4. ASSESSMENT OF POST PEAT MINING LAKES FOR AQUACULTURE

4.1 Characteristics of Lakes

If the peat mining would be implemented, the characteristics of the lakes would be expected to be as follows:

1) Leke is dug up to 9 m in depth resulting in a little shallow water area available.

2) Lake would be stratified with freshwater on top and salt water below, which layer would tend to be stagnant.

3) Nutrients in the lake are poor.

4) DO in the lake would range from 0 mg/ℓ at the bottom through o mg/ℓ at the middle to 5 mg/ℓ at the surface.

4.2 Possibility to Establish Shrimp/Fish Farming

Judged from the size and depth of the lakes, there is less possibility to establish shrimp/fish farming by means of pond culture. The cage and raft culture would be taken into account for utilizing the resultant lakes effectively as follows:

1) Tilapia culture in cage

Fish would be cultured from fingerlings to marketable size. According to Aquaculture Development and Coordination Programme (1983)[4], the total cost of production in Jamaica is more than J$2.5/lb, while the price is J$1.9/lb. This suggests that Tilapia culture in cage is not interesting.

2) Raft culture of oysters, Crassostrea spp.

The oyster culture has achieved relative successed in an experimental level by IFU. Generally, the return on management is expected to be about J$400/year (Aquaculture Development and Coordination Programme, 1983), and this is judged as too small. Moreover, there would be needs to improve the stratified water of the lakes, because oysters require a little saline water, about 15 - 35 ppt. These conditions suggest that the oyster culture in the lakes is inefficient, and not practicable.

The cost of pond culture of shrimp and fish would be considerably high by the size and depth of the lakes, and cage culture of Tilapia in the lakes is unprofitable. Raft culture of oysters might possibly be applicable in the lakes.

It is noted that, from the viewpoint of water quality, the decrease of DO in the lake resulted from the peat mining project provides disadvantage on aquaculture, because DO shows marginal levels to support the fisheries resources at present as mentioned in 2.3.1.

5. PROSPECTIVE PLAN OF FISHERIES DEVELOPMENT

5.1 Needs for Shrimp Culture in Jamaica

5.1.1 Recommendable policy by the Government and FAO/UNDP

Research on marine fisheries resources around Jamaica taken by IFU has shown that Jamaica's fishing grounds are near its maximum production levels. As a result of this, Jamaica has turned to the development of aquaculture, especially freshwater fish culture and oyster culture to assist in meeting its protein needs.

IFU under MOA prepared Five Year Aquaculture Development Plan for the years of 1984 - 1988. Main objectives of the plan are to:

1) increase food production,
2) increase income of farmers and rural coastal dwellers,
3) create employment, especially in rural and coastal areas,
4) improve nutrition in rural areas,
5) bring marginal and ruinate sugar cane lands into aquaculture,
6) increase skills and introduction of an appropriate technology,
7) develop a self-sustaining local industry, utilize agro/marine skills and locally available and recycled waste materials, and
8) assist the Government of Jamaica to mitigate its foreign exchange problem by import substitution.

Prospective inland fish pond development and its production indicated in the plan are shown in the following table:

Year	Inland Fish Pond (acre)		Production (1,000 lbs)		Revenue 1/ (1,000 J$)	
	Total	Shrimp	Total 2/	Shrimp	Total	Shrimp
1983	410	-	500	-	1,215	-
1984	610	ngl 3/	2,400	ngl	6,000	ngl
1985	760	50	3,100	250	8,525	3,000
1986	910	100	4,100	500	12,300	6,500
1987	1,060	150	5,100	750	16,575	10,500
1988	1,210	200	6,100	1,000	21,350	15,000

Remarks: 1/: Cost per pound increases by J$0.25 from a base price of J$2.25 in 1983. In case of shrimp, it increases by J$1.09 from a base price of J$12.00 in 1985.

2/: Amount of oyster raft culture is included.

3/: Negligible

FAO/UNDP prepared the report on a policy for development of aquaculture in Jamaica in 1983 and suggested as follows:

1) Pond culture of Tilapia
2) Pond culture of freshwater prawn (Macrobrachium rosenbergii)
3) Raceway culture of Tilapia
4) Pen culture of marine fishes
5) Culture of mangrove oyster

5.1.2 Demand of shrimp

It was felt that world market conditions for shrimp and, possibly, prawn were favorable. Presently, European supply for fresh-water prawn is only one-fifth of the demand and is seen as a great opprotunity for Jamaican suppliers, as this market is not available to U.S. producers. The U.S. market for shrimp, 70 percent of which is supplied by Central and South America, is currently undersupplied, and is expected to expand at roughly six percent per year.

Initially, as the Jamaican shrimp and prawn industries develop, local hotel and restaurant markets are expected to absorb all of the initial farm output until supply catches up with demand and the island

prices drop below commodity prices, less export processing and handling costs (proceedings of the Jamaican aquaculture symposium; U.S. business committee on Jamaica/1983).

In order for Jamaican shrimp and prawn supplies to successfully compete in both export and domestic markets, they must supply a product which reaches the market place with reliably high quality and in consistent amounts.

5.2 Present Conditions and Future Potentiality

5.2.1 Project area

The existing conditions and potentiality of fishing activities in the project area are summarized as follows:

1) Commercial fin-fish fishing is scarcely practised in the project area.

2) Although the present fish resources is considered to be in a state of balance, it is not expected to improve the fishing method on a large scale and to increase the fishing catch. This is brought by the topographic features in the project area.

3) Shrimp fishery is, on the other hand, actively practised in the project area, and it is concluded that the shrimp industry in the area is of importance from the viewpoint of not only socio-economic base in the area but assistance in meeting the island's food requirements.

4) There is a possibility to increase the wild shrimp resources in the project area by means of stocking. At present, the shrimp catch shows a considerable seasonal fluctuation, and thus the livelihood of fishermen varies on the season (see Chapter 2.1). The stocking trial would make their livelihood steady by two tactics as follows:

   a) The shrimp catch would increase as a whole, but in this case the fluctuation is not improved (Fig. K-9, Line A), and

   b) The fluctuation would be improved and the catch would be stabilized throughout the year (Fig. K-9, Line B).

5) The project area is also considered to be blessed with natural conditions for constructing shrimp farming. As for the species for potential aquaculture in the project area, the freshwater shrimp of the genus Macrobrachium is the most preferable.

5.2.2 Experiences of shrimp culture in Jamaica

There are two shrimp culture enterprises in Jamaica, BRUMDEC at Black River Upper Morass and Jamaica Aqua-Farms Ltd. at Ferris Cross. The activities of these enterprises with other private sectors are described below.

	M. rosenbergii		Tilapia	
	Fry production	Aqua-culture	Fry Production	Aqua-culture
BRUMDEC	***	***	*	**
Jamaica Aqua-Farms	***	*	*	*
Other private sectors	*	*	***	***

Remarks: ***: Carried out on commercial base
**: Partially carried out
*: Not carried out at all

In the BRUMDEC, shrimps (Macrobrachium rosenbergii) introduced from Israel were cultured successfully on the commercial bases, while the local Macrobrachium species have disappeared from its culture ponds. BRUMDEC is under negotiation with USA on the exporting of the cultured shrimp.

Since 1982, on the other hand, Jamaica Aqua-Farms Ltd. has reopened the Macrobrachium rosenbergii hatchery and is now offering postlarvae for sale.

5.3 Evaluation of Shrimp Culture Project

5.3.1 Financial appraisal of Macrobrachium rosenbergii aquaculture

The financial appraisal of M. rosenbergii aquaculture as a model of 1 ha unit is shown in Table K-8 under the assumptions as shown below.

1) Unit and facilities: The farm unit consists of four ponds of a quarter ha each. A storage is built close to the ponds. Water management installations are equipped.

2) Technical keys

- Size and age of fry: about 0.03 g postlarvae of 1 - 4 weeks of age.
- Stocking rate: 20 postlarvae/m^2. 200,000 tails/ha
- Feeding: Tilapia feeds can be used. The conversion ratio is about 0.4, which means that 2.5 g of feed are required for 1 g growth of shrimp.
- Survival rate: assumed to be 60%
- Production cycle: 8 months
- Marketable size: 30 g

3) Marketing: Initially, shrimps will be sold in Jamaica, and in the future, market will be expanded to foreign countries. The farm gate price is estimated to be J$15/lb (J$38/kg) at current price for domestic market.

As shown in Table K-8, investment of about J$100,000 per ha is required to initiate shrimp pond culture, and the return on management per farm (1 ha) per year is about J$27,000 in case of sales to domestic market. The actual return will be much more increased considering the external trade, i.e., to USA and Europe. Therefore, shrimp culture in Jamaica is considered to be financially viable even for sales domestically. And it will contribute to the increase of foreign exchange earnings.

5.3.2 Other economic benefits

Various socio-economic advantages are expected as follows:

1) Fishermen

The stocking of shrimp fry in the fishing ground will induce the increase of the resources. This would bring the fishermen a steady livelihood as well as a chance to start shrimp aquaculture in the future.

2) Increase of employment

The present unemployment problem in and around the project area is expected to be improved by the idea. The implementation of the idea itself as well as the development of the private sector of aquaculture is to increase the employment opportunity.

3) Other effects

These effects will certainly lead to the change of economic activity in the project area, and to contribute to the improvement of economic activities in Jamaica as well as the project area.

5.4 Recommended Project Plan

Taking the above-mentioned conditions into consideration, it is proposed to establish the National Aquaculture Research and Extension Center in the project area for improvement of the fishermen's livelihood and for the contribution of foreign exchange earnings in future.

5.4.1 Executive body

It is desirable that the Center is managed by the Inland Fisheries Unit under the Ministry of Agriculture.

5.4.2 Organization and major functions

The idea of the organization set-up is shown in Fig. K-10.

1) Production Department

The Production Department is functionally divided into two sections, Hatchery and Production Sections. The species cultured in the Center is recommended to be mainly Macrobrachium rosenbergii.

It is also encouraged to attempt the aquaculture of the indigenous shrimp species such as M. acanthurus, and it is desirable to attempt the stocking trial of the species.

2) Research Department

The Research Department is composed of two sections, Biology and Aquaculture Sections. The purpose of the Biology Section is to have knowledge the biology of the wild and introduced shrimp in the project area. The fishery statistics are also collected and analysed by this section. The following researches are initiated in the Aquaculture Section:

a) Shrimp culture in rice field,
b) Shrimp/fish mixed culture, and
c) Research on the possibility for rice bran to be used as a food of cultured species.

3) Marketing Department

This department is established for having knowledge on the marketing and or how to promote the aquaculture venture in order to formulate the manual of aquaculture in Jamaica.

4) Training and Extension Department

This department is established to provide general assistance to fishermen such as technical training of aquaculture methods and distribution of shrimp/fish fry, etc.

5.4.3 Recommended site

The site of the center should be determined by the criteria on the soil condition, topography, water quality and quantity, and infrastructures. On the basis of the field survey, the most suitable site of the center excepting the hatchery section is concluded to be in the Holland area, the right bank of the Black River (Fig. K-11). The Black River Estuary near the Black River Town market is considered to be the most suitable site of the hatchery section of the center based on the salt water supply (Fig. K-11).

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Table K-1 LIST OF FISH SPECIES RECORDED FROM THE LOWER MORASS

Family	Scientific name	Common name
Elopidae	Elops saurus	ladyfish
	Megalops atlanticus	tarpon
Albulidae	Albula vulpes	bonefish
Clupeidae	Opisthonema oglinum	threadfin herring
	Anchoa sp.	anchovy
Engraulidae	sp. unidentified	jibber broadhead
Anguillidae	Anguilla rostrata	eel
Muraenidae	Gymnothorax moringa	spotted moray
Belonidae	Strongylura timuca	gar
Poecillidae	Gambusia affinis	mosquito fish
Mugilidae	Mugil cephalus	grey mullet
	M. curema	mullet
	M. sp.	mullet
Sphyraenidae	Sphyraena barracuda	
Cichlidae	Tilapia mossambica	african perch
Centropomidae	Centropomis sp. (2)	snook
Carangidae	Caranx hippos	crevalle jack
	C. latus	horse-eye jack
Lutjanidae	Lutjanus apoda	snapper
	L. griseus	mangrove snapper
	L. jacu	dogtooth snapper
Gerridae	Diapterus rhombeus	macaback
	Eucinostomos spp. (2)	macaback
	Eugerres plumieri	stonebar
	Gerres cinereus	macaback
	sp. unidentified	silver fish
Sciaenidae	Bairdiella ronchus	croaker
	spp. unidentified (2)	drummer
Eleotridae	Dormitator maculatus	god-a-me
Gobiidae	spp. unidentified (2)	mudfish, sandfish
Soleidae	Achirus lineatus	sole
Bothidae	Syacium micrurum	flatfish
Myliobatidae	Aetobatis narinari	eagle ray

Sources: this study

Table K-2 BIOLOGICAL DATA ON THREE FRESHWATER SHRIMP SPECIES

Species	Local Name	FAO Name[1/]	Maximum[1/] Size	Distribution[4/] Type	Optimum Salinity for Larval Development (ppt)	Optimum[4/] Temp. (°C)
Macrobrachium acanthurus	Shrimp	Cinnamon river prawn	166 mm (M)[2/] 110 mm (F)[3/]	Low-gradient	15 - 20[5/]	20 - 30
M. faustinum	Crabonnay	-	-	Ubiquitous	19 - 20[6/]	20 - 30
M. carcinus	Crayfish	Painted river prawn	-	Ubiquitous	14 - 17.5[7/]	20 - 30

Remarks: 1/: After Holthuis (1980)[8)]
2/: Male
3/: Female
4/: After Hunte (1978)[7)]
5/: After Choudhury (1971)[9)]
6/: After Hunte (1976)[10)]
7/: After Choudhury (1971)[11)]

Table K-3 WATER QUALITY ANALYSIS

Station [1]	BOD	COD	DO	pH	SS	P [2]	N [3]
Black River							
A	1.2	26.0	5.2	7.4	6.8 [4]	0.07	1.8
B [4]	1.3	-	-	7.5	5.4	0.25	2.1
C	1.1	5.0	3.8	7.1	-	0.15	2.1
D	1.2	12.0	5.4	7.3	48.5 [4]	0.17	2.7
Y.S. River							
E [4]	3.5	-	-	7.1	18.8	0.12	0.9
F	0.9	7.0	7.8	7.9	21.4 [4]	0.11	2.3
M.Q River							
G [4]	1.7	-	-	7.4	44.8	0.13	0.8
Broad River							
H [4]	1.5	-	-	7.5	2.1	0.09	1.5
I	0.5	17.0	4.6	7.3	-	0.04	1.5
J [4]	1.8	-	-	7.1	5.1	0.05	3.9
WF [5]	<5.0	-	>5.0	6.5-8.5	10.0	-	-
WE [6]							
- River	<5.0	-	>6.0	6.7-8.5	25.0	<0.10	-
- Lake	-	<5.0	>6.0	"	3.0	<0.05	-

Remarks: Results in ppm excepting pH.

1/ Refer to Fig. K-6

2/ Phosphates

3/ Nitrates

4/ Source, NRCD and TGI (1982)[13)]

5/ "Water Quality Standard for Fishery"*

6/ "Water Quality Standard for Fishery Environment"*

*Japan Fisheries Resources Corporation 1965 and 1972 respectively

Table K-4 TRANSPARENCY AND COLOUR TEST

Station [1]	Transparency (cm) [2]	Colour
Black River		
A	45	Cloudy brown
B	45	"
C	45	"
D	38	Brown
E	35	"
F	40	"
G	39	"
H	34	"
Y.S. River		
I	300 (bottom)	Transparent
M.Q. River		
J	330	Pale green
K	360	"
Broad River		
L	195	Brownish green
M	228	Pale green
N	278 (bottom)	"

1/ See Fig. I-7, 2/ Measured by a white board (25 cm in diameter).

Table K-5 PROBABLE IMPACTS OF THE AGRICULTURAL DEVELOPMENT PROJECT ON INLAND FISHERIES RESOURCES

Agricultural Activities \ Impacts	I1 Dec. of Swamps	I2 Inc. of Suspended Solids	I3 Inc. of Turbidity	I4 Inc. of Colour	I5 Inc. of Petroleum Pollution	I6 Inc. of Outflow in Rainy Season	I7 Dec. of Outflow in Dry Season	I8 Intrusion of Sea Water
C1 Land Use	x							
C2 Construction of Dike		x	x	x	x			
C3 Construction of Road		x	x	x	x			
C4 Construction of Canal		x	x	x	x			
C5 Reclamation		x	x	x	x			
O1 Drainage						x		
O2 Irrigation							x	x
Impact on fisheries resources	N	-	-	-	-	+	-	N

C1 - C2, Activities causing the impacts in construction phase; O1 and O2, those in operation phase, I1 - I8, Impacts caused by agricultural activities. x indicates that there are relationships between the activities and impacts.

N, no impact; -, adverse impact; +, beneficial impact.

It should be noted that adverse impact in this project is expected to be avoidable by means of the careful management.

Table K-6 CHEMICALS APPLIED IN THE PROPOSED AGRICULTURAL DEVELOPMENT PROJECT

	Class*	TLm for Carp	Remarks
(Herbicide)			
Bentiocarb	B	3.6	
2,4 D	A	>40	
Diphenamid	A	88	Prohibited to use by mixture with other chemicals
Pentagon	A	>100	
Prometryne	A	>10	
Paraquat	A	-	Poisonous for mammals
(Pesticide)			
Trichlorphon	B	6.2	No danger to remain in animal body
Fenitrothion	B	8.2	No impact on animals
Mancozeb	B	4	
Monocrotophos	A	>40	
Diazinon	B-s	3.2	Scattering into river and swamp strictly prohibited
Dimethoate	B	>40	

Table K-7 EFFECTS OF PEAT MINING ON SHRIMP/FISH RESOURCES

Impacts (change)	Fin-fish		Shrimp	
	Max. 1/	Min. 2/	Max.	Min.
1. Increase flooding	No	No	+1	0
2. Inc. nutrients	+1	+1	+1	+1
3. Inc. total organic carbon	+2	+1	+2	+1
4. Decrease swamps	No	No	*	-1
5. Inc. suspended solid	-2	-1	-2	-1
6. Inc. BOD	-1	-1	-1	-1
7. Dec. DO	-2	-1	-2	-1
8. Inc. turbidity	-2	-1	-2	-1
9. Inc. colour	-1	-1	-1	-1
10. Inc. salinity	0	0	-1	-1
11 Inc. temperature	0	0	-1	-1
12. Inc. heavy metals	-1	-1	-1	-1
13. Dec. bay water quality	0	-1	-1	-1
14. Inc. petroleum pollution	-2	0	-2	-1

Source : NRCD and TGI (1982)[13].

1/ Maximum case.

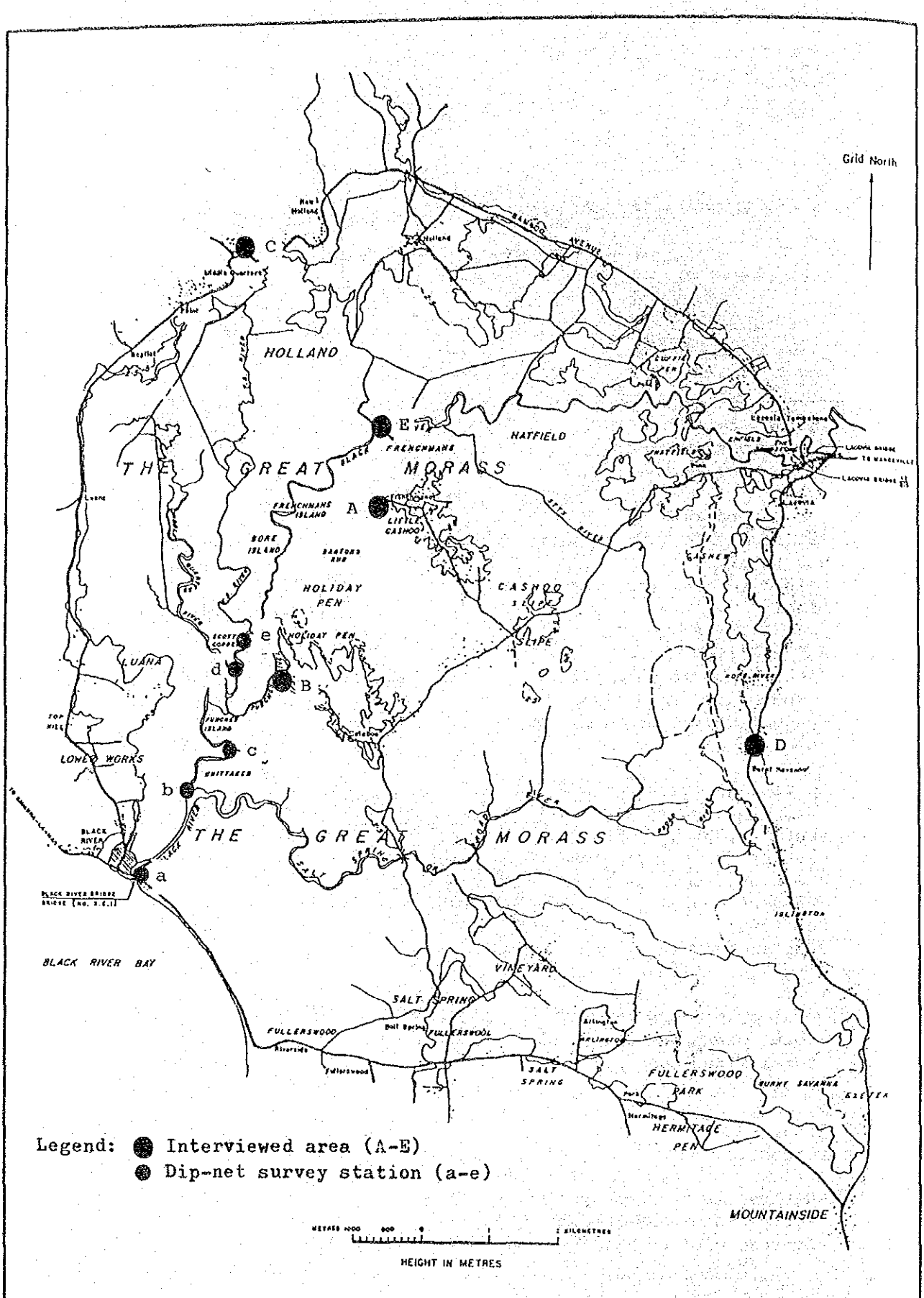
2/ Minimum case.

No, no change; -2, moderate adverse; -1, minor adverse; 0, relationship exists but no impact is expected; +1, minor benefit; +2, moderate benefit; *, effect exaggerated.

Table K-8 ECONOMIC ANALYSIS OF A TYPICAL 1 HECTARE MACROBRACHIUM ROSENBERGII POND CULTURE

Unit: J$

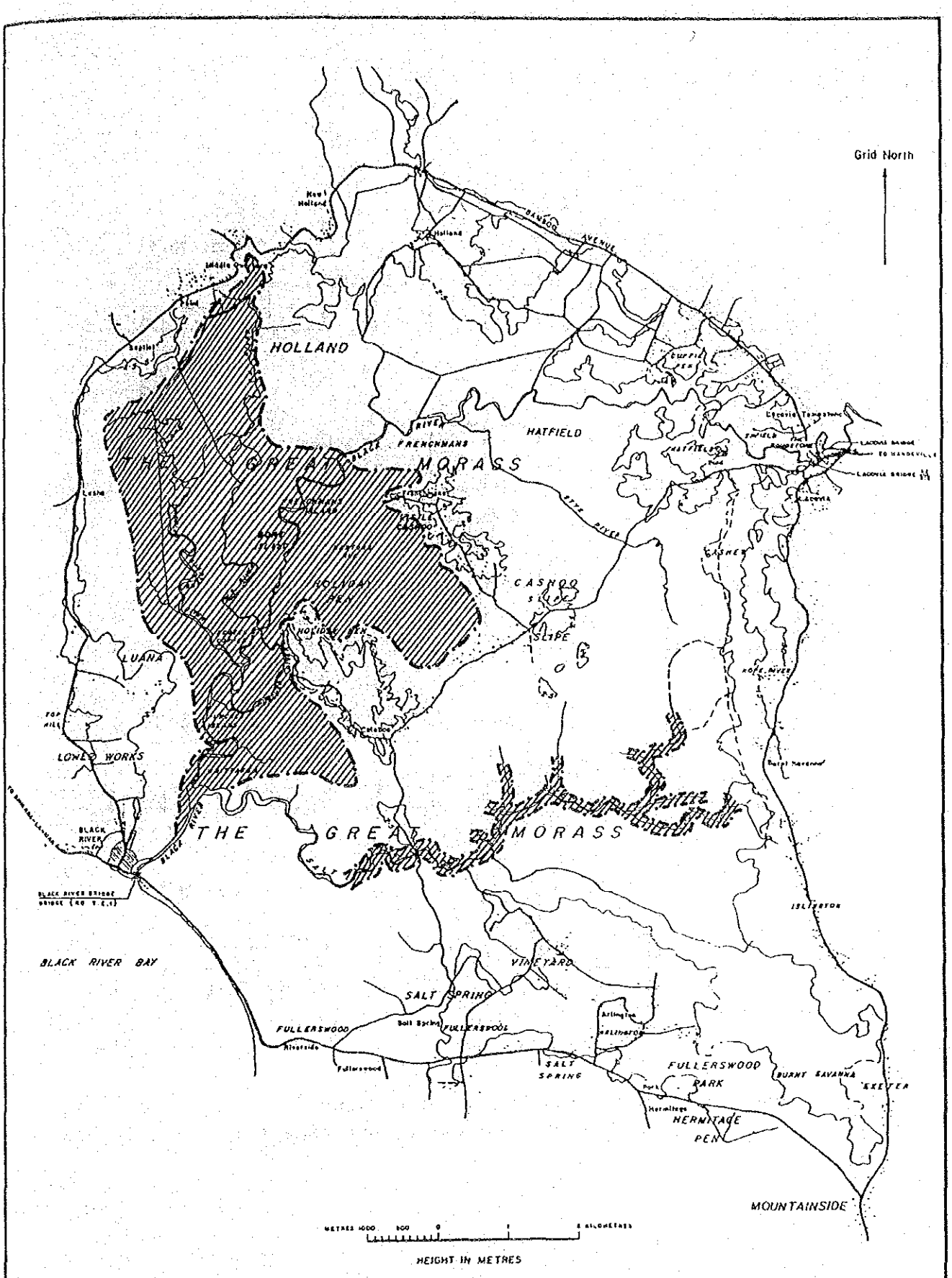
1.	Initial costs	
	-Pond construction	40,000
	-Water management installations	7,500
	-Nets	20,000
	-Scale, buckets	1,500
	-Storage shed ($20m^2$, J$1,500/$m^2$)	30,000
	Sub total	99,000
	-Miscellaneous (ca. 10%)	10,000
	Total	109,000
2.	Annual fixed costs	
	-Initial costs amortized at 12 % for 10 years	19,000
	-Pond maintenance (10%)	4,000
	-Annual depreciation of equipments (10%)	5,900
	Total	28,900
3.	Operating costs (per 8-month production cycle)	
	-Fry (200,000 tails, J$0.12 each)	24,000
	-Feed (8,969 kg; 19,800 lbs, J$1.4/lb)	27,700
	-Labour (2 men, 32 weeks, J$150/week/man)	9,600
	-Foreman(1 man, 32 weeks, J$300/week)	9,600
	-Harvest charge (3,588 kg; 7,920 lbs, J$0.4/lb)	3,200
	Sub total	74,100
	-Contingency (ca. 10%)	7,400
	Total operating cost	81,500
4.	Total crop costs (8 months)	
	-Total operating cost	81,500
	-Total fixed cost per crop	19,300
	Total	100,800
5.	Returns	
	-Gross returns (Average production of 3,588 kg; 7,920 lbs, J$15/lb)	118,000
	-Net return (per one production cycle)	18,000
	-Net average annual return	27,000
	-Average cost per kg (per lb) of shrimp produced	25.2 (11.4)



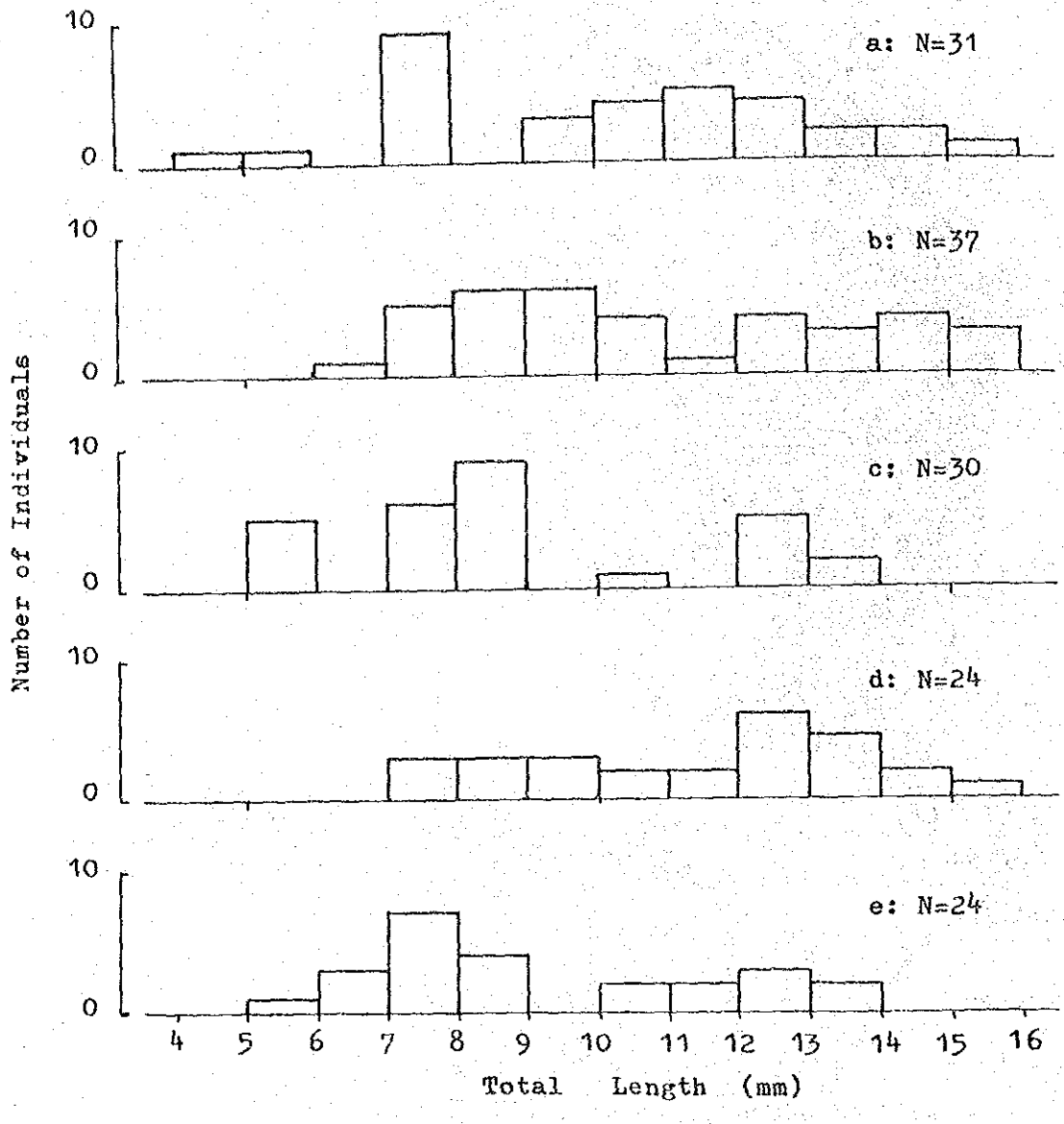
BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. K-1 INTERVIEWED AREA AND DIP-NET SURVEY STATIONS

JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT
Fig. K-2 FISHING GROUND
JAPAN INTERNATIONAL COOPERATION AGENCY



Remarks: Identification is not available;
For each station (a-e), see Fig. I-1.

BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

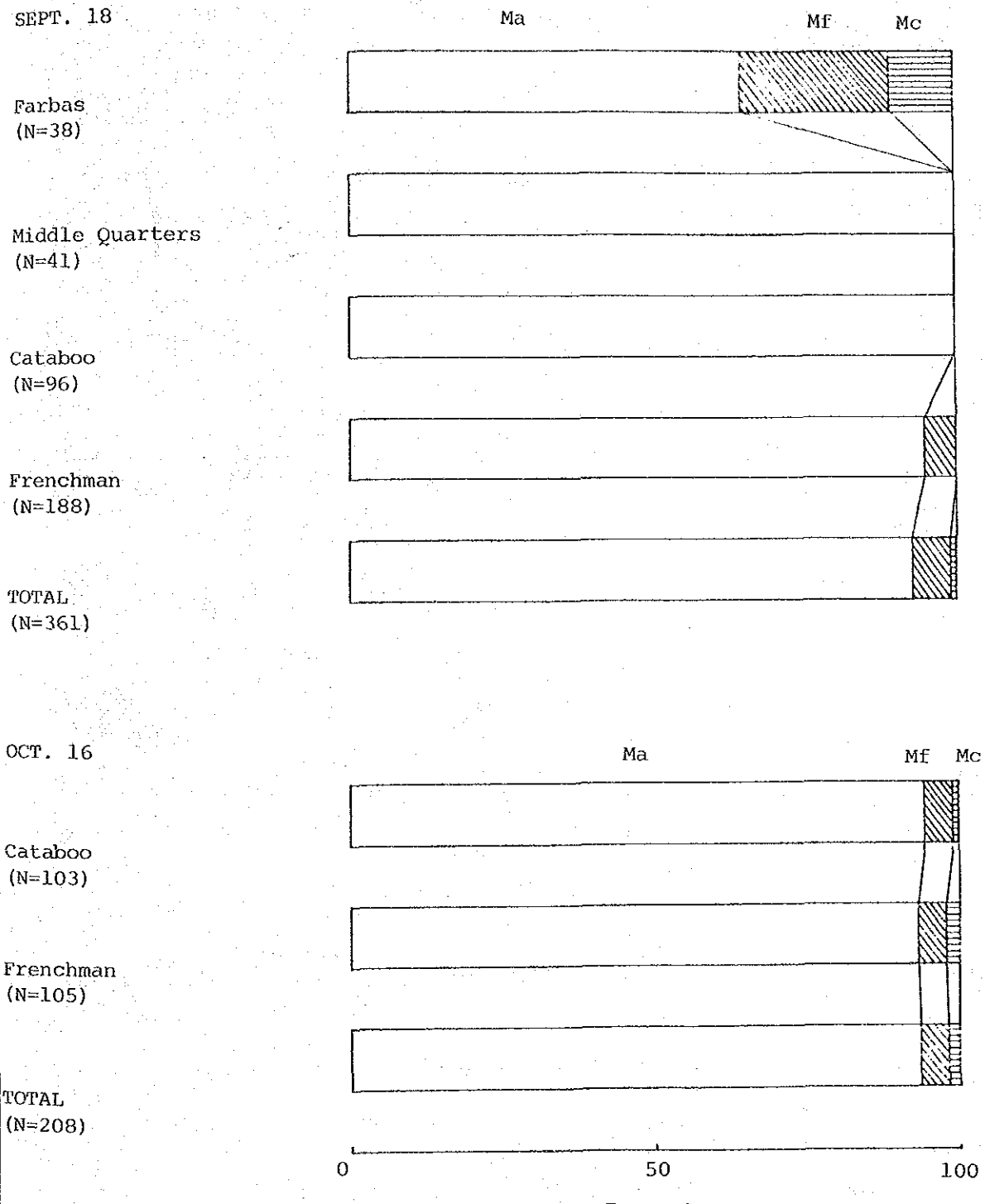
Fig. K-3 SIZE COMPOSITION OF JUVENILE SHRIMPS

JAPAN INTERNATIONAL COOPERATION AGENCY

Ma: Macrobrachium acanthurus

Mf: M. faustinum

Mc: M. carcinus

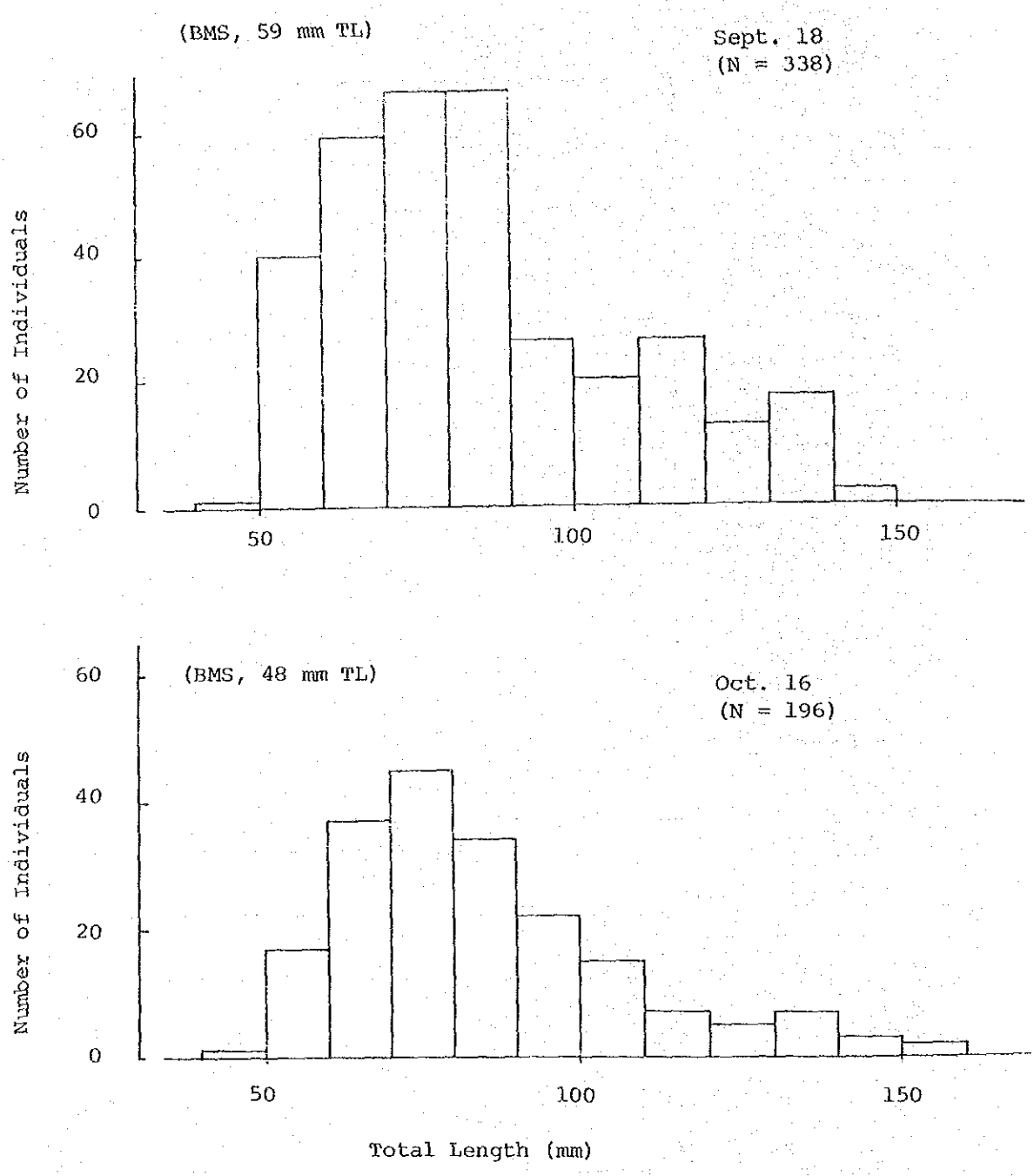


Remarks: Identification was followed to Hart (1961)

BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. K-4 SPECIES COMPOSITION OF OF SHRIMP CAUGHT BY FISHERMEN

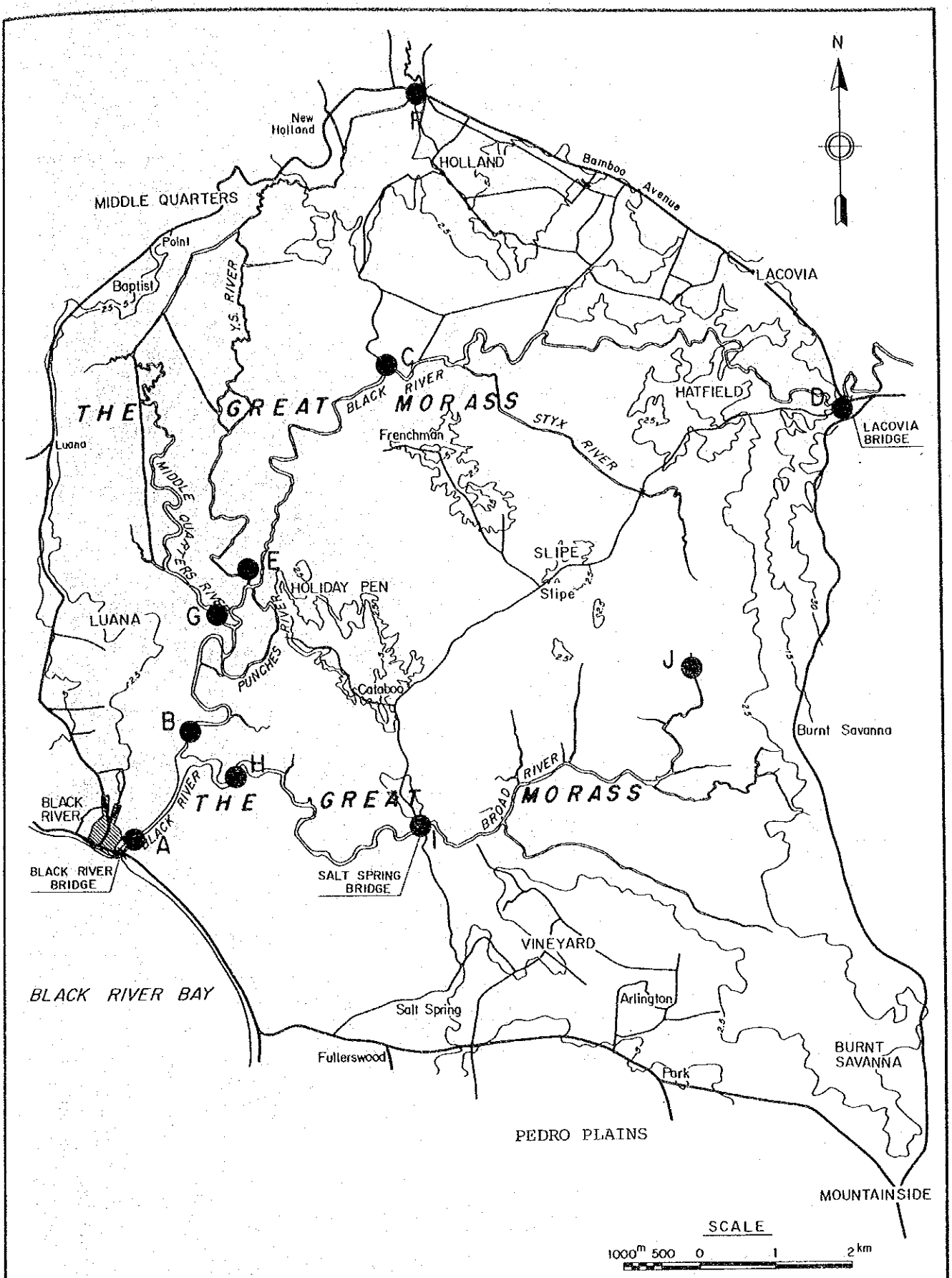
JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. K-5 SIZE COMPOSITION OF MACROBRACHIUM ACANTHURUS

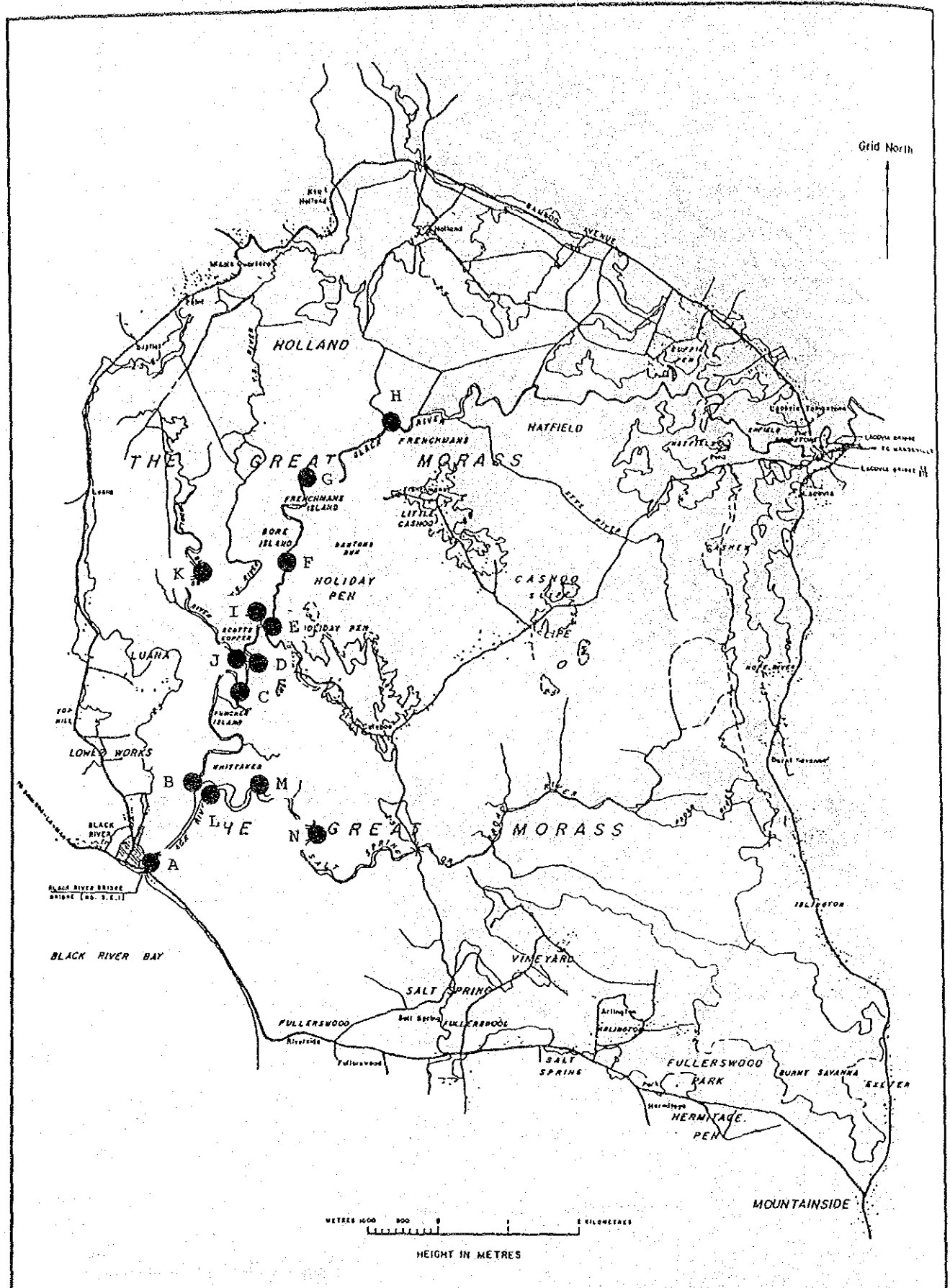
JAPAN INTERNATIONAL COOPERATION AGENCY



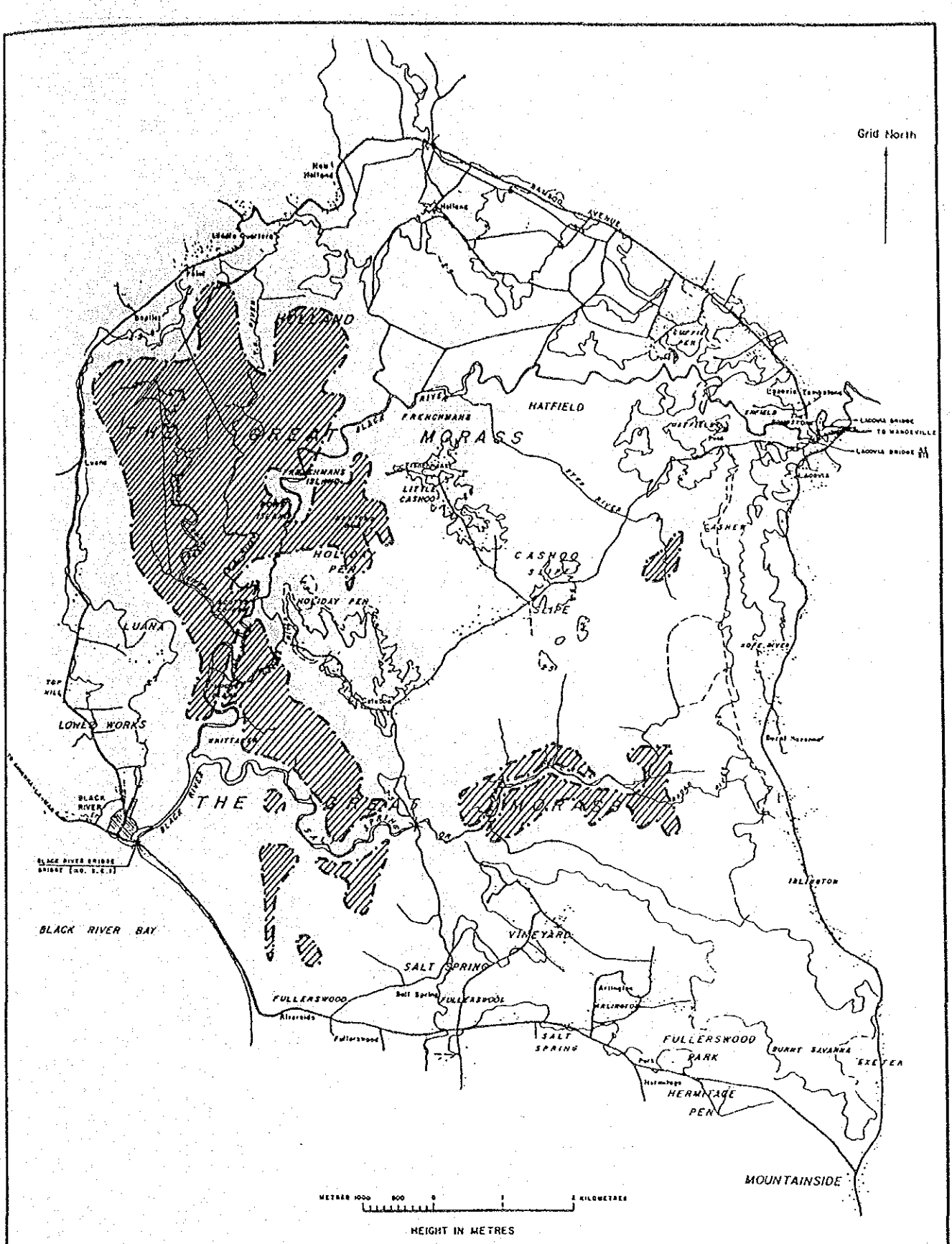
BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. V-6 STATIONS OF WATER QUALITY ANALYSIS

JAPAN INTERNATIONAL COOPERATION AGENCY

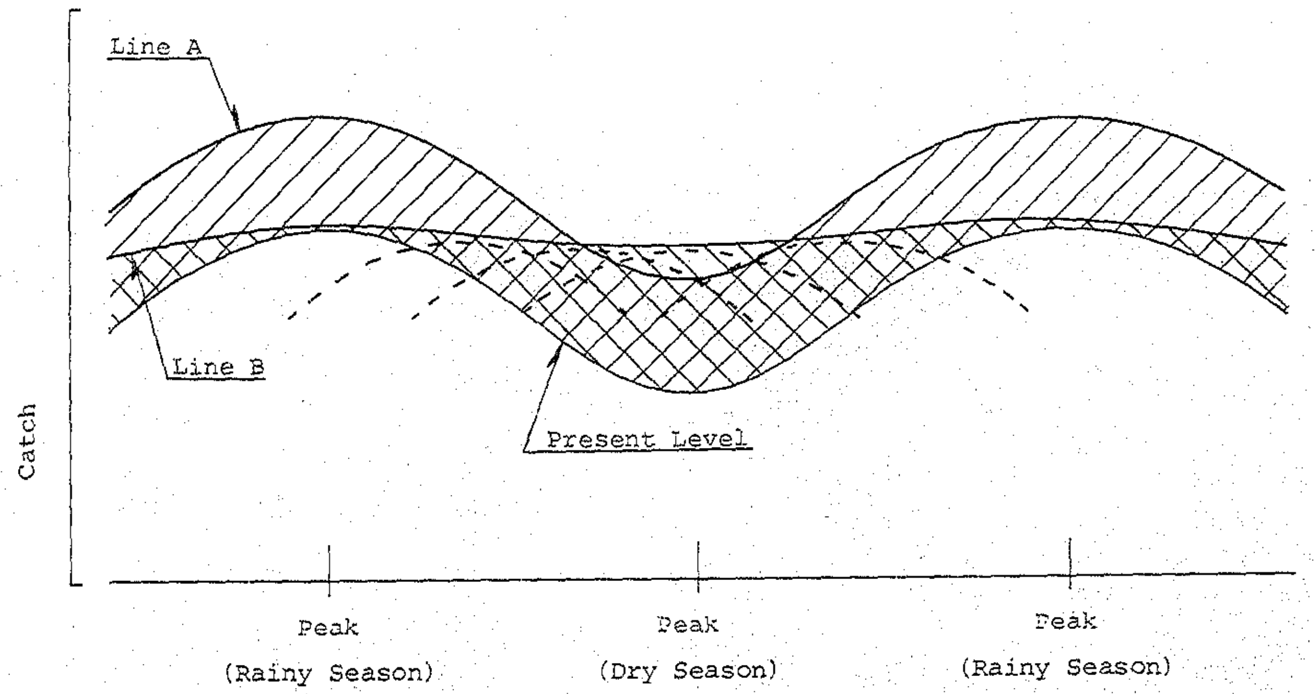


BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT
Fig. K-7 STATIONS OF TRANS-PARENCY AND COLOUR TEST
JAPAN INTERNATIONAL COOPERATION AGENCY



Source: NRCD and TGI[13].

BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT
Fig. K-8 POST PEAT MINING LAKES
JAPAN INTERNATIONAL COOPERATION AGENCY



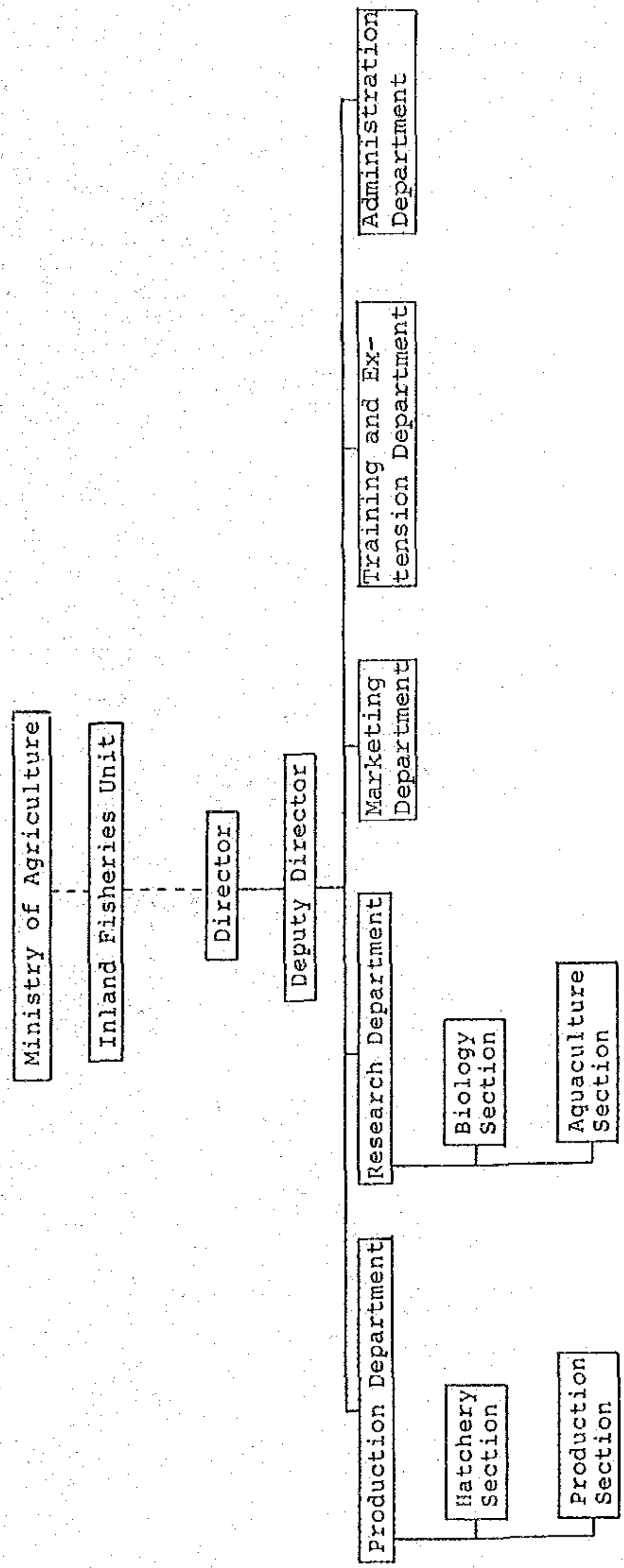
Remarks: The increments of catch by each tactics are shown by oblique lines; , by Line A; , by Line B. For details, see text.

It should be noted that the Line A is attained by one or two large scale stocking trials, while the Line B is composed of several small scale stocking trials (shown by broken lines).

BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. K-9 TWO TACTICS OF STOCKING TRIAL

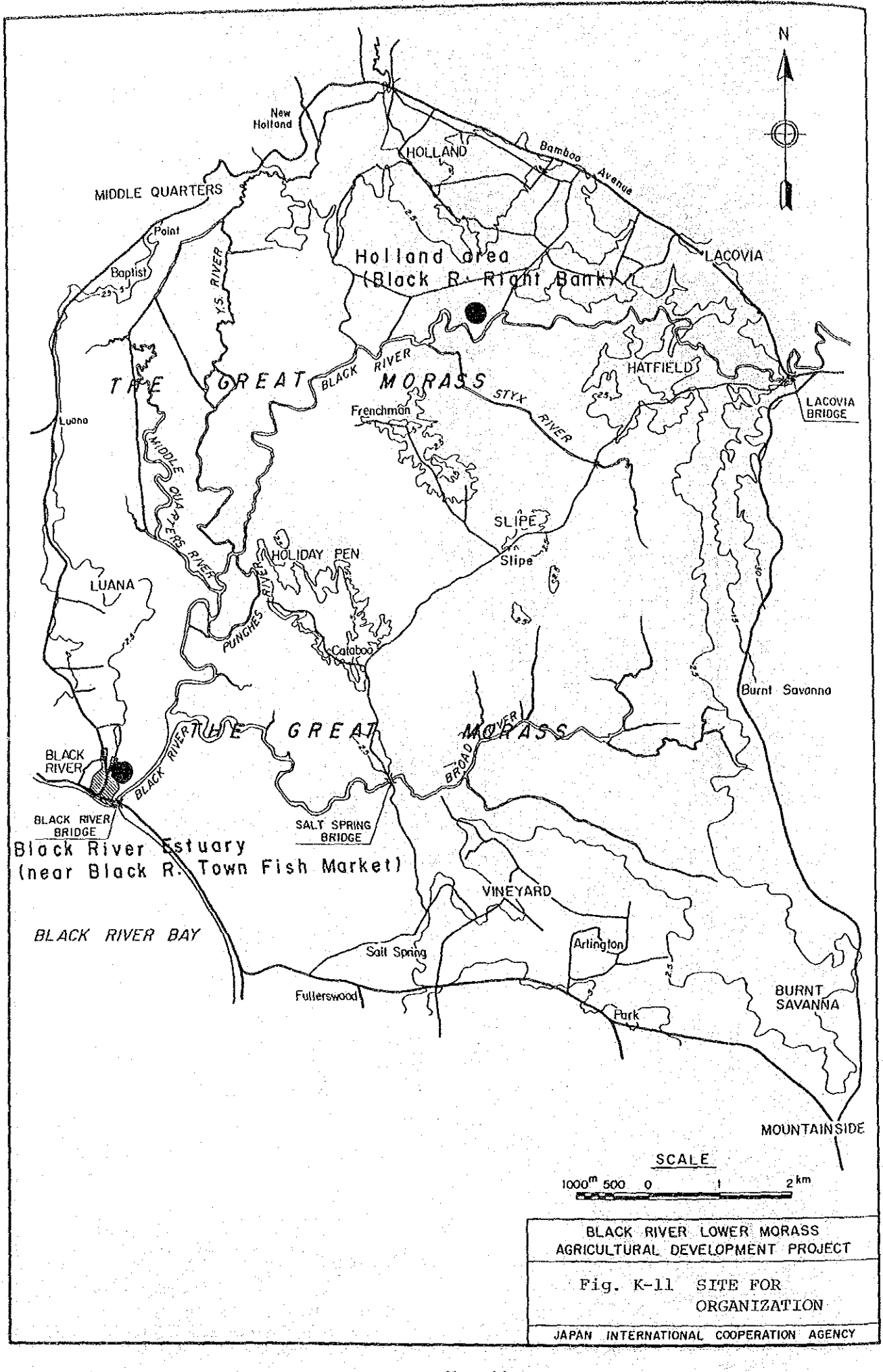
JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS
AGRICULTURAL DEVELOPMENT PROJECT

Fig. K-10 ORGANIZATION CHART OF PLAN OF FISHERIES DEVELOPMENT IN THE PROJECT AREA

JAPAN INTERNATIONAL COOPERATION AGENCY



BLACK RIVER LOWER MORASS AGRICULTURAL DEVELOPMENT PROJECT

Fig. K-11 SITE FOR ORGANIZATION

JAPAN INTERNATIONAL COOPERATION AGENCY

ANNEX L

ENVIRONMENTAL ASSESSMENT

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ENVIRONMENTAL ASSESSMENT

1. GENERAL

The Black River Lower Morass (6,000 ha) is the largest wet-land in Jamaica. It provides a unique ecosystem, which is particularly noteworthy for its herbaceous swamps, mangrove and swamp forests, and precious endemic wildlife as well as commercial species.

The Morass is situated in the western part of Jamaica, near the southern coast, in the Parish of St. Elizabeth and is located between 18°00' and 18°10' north latitude and between 77°45' and 77°55' in west longitude.

The Project area covers approximately 11,450 ha of which about 5,200 ha (excluding the forest area) are swamps at less than 1.0 m above mean sea level.

Over one hundred and ninety (190) vertebrate species are found within the Black River Lower Morass, of which over 140 are birds. In fact, the Lower Morass is the second most important bird habitat in Jamaica. Avian endemism is high: 2 general, 8 species are endemic in Jamaica. Four species of amphibian and 7 species of reptiles, besides the crocodile, also inhabit in the Morass.

There are possibilities for peat mining and agricultural development in the Black River Lower Morass. The major impacts from such activities would be the loss of the herbaceous swamp by peat mining, the pollution of water and the increasing of the suspended solids by agricultural development during its construction stage.

The Black River Lower Morass has ecological, scientific, educational, aesthetic and economic values. The Natural Resources Conservation Department (hereinafter called "NRCD") plans to establish the first National Park of Jamaica in this area, and prepares to designate the Lower Morass as "Cl ranks - class 1; Special areas" (NRCD, 1982). Furthermore, NRCD proposes a multipurpose approach to the wetland management and expects to maintain and further to expand the present inland fishery activities in the Lower Morass.

It is desirable that conservation of the natural environment be compatible with agricultural development and that other industrial development be integrated with the plan for wetland management.

2. OBJECTIVES AND METHODS

2.1 Objectives

The objectives of this study were:

(1) to collect data and information on present environmental conditions, fauna and flora in the project area as well as on policies for the natural environmental conservation and the plans of the natural resources development.

(2) to assess the impact to existing environmental conditions resulting from the construction and operation of the Lower Morass agricultural development, and

(3) to propose a plan for conservation of the area and of the wildlife species requiring protection through a comparison with conditions in other areas which are similar to the Lower Morass area, and enumeration of the native and other important species in the Lower Morass area.

2.2 Methods

A vegetation map was prepared at a scale of 1/25,000 based on aerial photo (1979) interpretation and confirmatory field surveys. The classification of plant communities follows Coke et al. (1983).

Collection of specimens of insects, amphibians, reptiles and mammals was done with the help of many local inhabitants. Identification of specimens was performed by Institute of Jamaica, NRCD and Hope Zoo.

Water samples collected in the Lower Morass were analysed by Montego Bay Laboratory of the National Water Commission, NRCD and Department of Biology, University of the West Indies.

For the survey of American Crocodiles, night-light counts were conducted by an outboard motor boat with the 160,000 CP beam lamp.

3. PRESENT STATUS OF THE BLACK RIVER LOWER MORASS

3.1 Environmental Conditions

Fig. L-1 shows the location of the Lower Morass. The Lower Morass area lies in the North East Trade Belt and has a tropical oceanic climate. The mean annual temperature is 25.8°C (78.4°F). January through March are the cool months with a mean temperature 24.3°C (75.9°F); June through August, the warm months, have a mean temperature 26.6°C (80.0°F). The annual mean relative humidity is 76%. The daily sunshine hours average 7.6 hours/day. The rainfall is heaviest in the north-western part of the Black River basin, of which the altitude is more than 600 m. The southern part has less rainfall due to low altitude. The average rainfall in the entire Black River basin is estimated to be 1,600 mm approximately, while the Y.S. River basin which is one of the largest tributaries has 2,500 mm of rainfall. Seventy percent (70%) of annual rainfall occurs during the period from May to October. 39.8 percent of the Project area is pasture or cultivated, and in the area there are 8,200 inhabitants, including 260 fishermen.

The Black River rises in the nearby mountains and adjacent Cockpit Country and flows into the Upper Morass which has been managed for intensive agriculture. The Black River then runs through a gorge at Lacovia and carries with it distillery effluent from the sugar estate at Appleton. This pollution makes the Black River the most turbid and nutrient rich of the water ways within the Lower Morass. The Y.S. River, which begins in the mountains near Ipswich, flows into the Lower Morass accompanied by high suspended solids. The Middle Quarters River and the Broad River rise from springs within the Lower Morass. The transparency of water in these rivers was estimated to be more than three meters. Seawater intrusion has been observed 4.5 km up the Black River and 7 km up the Broad River respectively.

3.2 Flora in the Black River Lower Morass

3.2.1 Classification of plant communities and species composition

The plant communities in the Lower Morass are classified into four major formations, i.e., (1) Forest, (2) Pasture and cultivated area, (3) Herbaceous swamp, and (4) Aquatic vegetation.

After Coke et al (1982), NRCD and Traverse Group Inc. (hereinafter called "TGI") (1981), the forest and herbaceous swamp are further sub-divided into the following 12 communities.

Forest

(1) Mangrove forest
(2) Swamp forest
(3) Secondary forest

Herbaceous swamp

(1) Crinum/Sagittaria zone
(2) Scirpus olneyi zone
(3) Hummocky swamp
(4) Thick Cladium zone
(5) Typha zone
(6) Typha hummocky swamp
(7) Cladium/Sagittaria association
(8) Typha/Thalia zone
(9) Cladium/Conocarpus zone.

The area of each plant community was measured from the map by planimeter. The results are tabulated in Table L-1. Fig. L-2 shows borders of the sub-divisions of the Project area. In the Project area, 144 plant species including 25 rare species were identified. The number of species in each plant community is shown in Table L-2. Vegetation of Lower Morass is shown in Fig. L-3.

3.2.2 Mangrove forest and swamp forest

The locations of the herbaceous swamp, the mangrove forest and the swamp forest are shown in Fig. L-4. Originally, both the mangrove forest and the swamp forest extended more widely in the lower part and the upper part of the wetland respectively (Björk, 1983; Digerfeldt and Enell, 1983). Now these formations suffer considerably from human activities. Although the swamp forest preserves much of the natural conditions, the mangrove forest has been affected by various kinds of human activities including felling trees for timber and firewood, and stripping bark for tannins, fires and agriculture.

The mangrove forest occurs in patches in the southern part of the Lower Morass and along the Black River. The dominant species are Rhizophora mangle (Red Mangrove) and Conocarpus erectus. Other mangrove species include Avicennia germinans and Laguncularia racemosa, but only in limited areas.

The swamp forest growing on peat within the Morass is located between the Black River and the Y.S. River. Forty-seven (47) plant species have been identified in the swamp forest (NRCD and TGI, 1981; Coke et al, 1983). The dominant species are Roystonea princeps (Swamp Cabbage Palm), Grias cauliflora (Anchovy Pear), Symphonia globulifera and Hibiscus spp. R. princeps and G. cauliflora are endemic in Jamaica and limited to swamp areas.

3.2.3 Herbaceous swamp

The Cladium-Sagittaria association around the upper part of the Broad River provides the most number of plant species (41 spp.) in the herbaceous swamp. Next to this community are the Typha zone (33 spp.), and Hummocky swamp (24 spp.) around the area of confluence of the Middle Quarters River, Y.S. River and Black River. In the vicinities of villages and pastures around the Lower Morass these herbaceous swamps suffer from fires caused by human origin, resulting in an advantage to the swagrass growing over the trees.

The hummocky swamp community in the Middle Quarters River seems to be associated with the relatively thick peat layer (more than 6 m) and the abundant water supply.

Other herbaceous swamp communities such as the thick Cladium zone, Crinum - Sagittaria and Typha - Thalia zone occur on the fringe of the Lower Morass, so that the influences of the human activities are more serious than on the others mentioned.

In the lower part of the Black River, two types of communities are found, the Cladium - Conocarpus zone and Scirpus olneyi zone. These two formations seem to be associated with sea water intrusion as well as with mangrove forest.

The riparian plant community developed in the area of confluence of the Middle Quarters River, Y.S. River and Black River contains, according to the Coke et al, 1983, seven plant species. In between the mangrove clumps the giant grass Phragmites communis, Typha domingensis and Cladium jamaicense are common riparian components.

3.2.4 Aquatic vegetation

The aquatic vegetation of the Black River and Y.S. River is dominated by Water Hyacinth (Eichnornia crassipes). The dense mat of Water Hyacinth is likely to be the effect of the nutrients of the Black River.

In the upper part of the Broad River and around the Blue holes, aquatic plants grow thickly. Eleven (11) plant species have been identified (NRCD and TGI, 1981). Water Hyacinths are dominant along the water ways. The unique aquatic plants growing in the Broad River are thought to be associated with the transparency of the water.

The following genera of aquatic plants were collected in the Blue Holes and the upper reach of the Broad River on 17th, October, 1984:

Family	Genus
UMBELLIFERAE	Hydrocotyle
CERATOPHYLLACEAE	Ceratophyllum
HALORAGACEAE	Nyriophyllum
NYMPHAEACEAE	Nymphaea
POTAMOGETONACEAE	Potamogeton
CHAROPHYTA	Chara

(Specific names are not known due to the lack of flowers.)

3.3 Plankton and Periphyton

Fifteen types of the z-o plankton have been identified in the Black River Lower Morass (NRCD and TGI, 1981). No significant differences in the varieties of the zooplankton have been found in the Black River estuary, the main stream of the Black River, and the Middle Quarters River. But zooplankton are slightly more abundant relatively in the estuary.

By contrast, the variety of periphyton species shows considerable differences between rivers and sites. The Broad River and the Middle Quarters River rising in the Lower Morass have many periphyton varieties 266 spp. in the Middle Quarters River and 269 spp. in the Broad River respectively due to the transparency of water.

According to Fritzon (1983), varieties of periphyton are relatively poor at Lacovia (77 spp.) and the Y.S. River bridge (69 spp.). The number of species of periphyton in the Black River and the Y.S. River, however increased with the sedimentation of the suspended solids. The number of periphyton species decreased in the mangrove forest with rising salinity from sea water intrusion. Therefore, in both the Black River and the Broad River the number of periphyton decreased respectively from 160 spp. to 127 spp. and 269 spp. to 64 spp.

3.4 Fin-fishes and Crustaceans

In the Lower Morass, approximately 40 fin-fish species and 7 crustacean species have been identified (see Annex K; Inland Fishery, Hunte, 1978). Out of these, three fin-fish species, i.e., tarpon Megalops atlanticus, Sphyraena barracuda and snook Centropomis spp., and three shrimp species, such as shrimp Macrobrachium acanthurus cray fish M. carcinus and crabonanny M. faustinum are commercially important species. Shrimp in particular have a high commercial value, and are sold by the highway vendors.

Inland fishing grounds are concentrated arund the confluences of the Black River, the Y.S. River and the Middle Quarters River, and along the Broad River.

3.5 Birds

In the Black River Lower Morass, 144 species of birds have been identified out of 244[1/] species for the entire island according to NRCD and TGI (1981) and Svesson (1983), corresponding to about 60% of number in Jamaica.

In a comparison with 10 other habitats in Jamaica, the Lower Morass was ranked second in Jamaica (NRCD and TGI, 1981). The avifauna of the Lower Morass contains 8 endemic species. Internationally, the Black River Lower Morass is an important area for birds because of the variety[2/] and the high level of endemism. The endemic species are:

TROCHILIDAE	
Jamaican Mango	Anthracothorax mango
Streamertail	Trochilus polytmus
TODIDAE	
Jamaican Tody	Todus todus
PICIDAE	
Jamaican woodpecker	Melanerpes radiolatus
VIREONIDAE	
Jamaican white-eyed Vireo	Vireo modestus
COEREBIDAE	
Orangequit	Euneornis campestris
THRAUPIDAE	
Jamaican Euphonia	Euphonia jamaica
FRINGILLIDAE	
Yellow-shouldered Grassquit	Loxipasser anoxanthus

1/: According to the NRCD, the total number is estimated 227 species.

2/: In Hellshire Hills, St. Catherine, 61 bird species were found (Woodley ed., 1971).

Most of the endemic species are found in the forests of the Morass, and several rare species are found in the Lower Morass, e.g. the Limpkin Aramus guarauna, the West Indian Tree Duck Dendrocygna arborea and the Spotted Rail Parirallus maculatus. These species are found in the upper reaches of the Middle Quarters River, the Y.S. River and the upper reaches of the Broad River (Fig. L-5). Table L-4. shows the avifauna of Jamaica and the Lower Morass.

Hunting of doves and pigeons is a popular sport in the entire Lower Morass especially in the forests during the shooting season (August - September). Since there is no full time warden, illegal hunting is prevailant.

3.6 Amphibians and Reptiles

3.6.1 Species composition

Table L-5 shows a species list of amphibians and reptiles of Jamaica and the Lower Morass. Four species of Salientia (frogs and toads), one species of Testudines (tortoises), seven species of Sauria (lizards) and one species of Crocodylia (crocodiles) have been identified. About 30% of all Jamaican species inhabit the Lower Morass, half of these being indigenous (Lynn and Grant, 1940; Underwood and Williams, 1959; McCoy, 1975). The Bullfrog Rana catesbiana was introduced in the 1960s with a view to export, but this has not been realized yet.

In the project area, we have collected the following Sauria (lizards).

Species Name	Sex	Collecting Site	Date	SVL 1/
Anolis sagrei	male	Black River Town	9.13	50.0
A. lineatopus	female	Black River Town	9.13	40.3
Allistelliger praesignis	female	Spring Hill	9.15	87.1
Anolis sagrei	male	Spring Hill	9.15	53.0
A. lineatopus	male	Spring Hill	9.15	53.7
A. lineatopus	female	Spring Hill	9.15	41.3
A. garmanni	female	Salt Spring	9.27	85.6
A. garmanni	female	Salt Spring	9.27	101.6
A. opalinus	male	Holiday Pen	10.7	51.3
A. opalinus	male	Holiday Pen	10.7	46.4
A. valenciennsii	male	Holiday Pen	10.7	47.7

Remarks: 1/: SVL = Shout-vent length, mm.

3.6.2 American crocodiles

The Black River Lower Morass is one of the largest remaining habitats of the American Crocodile (Crocodylus acutus), which is "an extremely endangered species" (IUCN 1982). Listed in Appendix I of the Convention on Trade in Endangered Species of Plants and Animals, and is a protected species under Jamaican Law*.

The result of night-light counts is shown in Table L-6 and the sites of crocodiles observed are pointed in Fig. L-6. Thirty (30) crocodiles were sighted in the short survey period, which was estimated to be as densely populated as about 0.22 individual/km along the stream. The density of crocodiles in the Lower Morass seems to be similar in level to that of Crocodylus novaeguineae in Papua New Guinea (Pernetta and Burgin, 1983).

Crocodiles are sighted in almost every water way in the Lower Morass from the estuary of the Black River up to the vicinity of the Holland Estate pumping station and the Blue Holes. According to the information of a local expert, the nesting sites of the crocodiles are distributed widely over the Lower Morass.

3.7 Mammals and Other Animals

3.7.1 Mammals

The following three mammal species excluding Chiroptera (small bats) are found in the Black River Lower Morass:

Trichechus manatus	Sea cow or American Manatee,
Rattus rattus	Rat, and
Herpestes auropunctatus	Mongoose.

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*: In Jamaica, selected animal species are classified as protected species under the law - The Wild Life Protection Act, Third schedule - They are (1) The Jamaican coney Geocapromys brownii, (2) The American Crocodile Crocodylus acutus, (3) The Jamaican Iguana Cyclura collei, (4) The American Manatee Trichechus manatus, (5) The Pedro Seal Monachus tropicalis, and (6) All marine turtle, in addition to all birds except for the species classified as pests.

Besides this, several species of Chiroptera are found in the Lower Morass, but names of the species are not known.

The rats and mongooses were introduced into Jamaica from abroad and are found almost everywhere in villages, pastures and cultivated areas. The manatee is one of three Atlantic siren (order Sirenia) species. Its distribution covers the whole Caribbean sea. The southern coast is the major habitat of the manatee in Jamaica. It is believed that at one time manatees made intensive use of the waterways of the Lower Morass for feeding. However, in historical times most of the manatees entering the river system have been killed for food. Since the population of manatees has declined remarkably in Jamaica, it is now designated as an endangered species.

The coney, the Jamaican Hutia Geocapromys brownii, another protected mammal species in Jamaica is found in the midden deposits in the estuary of the Black River. Its occurrence has also been confirmed in the Sant Cruz Mountains (Oliver, 1982). It is unlikely that the coney would ever use the morass itself, as it requires a habitat which contains suitable 'coney holes'.

3.7.2 Butterflies

Table L-7 shows the species list of the butterflies collected in the Black River Lower Morass and fourteen (14) sites where the butterflies were collected. The points of the collecting sites are shown in Fig. L-7. The collected specimens were classified by Dr. Farr, Institute of Jamaica. Anartia jatrophae and Dione vanillae are common species. Precis evarete, Eurema lisa and Pyrgus oileus can be easily found in almost every site in the Lower Morass.

In Jamaica the chief butterfly habitats are divided into four types (Brown and Heineman, 1972) i.e., (1) Dry limestone woodland, (2) Limestone forest, (3) Wet forest, (4) Wet forest fringes and related river valleys. The Project area is classified as Dry limestone woodland. Although more than half of the project area is composed of herbaceous swamp, mangrove forest and swamp forest, the species composition of the butterflies shows that of the dry limestone woodland which surrounds and intrudes the swamp area.

The dry limestone woodland is further sub-divided into the following three habitat types. (1) Dry salt marsh and coastal sands; (2) Dry woodland; (3) Water grounds and mixed meadows.

In the first habitat, there are few wild flowers and few butterflies. Precis evarete and Brephidium exilis are typical butterflies of this habitat and rarely found elsewhere. Precis evarete is found in the southern part of the Project area.

In the dry woodland, a number of butterflies are seen all year round. These include Mestra dorcas,several Eurema, Phoebis sennae, Ascia monuste, Kricogonia lyside, Papio andraemon most of the blues (Plebeinae) and the heliconiids. The third habitat is mainly found in this zone between the areas of woodland of the previous habitat, along roadsides, in pastures, and about cultivated fields. In this habitat, butterflies found here consistently include most of those of the previous habitat.

Anartia jatrophae, the most common butterfly in the Project area, is one of the typical species in this habitat. These species are also found in another major butterflies habitat, e.g., open woodland and pasture of limestone forest and ruinate, but not a common component in other habitats. From the species composition of butterflies, no endemic species are found in the Project area.

3.7.3 Other insects

The insects of the Morass have never been studied in detail. Some species such as grasshoppers, are fairly abundant but their significance in the food chain has not been assessed.

4. ENVIRONMENTAL ASSESSMENT

4.1 Project Impact

Major impacts of the project would be; (1) effects of the construction activity, (2) changes in river discharges, (3) sea intrusion, (4) changes in water quality and (4) changes in vegetation and animal habitats.

4.1.1 Construction activity

The irrigation area for paddy field is shown in Fig. L-8 and ratio of the irrigation areas to respective vegetations are shown in Table L-8.

(1) Holland, Lacovia and Y.S. River basin

In this area, the irrigation areas are restricted to the fringes of the morass, so most of the herbaceous swamp and swamp forest will not be affected by the irrigation development.

(2) Hatfield, Slipe, Frenchman and Holiday Pen (Black River Left Bank)

The irrigation of this area will change the entire area of herbaceous swamps and swamp forests. Since the herbaceous swamps and the swamp forests around the Hatfield and Frenchman are already affected by human activities such as pasturage and cultivation, the natural conditions are already modified to some extent. Holiday Pen area, however, is an important inland fishing ground and a part of the valuable ecosystem centered on the confluence of the Y.S. River, the Middle Quarters and the Black Rivers.

(3) Broad River Basin

Natural conditions will suffer significantly from the agricultural development in the Broad River Basin. Approximately 80 percent of the Typha hummocky swamp and Cladium - Sagittaria association will be altered into the paddy field. Due to the existance of some unique aquatic vegetation around the "Blue Holes" located in the area, development of the Broad River Basin will have to be undertaken carefully to minimize the disturbance of the natural conditions, and to protect the

water quality of the Broad River, and if possible, development of the Broad River Left Bank should be avoided altogether due to its ecological value.

(4) Habitat of the American Crocodile

The habitat of these crocodiles is estimated to be 7,400 ha in the Lower Morass including the Parottee Pond area (NRCD and TGI, 1981). Although crocodiles are thought to be found in most swamp area, suitable areas for nests seem to be restricted to the southern part of the Lower Morass and the Parottee Pond area where comparatively dense forests and outcrops of hard ground are to be found. Since agricultural development would be implemented mostly in the northern parts of the Lower Morass, the project would not directly affect the major habitat of the crocodiles.

4.1.2 Discharges of the rivers and their seasonal changes

In the dry season, discharges of the rivers will be reduced by abstraction for irrigation. The discharge of the Y.S. River will considerably decrease especially in the dry season. The Black River, however, will continue to provide ample flow even in a drought year. The discharge of the Broad River will be relatively greater since irrigation water from the Black River will be introduced into this basin.

4.1.3 Sea intrusion

Besides human activities, salinity is another major factor affecting ecosystems. At present sea intrusion is found up to about 7 km upstream in the Broad River and 4.5 km in the Black River (Björk, 1983). The effect of sea water may be seen in plant formations. The mangrove forest extends up to 4.5 km along the Black River and is found in the Broad River in the vicinity of the Salt Spring Bridge. After implementation of the agricultural development, sea water is likely to intrude further upstream particularly in a drought year, but this is expected to have negligible effects on plants and animals.

4.2 Changes of Water Quality

Waste water from the sugar factory distillery has polluted the water of the Black River, resulting in a drop in the density of dissolved oxygen (NRCD and TGI, 1981; Björk 1983). At present, the pollutant diluted by the Black River provides a nutrient to aquatic plants and animals.

Water qualities were investigated at 4 sites for suspended solids, at 4 sites for pesticides, and at 6 sites for other parameters (Fig. L-9). Other parameters examined were Calcium, Nitrates, Sulphates, Chlorides, Phosphates, Dissolved Oxygen (hereinafter called "DO"), Biochemical Oxygen Demand (hereinafter called "BOD"), Conductance, Alkalinity, pH, etc.

Transparency and colour tests in the Black River Lower Morass, showed that transparencies of the water varied considerably. In the Black River the colour of water is brown or cloudy brown and the transparency is from 35-45 cm. In the Y.S. River, the Middle Quarters River, and the Broad River, the water colour is brownish green, or pale green and the transparency is from 195-360 cm, and in the Y.S. River and the Broad River we could observe the bottoms of the rivers. All the rivers are expected to be suitable for fishing which is generally found requires a transparency in excess of 30 cm.

Although it was expected that use of nutrients in paddy fields upstream would have increased the amounts of potassium, nitrates and phosphates in the river water, no significant changes in water qualities were found from those tested in 1977, before the agricultural development of the Upper Morass as shown in Table L-9.

The present state of water quality in the project area is shown in Table L-10. The sampling points are shown in Fig. L-10. According to "Water Quality standard for fishing" and "Water quality standard for fishery environment", the present state of water quality in the project area indicates eutrophic conditions in BOD, a marginal level in DO, and rather high values of Suspended Solid (hereinafter called "SS") in the Black River (water analysis D station) and the Middle Quarters River.

Value of SS (ppm) and expected effects on fisheries are as follows, (from the European Inland Fisheries Advisory Commission).

SS (ppm)	Effect
25	No effect on fishing activities
25 - 80	Slight effect, but no problem
80 - 400	Poor fishing activities
400	No fishing activities

In general, the present state of water quality is expected to be appropriate for fishing but an improvement in the DO level would be desirable.

Prior to commencement of Agricultural development in the Upper Morass, close control of herbicides and pesticides, especially those of chlorinated hydrocarbons, was advised (Chin and Harza Overseas Engineering Company, 1977). In the agricultural development of the Lower Morass, it is recommended that application of chemicals for pest and weed control be made in accordance with "Standard for Safe Application of Chemicals in Japan", or similar international standards.

In the proposed agricultural project, several kinds of nutrients will be applied (for detailed design, see Annex G). Outflows of these fertilizers into the rivers and swamps will result in eutrophic conditions. Whilst excessive eutrophic conditions lead to the decrease of DO, because of the present marginal level of DO, careful management of fertilizers could in fact be expected to lead to improvement in DO.

It is assumed that the application of herbicides and pesticides under the above standard will maintain the soundness of the ecosystem in the Lower Morass and will not exert the injurious effects to the inland fishery. It is important, however, that the integrity of application procedures is verified through continuous monitoring of pesticides and herbicides in the environment.

Table L-11 gives a list of chemicals proposed for use in the agricultural development, and the standard safety application of chemicals for mammalian toxicity and toxicity to aquatic animals shows in Table L-12.

In the proposed agricultural development project, seven (7) kinds of herbicide and six (6) kinds of pesticide are planned to be applied to paddy fields and upland. These chemicals are classified as OS or DS rank for mammalian toxicity and A or B rank for toxicity to aquatic animals. These chemicals used in the proposed agricultural development project will not cause any serious impact, but the management of these chemicals should be carefully controlled. Any mixture of two or more chemicals, especially Diphenamid, should be strictly prohibited. Diazinon, B-S class for toxicity to aquatic animals, should not be released into rivers and swamps.

At present, no Standard Safety Act for application of chemicals exists in Jamaica except for one article in the Wild Life Act. Therefore, an arrangement such as the "Standard for Safe Application of Chemicals" is needed in Jamaica for the conservation of water quality and aquatic ecosystems as well as land ecosystems and the wellbeing of humans and cattle.

Although dissolved oxygen (DO) in the Black River is "marginal" at present, the values of other parameters indicate that it still acceptable according to the "Standard for Safe Application of Chemicals in Japan".

During the construction period, the drainage in the development area particularly peat soils is absolutely required to be made, which provides most important factor affecting on the natural environment, especially on water quality. In this period, average drain water is estimated to be as follows:

Black River, Holland pump station : 0.1 m^3/sec
Black River, Left bank pump station : 0.3 m^3/sec
Broad River, Right bank pump station : 0.2 m^3/sec
Broad River, Left bank pump station : 0.2 m^3/sec

Meanwhile, the discharge of the Black River ranges from 9.9 m^3/sec (Mar.) to 32.1 m^3/sec (Oct.) at Lacovia, and that of the Broad River from 0 m^3/sec (Jan., Feb. and Dec.) to 4.9 m^3/sec (Aug.).

In the Black River basin, effects of drain water will be expected to be slight because the average drain water (0.4 m^3/sec) is only 4% of monthly minimum discharge of the river.

But in the Broad River basin, if drain water will be discharged directory into the stream, water quality is considered to be affected significantly. Therefore, during the construction stage, drain water of the Broad River basin is recommended to be controled adequately for the preservation of water quality. In this context, it is proposed that the water drained would be diverted first to the settling basin to be proposed in the grass land some far from the river bank.

4.3 Changes of Vegetation and Animal Habitats

4.3.1 Vegetation

Fig. L-11 shows the alternative plans for agricultural development and the altered areas by the development are measured in respective alternative plans and shown in Table L-13. In the maximum case, substantial herbaceous swamp (including the forests) will be altered into the farm land. Even if the maximum case (alternative plan No. 1) be implemented, major natural forests, unique herbaceous swamps and the most important fishery fields would be preserved. The alternation of herbaceous swamp in the Broad River Basin would be more serious.

Taking into consideration the potential impacts of future population increases and their destructive effects on the natural environment, the zoning of the area to be preserved around the upper reaches of the Broad River including the Blue Holes is urgently required. The uniqueness of the aquatic vegetation in the Broad River could easily be destroyed unless careful advance planning and implementation of suitable control measures are undertaken in a timely manner. Black River diversion plan (alternative No. 4) would have a fatal effect on the aquatic vegetation of the Broad River.

4.3.2 Habitats of animals

The forests play an ecologically important role in the Lower Morass. The canopy of the forest provides foods, roosts and nest sites for birds. The roots of the mangrove also supply feeding grounds for small aquatic animals, e.g., fishes, swimming crabs, snails, etc. Mangroves provide shelters for small fishes, crocodiles and turtles. The habitats of the endemic bird species are more or less related to the forests. In general, any kind of forest in the Lower Morass should be conserved.

5. MULTIPURPOSE APPROACH FOR WETLAND MANAGEMENT

5.1 Multipurpose Approach for Wetland Management and Conservation of Natural Resources

5.1.1 Background on necessity of wetland management

The wetland has been left out of development so far as it was unsuitable and not appreciated for its ecological importance. It provides, however, vital benefits to its surrounding inhabitants. Virtually the whole of the Black River Lower Morass is utilized for various purposes of local industries such as shrimp fishing, timber bark of mangrove for tannin, home industry of basket making, etc.

It is now widely recognized that wetland ecosystems have an important role in the human environment. In Florida, U.S.A., for example, the destruction of mangrove forest resulted in substantial erosion of the coastline. The conservation of wetland is promoted internationally at present in the Ramsar Convention particularly for waterfowl habitat. In Falmouth in Jamaica, sea currents have transported marine sediment loads into the marsh land after destruction of mangrove forest which has resulted in the extinction of phosphorescent dinoflagettates. Since the ecosystem of the wetland is very delicate and liable to variation on its system from surrounding impacts, it is essential that any kind of development of the wetland is to be carefully approached in due consideration of the ecological management.

5.1.2 Specific approach for wetland management and conservation of natural resources

The origin of a wetland and its influence of human activities largely vary from place to place. In the specific development of a wetland, it is firstly necessary to clarify its characteristics in scientific terms. Traditional production activities by the inhabitants may be maintained as long as they are in balance with the ecosystem. Based on the specific circumstances and sound scientific knowledge of the particular wetland, a new development plan can be carefully elaborated without destroying the existing ecosystem. In this zoning of the land according to its characteristics is an essential element.

5.1.3 Wetland management plan

The main components of any meaningful management plan are:

(1) Scientific evaluation

Physical/chemical/biological evaluation which would include the following:

(i) Hydrological data
(ii) Water quality data
(iii) Identification of flora and fauna; especially the vegetation and the distribution
(iv) Identification of soil types stratification
(v) Identification of the present land use
(vi) Socio-economic role of the wetland.

(2) Identification of possible activities

The traditional socio-economic role and ascertainment of the best locations for these activities are to be classified.

(3) Assigning of sectorial responsibility to different government agencies

These government bodies would include the following Ministries:

(i) Ministry of Agriculture: Agriculture, forestry, fishery and horticulture.
(ii) Ministry of Mining and Energy: Biomass, silviculture and peat mining.
(iii) Ministry of Finance and Planning: Recreational areas
(iv) Ministry of Tourism: Recreational areas
(v) Ministry of Youth & Community Development: Development of craft industries.

(4) Identification of a working committee

This would be composed of members from the above-mentioned Ministries and possibly other interested groups. This committee would also be responsible for the implementation of various activities including the suggestions for new legislation or regulations and the safety standards for the wetland management.

(5)* Monitoring Mechanism

The NRCD would monitor these areas within the legal frameworks that already exist, e.g. Town and Country Planning Act. Fisheries Industry Act and Wildlife Protection Act.

5.2 Development of Agriculture and Other Industries

In the Black River Lower Morass, the expected multipurpose approach for wetland management includes the following activities; agriculture, aquaculture, silviculture, horticulture, livestock farming, cottage industry, crocodile industry and frog farming, bio-gas, peat mining, recreation, etc.

In the case of any development, besides enhancing ordinary activities such as shrimp fishery, the conservation of the wetland ecosystem should be taken into consideration. Furthermore, the general plan of development should be based on scientific data which provide the basis for zoning of activities in the wetland management.

5.2.1 Agriculture

For the agricultural development, rice Oryza sativa indica, soya bean Glycine max, corn Zea mays, peanut Arachis hypogaea, carrot Daucus carrota sativus and onion Allium cepa seem to be suitable crops for the agricultural development, where irrigation and drainage system are provided in the reclamation areas. Improvement of the pasture for intensive grazing would become possible with the growing of African stargrass Cynodon plectostachus and the use of fertilizers.

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*: Refer to the revised draft report by NRCD.

5.2.2 Inland fishery

For enhancement of ordinary inland fishery, such as shrimp fishery, it is necessary that the spawning grounds and the habitat of the shrimp larvae be protected in timely seasons. At present there are no definite data on spawning grounds, spawning seasons or the spawning behaviour of the shrimps. Therefore, intensive study of these items will be indispensible for enhancing the activities of the inland fishery.

5.2.3 Peat mining

The ponds which may be constructed by the peat mining proposed (if implemented) will be too deep for the habitat of shrimps. The proposed maximum scale of the peat mining would be a disaster for the inland fishery rather than providing a suitable habitat for fin-fishes and shrimps. Only shallow peat mining less than 1 - 2 m in depth will be acceptable for the habitat of shrimps.

5.2.4 Afforestation

The forests of the Lower Morass have suffered from human activities for a very long time. This has greatly reduced the economical value of the wetland as well as the value of the natural resources. The mangrove forests in particular are very important elements for providing economically useful materials and are the basis of the wetland ecosystem. Therefore, economically valuable trees should be preserved and replanted purposely, e.g., the silk cotton tree Ceiba pentanera for canoes, the red mangrove Rhizophora mangle for fire wood, charcoal and dyes.

5.2.5 Crocodile farming and frog farming

Crocodile farming has been started to protect wild populations from further exploitation in New Guinea. A network of farms with a total capacity of between 50,000 and 100,000 individuals has been envisaged to produce 30,000 skins per annum from farm raised animals in 3 - 4 years, with UNDP technical assistance. Unfortunately, since the prognosis for the farming scheme was not good, the farming project may well have increased the pressure on the resource rather than acting as a brake on cropping wild animals (Pernetta and Burgin, 1983).

The plan of the crocodile farming in the project area should be be carefully conducted because of the comparatively small population size of the American Crocodiles and the scarcity of information on the distribution, habitat, food habits, and especially the population of the crocodiles. Consequently, the first step for crocodile conservation is to establish a national conservation area, not crocodile farming.

The possibility of the frog farming in the Lower Morass is doubtful due to the effects of the salinity.

5.3 Conservation of Nature and Recreation

5.3.1 Multiple use within a national park

The national parks are usually regarded as inviolate areas and the development of national parks has been stressed as a major contribution to national and international conservation for the following reasons:

(1) Protection of ecosystems and their sustained productivity,

(2) Protection of genetic heritage, and

(3) Protection of endangered species.

Seventeen of the countries of the Caribbean already have national parks (Putney, 1980). These include Dominican Republic, Costa Rica, Virgin Island, etc.

In developing countries similar to Jamaica however, multiple use of national parks has been shown to have many economic benefits (Island Resources Foundation, 1981).

5.3.2 Value of the Black River Lower Morass as a national park

According to the estimation of NRCD, the areas proposed as national parks in Jamaica include John Crow Mountains, Blue Mountains, Cockpit Country, Canoe Valley, Portland Bight, Black River, Negril, Hellshire in addition to the two existing Marine Parks at Montego Bay and Ocho Rios. The Lower Morass is highly ranked being second only to the Blue Mountains and the highest among other Morass ecosystems (see Table L-14).

The biological uniqueness for genetic resources is remarkably higher in the Lower Morass than in Negril. Furthermore, in comparison with the Everglades National Park, Florida, U.S.A., the Lower Morass is also evaluated to have a far higher scenic quality (see Table L-15).

In order to establish a national park in the Lower Morass, one major problem is that no formal legislation exists at present for national parks in Jamaica. Such comprehensive legislation as well as Safety Standards for the Application of Chemicals is urgently required for the conservation of the natural environment.

The first step in the conservation of the Black River Lower Morass is the effective implementation of the existing acts. Existing Acts concerning the conservation of the natural environment and agencies and provisions are as follows.

ACT	AGENCY	PROVISIONS
Wild Life Protection Act	NRCD, Ministry of Agriculture	Wildlife Reserves and sanctuaries, Fish sanctuaries
Beach Control Act	NRCD, Ministry of Agriculture	Public Bathing Beaches Beach Development Control
Watershed Protection Act	NRCD, Ministry of Agriculture	Protected Watersheds
Forest Act	Forect Department, Ministry of Agriculture	Forest Reserve
Town Planning Act	TPD, Ministry of Finance & Planning	Development Orders, National Park declaration (proposed), Tree Preservation Orders
Bark of Trees Act	Forestry Department, Ministry of Agriculture	Control of removal and sale of tree bark
Land Acquisition Act	Commissioner of Lands	Land purchase
Land Authorities Act	TPD	Control of land development

The second step will be to prepare a draft of National Park Act and the third step will be zoning of the proposal park area, and zoning and classification of land use. On the classification of the land use, suggested categories are the following (according to NRCD's classification):

CLASS 1 - SPECIAL AREAS
CLASS 2 - WILDERNESS, RECREATION AREAS
CLASS 3 - NATURAL ENVIRONMENT AREAS
CLASS 4 - GENERAL OUTDOOR, RECREATION AREAS
CLASS 5 - INTENSIVE USE AREAS

(a) SPECIAL AREAS (CLASS 1)

Special areas should have unique or otherwise valuable qualities worthy of preservation and strict protection. There are two general types:

(1) SPECIAL ECOLOGICAL AREAS

These contain major plant types, entire water-sheds, animal habitats, and special research areas within the park. Management and use should be directed towards minimum of interference with the cycles of plant and animal communities.

(2) HISTORICAL OR CULTURAL FEATURES

These include those which have played a significant role in some aspect of human history or culture.

(b) WILDERNESS, RECREATION AREAS (CLASS 2)

In class 2 areas, the primary aim should be preservation of a wilderness recreation environment. Riding and hiking trails, primitive campgrounds, and wildlife habitat are the typical features. Access by any type of motor vehicle should be prohibited.

(c) NATURAL ENVIRONMENT AREAS (CLASS 3)

The concept of the wilderness threshold best describes these areas. They should serve as buffers between wild terrain and the more developed areas, present a natural background to developed facilities, and be essential to the preservation of the wildland character of the park. Some sections of this class of land might be regarded as land banks. Portions may be added to class 1 or 2 lands. However, no portion should be reclassified to class 4.

The same type of activities that take place in class 2 zones should be permitted, but at a higher intensity.

(d) GENERAL OUTDOOR RECREATION AREAS (CLASS 4)

The class 4 areas should delineate the units of existing and potential facility developments. They should include access roads, campgrounds, view points, and other outdoor activity areas. These areas will be subjected to intensive use, which may exceed their resource potential. This may require certain types of construction such as trails, paths, campsites, roads, parking lots, and drainage systems to reduce destruction of the landscape.

(e) INTENSIVE USE AREAS (CLASS 5)

These may consist of major visitor service centers or even townsites.

5.3.3 Research area and conservation area for endangered species

In the Black River Lower Morass, there are three important places for the conservation of the natural environment and the habitats of the endangered species. These places are classified as Class 1 - Special ecological area. In these areas, scientific studies are essential at all stages in the establishment, development and management of the national park systems.

Special ecological areas are the followings;

(1) The area of swamp forest and hummocky swamp among the Middle Quarters River, the Y.S. River and the Black River.

This area has (a) unique ecosystems such as swamp forest and hummocky swamp, and habitats of (b) endemic species -- Roystonea princeps (Swamp cabbage palm), Grias cauliflora (Anchovy pear) and Rare bird species -- Limpkin, Spotted rail, West indian tree duck, (c) economically valuable species -- Macrobrachium acanthurus (Shrimp), M. carcinus (Cray fish), M. faustinum (Crabonanny) and (d) endangered species such as Crocodiles acutus (American crocodile), and Trichechus manatus (American manatee).

(2) The area of Cladium / Sagittaria association, including the aquatic vegetation in the upper reach of the Broad River and the Blue Holes.

Not only for its unique aquatic vegetation and the transparency of water originated in the Blue Holes, but also for rare bird species and endangered species, this area is one of the most important area in the Lower Morass.

In case of the maximum development plan, this area will be surrounded by paddy fields, therefore sufficient space (more than 300 ha) for the protection of this unique ecosystem will be necessary.

Studies of water qualities including the transparency and chemicals should be continued in all stages of the proposed agricultural development.

(3) Area of the mangrove forest.

Mangrove forest supplies timbers, fuel and dyes for human and provides refugees and feeding ground for avian and aquatic animals including rare and endangered species. For example, most American crocodiles were sighted around the mangrove forests.

In these class 1 areas, studies on the wetland ecosystem, reproduction cycles and suitable habitats of rare and endangered species, and for the improvement of the environmental conditions especially DO level, will be indispensable.

6. RECOMMENDATIONS

6.1 Areas to be Preserved

The Black River Lower Morass fulfills all the criteria for a national park in Jamaica.

It is recommended therefore that the entire wetland (i.e. the Project area as shown in Figure L-1) be conserved as a national park for multiple use and sustainable development.

The following areas are judged to be high priority for conservation.

(1) The area of the swamp forest and hummocky swamp along the Middle Quarters River, the Y.S. River and the Black River.

The swamp forest and the surrounding areas contain unique forests, herbaceous swamps, and riparian communities. No equivalent of these formations exists in Jamaica. Furthermore, the surroundings of the Y.S. River and the Middle Quarters River and the forest area provide habitats for rare and endemic bird species. These areas are also the most important areas for inland fishery.

This area should be conserved for the inland fishery, and also as a sanctuary for birds and plant associations.

(2) The area of the Cladium - Sagittaria association, including the aquatic vegetation in the upper reach of the Broad River and the Blue Holes.

This area is also rich in plant species and contains an unique aquatic vegetation due to the transparent water rising from the Blue Holes.

The herbaceous swamp, the aquatic vegetation and the water quality including its transparency, should be protected strictly from any kind of development and human disturbance.

(3) Areas of mangrove forests;

These areas occupy an important position in the ecosystem of the Lower Morass. Today these mangrove forests remain patchy in the southern part of the Lower Morass due to various human activities including fires, cutting of trees for timber, stripping of bark for dyes, and cultivation. Conservation and recovery of these areas will be indispensable for management of the wetland.

6.2 Monitoring Programme

It is recommended that the following four major elements of environmental change should be continuously monitored in the Lower Morass.

(1) Water quality: the following parameters should be examined at no less than 7 points, e.g. Lacovia, the Y.S. River bridge, the main stream of the Black River, the Middle Quarters River, the Blue Holes, the Salt Spring bridge, and the estuary of the Black River.

Parameters: Metals, nitrates, sulphates, chlorides, phosphates, Dissolved Oxygen, Biochemical Oxygen Demand, pH, suspended solids, conductance, pesticides and herbicides.

(2) River discharges: the water levels and discharges of each river, especially of the Y.S. River should be surveyed in both dry and wet seasons. Sea water intrusion is likely to increase as a result of irrigation activity especially in the dry season and should also be monitored.

(3) Land use practices: with the agricultural development, the pattern of the land use will change. The alteration of the land use should be monitored especially in regard to deforestation.

(4) Changes in flora and fauna: because of the insufficient data on the ecosystem, intensive surveys are required especially on the distribution and the population of zooplankton, insects, avifauna and American Crocodiles.

In addition, a detailed survey is urgently required of aquatic vegetation in the Broad River and flora and fauna of the swamp forest.

6.3 Evaluation of the Alternative Plans for Agricultural Development

In case of Alternative 1 (full development), about 2,520 ha of Typha hummock swamp and Cladium - Sagittaria association in the Broad River basin will be altered to the paddy fields. Although these plant communities are seriously affected by fires, especially around the villages, it is necessary to preserve the natural condition of these plant communities whenever possible such as along the both side of the river. In this case, the dikes should be constructed sufficiently apart from the river bank as to not spoil the beauties of nature and to preserve the ecosystem.

Compared with Alternative 1, Alternative 2 is to be preferred for conservation of natural conditions in the Lower Morass. Alternative 3 will not cause any damage to the natural environment of the Lower Morass.

In case of Alternative 4, the Blue Holes and the Broad River would inevitably be polluted due to the intrusion of the large quantities of suspended solids and other pollutants from the Black River. This alternative plan would result in fatal effects to the unique aquatic vegetation and cannot be recommended.

6.4 Multipurpose Development for Sustainable Growth

From environmental consideration reviewed in this Annex, Alternative 1 is acceptable as the agricultural development plan compatible with sustainable development of the local economy, for securing of employment, and for improvement of living standards. The recommendations contained in Section 6.1 and 6.2 above will however be essential for maintaining the resource based upon which these benefits will be realized.

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Table L-1 AREA OF VEGETATION AND LAND USE IN 4 REGIONS (6 SUB-DIVIDED AREAS) OF THE LOWER MORASS

(Unit: ha)

Vegetation and Land Use	Holland/ Lacovia and Y.S. River Basin	Middle Quarters River and Estuary of Black River			Hatfield Slipe Frenchman and Holiday Pen	Broad River Basin and Vineyard			Total	% of Total Area
		A Area	B Area	Total		C Area	D Area	Total		
1. Forest	300	60	400	460	360	500	40	540	1,660	14.5
Mangrove Forest	10	20	390	410	0	70	10	80	500	4.4
Swamp Forest	140	0	10	10	40	0	0	0	180	1.6
Secondary Forest	150	40	0	50	320	430	30	460	980	8.6
2. Pasture/Grassland	390	530	100	630	730	640	370	1,010	2,760	24.1
3. Cultivated Area	970	30	0	30	420	320	60	380	1,800	15.7
Tree (including fruit-trees/Village/Pasture)	10	20	0	20	90	60	20	80	200	1.7
Upland Crop Field/Pasture	50	10	0	10	320	260	40	300	680	5.9
Sugarcane Field	910	0	0	0	10	0	0	0	920	8.0
4. Herbaceous Swamp	880	620	940	1,560	810	980	1,000	1,980	5,230	45.7
Crinum/Sagittaria Zone	0	0	0	0	170	0	0	0	170	1.5
Scirpus Olneyi Zone	0	40	480	520	0	0	0	0	520	4.5
Hummocky Swamp	190	300	20	320	0	0	0	0	510	4.5
Thick Cladium Zone	80	150	0	150	110	0	0	0	340	3.0
Typha Zone	320	20	0	20	140	0	0	0	480	4.2
Typha Hummocky Swamp	0	0	0	0	0	400	300	700	700	6.1
Cladium/Sagittaria Assoc.	0	0	0	0	0	550	690	1,240	1,240	10.8
Typha/Thalia Zone	0	0	0	0	160	0	0	0	160	1.4
Cladium/Conocarpus Zone	0	70	400	470	0	0	0	0	470	4.1
Unclassified Swamp and Water Surface	290	40	40	80	230	30	10	40	640	5.6
Total	2,540	1,240	1,440	2,680	2,320	2,440	1,470	3,910	11,450	100.0

Table L-2 NUMBER OF SPECIES IN EACH PLANT COMMUNITY
(After Coke et al., 1982 and NRCD & TGI, 1981)

Plant Community	No. of species	Dominant Species
Mangrove Forest	10	Rhizophora mangle Conocarpus erectus
Swamp Forest	47	Rostonea princeps Grias cauliflora
Crinum/ Sagittaria zone	20	Crinum americanum Sagittaria lancifolia
Scirpus olneyi zone	8	Scirpus olneyi
Hummocky Swamp	24	Cladium jamaicense Lippia nodiflora
Thick Cladium zone	19	Cladium jamaicense
Typha zone	33	Typha domingensis Cyperus giganteus
Typha Hummocky Swamp	16	Cladium jamaicense Eleocharis cellulosa
Cladium/ Sagittaria association	41	Cladium jamaicense Sagittaria lancifolia
Typha/ Thalia zone	17	Typha domingensis Thalia geniculata
Cladium/ Conocarpus zone	14	Cladium jamaicense Conocarpus erectus

Table L-3 LIST OF FISH SPECIES RECORDED FROM THE LOWER MORASS

Family	Scientific name	Common name
Elopidae	Elops saurus	ladyfish
	Megalops atlanticus	tarpon
Albulidae	Albula vulpes	bonefish
Clupeidae	Opisthonema oglinum	threadfin herring
	Anchoa sp.	anchovy
Engraulidae	sp. unidentified	jibber broadhead
Anguillidae	Anguilla rostrata	eel
Muraenidae	Gymnothorax moringa	spotted moray
Belonidae	Strongylura timuca	gar
Poecillidae	Gambusia affinis	mosquito fish
Mugilidae	Mugil cephalus	grey mullet
	M. curema	mullet
	M. sp.	mullet
Sphyraenidae	Sphyraena barracuda	
Cichlidae	Tilapia mossambica	african perch
Centropomidae	Centropomis sp.	snook
Carangidae	Caranx hippos	crevalle jack
	C. latus	horse-eye jack
Lutjanidae	Lutjanus apoda	snapper
	L. griseus	mangrove snapper
	L. jacu	dogtooth snapper
Gerridae	Diapterus rhombeus	macaback
	Eucinostomos spp.	macaback
	Eugerres plumieri	stonebar
	Gerres cinereus	macaback
	sp. unidentified	silver fish
Sciaenidae	Bairdiella ronchus	croaker
	spp. unidentified	drummer
Eleotridae	Dormitator maculatus	god-a-me
Gobiidae	spp. unidentified	mudfish, sandfish
Soleidae	Achirus lineatus	sole
Bothidae	Syacium micrurum	flatfish
Myliobatidae	Aetobatis narinari	eagle ray

Table L-4 (1/6) AVIFAUNA OF JAMAICA AND LOWER MORASS
(From Bond, 1979 NRCD & TGI, 1981
and Svensson, 1983)

Family and Species Name	Latin Name	NRCD	PCJ
PRODICIPEDIDAE			
Least Grebe	Podiceps dominicus		o
Pied-billed Grebe	Podilymbus podiceps	o	o
PROCELARIIDAE			
Black-capped Petrel	Pterodroma hasitata		
Leach's Petrel	Oceanodroma leucorha		
Wilson's petrel	Oceanites oceanicus		
PHAETHONTIDAE			
White-tailed Tropicbird	Phaethon lepturus		
PELECANIDAE			
Brown Pelican	Pelecanus occidentalis	o	o
SULIDAE			
Brown Booby	Sula leucogaster		
Red-footed Booby	S. sula		
PHALACROCORACIDAE			
Double-crested Cormorant	Phalacrocorax auritus		
Olivaceous Cormorant	P. olivaceus		
FREGATIDAE			
Magnificent Frigatebird	Fregata magnificens	o	o
ARDEIDAE			
Great White Heron	Ardea occidentalis		
Great Blue Heron	A. herodias	o	o
Green Heron	Butorides virescens	o	o
Little Blue Heron	Florida caerulea	o	o
Cattle Egret	Bubulcus ibis	o	
Reddish Egert	Dichromanassa rufescens	o	o
Great Egret	Egretta alba	o	o
Snowy Egret	E. thula	o	o
Tricoloured Heron	Hydranassa tricolor	o	o
Black-crowned Night Heron	Nycticorax nycticorax	o	o
Yellow-crowned Night Heron	N. violacea		o
Least Bittern	Ixobrychus exillis	o	o
American Bittern	Botaurus lentiginosus		
CICONIIDAE			
Wood Stork (or Ibis)	Mycteria americana		
THRESKIORNITHIDAE			
Glossy Ibis	Plegadis falcinellus	o	
White Ibis	Eudocimus albus		
Roseate Spoonbill	Ajaja ajaja	o	
PHOENICOPTERIDAE			
Roseate Flamingo	Phoenicopterus ruber	o	
ANATIDAE			
Fulvous Tree Duck	Dendrocygna bicolor		
West Indian Tree Duck	D. arorca	o	o
Mallard	Anas platyrhynchos		
Gadwall	A. strepera		
Northern Pintail	A. acuta		o
Green-winged Teal	A. crecca	o	
Blue-winged Teal	A. discors	o	o
American Widgeon	A. americana	o	o
Northern Shoveler	Spatula clypeata	o	o
Wood Duck	Aix sponsa		
Redhead	Aythya americana		
Ring-necked Duck	A. collaris	o	o
Canvasback	A. valisineria		
Lesser Scaup	A. affinis	o	o
Ruddy Duck	Oxyura jamaicensis	o	

Table L-4 (2/6) AVIFAUNA OF JAMAICA AND LOWER MORASS
(From Bond, 1979 NRCD & TGI, 1981
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Family and Species Name	Latin Name	NRCD	PCJ
ANATIDAE			
Masked Duck	O. dominica	o	o
CATHARTIDAE			
Turkey Vulture	Cathartes aura	o	
ACCIPITRIDAE			
Swallow-tailed Kite	Elanoides forficatus		
Sharp-shinned Hawk	Accipiter striatus		
Red-tailed Hawk	Buteo jamaicensis	o	o
Marsh Hawk	Circus cyaneus	o	o
Osprey	Pandion haliaetus	o	o
FALCONIDAE			
Crested Caracara	Caracara plancus	o	
Peregrine Falcon	Falco peregrinus		o
Merlin(Pigeon) Hawk	F. columbarius	o	o
Spallow Hawk	F. sparverius	o	
ARAMIDAE			
Limpkin	Aramus guarauna	o	o
RALLIDAE			
Clapper Rail	Rallus longirostris	o	o
Spotted Rail	Pardirallus maculatus		o
Sora Crake	Porzana carolina	o	o
Yellow-breasted Crake	P. flaviventer	o	o
Black Crake	Laterallus jamaicensis		o
Purple Gallinule	Porphyrula martinica	o	o
Common Gallinule	Gallinula chloropus	o	o
American Coot	Fulica americana	o	o
Caribean Coot	F. caribaea		o
JACANIDAE			
Northern Jacana	Jacana spinosa	o	o
CHARADRIIDAE			
Semipalmated Plover	Charadrius semipalmatus	o	o
Piping Plover	C. melodus		o
Snowy Plover	C. alexandrinus		o
Thick-billed Plover	C. wilsonia		o
Killdeer	C. vociferus		o
American Golden Plover	Pluvialis dominica		
Black-billed Plover	Squatarola squatarola		o
Ruddy Turnstone	Arenaria interpres		o
RECURVIROSTRIDAE			
Common Stilt	Himantopus himantopus	o	o
SCOIOPACIDAE			
Common Snipe	Gallinago gallinago		o
Whimbrel	Numenius phaeopus		o
Spotted Sandpiper	Actitis macularia		o
Solitary Sandpiper	Tringa solitaria		
Greater Yellowlegs	T. melanoleuca		o
Lesser Yellowlegs	T. flavipes		o
Willet	Catoptrophorus semipaimatus		o
Red Knot	Calidris canutus		
Pectoral Sandpiper	C. melanotos		
White-rumped Sandpiper	C. fuscicollis		
Least Sandpiper	C. minutilla		o
Semipalmated Sandpiper	C. pusilla		o
Western Sandpiper	C. mauri	o	o
Sanderling	Crocethia alba	o	o
American Dowitcher	Limnodromus griseus	o	
Stilt Sandpiper	Micropalama himantopus		o
Buff-breasted Sandpiper	Tryngites subruficollis		
Marbled Godwit	Limosa fedoa		

Table L-4 (3/6) AVIFAUNA OF JAMAICA AND LOWER MORASS
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Family and Species Name	Latin Name	NRCD	PCJ
SCOLOPACIDAE			
Hudsonian Godwit	L. haemastica		
Ruff	Philomachus pugnax		
STERCORARIIDAE			
Parasitic Jaegen	Stercorarius parasiticus		
LARIDAE			
Herring Gull	Larus argentatus		o
Ring-billed Gull	L. delawarensis		o
Laughing Gull	L. atricilla	o	o
Forester's Tern	Sterna forsteri		o
Gull-billed Tern	S. niloteca	o	
Common Tern	S. hirundo	o	o
Roseate Tern	S. dougallii		o
Bridled Tern	S. anaethetus		
Sooty Tern	S. fuscata	o	
Least Tern	S. albifrons	o	
Royal Tern	Thalasseus maximus	o	
Sandwich Tern	T. sandvicensis	o	o
Caspian Tern	Hydroprogne caspia	o	
Black Tern	Chlidonias niger	o	o
Brown Noddy	Anous stolidus		
COLUMBIDAE			
White-crowned Pigeon	Columba leucocephala	o	o
Red-necked Pigeon	C. squamosa		
Ring-tailed Pigeon	C. caribaea		
Plain Pigeon	C. inornata		
Mourning Dove	Zenaida macroura	o	o
Zenaida Dove	Z. aurita		o
White-winged Dove	Z. asiatica	o	o
Common Ground Dove	Columbina passerina	o	o
White-billed Dove	Leptotila jamaicensis	o	o
Crested Quail Dove	Geotrygon versicolor		
Ruddy Quail Dove	G. montana		
PSITTACIDAE			
Yellow-billed Parrot	Amazona collaria		
Black-billed Parrot	A. agilis		
Olive-throated Parakeet	Arotinga nana	o	o
Guiana Parrotlet	Forpus passerinus	o	o
CUCULIDAE			
Mangrove Cuckoo	Coccyzus minor	o	
Yellow-billed Cuckoo	C. americanus	o	
Black- billed Cuckoo	C. erythropthalmus		
Chestnut-billed Cuckoo	Hyetornis pluvialis		
Jamaican Lizard Cuckoo	Saurothera vetula		
Smooth-billed Ani	Crotophaga ani	o	o
STRIGIDAE			
Barn Owl	Tyto alba	o	
JamaicanOwl	Pseudoscops grammicus	o	
NYCTIBIIDAE			
Common Potoo	Nyctibius griseus		
CAPRIMULGIDAE			
Chuck-will's-widow	Caprimulgus carolinensis		
Common Nighthawk	Chordeiles minor	o	
APODIDAE			
Chimney Swift	Chaetura pelagica		
Collared Swift	Streptoprocne zonaris	o	
Black Swift	Cypseloides niger		
Antillean Palm Swift	Tachornis phoenicobia	o	o
TROCHILIDAE			
Jamaican Mango	Anthracothorax mango	o	o

Table L-4 (4/6) AVIFAUNA OF JAMAICA AND LOWER MORASS
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Family and Species Name	Latin Name	NRCD	PCJ
ROCHILIDAE			
Streamertail	Trochilus polytmus	o	o
Ruby-throated Hummingbird	Archilochus colubris		
Vervain Hummingbird	Mellisuga minima	o	o
AICEDINIDAE			
Belted Kingfisher	Ceyle alcyon	o	o
TODIDAE			
Jamaican Tody	Todus todus	o	
PICIDAE			
Jamaican Woodpecker	Melanerpes radiolatus	o	o
Yellow-bellied Sapsucker	Sphyrapicus varius	o	
COTINGIDAE			
Jamaican Becard	Platypsaris niger		
TYRANNIDAE			
Eastern Kingbird	Tyrannus tyrannus		
Grey Kingbird	T. dominicensis	o	
Loggerhead Kingbird	T. caudifasciatus	o	o
Stolid Flycatcher	Myiarchus stolidus	o	o
Dusky-capped Flycatcher	M. barbirostris	o	o
Rufous-tailed Flycatcher	M. validus	o	
Wood Pewee	Contopus virens		
Greater Antillean Pewee	C. caribaeus		
Greater Antillean Elaenia	Elaenia fallax		
Yellow-crowned Elaenia	Myiopagis cotta		
HIRUNDIDIDAE			
Golden Swallow	Kalochelidon euchrysea		
Tree Swallow	Iridoprocne bicolor	o	
Bank Swallow	Riparia riparia		
Rough-winged Swallow	Stelgidopteryx ruficollis		
Barn Swallow	Hirundo rustica		
Cave Swallow	Petrochelidon fulva		
Carribean Martin	Progne dominicensis	o	
Northern Purple Martin	P. subis	o	
CORVIDAE			
Jamaican Crow	Corvus jamaicensis		
MIMIDAE			
Northern Mockingbird	Mimus polygottos	o	o
Bahama Mockingbird	M. gundlachii		
Catbird	Dumetella carolinensis		
TURDIDAE			
American Robin	Turdus migratorius		
White-eyed Thrush	T. jamaicensis		
White-chinned Thrush	T. aurantius		
Olive-backed Thrush	Catharus ustulatus		
Grey-cheeked Thrush	C. minimus		
Veery	C. fuscescens		
Rufous-throated Solitaire	Myadestes genibarbis		
BOMBYCILLIDAE			
Cedar Waxwing	Bombycilla cedrorum		
STURNIDAE			
Common Starling	Sturnus vulgaris	o	o

Table L-4 (5/6) AVIFAUNA OF JAMAICA AND LOWER MORASS
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Family and Species Name		Latin Name	NRCD	PCJ
VIREONIDAE				
	Jamaican White-eyed Vireo	Vireo modestus	o	o
	Blue Mountain Vireo	V. osburni		
	Yellow-throated Vireo	V. flarifrons		
	Solitary Vireo	V. solitarius		
	Red-eyed Vireo	V. olivaceus	o	
	Black-whiskered Vireo	V. altiloguus	o	
PARULIDAE				
	Black-and-white Warbler	Moniotilia varia	o	o
	Prothonotary Warbler	Protonotaria citrea	o	
	Swainson's Warbler	Limnothlypis swaisonii	o	o
	Worm-eating Warbler	Helmitheros vermivorus	o	o
	Golden-winged Warbler	Vermivora chrysoptera		
	Blue-winged Warbler	V. pinus		
	Tennessee Warbler	V. peregrima		
	Parula Warbler	Parula americana	o	o
	Yellow Warbler	Dendroica petechia	o	o
	Magnolia Warbler	D. magnolia		o
	Cape May Warbler	D. tigrina		o
	Black-throated Blue Warbler	D. caerulescens		o
	Myrtle Warbler	D. coronata		
	Black-throated Green Warbler	D. virens		
	Cerulean Warbler	D. cerulea		
	Blackburnian Warbler	D. fusca		
	Yellow-throated Warbler	D. dominica		
	hestnut-sided Warbler	D. pensylvanica		
	Bay-breasted Warbler	D. castanea		
	Blackpoll Warbler	D. striata		
	Prairie Warbler	D. discolor	o	
	Palm Warbler	D. palmarum	o	o
	Arrow-headed Warbler	D. pharetra		
	Ovenbird	Seiurus aurocapillus		o
	Northern Waterthrush	S. noveboracensis	o	o
	Lousiana Waterthrush	S. motacilla	o	
	Kentucky Warbler	Oporornis formosus		
	Conneticut Warbler	O. agilis		
	Common Yellowthroat	Geothlypis trichas	o	o
	Hooded Warbler	Wilsonia citrina		
	American Redstart	Setophaga ruticilla	o	o
COEREBIDAE				
	Bananaquit	Coereba flaveola	o	o
	Orangequit	Euneornis campestris	o	o
THRAUPIDAE				
	Jamaican Euphonia	Euphonia jamaica	o	o
	Stripe-headed Tanager	Spindalis zena		
	Scarlet Tanager	Piranga olivacea		
	Summer Tanager	P. rubra		

Table L-4 (6/6) AVIFAUNA OF JAMAICA AND LOWER MORASS
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Family and Species Name		Latin Name	NRCD	PCJ
ICTERIDAE				
	Glossy Cowbird	Molothrus bonariensis		
	Greater Antillean Grackle	Quiscalus niger	o	o
	Jamaican Oriole	Icterus leucopteryx	o	o
	Baltimore Oriole	I. galbula		
	Troupial	I. icterus		
	Jamaican Blackbird	Nesopsar nigerrimus		
	Bobolink	Dolichonyx oryzivorus		
PLOCEIDAE				
	House Sparrow	Passer domesticus		
FRINGILLIDAE				
	White-winged Crossbill	Loxia leucoptera		
	Saffron Finch	Sicalis flaveola		
	Greater Antillean Bullfinch	Loxigilla vilacea	o	o
	Yellow-faced Grassquit	Tiaris olivacea	o	o
	Black-faced Grassquit	T. bicolor	o	o
	Yellow-shouldered Grassquit	Loxipasser anoxanthus	o	o
	Rose-breasted Grosbeak	Pheucticus ludovicianus		
	Blue Grosbeak	Guiraca caerulea		
	Indigo Bunting	Passerina cyanea		o
	Painted Bunting	P.ciris		
	Dickcissel	Spiza americana		
	Grasshopper Sparrow	Ammodramus savannarum		