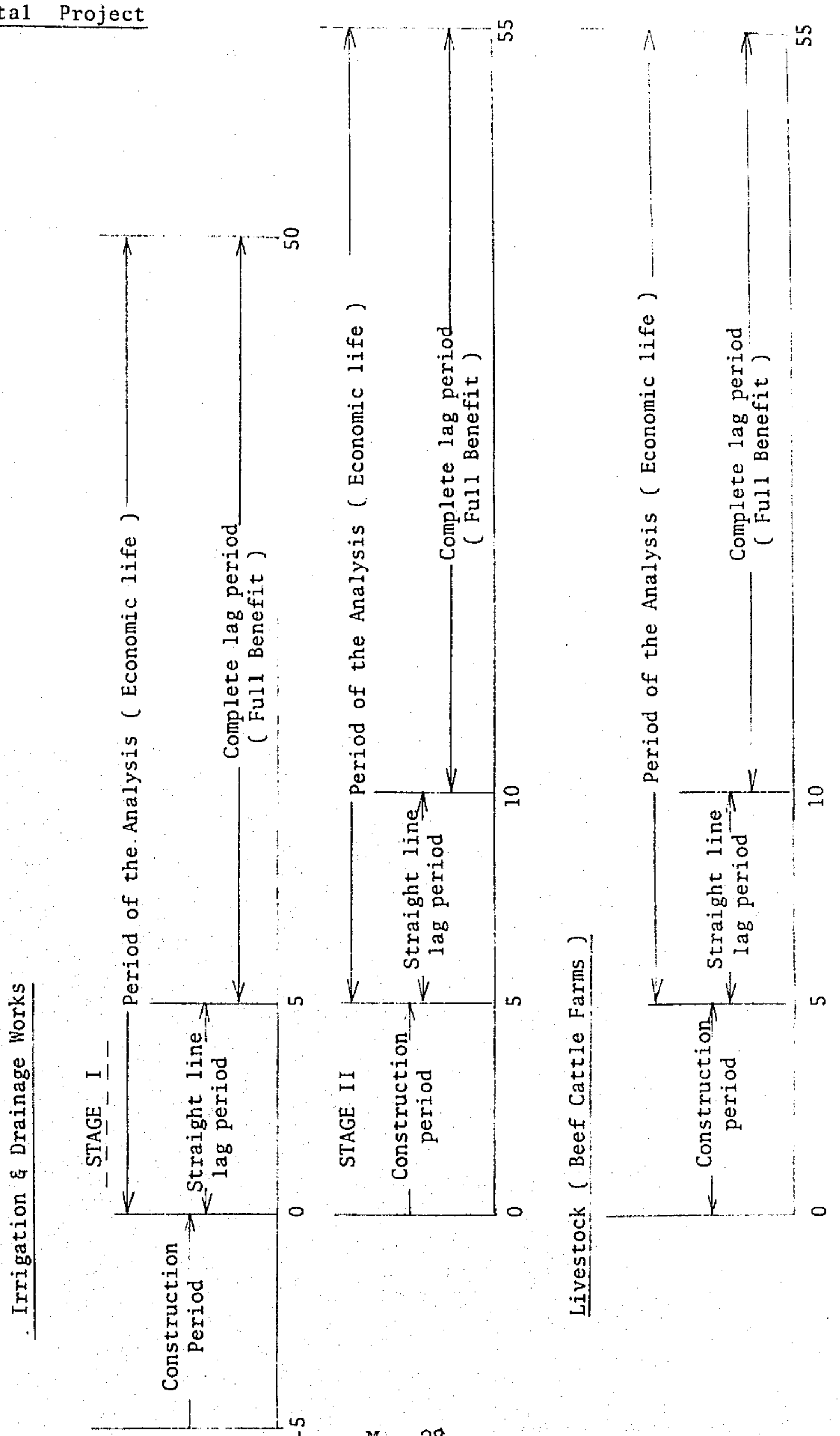
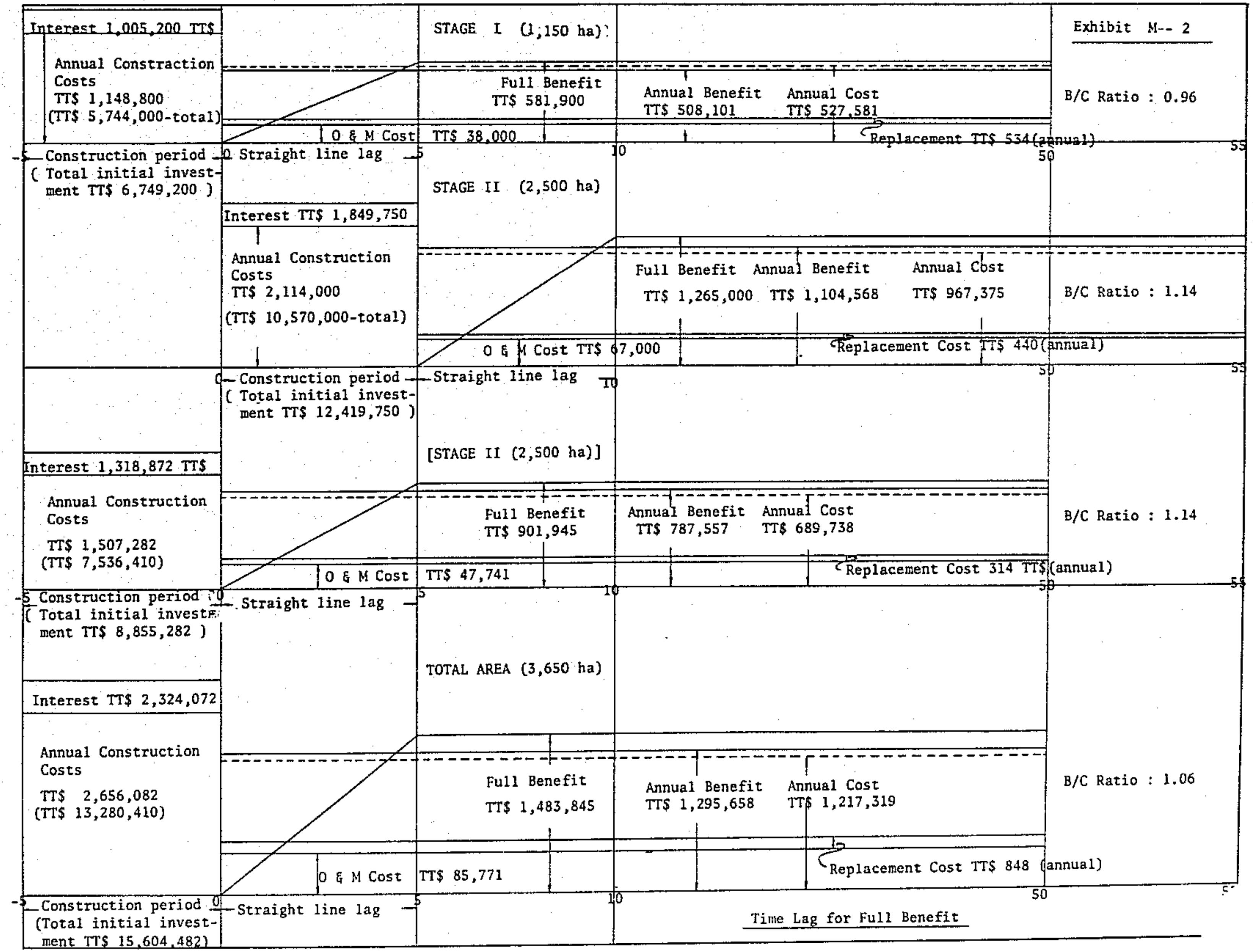
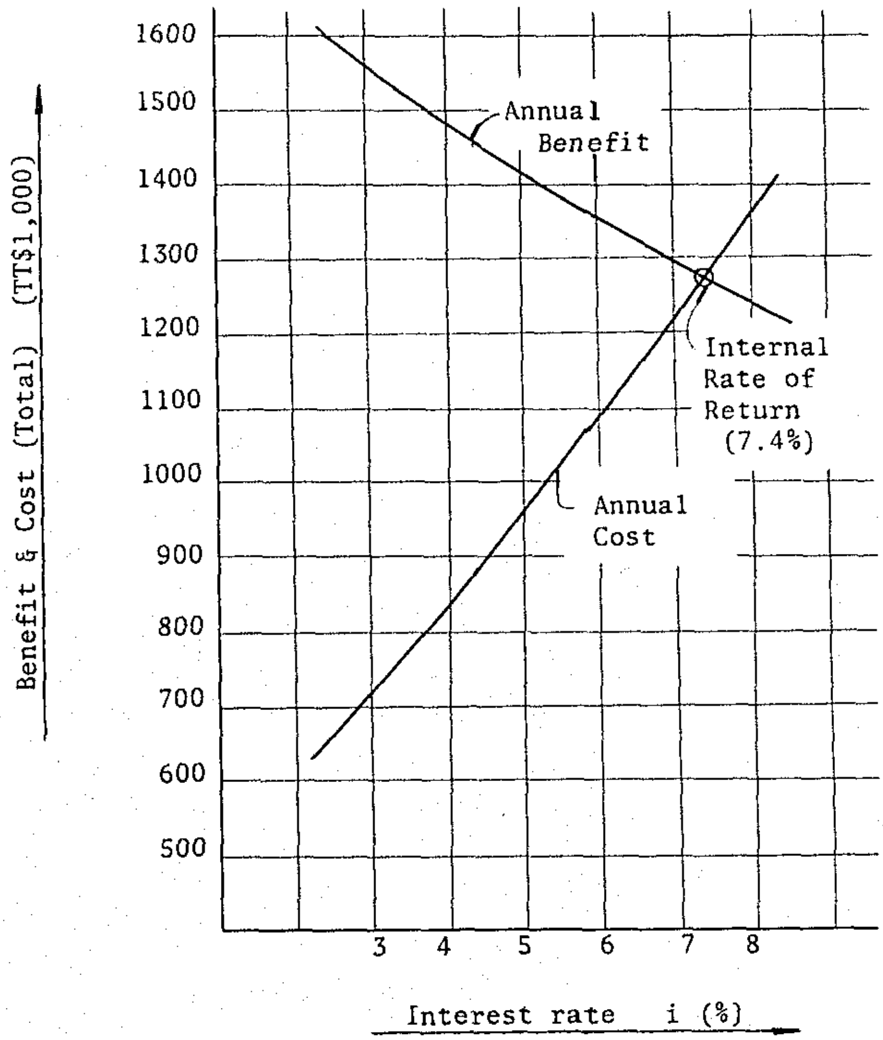


Exhibit M-- 2

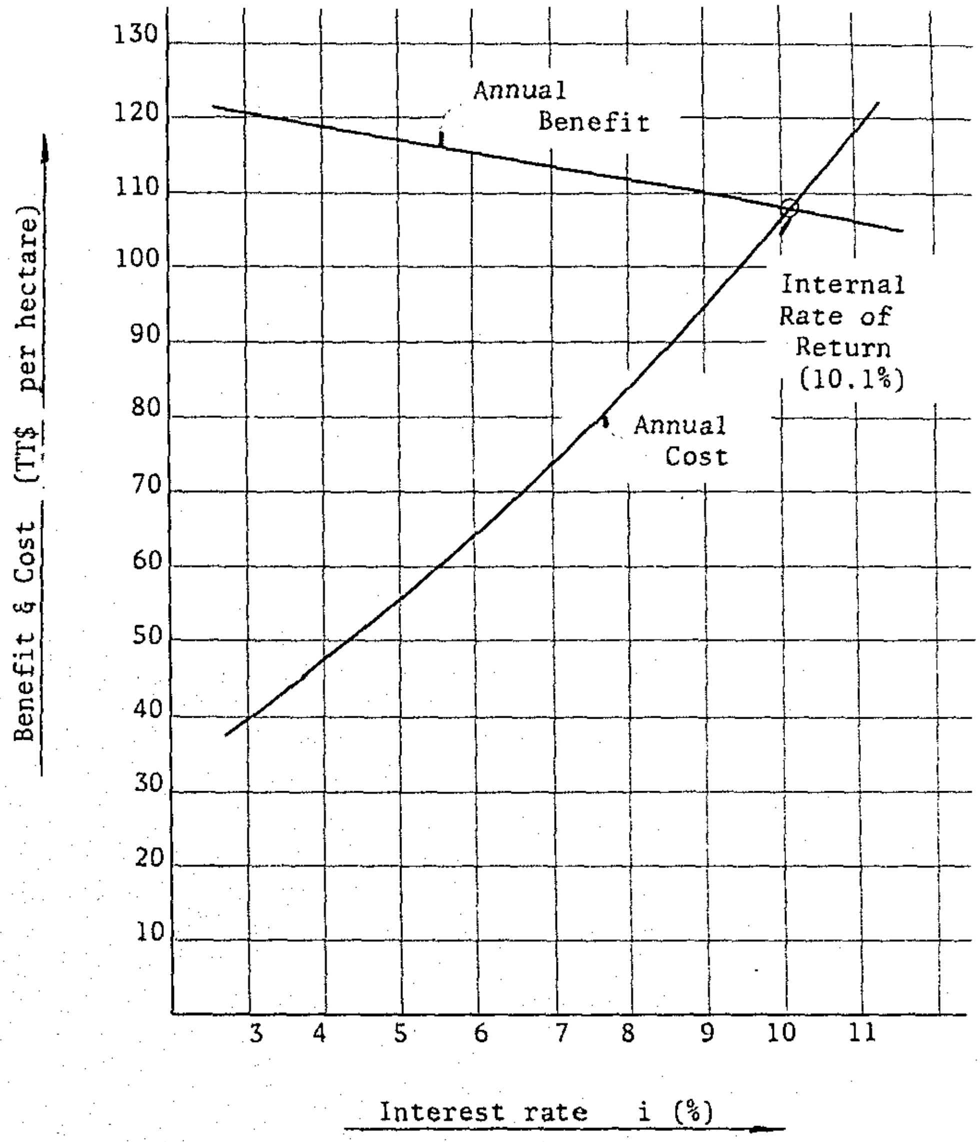


STAGE I (1,150 ha)
Interest 1,005,200 TT$
Annual Constraction Costs
TT$ 1,148,800
(TT$ 5,744,000-total)
Full Benefit
TT$ 581,900
Annual Benefit
TT$ 508,101
Annual Cost
TT$ 527,581
B/C Ratio : 0.96
O & M Cost TT$ 38,000
Replacement TT$ 534(annual)
Construction period
(Total initial investment TT$ 6,749,200)
Straight line lag
STAGE II (2,500 ha)
Interest TT$ 1,849,750
Annual Construction Costs
TT$ 2,114,000
(TT$ 10,570,000-total)
Full Benefit
TT$ 1,265,000
Annual Benefit
TT$ 1,104,568
Annual Cost
TT$ 967,375
B/C Ratio : 1.14
O & M Cost TT$ 67,000
Replacement Cost TT$ 440(annual)
Construction period
(Total initial investment TT$ 12,419,750)
Straight line lag
[STAGE II (2,500 ha)]
Interest 1,318,872 TT$
Annual Construction Costs
TT$ 1,507,282
(TT$ 7,536,410)
Full Benefit
TT$ 901,945
Annual Benefit
TT$ 787,557
Annual Cost
TT$ 689,738
B/C Ratio : 1.14
O & M Cost
TT$ 47,741
Replacement Cost 314 TT$(annual)
Construction period
(Total initial investment TT$ 8,855,282)
Straight line lag
TOTAL AREA (3,650 ha)
Interest TT$ 2,324,072
Annual Construction Costs
TT$ 2,656,082
(TT$ 13,280,410)
Full Benefit
TT$ 1,483,845
Annual Benefit
TT$ 1,295,658
Annual Cost
TT$ 1,217,319
B/C Ratio : 1.06
O & M Cost
TT$ 85,771
Replacement Cost TT$ 848 (annual)
Construction period
(Total initial investment TT$ 15,604,482)
Straight line lag
-5
0
5
10
50
55
Time Lag for Full Benefit

Exhibit M-3



Internal Rate of Return
(Irrigation)



Internal Rate of Return
(Beef Cattle)