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ANNEX 3: DEVELOPMENT OF IRRIGATION PROJECTS IN THE BAHAMAS

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COMMONWEALTH OF THE BAHAMAS
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THE BAHAMAS
AGRICULTURAL SERVICES DEVELOPMENT PROJECT

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ANNEX 3

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DEVELOPMENT OF IRRIGATION PROJECTS IN THE BAHAMAS

This report was prepared by Dr. Bishay G. Bishay,
assisted by Mr. Simeon Pinder (counterpart)
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INTER-AMERICAN INSTITUTE FOR COOPERATION ON AGRICULTURE

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COMMONWEALTH OF THE BAHAMAS
MINISTRY OF AGRICULTURE, TRADE AND INDUSTRY
AGRICULTURAL SERVICES DEVELOPMENT PROJECTS
DEVELOPMENT OF IRRIGATION PROJECTS IN THE BAHAMAS

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SUMMARY AND CONCLUSIONS

i. The Bahamas consists of low-lying, narrow and long islands formed of limestone soil. There are no sharp climate variations in the monthly mean temperatures or in the vapor pressure. The annual rainfall varies from 1550 mm in the northern islands to about 660 mm in the far southeastern islands.

ii. The only source of irrigation is groundwater, which behaves with the typical hydrological characteristics of small oceanic islands. A freshwater lens overlies salt water, and both are governed by the Ghyben-Hertzberg relation. The major study that has been done on the hydrological characteristics of groundwater was made in 1977, by Little et al, and was intended for the general developmment of the islands, not directed toward irrigation purposes. In this study, the freshwater section of the aquifer is defined as a potable water of about 400 ppm chloride content. Based on that, different abstraction (extraction) rates have been recommended for the explored islands. Great freshwater lenses, which may be up to 110 feet thick, exist in the northwestern island of Andros, and limited ones no more than 25 feet thick can be found in the southeastern island of Mayaguana. The soils of the Bahamas are highly permeable and the hydrological profile is deep. Such characteristics result in no drainage problem and no erosion problem being caused by rainfall.

iii. Irrigation is practiced in the Bahamas on medium to large-scale farms by using either the gun-sprinkler or the drip irrigation systems. The total irrigated areas in the Bahamas amount to about 7,310 acres, located on Eleuthera, Andros, Abaco, New Providence and Grand Bahama islands. The performance of these systems have been evaluated in situ as shown in this report.

iv. In the context of defining the overall potential agricultural land, a design of irrigation programs was made in this report. The water requirements for certain representative vegetable and fruit crops have been estimated for each island, by processing the climatological data of more than 20 years averages. Their site water balance, water scheduling, crop irrigation requirements, their pumping requirements,and the availability of groundwater for irrigation have also been estimated. This exercise showed clearly that supplementary unlimited irrigation can be successfully practiced on suitable lands that have freshwater lenses more than 40 feet thick. Most of these lands are located in the northern islands. On the other hand, only supplementary, but limited irrigation, can be practiced during the critical growth periods of crops in lands that have freshwater lenses which range between 20 and 40 feet thick. Most of these areas are located in the southeastern islands. Irrigation scheduling for adequate water supplies, as well as for water constrained projects, have been prepared in this report.

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v. Two automatic irrigation systems that have been successfully tested in the Bahamas were selected to provide the unlimited irrigation needed for commercial production. In addition, a simple, cost effective sprinkler system was designed to provide the limited irrigation needed during the critical growth periods on water constrained islands. Their specifications and guidelines for operation and maintenance are:

(a) a gun-sprinkler system for a model farm of 35 acres (as a modular) designed to produce commercially forage, vegetable or fruit crops. The installation costs amount to US$15,600 (CIF Bahamas), to be depreciated over 10 years. The annual operation and maintenance cost amount to US$4,140.00 per 35 acres;

(b) a drip system for a model farm of 40 acres (as a modular) designed to produce commercially citrus crops. The installation costs amount to US$16,078.5 (CIF Bahamas), to be depreciated over 10 years. The annual operation and maintenance costs amount to US$10,707.9 per 40 acres;

(c) a drip system for a model farm of 32 acres (as a modular) designed to produce commercially vegetable crops. The installation costs amount to US$29,434.5 (CIF Bahamas), to be depreciated over 10 years. The annual operation and maintenance costs amount to US$17,261.1 per 32 acres; and

(d) a simple sprinkler system to provide limited irrigation to a model farm of one acre (as a modular) designed to produce mixed crops in the southeastern islands. The installation costs amount to US$1070 (CIF Bahamas), to be depreciated over 10 years. The annual operation maintenance costs amount to US$54.8 per acre.

vi The areas that can be put under unlimited irrigation, particularly in the northern islands, are vast. Among them are 50,962 acres that can be considered as the minimum possible size of potential land available for a first phase of an irrigation programme. This area is equivalent to 25 per cent of the explored areas of the freshwater lenses, 3 per cent of the total land surface area of the islands and seven times the total areas presently irrigated in the Bahamas. Approximately 40,000 acres (80 percent) are crown lands located near existing roads, and their soils are of good quality. All or part of them can be cleared and then supplied with irrigation systems. In addition, there are another 7810 acres that can be considered as the minimum size of potential agricultural land in the southeastern islands that can be put under limited irrigation. The location of the potential agricultural land was identified on each island, as shown on the maps attached to this report. New Providence Island was excluded due to increasing urban development pressure; Grand Bahama Island,

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due to the lease of most potential land to the Port Authority Co., although this is no impediment to the implementation of irrigation schemes.

vii. Guidelines for efficient aquifer management have been prepared in this report which includes: balancing the aquifer, mining the aquifer, efficiency of groundwater use, developing the shallow freshwater lenses, water quality evaluation and water quality control.

viii. Three training programs on irrigation and land water development have been prepared. The first is a six-week, in-country program recommended to be held on Abaco Island in 1990 for 10-24 participants, the cost of which is estimated at US$40,632. The second program is a specially designed, long-term post graduate training plan. In this program, four target problems have to be studied and solved through MSc or Ph. D. programas in the USA,with the field work being done in situ in the Bahamas. The duration of this plan is around 3 years, and the total costs amount to about US$284,000. The third type of training is a 3-to 4-week program to visit irrigation projects in other countries, whose conditions are some what similar to those in the Bahamian. There are no costs attached to this program, which is expected to be executed through invitations from other countries.

ix. A land and water policy in relation to irrigation projects is suggested in this report. If includes: a national master plan for land and water development projects; the investigation needed for groundwater and land resources; the preparation of final designs; land tenure and water legislation issues; project promotion; control of construction works; irrigation research, and rural extension.

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COMMONWEALTH OF THE BAHAMAS
MINISTRY OF AGRICULTURE, TRADE AND INDUSTRY
AGRICULTURAL SERVICES DEVELOPMENT PROJECTS

DEVELOPMENT OF IRRIGATION PROJECTS IN THE BAHAMAS

BY

Bishay G. Bishay

I. INTRODUCTION

1.01 Unpredictable fluctuations in rainfall make traditional farming in the Bahamas a risky venture. Irrigation reduces these uncertainties through the provision of supplementary water in times of low rainfall. Groundwater is the only source for irrigation. In the 1960's, irrigation began to play an important role in the agriculture of the country, particularly in the northern islands. Large-scale commercial farms adopted automatic irrigation systems in Abaco, Andros, Grand Bahama and Eleuthera islands. However, despite the advantages of these systems, and the abundance of fresh groundwater lenses, the total irrigated areas are negligable when compared with the large size of their aquifers. In the southeast, smaller aquifers limit irrigated agriculture.

1.02 A fuller use of land and water resources through the development of irrigation facilities could lead to substantial increases in food production in the Bahamas. Properly applied, the automatic irrigation methods can raise crop yields, while minimizing water losses.

1.03 The basis of modern irrigation is an approach which takes into account the composit climate groundwater crop irrigation system human being. This report asseses the irrigation issues of the project areas, in order to provide sound technical bases for the design of production plans. The potential agricultural areas have been estimated for each of the project islands, after taking into consideration the capacity of their calcareous soils, as well as the availability and suitability of groundwater to satisfy the crop irrigation requirements, within the limits set by extraction rates. In addition the report presents, a suitable irrigation schedule for each of the project areas; alternative and automatic systems were evaluated, with their specifications and costs, for each farm model. Training programs, as well as policy guidelines on irrigation and related activities, are recommended in the report.

1.04 It is hoped that the information contained herein will contribute to a heightened awareness of both the limitations and potentialities of irrigated agriculture in the Bahamas, and, in this way, promote the knowledgeable selection and adaptation of appropriate technologies for more sustainable production as well as resource utilization and conservation.

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II. PRESENT SITUATION
A. AGROCLIMATOLOGICAL AND HYDROLOGICAL CHARACTERISTICS OF THE BAHAMAS

Regional Setting

2.01 The Bahamas consist of 14 shallow, marine banks that emerge locally to form an irregular pattern of relatively low-lying limestone islands, as shown in Map (1). This chain of islands stretches over a distance of about 200 km in a southeasterly direction from the Florida peninsula. The islands of the Bahamas occur unevenly over the banks, but are usually on the margins of the larger and in the center of the smaller banks. Most of the islands are long and narrow and oriented from northwest to southeast, with elevations below 60 m. The upper portions of the Bahamas Platform were exposed several times in the geologic past as a result of Pleistocene sea-level fluctuations. The exposed marine sections vary from 6 m above present sea level to 135 m below present sea level. The geology of the islands is basically similar , consisting of Pleistocene limestone in most parts with unconsolidated sands and marshland sediment in some places.

Agroclimatology

2.02 The 21 years of climatological data collected from the project islands, and shown in Tables 1 to 11 of the Appendix, indicate the following characteristics:

(a) Annual rainfall is heaviest in the Northern Islands ranging from about 1550 mm at Freeport on Grand Bahama Island to 660 mm at Matthew Town on Great Inagua Island. The seasonal rainfall pattern for all islands exhibits a dry period from November to April, when monthly rainfall is generally less than 100 mm. Some of the southeastern islands receive a monthly rainfall of less than 50 mm during the driest months of February, March and April. The wet season exhibits a double peak, one during June, and the other during September in the northern islands. Because of the annual variability of rainfall, seasonal drought is not uncommon.

(b) There are no sharp climate variations in the Bahamas. The monthly mean temperatures range between 4 degrees celcius around the mean annual value of 24 degrees celcius in the northern islands, and 3 degrees celcius around a mean annual value of 27 degrees celcius in the southeastern islands. The coolest month is February and the warmest are July and August. Cool temperatures during the winter months in the northern islands may be a deterrent to obtaining sustained and uniformly high seasonal yields from some tropical crops. Freezing temperatures are rare, but on one occasion in Jan.1977 damage was done to cassava plants at the Agricultural Research Station on Andros Island.

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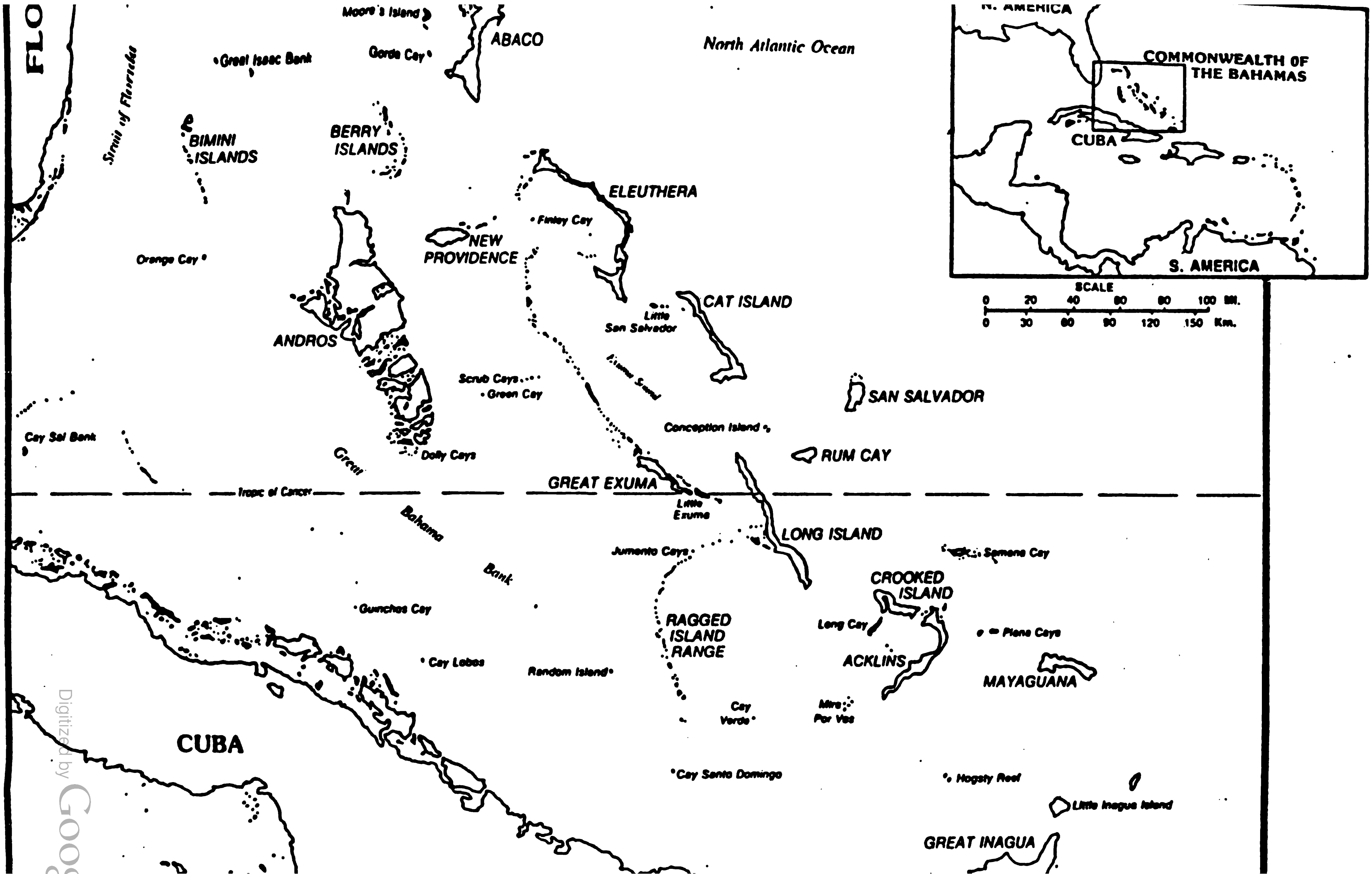

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(c) Hurricanes are a continual threat in the Bahamas. Their return period averages about 9 years, and the season is from July to November.

(d) Vapor pressure ranges from about 17 mbs in the winter months to about 30 mbs in the summer months. The high humidity, along with high temperatures is conducive to outbreaks of diseases, particularly in the summer months.

Hydrology

2.03 The only source of irrigation water in the Bahamas is groundwater. The results of many studies indicate that, in general, the hydro-physical characteristics of the ground surface limestone of the Bahama Island provide excellent conditions for rainfall to percolate down to the underlying water table. It appears that little if any, of the rainfall runs off at the surface. Fresh groundwater occurs as a lens floating on the underlying brackish, and then saline, groundwater. All of the recharge to the fresh water lens comes from rainfall occurring on the islands. Part of the rain that falls on an island is evaporated directly from the land surface and its vegetation, a second part is consumed by plants from the soil before it reaches the water table, and the remainder percolates down to the water table.

2.04 The freshwater bodies that occur on each island as a result of the entrapped part of rainfall are known as Ghyben-Hertzberg lenses. These lenses take the form of fresh water floating on more saline water beneath. The latter is a result of the intrusion of a wedge of sea water beneath these coastal areas. Under such free groundwater conditions, the water table is slopes toward the sea, and fluctuates according to tidal movements. As an example, Guyton (1986) found that the water levels in part of Great Abaco fluctuate between 0.5 to 1.7 feet between high and low tides.

2.05 The Ghyben-Hertzberg theory describes the relation between the fresh and the saline water. According to the Ghyben-Hertzberg relationship, the saline groundwater is encountered, not at sea level, but at a depth below sea level equivalent to about forty times (in relatively thick lenses) the height of the water table above sea level, as shown in Figure (1-A). This relationship represents the condition of approximate hydrostatic equilibrium between the higher fresh groundwater (density 1.00), and the heavier saline groundwater (density 1.03). When excessive pumping upsets this normal relationship by lowering the water table around the pumped well, the interface between the fresh and saline groundwater is raised toward the surface by approximately 40 times the amount of water table lowering, as shown in Fig. (1-B). As a result, saline water, as well as fresh, will now be pumped from the well unless a markedly reduced abstraction is carefully located only in the remaining overlying fresh groundwater.

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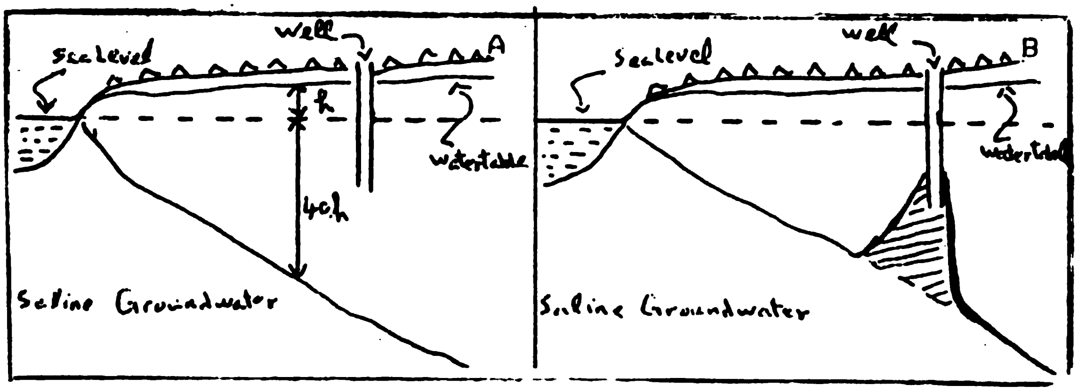

Fig (1) Diagrams (not to scale) illustrating (A) the Ghyben-Herzberg relationship between fresh and saline groundwater and (B) the effect of excessive pumping from the well. The incursion of saline water after pumping is represented by the shaded area.

Quality of Groundwater

2.06 Groundwater quality, which is determined by a large number of variables, may be considered in terms of chemical content, bacteriological content and physical characteristics. Under the conditions in the Bahamas, the chemical characteristics of groundwater are of most concern to irrigation. In general, the Bahamas islands have a limestone geological formation which results in fresh ground water that usually has a rather high calcium and bicarbonate content. As an illustrative example, based on ground water samples collected from Abaco island, Guyton (1966) stated the water is hard, but otherwise, the chemical quality is good. The total soluble salts range from 188 to 326 parts per million. Total hardness ranges from 134 to 201 parts per million. The iron is less than 0.1 parts per million and the laboratory pH values range between 7.33 to 7.61, as shown in Table (12) of the Appendix.

2.07 When water standards are established, as in the case of groundwater required for irrigation, upper limits to the contents of total soluble salts should be suggested, rather than an average concentration. Accordingly, interest should centre on the factors which result in excessively high concentrations of salinities, and individual constituents. Kant and Weech (1986) considered water having from 500 to 1500 ppm as brackish, the potable section of the lens, that is, up to a chloride content of about 400 ppm as fresh

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water. They stated that the shape, thickness and chemical characteristics of the lenses in the Bahama islands shown in Table (1) are subject to many physical influences, but that present a depth profile generally composed of; (1) a freshwater (potable) section where the chloride content ranges from 90 to 400 ppm; (2) a transition zone, commonly about 1-2 m thick, in which chlorides increase rapidly from 400 to 1200 ppm; and (3) a saline portion in which chlorides increase rapidly from 1200 ppm to levels approaching that of seawater. They also reported that on the larger islands the freshwater (potable) section is separated from levels containing sea water by approximately 10 m.

TABLE (1). Features of the Islands Selected for the Study; Land Size and Characteristics of Fresh Water Lenses Studied

ISLAND	LAND SIZE (acres)	MEAN RAINFALL (m m)	TOTAL AREA OF FRESH-WATER LENSES (acres)	RATIO OF TOTAL FRESH-WATER LENS TO LAND SIZE	VOLUME OF WATER IN LENS (1000 m3)
NORTHERN ISLANDS					
Eleuthera	127,996	1,141	16,598	0.1297	146,816
Andros		1,175			
North	836,370		338,577	0.4199	4,307,000
South	550,381		202,204	0.3670	1,496,000
Mangrove Cay	115,194		42,624	0.3700	315,000
New Providence	51,196	1,341	17,502	0.3400	120,448
Abaco		1,547			
Great	399,985		113,146	0.2838	1,218,000
Little	15,360		2,750	0.1797	17,000
Grand Bahamas	332,790	1,496	146,207	0.4393	1,532,000
August Cay	2,560		415	0.1625	2,000
Bush Cay	2,560		1,255	0.4900	9,000
SOUTHEASTERN ISLANDS					
Long Island	110,714	904	9,301	0.0840	26,231
Cat Island	95,997	960	14,776	0.1539	130,916
Exuma		1,008			
Great	63,998		6,365	0.0995	40,996
Little	6,400		220	0.0344	1,085
Barraterra	1,920		99	0.0520	1,532,000
Acklins	95,997	813	15,782	0.1644	63,566
Crooked Island	58,876	881	5,923	0.1006	19,490
Mayaguana	70,398	864	2,340	0.0332	5,772

Source: Cant and Weech (1986).

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Lens Development

2.08 According to Cant and Weech, the Bahama islands with large land masses have more potential for developing freshwater lenses with greater volumes than do small ones. Regarding climatic conditions, less than one per cent of the driest islands are underlain by freshwater that is more than 5 feet thick, with considerable areas that are saline or brackish. This is the case on the eastern side of Mayaguana, and the southern tips of Long Island, Crooked Island, and Acklins, where the average annual rainfall is 900 mm or less, and where the aquifer allows the rapid mixing of rainfall and saline groundwater. A high proportion of the land in the brackish and saline sections of the southeastern islands is low-lying, which causes direct evaporation from the water table. In these circumstances, actual evaporation exceeds precipitation, and groundwater salinities may be as much as 10,000 ppm chlorides. Kant and Weech stated also that such high chloride levels seldom occur at the water table within the body of a landmass that receives an annual average of more than 900 mm of precipitation. As a conclusion, it would appear that the "critical" amount of the annual average rainfall is 1150 mm, above which the lenses are permanent.

2.09 Geological factors also influence the development of fresh water lenses. Beach and Ginsburg (1980) found that the Pleistocene formation, named Lucayan limestone, is the main freshwater aquifer of the Bahamas. Holocene deposits can contain freshwater, but no older formations are known to be able to prevent freshwater from mixing with saline water. Because of this, the base of the Lucayan limestone represents the maximum thickness to which the freshwater lens can develop. According to Cant and Weech, the results shown in Table (2) reveal that it is the shallow depth of the Lucayan limestone in the Little Bahamas Bank that effectively limits the thickness of the freshwater lens in Grand Bahama and Abaco islands.

Table (2). Measurements of Lucayan Formation Dimensions for Various Banks of the Bahamas Archipelago

Island or Bank	Average Thickness of Lucayan Limestone (m)	Depth (BMSL) to Base of Lucayan Limestone (m)
Andros Island & Great Bahamas Bank	43	43
Long Island	40	38
Crooked Island	25	21
Grand Bahamas & Little Bahamas Bank	24	21
Mayaguana	10.5	3

Source: Cant and Weech (1986).

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have greater rainfall, but the freshwater lenses are thinner than on Eleuthera. This is due to the fact that the Lucayan Limestone extends down to about 40 m in Eleuthera, as compared to 21 m below mean sea level in the Little Bahamas Bank. In addition to the Lucayan limestone, freshwater can also occur on Holocene sands. Large lenses are known to occur in parts of Eleuthera, Abaco, Cat Island, Exuma, and in many other islands where such sand bodies occur in coastal areas. On many of the long thin islands of the Central Bahamas, fresh water occurs only where there are sands that can effectively reduce seepage losses to the sea, allowing lenses to form in both the rock and sand.

2.10 Mather and Buckley (1973) stated that fresh water, however, does appear to be "floating" on brackish and saline water particularly in some of the cavern systems on the larger islands. This may be the apparent effect made possible by the dynamic nature of the lens. This effect is better displayed in certain bore holes which penetrate the interface. When the wells are pumped, the interface disappears, but it reappears as soon as the pump is turned off. Water density does not create the new interface in the bore hole. Instead, it is redefined by the inflow of water from the surrounding aquifer. The fact that a lens may be well defined in a tidally active Blue Hole on the island of Andros helps to support the theory that lenses are maintained at least in part by the difference in density of the two types of water.

Features of the Groundwater Resources in the Project Islands

2.11 Beginning in 1968, Little et al. (1977) carried out a study on the land resources of the Bahamas, which included the results of an exploratory program intended mainly for general development. The results of this study are summarized in groundwater maps showing the location and thickness of the fresh water bodies in certain parts of the islands. The thickness of the fresh water lenses existing within the porous rocks are indicated by contours, each being a measure from the water table down to the point where the 500 ppm chloride isochlore occurs. Although the study was not intended specifically for agricultural development, results summarized below provide an appropriate base for this report.

The Northern Islands

ELEUTHERA ISLAND

2.12 Eleuthera is a long island possessing many small and scattered freshwater bodies, with the best water resources occuring where the island widens in the north and south. The total areas of Eleuthera island and its freshwater lenses are 127,996 and 16,598 acres, respectively. The area of freshwater lenses constitutes about 13 per cent of the total area of the island. The aquifer on Eleuthera has low specific capacities and the Bogue well

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field in the north exploits the best lens on the island. It is expected that the largest lenses in the south, located between Tarpum Bay and Rock Sound, and between Wemyss Bright and Cape Eleuthera, have some potentialities. Maximum recommended abstraction for Eleuthera is about 490 gpd/acre.

ANDROS ISLAND

2.13 In the whole clain of Bahama islands, Andros has the best freshwater resources. Freshwater lenses underlie more or less the whole island. The total areas of Andros and its freshwater lenses are 1,501,945 and 583,205 acres, respectively. The area of freshwater lenses constitutes about 38.83 per cent of the total area of the island. The maximum lens thickness is 110 ft., which occurs just north of Twin Lakes Farms. The water resources on Andros are huge, and, at present, about three million gallons of potable water are transported by barge to New Providence per day a plan to increase this amount to six million gallons in the future. This water is obtained from a trench well field to the north of San Andros. The average specific capacity in tests on the Andros aquifer is about 12 gpm/ft/ft. Maximum recommended abstraction rate is 620 gpd/acre.

ABACO ISLAND

2.14 Abaco has considerable freshwater resources, and there is great potencial for groundwater development. The total areas of Abaco and its freshwater lenses amount to about 415,395 and 115,986 acres, respectively. The total area of fresh water lenses constitutes about 27.9 per cent of the total area of the island. The main part of the freshwater occurs in four relatively large bodies (a) the Norman Castle lens, (b) the Marsh Harbour - Lake City Lens, (c) the Lake City - Crossing Rocks lens, and (d) The Crossing Rocks - Hole in the Wall lens, which is the most extensive body. Maximum recommended abstraction in Abaco is 680 gpd/acre.

GRAND BAHAMA ISLAND

2.15 Good freshwater resources exist in all areas of Grand Bahama, except for a stretch between Eight Mile Rock and West End, and in the vicinities of Hawksbill Creek, and the Grand Lucayan Waterway. The total areas of the Grand Bahama and its freshwater lenses amount to about 337,910 and 147,877 acres, respectively. The total area of fresh water lenses constitutes about 43.76 per cent of the total area of the island. Many saline and brackish creeks transect the island, particularly in the east. Beneath these the freshwater lenses tend to thin. Test drilling in the wider portion of Grand Bahama revealed a uniformily flat lens with limited apparent thickness. This results from the high porosity of the aquifer. How ever though the lens appears thin, there is a large volume of water present. Transmissibilities in the Grand Bahama aquifer are very high, and the rapid movement of water

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outward from the center of the island results in the uniformity of the lens-a feature that extends all the way to the margin of the southern coastline. In general, the specific capacity in the Grand Bahama aquifer is consistently higher than it is in the other islands. Maximum recommended abstraction rate is 630 gpd/acre.

The Southeastern Islands

LONG ISLAND

2.16 Long Island is a long thin island featuring scattered and patchy freshwater resources. The total areas of the island and its fresh water lenses amount to 110,714 and 9,301 acres, respectively. The total area of the freshwater lens constitutes about 8.4 per cent of the total area of the island. It is unlikely that public services supplies will ever be able to provide for the whole island. The Long Island aquifer is variable, with specific capacities ranging from very low (1 g.p.m./ft/ft). The thickest lens, at Stella Maris, results largely from the low permeability of the area and does not indicate voluminous quantities of freshwater. Abstraction on the island should not exceed 310 gallons per day per acre.

CAT ISLAND

2.17 Cat Island is a long, thin, hilly island that possess dispersed freshwater resources, with the ground water in many areas being brackish or saline. The total areas of land and its freshwater lenses amount to about 95,997 and 14,776 acres, respectively. The total area of the freshwater lens constitutes about 15.4 per cent of the total area of the island. Good lenses occur between Dumfries and Bain Town, between Smith's Bay settlement and the Bight Airstrip, south of Old Bight and north of Devil's Point. The latter lens is the best water resource on the island, and could be used for future agricultural projects. The aquifer on Cat Island is hightly variable, with specific `capacities' ranging from 0.03 gpm/ft/ft (very low) to 9.23 gpm/ft/ft (average). Maximum abstraction rates in Cat Island should be about 450 gpd/acre.

EXUMA ISLANDS

2.18 The total areas of the Exumas and their freshwater lenses amount to about 72,318 and 6,684 acres, respectively. The total area of the freshwater lenses constitute about 9.24 per cent of the total area of the island. The lenses are relatively thick in proportion to their width, a fact that reflects the low aquifer permeability. On Great Exuma there are two thick freshwater bodies, one in the forest area and the other to the south of George Town. The remaining lenses are limited in their development by the saline marshes, ponds, and creeks that dissect the island. This is particularly true of north Great Exuma and Little Exuma.

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Maximum abstraction rates in Exuma should be limited to about 440 gpd/acre.

ACKLINS ISLAND

2.19 The total areas of the island and freshwater lenses amount to about 95,997 and 15,782, respectively. The total areas of freshwater lenses constitute about 16.44 per cent of the total island area. Three major freshwater lenses were discovered to the south of Mason's Bay and between Spring Point and Delectable Bay, which may allow limited irrigation by using infiltration galleries. The aquifer on Acklins can be described as moderate, specific capacities being on the order of 12 gpm/ft/ft. The recommended abstraction rate for the island is about 276 gpd/acre, which would reduce lens thickness by one-third.

CROOKED ISLAND

2.20 The total areas of the island and its freshwater lenses amount to about 58,876 and 5,923 acres, respectively. The total area of the freshwater lenses constitutes about 10.1 per cent of the total area of the island. The main body of the limited freshwater resources occurs around Church Grove and Colonel Hill, and is considered to be the only suitable one for water supply purposes, with a specific capacity of about 20 gpm/ft/ft. A cautious view should be taken of future abstraction, on the order of 293 gpd/acre, which will reduce lens thickness by one-third.

MAYAGUANA ISLAND

2.21 Mayaguana receives little rainfall and, consequently, possesses little fresh water. Only one area between the airfield and a point halfway along the road to Pirate's Well is underlain by an exploitable lens. The total area of the island and its explored freshwater lens amount to about 70,398 and 2,340 acres, respectively. The area of the explored freshwater lens constitutes about 3.32 per cent of the total area of the island. The aquifer in Mayaguana appears to be good where the freshwater occurs, and exceedingly bad where there is none. This variation results from the different degrees of rock cementation, which itself is related to the depth of the water table. On the eastern end on the island, for example, the rock is low-lying and very dense, and the groundwater there is highly saline. In the area of the airfield, however, the land is slightly higher and the rock less altered. In the dense rock areas, evapotranspiration is probably excessive, and rock alteration has given rise to permeabilities that are too high for the limited recharge to accumulate. Another factor that appears to control the distribution of the freshwater is the varying rainfall from one end of the island the other. On Mayaguana the island clouds often develop in a pattern which would

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cause more rainfall to fall in the west. Abstraction in Mayaguana should be restricted to about 276 gpd/acre.

B. LANDS PRESENTLY IRRIGATED AND AN EVALUATION OF THEIR ON-FARM IRRIGATION PRACTICES

Areas of Irrigated Lands

2.22 The only irrigation systems in use in the Bahamas are mechanical ones, namely; the sprinkler and the drip systems that have been introduced since the seventy's. At present, there are about 4,000 acres under the sprinkler irrigation system, and 3310 acres under the drip irrigation system, distributed within the Bahamas as shown in Table (3). The performance of these systems has been studied in situ. The following is an evaluation made during the mission period.

Table (3).IRRIGATED LANDS IN THE BAHAMAS, ESTIMATED IN 1989; AREA, IRRIGATION SYSTEMS AND CROPS PRODUCED.

ISLAND	AREA, ACRE	IRRIGATION SYSTEM	CROPS PRODUCED
Eleuthera	400	Drip	Papayas
Andros	2,000	Gun Sprinkler	Mainly Vegetables
Abaco	2,200	Drip	Citrus
	2,000	Gun Sprinkler	Citrus
New Providence	50	Trickle Systems	Vegetables
Grand Bahama	158	Drip	Papayas
	365	Drip	Limes
	80	Drip	Avocados
	57	Drip	Vegetables
TOTAL	7,310		

Irrigation Systems in Use and an Assessment for Their Performance
Sprinkler Irrigation

2.23 Sprinkler irrigation is the application of water above the ground surface, in the form of spray somewhat resembling rainfall. The spray is developed by the flow of water under pressure, obtained by pumping, through small nozzles. The most commonly used sprinkler irrigation system in the Bahamas is the "Big Gun" sprinkler, existing on commercial farms ranging between about 20 and 2000 acres located mainly on Abaco and Andros islands.

2.24 The Gun sprinklers in use have about one inch or larger range nozzles attatched to long (30 inches) discharge tubes. Most "Big Gun" sprinklers are rotated by means of a "rocker farm drive" and they can be set to irrigate part of a circle. They prove to be well adapted to supplemental irrigation and can be used on irregular fields with obstructions. Gun sprinklers usually

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discharge more than 400 gpm, and are operated individually. The gun sprinklers in use are operate by any of the following systems:

(a) An engine-driven pump mounted on a trailer (6-inch suction, 4-inch discharge). The Gun sprinkler discharge is between 400 - 600 gpm or 0.43 to 0.64 inches of water per hour under about 150 psi. About two acres can be irrigated in 30-35 minutes for each set with 300x300 well spacing.

(b) A self-propelled pump mounted on a truck (6-inch suction, 4-inch discharge). The Gun sprinkler discharge is between 400-600 gpm or 0.43 to 0.64 inches of water per hour under about 150 psi. About two acres can be irrigated in 30 to 35 minutes for each set with 300x300 well spacing.

(c) A 3-point hitch pump mounted on the rear of a farm tractor. The pumps are; (i) 4-inch suction, 4-inch discharge. The discharge is about 200 gpm under about 150 psi. About 0.75 acres can be irrigated in 30-35 minutes, and (ii) 3-inch suction, 3-inch discharge. The discharge is about 200 gpm under about 150 psi. About 0.75 acres can be irrigated in 30-35 minutes.

2.25 Irrigation by the "Big Gun" sprinklers proved to be suitable for most vegetable and fruit crops grown in the Bahamas, and is also adaptable to the prevailing calcareous soils and to the irregularly-shaped fields with obstructions. Irrigation is usually practiced every 7 days when rainfall does not occur. With proper spacing, water may be applied at any selected rate above 0.12 inch per hour (3 mm/hr), for periodic move systems.

2.26 The advantages of using the sprinkler method observed in the fields in the Bahamas are:

- Problem soils with intermixed stones can be properly irrigated.
- Shallow soils which cannot be graded without determintal results, can be irrigated without grading.
- Steep and rolling topography can be easily irrigated.
- Light, frequent application can be efficiently applied.
- Labor utilized for a short period daily in each field and mechanization are practical to reduce the problem of labor shortage in the Bahamas. Unskilled labor can be utilized since decisions are made by the manager rather than the irrigator.
- Intermittent irrigation to suppliment erratic or deficient rainfall or to start early grain or fruit is economical under some conditions.

2.27 The more important disadvantage of sprinkler irrigation are:

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- Windy and excessively dry locations cause appreciably lower efficiencies. Observations on the "Big Gun" sprinkler in use leads to believe that the distribution pattern is highly variable. Preliminary tests made on Andros Island and reported by Kyle (1970) showed the actual amount of water applied to specific areas may range from 1.8 to 0.02 inches, with a wind averaging 7.4 miles per hour. Experience gained from other countries show that application uniformity and efficiency are not appreciably reduced as long as wind speed is below about 6 m/hr, but deteriorate progressively as windspeed increases beyond 9 m/hr.

- Field shapes, other than rectangular, are not convenient to handle.

- Careful management must be exercised to obtain maximun efficiency from of the method, especially the stopping of application when the soil moisture deficiency is satisfied.

- System must be well-designed by a competent specialist with full consideration for efficient irrigation, economics of operation, and availability of labor.

Drip Irrigation

2.28 Drip irrigation is the slow application of water through small emitter openings to the soil surface. Rates of discharge for wide-spread individual applicators are generally less than 3 gph, but for close-spaced outlets along a lateral tube (or along porous tubing), these rates are usually less than 1 gph per foot (1 gph=3.78 lph). The drip system is used on commercial farms located mainly on Abaco, New Providence and Grand Bahama islands. It proved to be a convenient and efficient means of supplying individual plants, such as trees, with low tension soil moisture, sufficient to meet demands imposed by evapotranspiration. A drip irrigation system offers special agronomical, agrotechnical, and economic advantages for efficient use of water and labo. Attainable field efficiencies range from 90 to 95 percent. Drip irrigation costs are closely related to the number of lateral lines and emitters per unit area, as will be discussed later in this report.

2.29 The advantages of a drip system like that observed in the fields in the Bahamas are:

- A drip system can irrigate some kinds of crops with significantly less water than taht required by more commonly used irrigation methods. For example, young orchards irrigated by a drip system may require only one-half as much water as orchards irrigated by sprinkler irrigation. As orchards mature, savings of water from operation of a drip system diminish, but they may still be

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important to growers who need to irrigate efficiently because of the scarcity and high price of water. Drip irrigation can reduce the cost of labor, because water applied by a drip system needs merely to be regulated, not tended to. Such regulation is ussually accomplished by automatic timing devices.

- Because much of the soil surface is never wetted by irrigation water, drip irrigation hinders weed growth. This reduces costs for labor and for chemicals needed to control weeds. Also, because a drip system wets less soil during an irrigation, uninterrupted orchard operations are possible. Injecting fertilizers into the irrigation water can avoid the labor needed for ground application. Several highly soluble fertilizers are available for this purpose, and newly introduced products widen the choice. Greater control over placement and timing through drip irrigation may lead to improved efficiency in fertilization.

- Frequent irrigations maintain a condition of soil moisture that does not fluctuate between dry and wet extremes, and also keeps the soil well aerated. Less drying down between irrigations keeps salts in soil water more diluted, making possible the use of waters that are more saline than those that can be applied by other irrigation methods.

- Drip irrigation system can be designed to operate on almost any topography. In fact, some drip systems are operating successfully on avocado ranches in Californiaa that are almost too steep to be harvested. Since the water is applied close to each tree, rocky areas, which are common in the Bahamas, can be irrigated effectively by a drip system.

2.30 The main disadvantages inherent in drip irrigation systems as noticed in situ, are:

- Because emitter outlets are very small, they can easily become clogged by particles of minerals. Clogging reduces emission rates, upsets uniformity of water distribution, and, thereby, causes damage to plants. Sometimes the particles of minerals present in water are not removed before they enter the pipe network. Also, particles may form in water as it stands in the lines or evaporates from emitter orifices between irrigations. Calcium carbonate, iron oxide and algae may be formed in some irrigation systems. Filtration and chemical treatment of waters can prevent or correct most of these causes of clogging.

- Most drip irrigation emitters operate at pressures ranging from 3 to 20 psi. If a field slopes steeply, the emitter discharge during an irrigation may differ by as much as 50 percent from the volume intended, and the lines may drain through lower emitters after water is shut off; hence, some plants receive too much water and others too little.

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- If uncontrolled events interrupt an irrigation, crop damage may occur rather quickly. The ability of roots to forage for nutrients and water is limited to the relatively small volume of soil wetted.
- Should a main supply line break or should the filtration system malfunction, contaminants may enter the system. One malfunction of this type could plug up a large number of emitters, which would have to be cleaned or replaced.

- Drip irrigation only wets a small portion of an orchard area. This can be considered an advantage in the northwestern islands of the Bahamas where commercial production is intended. How ever, the drip system is not practical in the southeastern islands where farms are small and where an irregular type of intercropping between trees is only possible to achieve due to the scattered rocks on soil surface.

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III. THE PROJECT
A. DESIGN OF IRRIGATION PROGRAMS FOR THE PROJECT AREAS

Crop Water Requirements

3.01 As a first step in the proper design of an irrigation scheme it is necessary to know the crop water requirement, which is equivalent to the rate of evapotranspiration (ETcrop) necessary to sustain optimum plant growth. The data required can be obtained through direct measurements under field conditions.This has never been done in the Bahamas. Nevertheless, an estimation has been made in this report by processing the metereological data collected from each one of the project islands (except the northern part of Andros), using the most widely-known method developed by Frere and Papov (1979), which represents the experience acquired by FAO with the Penman formula, expressed as:

$$PET - (C \times Ht \times At)/(C + 1)$$

where;

PET = potential evapotranspiration (expressed also a reference cropevapotranspiration "ETo" or cosumptive use),
C = a correction term,
Ht = the difference between the shortwave radiation, absorbed by the evaporating surface, and the infrared effective radiation.

About 21 years of climatological records on temperature (maximum and minimum), vapor pressure, sunshine duration and wind speed, shown in Tables (1 to 11) of the Appendix, were used to calculate the PET values shown in Tables (13 to 23) of the Appendix. The crop evapotranspiration values (ETcrop) have been estimated for certain representative vegetable and fruit crops that can be grown in these islands, after introducing the crop coefficients recommended by FAO (1977) and the results as shown in Tables (12 to 21) of the Appendix.

Site Water Balance and Water Scheduling

3.02 The second step needed for the proper design of the irrigation program needed for the project islands is the estimation of the effective water balance. The average rainfall distribution and the crop evapotranspiration values calculated for each of the project islands have been plotted in Figures (1 to 12) of the Appendix, in order to show the site water balance through the whole year. The results show that Abaco and Grand Bahama islands have the most favorable balance of all the islands. The annual negative water balance that can result from planting vegetables and fruit crops on Abaco and Grand Bahama Islands is almost less than or equal to 50 per cent of the same crops when grown in central and

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south Andros as well as New Providence Islands. The situation on Eleuthera, Cat Island, Exuma and Long Island are almost the same, but and their annual negative water balance values are more or less three times those of Abaco Island. The deficit increases in Crooked, Acklins and Mayaguana islands.

3.03 When the site water balance is negative water must be applied by supplementary irrigation. Chart (1) illustrates the comparative water scheduling that might be needed under the climatological conditions of the project islands.

Chart (1).

<u>Irrigation Requirements</u>

3.04 The irrigation water requirement is the amount of the water which must be supplied to the crop plant to ensure that it receives its full water requirement, or a predetermined portion thereof. The crop water requirement is influenced by the ground cover. Localized (trickle) irrigation such as the drip system is used mainly for orchards and row crop where only part of the soils surface is occupied by the crops. The canopies of young and widely-spaced crops intercept only a portion of the incoming radiation. On the other hand, when an unshaded surface is wetted by a sprinkler irrigation system, a portion of the potential benefit of the water applied is lost through evaporation from the soil or transpiration from weeds. Therefore, the figures of crop water requirements estimated in this report included the non-beneficial evaporation and transpiration. Moreover, for any irrigation system, the uniformity and efficiency of water application have to be considered in determining the crop irrigation requirements. In order to simplify the example used in this report, the irrigation requirements of each of the representative crops have been estimated by dividing the ETcrop value by an application efficiency of 60 per cent for the Gun-Sprinkler, and an attainable field efficiency of 94 per cent for the drip. The results are shown in Table (4).

<u>Developing Irrigation Water Saving Methods</u>

3.05 Plant factors influence evapotranspiration from a crop. The greatest difference among crops occurs during the growth period when the crop cover is less than 50 per cent complete. During this time, evapotranspiration of most irrigated crops is less than where cover is greater, because evaporation from bare soil decreases faster than does transpiration by crops. Height of the groundwater table will appreciably affect evapotranspiration, only if the capillary fringe will be higher than where the surface dries intermittently. After full crop canopy is present, the capillary fringe may provide much of the water required to sustain evapotranspiration and crop growth, thus eliminating need for irrigation. This was illustrated by the bananas successfully grown

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Chart (1). Water Scheduling of Certain Vegetable and Fruit Crops that can be Grown under Normal Conditions in the Project Islands.

ISLAND	CROP	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
GRAND BAHAMA	VEGETABLES												
	CITRUS: NO WEEDS												
	WEEDS												
	BANANA												
ABACO	VEGETABLES												
	CITRUS: NO WEEDS												
	WEEDS												
	BANANA												
NEW PROVI-DENCE	VEGETABLES												
	CITRUS: NO WEEDS												
	WEEDS												
	BANANA												
NORTHERN ANDROS	VEGETABLES												
	CITRUS: NO WEEDS												
	WEEDS												
	BANANA												

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	CITRUS:												
	NO WEEDS												
	WEEDS												
	BANANA												
EXUMA	VEGETABLES												
	CITRUS:												
	NO WEEDS												
	WEEDS												
	BANANA												
CAT ISLAND	VEGETABLES												
	CITRUS:												
	NO WEEDS												
	WEEDS												
	BANANA												

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CONT'

ISLAND	CROP	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LONG ISLAND	VEGETABLES												
	CITRUS:												
	NO WEEDS												
	WEEDS												
	BANANA												
MAYAGUANA	VEGETABLES												
	CITRUS:												
	NO WEEDS												
	WEEDS												
	BANANA												
ACKLINS & CROOKED ISLANDS	VEGETABLES												
	CITRUS:												
	NO WEEDS												
	WEEDS												
	BANANA												

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GRAND BAHAMA	9.4	0.026	6	0.016	11.4	0.031	7.2	0.02	8.3	0.023	5.3	0.015	16.4	0.046	10.5	0.029
ABACO	6.4	0.018	4.1	0.011	12.0	0.033	7.3	0.02	6.4	0.018	4.1	0.011	14.6	0.04	9.3	0.026
NEW PROVIDENCE	16.6	0.046	11.2	0.031	20.2	0.055	12.9	0.035	15.5	0.042	9.9	0.027	24.2	0.067	15.4	0.042
ANDROS:																
NORTH	9.5	0.026	6.0	0.016	14.9	0.041	9.5	0.026	10.4	0.029	6.6	0.018	16.4	0.046	10.5	0.029
CENTRAL	18.1	0.05	11.5	0.032	20.0	0.055	12.8	0.035	18.0	0.05	11.5	0.031	30.0	0.082	19.1	0.052
ELEUTHERA	23.5	0.064	15.0	0.041	28.3	0.078	17.9	0.049	25.4	0.07	16.2	0.04	40.6	0.111	25.9	0.071
EXUMA	27.3	0.075	17.4	0.048	24.7	0.068	15.8	0.043	24.8	0.067	15.8	0.042	41.4	0.113	26.4	0.072
CAT ISLAND	26.1	0.071	16.7	0.046	24.7	0.068	15.8	0.043	24.5	0.067	15.7	0.043	40.0	0.11	25.6	0.07
LONG ISLAND	29.2	0.08	18.7	0.051	22.7	0.06	14.5	0.04	24.8	0.067	15.9	0.043	43.5	0.119	27.8	0.076
MAYAGUANA	43.0	0.118	27.5	0.075	31.6	0.087	20.2	0.055	38.8	0.106	24.8	0.067	56.6	0.155	36.1	0.1
ACKLINS & CROOKED IS	36.5	0.1	23.3	0.064	30.6	0.084	19.5	0.053	34.5	0.1	22.0	0.06	54.8	0.15	35.0	0.1

on a field in North Eleuthera, where the water table was observed at some 2 feet from ground surface on July 25, 1989. One practical method for decreasing evapotranspiration is to plant crops so that the per cent of cover is minimized. To use varieties of plants of short growth cycle or to take advantage of natural periods of high rainfall are other possibilities. In orchards, the elimination of cover crops would also decrease evapotranspiration. There appears to be little difference in evapotranspiration among many crops, after cover is more than 50 per cent until maturity. Pinneapple, however, is a notable exception. A possibility would be the introduction of useful crops of succulent plants (such as pineapple) that close their stomata during the day. The possibilities of decreasing evapotranspiration by as much as one half seem pratical.

3.06 The best opportunity for water savings lies in the removal of all other factors which inhibit plant growth, thus ensuring the maximum possible yield for the water expended. The elimination of unwanted vegetative growth (weeds) remains a real part of the measures to increase the efficiency of production. This has been illustrated in Chart (1) and Table (4) which show that the irrigation requirements for citrus grown with weeds are higher by about 50 per cent, than the requirements for citrus grown on clean fields.

3.07 Equally important are night irrigation, selection of low-lying lands with relatively high water tables and mulching either by plant or by plastic covers.

<u>Availability of Groundwater for Irrigation</u>

3.08 Afther having estimated the expected magnitude of the crop irrigation requirements, and in order to recommend safeguard measures for the operation of extraction wells, a working data base has been established as follows to estimate the potential for the future expansion of agricultural land throughout the project areas.

3.09 Considerable amounts of water may exist in storage in the fresh water lenses. However, it cannot be mined because the lens must remain thick enough to supply irrigation water during periods of very little or no rainfall. As discussed earlier in this report, all of the recharge to the freshwater lenses in the Bahamian islands comes from rainfall. A part of the rain that falls on any island is evaporated directly from the land surface and the vegetation on the land surface, a part is consumed by plants from the soil before it reaches the water table, and a portion moves through the ground in a downward and outward direction to the ocean. The data required for estimating the amount of rainfall that reaches the water table, the amount lost by evapotranspiration from the water table, and the amount that moves through the ground and discharges to the ocean (a part of which can be intercepted by pumping) are not available. However,

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.scharge to the ocean that can be intercepted by ın estimated in this report for each island, as shown ased on comparison with groundwater studies in other ıxample, Guyton (1966) carried out a groundwater ɔn part of Great Abaco island in which he indicated Geological Survey estimated that the groundwater ocean from limestone formation in southeastern Dade a, was about one-fourth to one-third of the average l of 60 inches. The U.S. Geological Survey made a ıdy at the auxiliary air force base on Grand Bahama imated, based on the works done on Florida, that the tflow from the freshwater lens is about 15 inches, ge rainfall of about 50 inches. Thus, probably no ıches of the average annual rainfall on Abaco (54.25 away to the ocean as groundwater discharge.

<u>ements</u>

r to safeguard pumpage in the project areas, the e assumptions have been considered:

um amount of available water for pumping from wells part of the recharge to the freshwater lens which cean as groundwater discharge. The water level in must be lowered by pumping, to reduce the natural is not advisable, however, to try to recover all discharge by pumping, because this would require reshwater head, which creates the freshwater lens, that in time the freshwater lens probably would be educing the natural discharge by one-half, will actical.

assumption was made that abstraction is equivalent n in the amount of recharge for any given lens. amount of recharge for a given island, and not the he lens, played the dominant role in obtaining the tes calculated by the Henry equation (1964), and (5).

assumption adopted in this report is the chloride to 500 PPM considered by Little et al as the upper le water. It is important to mention here that the for irrigation water quality are higher than the evels adopted, as will be discussed later in this dingly, the base of the freshwater lens underlying sidered as potential agricultural lands has been ables (8a &8b).

nsidering that one acre-inch of water is equal to ., it becomes clear that the rough estimate of daily quirements shown in Table (4) fall within the ecommended abstraction rates for the northwestern

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Table (5) AVERAGE RAINFALL DATA FOR THE PERIOD 1961-1982
AND RECOMMENDED ABSTRACTION RATES.

ISLAND	MEAN ANNUAL RAINFALL, IN INCHES	ESTIMATED RECHARGE AFTER ASSUMING 75 PER CENT LOSSES BY ET, IN INCHES	ABSTRACTION RATE IF RECHARGE IS REDUCED BY 50%, IN INCHES IN US GAL PD/ACRE
ELEUTHERA	44.22	11.1	606
ANDROS:			
NORTH	55.76	14.0	763
CENTRAL	42.02	10.6	514
NEW PROVIDENCE	52.49	13.1	715
ABACO	54.25	13.6	743
GRAND BAHAMA (W.E)	49.19	12.3	672
LONG ISLAND	38.24	9.6	524
CAT ISLAND	35.88	9.0	492
EXUMA	37.63	9.4	514
ACKLINS	34.11	8.5	464
CROOKED ISLAND	34.11	8.5	464
MAYAGUANA	28.04	7.0	383

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islands, shown in Table (5). Accordingly, it is recommended that supplementary unlimited irrigation, as will be described later, can be provided to these islands, as well as certain parts of Cat Island. On the other hand, the significantly higher irrigation requirements estimated for the crops that can be grown on the rest of the southeastern islands exceed their recommended abstraction rates. Accordingly, only supplementary LIMITED IRRIGATION, as will to be described later, would be possible at this time.

3.12 The maximum thickness and the depth to the interface of each lens shown in Tables (8a & 8b) are based on the findings of the report made by Little et al. This information has been used to recommend an approximate range for the depths of wells, as shown in these tables. The wells should be uniformly spaced over the same area. For economy, it is preferable to drill the wells with rotary drilling equipment, using water for the drilling fluid. The diameters of the wells should be around 10 inches. In the areas designated for supplementary LIMITED IRRIGATION located in the southeastern islands, an abstraction pit 9' x 9' extending 2-3 below water table,should be excavated instead of bore holes.

Irrigation Scheduling for Projects with Adequate Water Supply

3.13 Adequate water supplies from rainfall, and relatively thick fresh groundwater lenses (more than 40 feet)capable de providing supplementary and limited irrigation, exist in Abaco, Gran Bahama and the explored parts of Andros Islands, as well as some of the explored parts of Cat Island. These areas are marked on the maps of the potential agricultural land selected for the project.

3.14 The frecuency of irrigation for these areas should be planned to meet to soil water replenishment demands of the crop for a given climatic condition, on the assumption that water is not a constraint and that the objective production function is maximum yield per unit of land. Water scheduling should be determined throughout the crop season, so as to avoid any decrease in crop yield due to soil water shortages. In projects where water is not a constraint and maximum production per unit of area (kg per m squared) is the objective production function, irrigation should provided as frequently as possible so as to maintain high soil moisture conditions. This approach uses linear relationships between anticipated yields and evapotranspiration deficits and assumes that the varieties grown are HYVs, well adapted to the local soil and climate, and that farm management is at high levels. Under such conditions, the question do when to irrigate is answered by -"as frequently as possible". To the question of how much, the reply is -"to meet evapotranspiration losses, prevent excessive salinity levels in the root zone, and not to exceed the recommended abstraction rates of ground water".

3.15 Proper irrigation intervals should be designed according to certain parameters. No such parameters have been established in the Bahamas. However, the following approach based on farmer

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practices and worldwide standards has been tried in order to reach a tentative estimation. Farmers are using identical intervals for both the Gun-Sprinkler and the Drip Systems, and most of them have reported obtainable high yields. The present intervals followed by farmers are about 7 days for the Gun-Sprinkler and 2 days for the Drip systems, and farmers indicate that they do not irrigate when a precipitation of about 1/2" occurs.

3.16 Irrigation system do not normally aim at maintaining maximum potential evapotranspiration at all times. On the other hand, the crop should not be stressed. Optimum returns will be obtained when the system is designed to be maintained at a fairly high evapotranspiration rate. The maintenance of a high rate is dependent upon the moisture status of the soils, and this, in turn, is dependent on the interval between successive irrigations.

3.17 Before suggesting what the intervals between irrigations should be, it is important to review the experimental results of Denmead and Show (1962) done in Australia. Their work indicated that there is no fixed optimum interval between irrigations, nor any fixed soil suction at which to irrigate. Rather, they showed that irrigation should be applied to keep the soil suction sufficiently low to allow transpiration up to the design rate under the prevailing atmospheric conditions. This means short intervals and low suction between irrigations during cooler and wetter periods.

3.18 Under Bahamian conditions, the design of irrigation systems on a fixed interval between irrigations is recomended. The predetermined frequency being such that maximum water requirements of plants are met. There is no information on the sensitivity of various plants to irrigation intervals. However, it can be said, that in general, the shallow-rooted crops (vegetables) are likely to be sensitive, while much deeper-rooted crops (fruit trees), will be less affected since they are likely to be able to use some of the water stored in the soil outside the irrigated zone. It seems that by slightly increasing the interval without stressing the plant unduly, some advantages are achieved: slightly deeper root distribution. The recommended intervals between irrigations, if "fixed intervals" are to be used in the design, should take into account the prevailing water balance and scheduling similar to the illustrations shown in Tables (12 to 22) of the Appendix. For the Gun-Sprinkler, under dry conditions, a twice-a-week interval can be considered during the first two weeks after planting,which could be increased to once-a-week there after. Regarding the Drip, under dry conditions, the following intervals are tentatively suggested:

Evapotranspiration Rate	irrigation intervals, day
high	2
moderate	2 - 3
low	3 - 4

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3.19 The use of tension meters as a guide for irrigation scheduling is not recommended for the Bahamian calcareous soils, because they which can not be uniformly wet and root development is irregular. This, wide differences in suction can easily occur at similar depths. The most suitable index for irrigation scheduling in the Bahamas is a combination of the plant water indicators and the meteorological approaches. The water plant indicators recommended are:

(a) Visual indicators of water stress such as; plant color, plant movements and exudation from topped plants.

(b) Plant growth indicators of water stress such as; fruit growth, leaf growth, stem and trunk growth.

The meteorological approaches recommended to determine need for irrigation require a knowledge of:

(a) Short-term evapotranspiration rates (ET) at various stages of plant development.

(b) The effective rooting depth of the crop grown.

(c) The permissible soil water deficits in relation to evaporative demands.

<u>Irrigation Scheduling For Water Constrained Project</u>

3.20 The difficulties encountered by agriculture in the southeastern islands of the Bahamas, such as Long Islands, are commonly dramatic. The traditional rain-fed production system is reaching its limits and is hardly capable, and in some cases is no longer capable, of satisfying basic food requirements. The most feasible solution to the problem of crop production in these islands, as recommended by this report, is to assign a certain rule to the systematic use of groundwater. The aquifers on these islands are shallow, as shown later in Table (8b), and they can easily be mined if being overpumped. However, groundwater exploration from these shallow aquifers can play a significant role in any overall strategy for improving agricultural production in these areas. It is felt that the activity of traditional villagers cultivating modest scattered areas (of about one acre each) can contribute to reversing the trend of decreasing agricultural production. It is, however, essential to combine their traditional rain-fed agriculture with more modern techniques, enabling access to the available groundwater resources, which are limited. This is discussed later in this report.

3.21 One of the most important concepts related to the effect of

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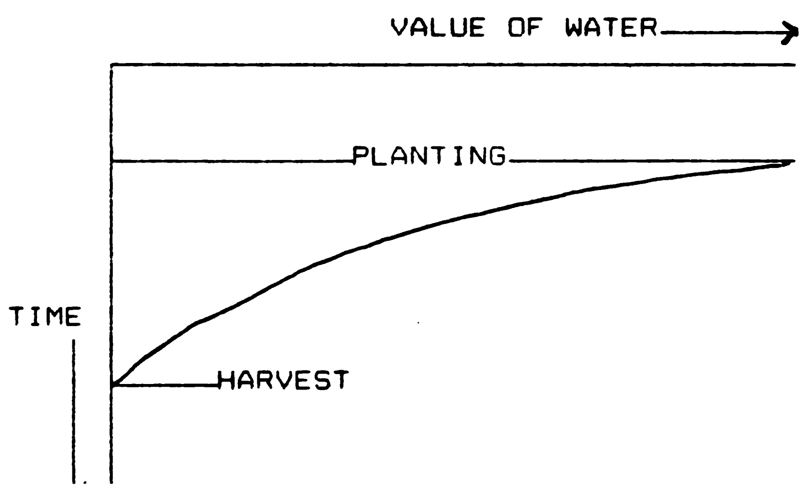
water deficits is the recognition that yield responses to water stress vary greatly during the life of a plant, and at any point in time, are dependent on the sensitivity of the plant at that particular growth period. Yield responses vary considerably even among varieties of the same crop. High-yield varieties are generally more sensitive to water stress than traditional and lower-yield producing varieties, which are often drought resistant. In general, plants are more sensitive to water shortages during the critical growth stages of emergence, flowering and yield formation than they are during the early vegetative growth period after establishment and during the late ripening period.

3.22 Consequently, under the conditions of limited water supplies, irrigation must be scheduled according to the relative sensitivity of the various crop growth stages. The timing of irrigation, rather than the total seasonal amount, becomes the critical issue - subject to the condition that the total seasonal amount is sufficient to meet the full crop growth requirements at the most sensitive and critical stages. Irrigation must be scheduled so that water deficits occur during periods when their effects are marginal. In some cases, the stress condition may be timed to be beneficial to the plant. Water delivered at critical stages always has a greater production value than when it is delivered during non-critical growth periods. Critical growth stages and yield response factors for selected common crops are given in Table (6).

3.23 The concept of "critical water" can be of value in considering the enormous contribution that groundwater can make. Figure 2 illustrates the principle in schematic form, and is based on the fact that water is more valuable for a particular crop at one time than it is for another. In the extreme case, with a single crop, it may be that, if water is not available by a certain date, the crop cannot be planted at all. Once it has been planted, then perhaps the next increment has the most value until, at the point of harvest, the marginal value of water is zero.



3.24 The "critical" water concept is valid even if the extreme case is not severe. Generally, it is possible to plant another season if there is no water to plant the most profitable first choice of the rainy season. However, there is obvious merit in using groundwater to plant the first choice, if the rainfall fails to arrive. It is possible to optimize the cropping pattern to fit in with some programme of planned water availability allowing for some deficiency. The principle envisaged here is that there may be better overall returns from a system that is deficient, let's say, for a month, rather than adopting the conservative assumption restricting the area cropped so that there is no water deficiency.

TABLE (6) Critical Growth Stages and Yield Responses Characteristics for Selected Crops*

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Table (6). Critical Growth Stages and Yield Responses Characteristics for Selected Crops *

CROP	RELATIVE SENSITIVITY	CRITICAL PERIODS	YIELD RESPONSE FACTOR **	HARVESTED CROP	LAND USE EFFICIENCY KG/HR***	WATER USE EFFICIENCY KG/m cubed ****
Banana	High	Throughout	1.3	Fruit	40.0-60.0	2.0-4.0
Beans	High	Throughout Pod Filling	1.2	Dry Seed	1.5-2.0	0.3-0.6
Groundnut	Medium	Flowering, Pod Setting and Yield Formation	0.8	Unshelled Dry Nut	3.0-4.0	0.6-0.8
Maize	High	Early Vegetation Stage, Tasselling and Silking Grain Filling	1.3	Grain (10% Moisture)	6.0-8.0	0.8-1.6
Peas	Medium to High	Flowering and Yield Formation, Vegetative	1.2	Dry Shelled (12% Moisture)	0.6-0.8	0.-0.2
Potatoes	Medium to High	Atolonization, Tuber Initiation, Yield Formation> Early Vegetative Period and Ripening	1.1	Fresh Tuber (70% Moisture)	0.6-0.8	0.-0.2
Sorghum	Medium to low		0.9	Seed (12% Moisture)	3.5-5.0	0.6-1.0

* Adapted from "Yield Responses to Water" FAO (1979); and from "Water Requirement and Irrigation Management of Crops in India", I.A.R.I. Monograph NO.4 (New Series), Water Technology Center, New Delhi (1977).

** Ratio of relative yield decrease in relation to evapotranspiration deficit for HYVs adapted to local environment and with high levels of management. Relative yield decreases will be larger for crops with high response factors than those with low response factors.

*** Indicates more sensitive than.

**** Under well managed or small plot conditions.

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It is certain that the volume of water resources nted by limited replenishment and regulated by thin aquifers ctor which limits the expansion of irrigated areas. It is wever, at least in the initial stages, advisable to regard nitation as a drawback to installation of small-scale pilot ion projects in these areas. As a preliminary nation, the total volume of available water in the lenses are more than 20 feet thick might be sufficient for cant development. It is felt that the food requirements of outheastern islands can be satisfied by:

ucing LIMITED IRRIGATION to selected areas located above ter lenses more than 20 feet thick

termination of pumping requirements, and

onstruction of INFILTRATION GALLERIES, as a means of ing the limited freshwater resources more than 20 feet thick ed.

In relation to the available groundwater resources, the for irrigation water to cover the crop cycle (or season) is ed to be such that, depending on the climatic zone, it is e to provide LIMITED IRRIGATION on land over water lenses than 20 feet during the dry season. That would increase the wet season. With a mean annual rainfall around 700 mm, straints can be less marked and LIMITED IRRIGATION can spectacular results, particularly in those zones where l distribution is uneven. The main objetives of cting LIMITED IRRIGATION in these areas are:

safeguard agricultural production during the rainy season iding complementary irrigation, this making agricultural ion possible during the dry season during only the crop l growth stages,

secure the limited freshwater lenses, and

improve the level of rural employment and the standar of of producers, thus contributing to rural development by cing population movement. This factor is of prime nce given the prevailing demographic pressures in the

The revenue from exploitation should enable the farm s concerned to be self-sufficient in food, to pay the on and maintenance costs for the pump and irrigation nt, and under certain financial conditions, to reimburse the such equipment, and to pay for seed and overhead, while aking a relatively adequate income.

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3.28 It is important that villagers be informed (and trained, in association with the rural extension service of the Ministry of Agriculture) as to the basic principles of LIMITED IRRIGATION, on the way in which installations should be used, and on the operation and maintenance of selected areas.

3.29 Selection of crop varieties has been made is light of the prevailing traditions, natural potential, distribution possibilities and the specific water requirements for each season and each crop. From August to November, complementary irrigation should be carried out to safeguard against variations in rainfall. The object should be to optimize production per unit volume of water and not to maximize production as a whole. A study of the rainfall data demonstrates that gross intake for irrigation of 1.2 millimeters per day (145 mm over a 120-day cycle) does not satisfy the day-to-day water requirements for crops, but limits any substantial decrease in the crop yield. In any area where water supply is limited, the justifiable annual pumpage requirement for irrigation can not be determined on the basis of providing a full water supply in the year or years of worst drought. To do so will obligate excessive amounts of water in non-drought periods and thereby unduly limit irrigation development opportunities. A more practical approach is to recognize that limited shortages can be tolerated occasionally without a severe reduction of farm income. Groundwater pumping can be increased during years of short rainfall supplies. Even though the groundwater may be of poor quality, little or no significant damage may be experienced if it is used only for brief periods during the crop critical growth stages.

3.30 An evaluation should be made not only of the potential of the various technical solutions proposed, but also of their economic feasibility and of the practical possibility of disseminating such techniques. Particular emphasis should will be placed on the progressive nature of any intensification, and on the necessity to take account of the use made of rain cultures, when it is suggested that an individual farmer irrigate and intensify exploitation of part of his land.

3.31 The entire population of a community cannot benefit from the small farms to be placed under LIMITED IRRIGATION, because of the limitations of water resources. It is not proper enough to claim that a project will benefit the entire population of a target zone. It is necessary to design the project in such a way as to reduce rather than create social and economic differences, particularly between those who benefit from the project and those who do not. It is, therefore, desirable to foresee measures for improving rain cultures and livestock production and to enable such farmers to benefit from the effects produced by the project (sources of supply, credit and marketing; changes in the growing cycle). It is also necessary to specify the use of abstraction pits with a discharge regarded as insufficient for irrigation.

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3.32 In the southeastern islands of the Bahamas, LIMITED IRRIGATION can be introduced to supplement the rainfall during the rainy season. In order to prepare irrigation scheduling, the rainfall patterns and probable frequency and length of the dry spells must be fully understood. The seasonal rainfall patterns vary from year to year, and are characterized by series of active storms interspaced with dry spells. Therefore, the intervals between irrigations in these islands will depend mainly on three factors:

(i) The duration of dry spells,
(ii) The effective depth of the previous significant rainfall or irrigation, and
(iii) The crop consumptive use and the available moinsture stored in the root zone.

3.33 A simple planning method based on a periodic water balance calculation should be used. The irrigation interval to be calculated is simply the available root-zone moisture divided by the ET crop value, assuming that rain will not fall during this period. If rain does not occur during the interval, the period can then be extended. Not all rainfall is effective for crop growth. Light showers are spotty, seldom cover the whole project area and have little influence on irrigation schedules. There are many approaches to calculate effective rainfall. All are subject to errors because the effective rainfall is also dependent on the irrigation schedule. Rain falling immediately after irrigation is less effective than that which falls before the irrigation.

3.34 Irrigation in water-constrained projects during the dry season must aim at achieving maximum yield per unit of water (kg per m cubed) rather than maximum yield per unit of land. The planning approach accepts that when water shortages occur, plant transpiration is reduced and growth is retarded; but also takes into account the fact that the magnitude of growth reduction and consequent yield reduction depends on the sensitivity of plant, its growth stage and the soil moisture tension level prevailing at the time of stress. Irrigation schedules are, therefore, planned according to the relative sensitivity of various plant growth stages. At the same time, the plan ensures that the seasonal allocation is not exceeded and that the dates of irrigation meet the crop water requirements during the most sensitive critical growth stages, mentioned in Table (6). The timing of irrigation will be such that the water deficits will occur when their effects are minimal or marginal. This ensures maximum production per unit of water (Kg/m cubed), because water is applied when it has the greatest production value. When water is limited and supplies are not sufficient to meet full crop requirements over an entire project area, two options are available to farmers:

(a) reduce the irrigated area so that full crop water requirements are met in the planted area, or

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(b) meet the crop water requirements only partially in the planted area.

In the first option, water schedules in the planted area would be similar to those described for a project with adequate supplies. As shown below, this policy would neither maximize returns per unit of water nor maximize farmer's net returns. An economic management policy should develop an irrigation scheduling program based on the second option, and aim to maximize net returns per unit of water (Kg/m cubed). Farmers would then select crops that give acceptable yields with the limited water supplies. They would be able to manage their farming operation satisfactorily, provided they had been informed, before the beginning of the irrigation season, of the anticipated irrigation quantities and dates.

3.35 The policy of spreading water "thinly" over extensive areas recognizes the fact that the crops will suffer from water deficits during the growing season. Plant transpiration would be reduced and growth retarded in these periods of shortage. The magnitude, however, of the reduction in growth and the consequent loss in yield would depend on the plant, its growth stage and the levels of moisture tension allowed in the soil. Plants vary widely in their responses to water stress. Some plants (sorghum, for example) increase their water utilization efficiency while others (such as maize) decrease it under stress. Yield per unit of area (Kg/acre) may be reduced for both types of plants, growing under moisture stress conditions -with a greater relative reduction for those that decrease their water utilization efficiency under stress. Yield per unit of water (Kg/m cubed), however, is not necessarily reduced, and, in most cases, production per unit of water increases under moderate stress conditions, provided the stresses do not occur during certain specific critical growth periods.

B. SELECTION OF IRRIGAGION METHODS, SPECIFICATIONS AND THEIR ESTIMATED COSTS FOR DIFFERENT FARM MODELS (AS MODULARS)

3.36 Since groundwater is the only resource for irrigation water in the Bahamas, only the mechanical systems can be recommended. The major advantages of the systems are: easy to manage reduced labor requirements, less drudgery, less irrigation skill needed to operate efficienthy, more precise water application, significant water saving, and the relatively low investment and operational costs, as will be described later in this report. Further more the mechanized systems have proven to operate effectively in the calcareous soils and hilly lands of The Bahamas. Thus, through innovative irrigation tools, it is easy to expand The Bahama's capacity to produce food. Mechanical systems provide frequent irrigations to any terrain and can reduce the need for the soil to hold water.

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3.37 The selection of appropriate irrigation methods, in view of the combined physical, agronomic, and socioeconomic conditions, and the system of agricultural production in The Bahamas, involved complex considerations. Among the physical factors involved in system selection are topography, soils, crops, climatic conditions, groundwater quality and availability, water table depth, and size of irrigation unit. Among the socioeconomic factors involved are relative costs of land, water, energy and labor cost in relation to expected returns, availability of capital, services and expertise and the general level of labor and management skills. Not all the relevant factors can be weighed quantatively. Therefore, the decision asto which system to adopt is based on the evaluation of the relative importance of the factors involved, some of which are listed in Table (7). Certain methods andpecifications are needed to provide supplementary UNLIMITED IRRIGATION intended for commercial type production in the northwestern islands, where relatively thick freshwater lenses exist. Other methods and specifications are needed to provide suplementary LIMITED IRRIGATION in the southeastern islands, where these freshwater lenses have to be managed with care.

<u>The Northern Islands</u>

3.38 There are adequate ground water resources in the northwestern islands on can easily satisfy the irrigation requirements of highly-intensive and commercial agricultural production. Many automatic methods can be used, but the selection made in this report considered only the two methods that have been successfully tested under Bahamian conditions. Accordingly, the following two alternatives have been selected: the Gun-sprinkler and the Drip systems.

a) <u>The Gun-Sprinkler System</u>

3.39 The specifications and costs of the recommended gun-sprinkler system have been prepared for irrigating fruit trees, vegetables or forage crops that can be grown on a 35-acre model farm, as shown in Table (22) of the Appendix. The total investment costs are about US$15.600 (F.O.B. Bahamas), to be depreciated over 10 years, and the annual operation and maintenance costs amount to US$ 4140 per 35 acres. The Gun-sprinkler can be used to irrigate vegetable, fruit, forage and field crops. How ever , they produce high application rates and large water drops that may cause some damage to germinated plants if the nozzzle is not adjusted. Gun - sprinklers are suitable for providing supplemental irrigation to the calcareous soils with high infiltration rates. It can be used on both small and big farms.

3.40 Gun-sprinkler systems should be arranged to apply water at a rate that does not exceed the high infiltration factor of the calcareous soils. The uniformity of water application under

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sprinkling depends on the uniformity of the sprinklers themselves, not on soil characteristics. Hence, high application uniformity (greater than 85 percent as defined by the commonly used Christianson Uniformity Index) and high application efficiency can be achieved with properly operated systems. Gun-sprinkling, if practiced properly, allows the application of frequent, light and uniform irrigations, as required for the calcareous soils, due to their low moisture retention and to the high evaporation on factor of the climate.

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Table (7) Factors Affected The Selection of Appropriate Irrigation Methods For The Bahamas

Irrigation Method	Factors Affecting Selection				Pluses	Minuses
	Land	Soil	Crop	Climate		
Sprinkler	For all slopes; regular & irregular	For all calcariaous soils & intake rates	For most crops except sensate. to fungi disease & leaf scorch by soils	Affected by wind (drift, evaporation & poor distribution	Control of rate and frequency allows irrig. sloping & calcarous soils	Initial costs and pressure requirements
Drip	For all slopes; regular & irregular	For all calcarous soils & intake rates	For most crops & orchards but not close-growing crops	Not affect- by wind. Adapted to all climates	High freqency & precise irrig. can use saline water on rough land. Reduced evaporation	Initial & annual costs. Requires expert management. Prone to clogging & requires filtration

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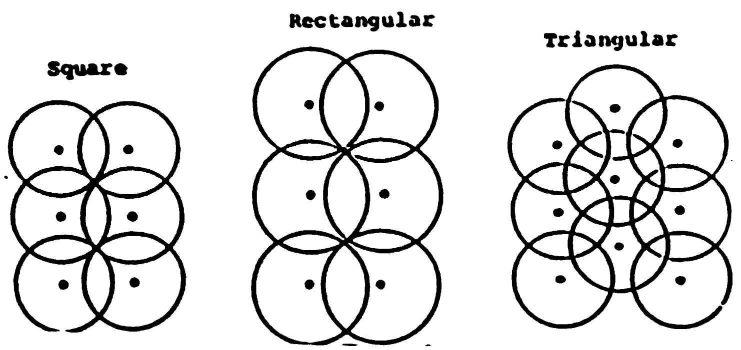
3.41 Water application efficiency under gun-sprinkling is strongly affected by wind, especially during the daytime, when the air is warm and dry. Application uniformity and efficiency are not appreciably reduced as long as wind speed is below about 10 km/hr. (6.25 miles/hr.). To avoid excessive losses due to wind drift and evaporation, night time irrigation may be preferable, though it is less convenient for the operator, if he must be present. Moroever, the establishment of suitable wind breaks around the farms are highly recommended. The gun-sprinkler is an effective water applicator for many, but not all crops. Some crops are especially sensitive to fungal diseases, leaf scorch, or fruit damage.

3.42 The application rate of a gun-sprinkler system in The Bahamas depends on the spacing between wells, on the sprinkler and the radii of its nozzle and on the operating pressure. Precise tailoring of application rate to soil properties and crop water requirements is difficult to achieve and generally involves trial and error experience under local conditions. Sprinklers spread the water over a circular area at a rate that diminishes with radical distance from the sprinklers. If uniform distribution over the field is desired, the sprinkled circles must overlap. Alternative geometric patterns (square, rectangular or triangular) shown in Figure (3) can be used to obtain the optional overlap among adjacent units.

Figure (3). Alternative Arrangements of Sprinkler Grids



For maximum efficiency of water utilization, the rate of water application should be equal to the water requirements of the crop, not just on the average, but everywhere in the field. If the application rate is not uniform spatially, some parts of the field may receive insufficient water and will provide low yields, while other parts of the field may receive excessive water - again leading to reduction of yield, as well as to waste of water and leaching of nutrients. The operating pressure affects no only discharge, but also the array of drop sizes emitted by the sprinklers. Low pressures result in large drops and poor distribution around each sprinkler. High pressures, on the other

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hand, result in a fine spray, a smaller radius of coverage and greater vulnerability to wind drift and evaporation. Each type of sprinkler has an optional operating pressure, generally specified by the manufacturers, and a characteristic functional dependence of discharge and of drop size distribution on hydraulic pressure. The designer must set his operating pressure and choose sprinklers accordingly.

General Maintenance of a Gun-Sprinkler Irrigation System

3.43 Constant and meticulous maintenance of the gun-sprinkler system is crucial, if this system is to justify its cost. The saving in labor costs, resulting from mechanization and automation can quickly be offset and even exceeded by losses due to yield decline caused by failure of the system during critical periods in the growing season.
The danger of system failure increases with the complexity of the technology, the requirements for expertise and quick availability of spare parts.

b) The Drip Irrigation System

3.44 Drip irrigation is the slow localized application of water drop by drop, at points on, or just below, the soil surface. Drip irrigation can be used to irrigate vegetables and fruit crops.

3.45 Two model farms under the drip irrigation systems have been prepared for the commercial production of citrus and vegetable crops. The layout of a 40-acre model farm for citrus is shown in Sketch (1) and its specifications and costs are shown in Table (24) of the Appendix. The total investment costs of this model are about US$16,0978.5 (F.O.B. Bahamas), to be depreciated over 10 years. The annual operating and maintenance costs amount to US$10,707.9 per 40 acres. Ther layout of a 32-acre model farm for vegetable crops has been designed, and is shown in Sketch (2). Its specifications and costs are presented in Table (25) of the Appendix. The total investment costs of this model are about US$29,434.5 (F.O.B. Bahamas) to be depreciated over 10 years. The annual operating and maintenance costs amount to US$17.261.1 per 32 acres.

3.46 The general specifications of drip irrigation system consist of a control head head unit, including the pump station, filtering equipment, fertilizer and chemical injection equipment, controllers, main pressure regulators, valves, and water measuring devices. The mainlines transfer water from the source to the manifolds which are usually connected to the mainline through control valves. The manifolds, in turn, connect and supply water to laterals which branch from the manifolds on one or both sides. Both the submain and the manifold may be on the surface, but are usually buried to facilitate the passage of farm machinery and to protect them from lightning. Headers which are connected to and

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run parallel with the manifold are often used on steep topography to serve every 2 to 5 laterals. The lateral line is usually 3/8-inch to 2-inch diameter polyolefin or PVC hose or tubing (1.0 inch = 25.4 mm), and supplies water to the emitter. Pressure controllers (manual or automatic), valves (hydraulic or manual) and secondary filters are often located at the entrance at the manifolds, headers, or lateral lines. The major new advances in drip irrigation involve improving emitter characteristics and learning how to deal with emitter clogging through better filtration and maintenance. The emitter is an applicator designed to disspate pressure and to discharge a small, uniform flow of water at a constant rate that does not vary significantly because of minor differences in the pressure head. Ideally, emitters should have a relatively large flow cross-section or some means of flushing in order to reduce clogging problems. Emitters should be inexpensive, compact, and easily flushed or cleared. Different types of emitters are often classified according to the mechanism each uses to dissipate pressure. For example, Long Path emitters use a long capillary-sized tube or channel to dissipate pressure, while Orifice emitters rely on a series of orifices, and Vortex emitters employ a vortex affect. Flushing emitters are designed to produce a flushing flow of water to clear the discharge opening every time the system is turned on. Continuous-flushing emitters permit continous passage of large solid particles, while operating at a drip flowe. This slow flow reduces requirements for filter fineness. Compensating emitters discharge water at a constant rate over a wide range of lateral line pressures. Multi-outlet emitters supply water to two or more points through small-diameter auxiliary tubing.

General Operation of a Drip System

3.47 In drip irrigation, water is delivered under low pressure in a predetermined pattern thought a pipe distribution network. The hose lies on the soil surface alongside a row. Affixed to it are emitters which dissipate the pressure in the pipe distribution network by discharging water through narrow nozzles, thereby allowing the discharge of only a few gallons per hour to each tree. Upon leaving the emitter, water flows through the soil profile by gravity. Duration and frequency of application should be based on the evapotranspiration of the crop, the high infiltration rate and the low water holding characteristics of calcareous soils.

3.48 For widely spaced permanent crops such as trees, emitters are manufactured individually as units that are attached by a barb to a flexible supply line called an "emitter lateral", "lateral hose", or simply, "lateral." Some emitters have more than one outlet that supplies water through small diameter "spaguetti" tubing to two or more emission points. This method can be used to wet a larger area with a minimum increase in cost. For seasonal row crops such as vegetables, the lateral with emitter outlets is manufactured as a single disposable unit. These disposable

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laterals may have either porous walls from which water oozes, or single or double chambered tubing with perforations spaced every 9 to 36 inches. For both types, the laterals are connected to supply lines called "manifolds."

3.49 Regarding fertilization, dry fertilizer broadcast over the soil surface is not moved into the root zone by irrigation from a drip system. Therefore, much of the the required fertilizer, especially nitrogen, must be directly added (injected) to the water. This process is often referred to as "fertigation." Applying fertilizers through the irrigation water reduces costs for labor and equipment that the conventional spreading methods require. Many commercial fertilizers can be added during the growing season without damaging the irrigation system or the crop. Therefore, fertilizers can be maintained at ideal levels, even in calcareous soils, through the growing season. Unfortunately, phosphorous fixation problems may be associated with the injection of phosphorous fertilizers in the irrigation water that drips on the calcareous soils of the Bahamas.

General Maintenance of a Drip System

3.50 Clogging of emitters is the most difficult problem encountered in using a drip irrigation system. The most common cause of clogging is presence of mineral and organic particles in the water supply. To filter the water and prevent contaminants from entering or forming within the system is the best defense against clogging. It is difficult to detect and expensive to clean or replace a clogged emitter. Another common cause of clogging is the presence of precipitates, bacterial slime, or both, caused by the presence of dissolved calcium from the limestone soils of the Bahamas. Periodic chemical treatment of the water supply will prevent slow clogging or plugging caused by precipitates. Clogging causes poor distribution of water along the laterals. This may damage a crop severely if emitters are clogged for a long time before they are cleared of repaired. Therefore, spot checks on the discharge from a representative sample of emitters should be made several times during the growing season. Normally, the main bank of filters and the chemical injection equipment is located at the pumping plant. In addition, it is useful to include screens near the inlet of each hose as an additional safety factor. These screens stop any debris that has entered line during cleaning of the main filters, or during the repair of breaks in the main line. The filters recommended in drip irrigation are graded sand filters.

3.51 Slow clogging and eventual plugging of emitters by precipitates and organic deposits must be dealt with by injecting acids, chlorine, and/or chelating agents; or by aeration with a mechanical aerator and settling in a reservoir. Precipitates are caused by dissolved minerals coming out of solution because of a change in pH or temperature. Calcium precipitates are a potential problem with most well waters. Algae are a family of plant organisms that grow by converting light energy and the nutrients

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present in their environment into food. Because small particles of algae can pass through filters, it is important to keep them from growing inside the system. This is accomplished by using black emitters and black pipe above ground, since most algae need light to grow. In darkness, bacteria break down the algae particles, and they leave the system through the emitters, along with suspended soil particles.

3.52 Good maintenance requires that filters be kept in perfect operating condition and that discharge from the emitters be uniform and sufficient to meet the moisture requirements of the crop. Therefore, the main filters must be cleaned periodically, and the secondary filters at inlets to the manifolds and laterals must be routinely checked. Fine soil particles usually settle in the slow flow region at the ends of manifolds and laterals. Since high concentrations of fine contaminants are more likely to clog emitters than low concentrations, periodic flushing of a system is recommended for good maintenance. Annual flushing is sufficient for many systems, but some combinations of water and emitters require almost daily flushing to prevent clogging.

3.53 Systematic checking is required to spot malfunctioning emitters. Discharge from an emitter may be affected by partial or total blockage, or by physical deterioraton of emitter parts. Slow clogging that causes partial blockage can result from of sediments, precipitates, organic deposits, or mixtures of these. Physical deterioration is a concern in pressure compensating emitters. The flow passage may slowly close as the compensating portion distorts with time. Mechanical malfunction can also be a problem in flushing emitters. Discharge from emitters should be checked periodically for uniformity. A good practice is to determine the field emission uniformity at least once in each irrigation season. In addition, the average discharge of all the emitters should be computed from the system flow rate data used for scheduling irrigation, to evaluate the systems performance.

The Southeastern Islands

3.54 Regarding the southeastern islands, the thickness of freshwater lenses and their effective recharge allow for only LIMITED IRRIGATION; otherwise, the aquifer would be mined. As for the selection of a suitable method, the guidelines are: simple technology, low initial costs and controlled pumping. The fields in the southeastern islands are scattered above relatively thin freshwater lenses, their land surface is rough and an irregular type of inter-cropping is practiced. Accordingly, an economic sprinkler system that suits the prevailing limiting conditions and the goals of production seen before has been designed, to irrigate from an abstraction pit, instead of the bore holes considered for the northwestern islands. A simple small pump of 3 hp capacity

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operated by gasoline rather than diesel has been selected to discharge 100 gpm. This system would operate to provide LIMITED IRRIGATION during the critical plant growth stages indicated before. The recommended irrigation system is too simple to be operated and maintained by the small farmers of these islands, where maintenance services are limited. The specifications and costs of the recommended system are shown in Table (26) of the Appendix. The installation costs for a one-acre model farm amount to US$1070.0 (F.O.B. Bahamas), to be depreciated over 10 years. The annual operating and maintenance costs amount to US$54.8 per acre.

C. SELECTION OF POTENTIAL AGRICULTURAL LAND TO BE SUPPLIED WITH SUPPLEMENTARY IRRIGATION IN THE PROJECT AREAS

Criteria Used for Selection

3.55 The areas that can be considered as potential agricultural land, which may be supplied with supplementary irrigation in the Bahamas are vast. However, this project adopted a conservative approach in selecting them. The factors considered are:

(a) Insofar as practical, the selection of these sites was based on obtaining the greatest hydrologic advantage, from the standpoint of such factors as maximum recharge and maximum protection from salt water and interference form other pumping. Accordingly, the area most favorable for agricultural production is that in which the freshwater lens is the thickest, the water table is the highest, and the limestone is the most permeable at shallow depths. Accordingly, the areas on the freshwater lenses of more than 40 feet in the northern islands were considered to be supplies with supplementary unlimited irrigation, while those located on the lenses from 20 on 40 feet thick in the southeastern islands were considered to be supplied with suplementary limited irrigation. Some of these areas have been selected as the minimum possible potential agricultural lands.

(b) Based on the findings of Little et al, the center of the island is considered as the center of the recharge area, and the elevation of the water table there is expected to be relatively high. Therefore, it is believed that the well fields of the selected potential agricultural lands should lie as close to the center of the island as possible.

(c) Any area selected as potential agricultural land should be surrounded by an area of reasonable width, located on the freshwater lenses. This surrounding area should be reserved for expansion in the future. This is to provide more area for well fields to increase groundwater withdrawals, if it is found feasible based on observation of the first well field, or to expand the well

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field to maintain a groundwater withdrawal, if it is found to be necessary.

(d) The selection criteria considered as practical as possible the land capability classes prepared by Little et al, which are based on the physio-graphic features of the land. However, the field visits done during the mission period have provided necessary adjustments for using these maps.

(e) The proximities of these projects to roads that would offer better transport for agricultural produce, which, in turn, would enable the success of the projects and would reduce the costs of road construction.

(f) New Providence Island,which is faced with continuos expansion of urban development, has been avoided.

(g) Large potential areas on Grand Bahama Island (about 50,000 acres) are not included in this initial stage of the project since these lands have been leased to a private company called "Port Authority." In addition to that area, there are some 5435 acres of potential agricultural land on Grand Bahama Island that have not been included because there are timber concessions.

(h) The selection avoided the areas where the groundwater resources have not been explored, regardless of their expected high potentialities, such as the southern parts of Andros and Eleuthera islands.

(i) The site water balance, the pumping requirements and the possible irrigation program analyzed earlier in this report.

(j) The selection did not include the large areas reserved by the Water and Sewerage Corporation for pumping potable water. The reason is to avoid any interaction between potable water pumping and irrigation water pumping which might result in negative impacts on agricultural development. The possibility of groundwater contamination as a result of agricultural practices is not a factor to be considered under the Bahamian conditions, as will be analyzed from the hydrological, agricultural and engineering points of view later in this report.

The Selected Minimum Area of Potential Agricultural Lands

3.56 Based on the aforementioned criteria, the locations and minimum areas of land considered to be potential on each island have been indicated on the maps prepared for this report. Their features are presented in Tables (8a & 8b).

3.57 The total minimum number of acres of potential agricultural land that can be put under supplementary unlimited irrigation during the initial stage of the project is about 50,962. This

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amounts to 25 per cent of the explored areas of the freshwater lenses more than 40 feet thick. It also amounts to about seven times the areas presently irrigated in the Bahamas. It also constitutes about 3 per cent of the total land surface area of the islands. About 40,000 acres out of this area (80% is public (crown) land.

3.58 The total minimum acres of potential agricultural land that can be put under supplementary limited irrigation in the southeastern islands during the initial stage of the project is about 7810. This amounts to 30 per cent of the explored areas of the freshwater lenses ranging between 20-40 feet thick. It also amounts to about one percent of the total land surface area of the islands. At least 3061 acres out of this area (39 per cent) is public land.

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TABLE (8a). CHARACTERISTICS OF MINIMUM POTENTIAL AGRICULTURAL LAND AND THEIR FRESHWATER LENSES AS WELL AS RECOMMENDED DEPTHS OF WELLS IN NORTHWESTERN ISLANDS

ISLAND	TOTAL ISLAND AREA, ACRES	CHARACTERISTICS OF FRESHWATER LENSES OF MORE THAN 40 FEET THICKNESS				FEATURES OF MINIMUM POTENTIAL AGRICULTURAL LAND			
		NAME OF LENS	AREA OF LENS, IN ACRES	MAXIMUM LENS THICKNESS IN FEET	AVERAGE DEPTH OF INTERFACE, IN FEET	TOTAL AREAS IN ACRES	TYPES OF LAND TENURE OR USE	AREAS THAT CAN BE CONSIDERED FOR IRRIGATION IN THE 1st PHASE	RECOMMENDED DEPTH OF WELLS FEET
ABACO IS.	415360								
		BLACKWOOD VILLAGE (AREA I)	11276	50	50	564	LEASED C.L	-	20
		PUMKIN BAY (AREA II)	327	42	45	376	PRIVATE		
		LAKE CITY TO MARSH HABOR:	33942.7	65	60				20
		AREA IV				1341	LEASED C.L	-	
		AREA V				6296.3	UNGRANTED C.L	6296.3	
		AREA VI				615	LEASED C.L	-	
		AREA VII				343.4	LEASED C.L	-	
		AREA VIII				2960	UNGRANTED C.L	2960	
		EIGHT MILE BAY (AREA IX)	1823.5	42	45	744	UNGRANTED C.L	744	20
		CROSSING ROCK TO HILL IN THE WALL (AREA X)	26706.1	64	45	4775	UNGRANTED C.L	4775	20
		SUBTOTALS	74075.3			18014.7		14775.3	
ELEUTHERA IS.	128000	*							
		NORTH ELEUTHERA:	6698.2	70	80				20
		AREA I				43	UNGRANTED C.L	43	
		AREA II				57	UNGRANTED C.L	57	
		AREA III				204	COMMONAGE	204	
		AREA IV				53	COMMONAGE	53	
		AREA V				164	COMMONAGE	104	
		TARPUM BAY TO ROCK SOUND (AREA VI)	1777.4	40	50	703.3	PRIVATE		15-20
			8475.6			1241.8		538.5	

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		FRESH CREEK:		10090.8	110	55				
			AREA V				2935	UNGRANTED C.L	2935	20
			AREA VI				790	UNGRANTED C.L	790	
			AREA VII				555	UNGRANTED C.L	555	
			AREA VIII				564	UNGRANTED C.L	564	
			AREA IX				1102.8	UNGRANTED C.L	1102	
			AREA X				188	UNGRANTED C.L	188	
			AREA XI				1578.6	PRIVATE		
			AREA XII				5500	UNGRANTED C.L	5500	
			AREA XIII				1808	UNGRANTED C.L	1808	
		SUBTOTALS		62818.8			26270.6		24692	
GRAND BAHAMA	339200	FREE TOWN TO HIGH ROCK:		** 50007	40	55				20
			AREA Ao				2550	FORMER AIRFORC BASE	-	
			AREA A1				1390	TIMBER CONCESSION	-	
		MOUNT PLEASANT TO HIGH ROCK (AREA II)		7281.4	45	60	572	TIMBER CONCESSION	-	20
		PELICAN POINT (AREA III)		1424.9	45	60	278	TIMBER CONCESSION	-	20
		YAM PATCH:		1311.9	47	50				
			AREA IV				278.1	TIMBER CONCESSION	-	
			AREA V				367	TIMBER CONCESSION	-	
		SUBTOTALS		60025.2			5435.1			
TOTALS				205394.9			50962.2		40005.8	

* FRESHWATER LENSES EXIST IN SOUTH ANDROS & SOUTH ELEUTHERA BUT THEY HAVE NOT BEEN EXPLORED.
** MOST AREAS HAVE BEEN LEASED TO PORT AUTHORITY CO.

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TABLE (8b). CHARACTERISTICS OF MINIMUM POTENTIAL AGRICULTURAL LAND AND THEIR FRESHWATER LENSES AS WELL AS RECOMMENDED DEPTHS OF ABSTRACTION PITS IN SOUTHEASTERN ISLANDS

ISLAND	TOTAL ISLAND AREA, ACRES	CHARACTERISTICS OF FRESHWATER LENSES OF MORE THAN 20 FEET THICKNESS				FEATURES OF MINIMUM POTENTIAL AGRICULTURAL LAND			
		NAME OF LENS	AREA OF LENS, IN ACRES	MAXIMUM LENS THICKNESS IN FEET	AVERAGE DEPTH OF INTERFACE, IN FEET	TOTAL AREAS IN ACRES	TYPES OF LAND TENURE OR USE	AREAS THAT CAN BE CONSIDERED FOR IRRIGATION IN THE 1st PHASE	RECOMMENDED DEPTH OF ABSTRACTION PITS, FEET
LONG ISLAND	286.72								
		DEADMONS CAY *							
		BURNT GROUND	40.9	25	20	40.1	PRIVATE	21	] 2-3
		STELLA MARRIS	374.6	40	20	374.6	PRIVATE	187	] FEET
		ROSES	49.1	20	20	49.1	PRIVATE	25	] BELOW
		CABBAGE HILL	49	20	20	49	PRIVATE	25	] WATERTABLE
		SUBTOTALS	554.3			512.8		258	
CAT ISLAND	96000								
		OLD BIGHT	413.9	20	30	278	LEASED C.L.	138	8-10
		ARTHUR'S TOWN	770	50	35	500	LEASED C.L.		8-10
		DEVIL'S POINT TO McQUEENS:	9457.6	50	50				
						832	MOSTLY GRANTED	832	[1 8-10
						1400	MOSTLY GRANTED	710	8-10
		TEA BAY	50	30	25	14.5	PRIVATE	7	8-10
		SMITH BAY & BIGHT *	1797.7	30	25	337.3	CROWN LAND	2179	8-10
		SUBTOTALS	12489.2			3351		2179	
EXUMA ISLAND	71800								2-3
		FOREST	4914.4	47	45	1040	PRIVATE	350	] FEET
		GEORGE TOWN	3741.5	45	30	855	PRIVATE	351	] BELOW
									] WATERTABLE
		SUBTOTALS	8655.4			1895		701	

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		DELECTABLE BAY	770.2	28	40	300	UNGRANTED & CROWN LAND	300		
		POM PEG BAY	2840.1	27	45	1160	UNGRANTED & CROWN LAND	430		2-3 FEET BELOW WATER TABLE
		SUBTOTALS	3610.3			1461		730		
MAYAGUANA ISLAND	70400	AIR FIELD TO CENTER	659.6	30	30	330	UNGRANTED CROWN LAND		151	2-3 FEET BELOW WATER TABLE
TOTALS	677800		25968.8			7809.8	3061 CROWN LAND + 1219 PRIVATE LAND			

* FRESHWATER LENSES EXIST BUT FURTHER STUDIES ARE NEEDED
1] AREA CONSIDERED FOR SUPPLEMENTARY UNLIMITED IRRIGATION. OTHER AREAS ARE CONSIDERED FOR SUPPLEMENTARY LIMITED IRRIGATION

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D. TRAINING PLAN ON IRRIGATION AND LAND/WATER DEVELOPMENT

Concept

3.59 The most suitable training programs on irrigation-related matters that can be provided for the Bahamas are the tailor-made and specialized theoretical and practical programs relevant to the agricultural/engineering/managerial aspects of the curricula, which can be summarized as follows:

- Crops are produced on the calcareous soils of the Bahamas under three different systems of watering; (i) rainfall in areas of relatively deep groundwater tables, (ii) rainfall and groundwater tables in areas of relatively shallow water table and (iii) trickle irrigation systems (mainly drip).

- The only source of irrigation water in the Bahamas is a partially confined aquifer consisting of freshwater lenses overlying salt water. The utilization of such an aquifer through pumping should be practiced without upsetting the Ghyben-Hertzberg relation between the freshwater lenses and the salt water underneth.

- Commercial production of cash crops that needs supplementary irrigation is only possible at the moment in the northwestern islands. Crop production in the southeastern islands occurs mainly under rain-fed conditions, and LIMITED IRRIGATION can be provided to satisfy the domestic needs.

- The training should be provided at this stage to professionals with variable technical backgrounds such as agronomy, hydrology, engineering and meteorology.

- The participants are presently working in separate institutions belonging to the Ministry of Agriculture, the Ministry of Works and the Ministry of Transportation. Their numbers are limited, their responsibilities are intense and their institutions should not allow losing their services by enrolling them in long training programs.

3.60 Based on the preceding concept, three types of training programs are recommended:

(a) An in-country training program to be executed in the Bahamas,

(b) A long-term post graduate training program consisting of practical work to be done in the Bahamas and a theoretical

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part to be done overseas,

(c) A short-term visiting program to agricultural production projects that have more or less the same characteristics as the Bahamas.

3.61 The purpose of these programs is to give participants the techniques and knowledge to develop the groundwater resources for agricultural production, including pumping requirements, irrigation by automatic systems, natural supplies form shallow water tables, optimization of crop scheduling under rain-fed conditions, and land development.

a. Short Term In Country Training Program

3.62 An intensive in-country training program on land development and the optimization of agricultural water management is urgently needed, and should be carefully designed to suit Bahamian conditions. Developing such a program requires the integration of many agricultural/engineering/hydrological subjects. Unfortunately, the integration of these subjects is neglected in the curricula of universities or technical institutes, and, instead, each treated separately. The purpose of the recommended training program is to help bridge the gaps between these disciplines, by focusing on future projets considered by The Ministry of Agriculture of the Bahamas.

3.63 The outlines of the program, shown below, have been prepared to cover the project cycle, including: the identification, design, implementation, operation, maintenance and evaluation stages, as well as irrigation assistance to farmers.

3.64 The major advantages of holding such a tailor-made in-country program in the Bahamas are:

- the different government sectors involved will not lose the services of their staff for any period of time, since the program is aimed at finding solutions for the technical problems treated in the program as case studies, and

- training can be given to a large number of participants at less cost than sending them overseas.

Location of the Program: Abaco Island
Duration of the Program: Six Weeks
Number of Participants: From 10 to 24 participants, who can be selected mainly from the technical staff of the Ministry of Agriculture, as well as from any other institution involved.
Qualifications of Participants: University-level and middle level with some experience.
Year of Implementation: 1990

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Cost Estimates of the Program: foreign consultants, a hydrologist and an agricultural engineer are needed to prepare the manual, and to conduct the training program. Their costs are roughly estimated as follows:

Honoria:	12 men/week	US$ = 12 x 2000 = 24,000
Per Diem:	12 men/week	US$ = 12 x 1386 = 16,632
TOTAL (including the preparation of the manual)		= 40,632

Organization of the Program: A Senior Officer from the Ministry of Agriculture must be appointed as the Director of Studies. The Technical Assistance program of the Inter-American Development Bank may be used in financing the training needs.

Outlines of the In-Country Training Program on Land Development and the Optimization of Agricultural Water Management in the Bahamas

I. Hydrology of the Bahamas Islands

Water Balance in the Bahama Islands.
Geological Formation of the Bahama Islands.
Occurrence of Groundwater in the Bahamas.
Hydrological Characteristics of Groundwater on the Different Islands.
Mining of the Aquifer.
Evaluation of Groundwater Quality, with Regard to Irrigation.
Aquifer Management.
Optimization of Pumping Requirements.
Suitable Abstraction Rates from Groundwater to be used for Irrigation.
Control of Groundwater Quality.
Establishment of Water User's Organizations.
Case Studies on all the Northwestern and Southeastern Islands.

II. Land Development Projects in the Bahamas

Classification of the Calcareous Soils and their Land Capabilities.
Site Selection for Agricultural Land Development.
Land Clearing and Land Surface Preparation Practices.
Problems and Solutions Related to the Fertility and Management of Calcareous Soils.
Costs of Land Development.
Case Studies on Abaco and Mayaguana Islands.

III. Agricultural Water Management

A. Automatic Irrigation Systems
Design Procedure for Automatic Irrigation Systems.
Crop Water Requirements

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Irrigation Uniformity and Efficiency.
Irrigation Water Requirements.
Water Distribution to Plants.
Irrigation Intervals.
System Capacity and Pumping Requirements
Basic Hydraulic Concepts Related to Flow Regime.
Characteristics of Distributors.
Design of Pipe Network.
Selection of Irrigation Equipment.
Selection of Pumping Units.
Installation of Wells and Infiltration Galleries.
Installation of Automatic Irrigation Systems.
Operation and Maintenance.
Cost Estimates of Irrigation Methods.
Evaluation of Irrigation Projects.
Establishment of Water User's Organizations.
Case Studies on Abaco, Mayaguana and Cat Islands.

B. <u>Traditional Watering Regimes</u>

Rain-fed Agriculture.
Rain-fed Capillary Water Supply From Shallow Groundwater Table.
Improvement of Traditional Watering Regimes.
Site Selection.
Selection of Crops, and Their Critical Growth Stages.
Optimization of Crop Scheduling.
Development of Thin Freshwater Lenses.
Provision of Limited Irrigation.
Water Conservation.
Case studies on North Eleuthera, Mayaguana and Cat Islands.

b. <u>Long Term Post Graduate Training Program</u>

3.65 The problems of the water demand and supply related to crop production that have been analyzed in this report can be used as a reference for overseas training. Specific problems should be selected for study in post graduate studies (M.Sc and the Ph.D. programs).

3.66 The program must be designed according to the needs of the agriculture of the Bahamas. A limited number of the present technical staff should be selected for the studies to be done in the Bahamas and abroad. The field work should be carried out in the Bahamas, and the supervisor must follow their execution through short visits. After completing the field work, the student can join his/her supervisor at the university for about five semesters which will be spent in processing the data, attending the required theoretical courses, reviewing the literature and defending his/her thesis.

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3.67 In this way, two birds can be killed with one stone. The first goal is the practical training provided to the post graduate student, in the form of a higher academic degree. The second goal is solutions for the major problems encountered in crop production in the Bahamas, instead of studying non-relevant problems of interest to other countries. In this way, an excellent FEASIBILITY STUDY could be produced in the form of a THESIS.

Location of the Program Universities located near the Bahamas, such as southern or western us universities involved in carrying out research programs relevant to Bahamian conditions.

Duration of the Program Approximately 3 years, including 5 semesters on campus.

Number of Participants Their qualifications: post-graduates can be enrolled at once under such a program. They can be selected from the technical staff of the Ministry of Agriculture, the Meteorological Department of the Ministry of Transport, and the Water & Sewerage Corporation of the Ministry of Consumer Affairs. The major fields recommended for study are"
(a) Agro-hydrology (developing the groundwater resources in small oceanic islands to satisfy the irrigation requirements).

(b) Irrigation Engineering (design, operation and monitoring of automatic irrigation systems).

(c) Soil & Water (developing and managing calcareous soils).

(d) Agro-climatology (water balance studies & crop irrigation requirements).

Year of Implementation The 1990 / 1991, fiscal year if possible.

Estimated Costs for the Program

Tuition fees for one student for 3 years		US$54,000
Accommodation costs for one student for the five semesters to be spent on campus		US$15,000
Travel Costs		US$ 2,000
TOTAL COSTS		US$71,000
Total cost the four students	US$284,000	

The government of the Bahamas will pay the salar of the student/civil servant during the study period.

c. Short Term Visiting Program:

3.68 The Government of the Bahamas has received numerous invitations to visit agricultural projects in many countries.

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These invitations can be directed towards visiting irrigation and groundwater development projects.

Countries to be Visited: USA, Taiwan, Japan, Australia and Israel.

Duration of the Visit: Two to three weeks

Qualifications: The candidates should be selected on the basis of their abilities to profit from training and not only grade, seniority or academic qualifications.

Cost Estimates: None.

IV. RECOMMENDED GUIDELINES AND POLICY ISSUES

A. GUIDELINES FOR AN EFFICIENT AQUIFER MANAGEMENT

Balancing the Aquifer

4.01 An aquifer in any of the Bahamian Islands should be looked upon as a repository for water. If there is the opportunity for public sector control, it can be operated as a reservoir or a mine. Which in closen depends largely on the degree to which explotation is balanced by replenishment.

4.02 For part of the year, when rainfall is available, or when crop demands are low, the induced recharge will have zero farm opportunity cost and irrigation at this time would be a waste. In most circumstances, induced recharge will have a positive opportunity cost and any decision models for listing operating policies should include this assumption. There should be that trade-off, between quantity pumped and consequent soil water depletion.

4.03 The concept may be extended further in that it is not strictly necessary to balance the recharge from season to season. If, in the longer term, an overall balance is achieved, then it might be possible to develop an optimal regime for the operation of the groundwater reservoir, which allows a great degree of flexibility. This, if there is sufficient data on rainfall and infiltration rates, the groundwater can be operated to achieve a long-term balance, and, hence, allow a greater average volume of total water to be utilized than would otherwise be possible.

Mining the Aquifer

4.04 In the event that there is limited replenishment of the aquifer, it is then necessary to consider mining. A similar situation exists when the recharge will be insufficient to meet the

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irrigation demand. Such a process cannot go on indefinitely. It is possible to argue that equilibrium will eventually be established without public interface and that efficient farmers will then pump recharge. Such a conclusion ignores inter alia the additional costs of pumping the recharge, the possible loss of storage capacity and the incidence of benefits.

4.05 When a longer period of groundwater development and mining takes place, the extraction exceeds recharge and water levels in the wells fall upsetting the Ghyben- Herzberg relation described earlier in this report. Therefore, mining, if needed, should be included in planned development only on a termporary basis. Permanent mining is usually the result of intensive, but unmanaged groundwater development. It is not simply on small farms that socially sub - optional pumping policies would be expected to take place. Well-informed farmers operating high profit systems can fail to recognize their collective interest. In some aquifers located in other countries, this mining has led to land subsidence. Therefore, some relevelling costs were incurred, but not necessarily by those who benefited from the original mining, and there is a permanent loss of aquifer capacity. By virtue of its uncontrolled nature, the effects of such mining cannot be predicted except in general terms. One can forecast, for example, little more than that freshwater sources will be salinized and that water supplies will fail because of base flow depletion.

4.06 The problem of mining groundwater can be treated economically in the same way as any other exploitable resource. When there is some element of recharge, the cost of mining will include two components. The first is the cost of pumping the quantity of water mined. The second is the extra cost of pumping any annual recharge through the extra head which results from the mining. If the total cost of mining is less than the net present value of the water derived, the mining is economically justified. In assessing the benefits, it should be noted that it is the marginal, not the average, return on the mined water used on farms that is relevant. In that regard, a study should be made on the economic assessment of mining by modelling both the aquifer behavior and the proposed agricultural production system by using a suitable programming approach.

<u>Efficiency of Groundwater Use</u>

4.07 The issue of efficient use of ground water for irrigation purposes is important to the welfare of Bahamian farmers. The concept that the government could easily control pumping has been superseded in many countries by the reality of farmer control. Experience gained from other countries has shown that even when is controlled by the goverment the management problems have been too difficult for existing irrigation bureaucracies to resolve satisfactorily. It is recommended that the government of the

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Bahamas encourage the farmer objective of some control over the water allocation process. Since farmer participation will inevitably require cooperation among farmers, the need for development of water users organizations in the Bahamas should become top priority when implementing the project. The Ministry of Agriculture is advised to execute a program of research on cooperative use of water, which could prove highly productive in terms of improved understanding and more effective irrigation projects.

4.08 An essential condition for the efficient management of groundwater in irrigation is that the water used be measured. Devices for measuring water in closed conduit (piped) irrigation systems, such as the drip, are generally flow meters which are inserted into the pipe line, typically at the head of the farm or the field unit. They are generally usually with gauges showing cumulative discharge in cubic meters. Among the more sophisticated modern devices are metering valves, capable of automatically shutting off after delivering a pre-determined volume of water. Such devices (each controlling a particular vegetable field or orchard) can be arranged to operate in sequence, in a programmable manner. In addition to helping to achieve economical water use, such valves are important as labor saving devices. Where nutrients are applied through the irrigation system, these valves can help control the rate of ferilization, as well as of irrigation. Such devices are most useful in large-scale drip and micro-sprayer systems, but may be too expensive for small-scale irrigation.

4.09 When using irrigation and water use efficiency to define the financial return in relation to the investment in the water supply, an important problem will arise. The problem is that some of the costs of irrigation, and certainly some of the benefits, cannot easily be quatified in tangible economic or financial terms, especially in the Bahamas, where a market economy is not yet fully developed. Only the short-term costs and immediate benefits are discernible, whereas the long-term advantages or disadvantages are unknown. It is difficult to assign a monitor value, for example, to the possibility that an irrigation project might save the production of a region from the dire effects of a drought, if the frequency or probability of drought of various degrees of severity cannot be determined. However, Bahamian irrigators are paying the costs of operating and maintaining their irrigation systems.

4.10 The farmer pays the operating and maintenance costs required to irrigate his field by pumping. Therefore, it is advisable to establish irrigation rights. There is an urgent need for research to devise appropriate legal frameworks for the development of groundwater used in irrigation, in order keep the momentum going.

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Developing the Shallow Freshwater Lenses

4.11 In some areas of the Bahaman Islands, sub-surface conditions, wich include the presence of thin aquifers or a thin freshwater layer underlain by saline water, preclude ground water development. In such areas, an infiltration gallery can be considered as a horizontal well or sub-surface drain that intercepts underflow in permeable materials or infiltration of rainfall. A gallery may be a source of an adequate and suitable water supply. Where aquifer materials have good permeability, such The those in the Bahamas, the gallery can be placed in the direction of flow of the groundwater, and at a depth which will preclude draw downs great enough for saltwater to come up to the gallery.

4.12 Infiltration galleries are usually constructed to discharge into a sump whose bottom is some distance below the invert of the gallery screen and casing. The sump may be of almost any dimensions, but commonly is a circular or square structure 120 to 240 cm in diameter or on a side. Depth should be adequate to permit the sump bowls to be set with adequate submergence and clearance. The sump is usually cased with concrete or corrugated culvert pipe, although wood shoring, brick, or concrete block have been used in many countries. The bottom is sealed with concrete or a metal plate. The top is finished with a reinforced concrete slab with manhole for inspection and cleaning and a hole though which the pump is installed, as shown in Figure (3). The conductor pipe, usually corrugated pipe, leads from the sump, to which it is tightly sealed, to the screen or manifold of the gallery. It may be horizontal or slope slightly downward toward the sump. After the gallery installation, the trench should be completely back-filled.

4.13 In any infiltration gallery, the design should provide for an average entrance velocity of 10 cm per second or less. The smaller the entrance velocity, within economical and physical limits, the better. Depth beneath the minimum water surface should be as great as physically possible and economically practical. Permeability and sorativity of a natural aquifer should be determined by pumpout tests. Recommended minimum diameter of screen and conductor pipe is about 45.0 cm. If sealing by sediments, and the resultant decline in yield, are to be expected, infiltration galleries should be over designed by increasing the screen diameter or length to compesate for decline in yield. When a gallery is installed to skim freshwater from a saltwater wedge or lens, as shown in Figure (4), the gallery should be placed according to the prevailing direction of flow. The equations recommended by the US Department of the Interior (1981) can be used to determine the yield per foot of length of the gallery and the maximum distance"s" between the water table and the top of the screen.

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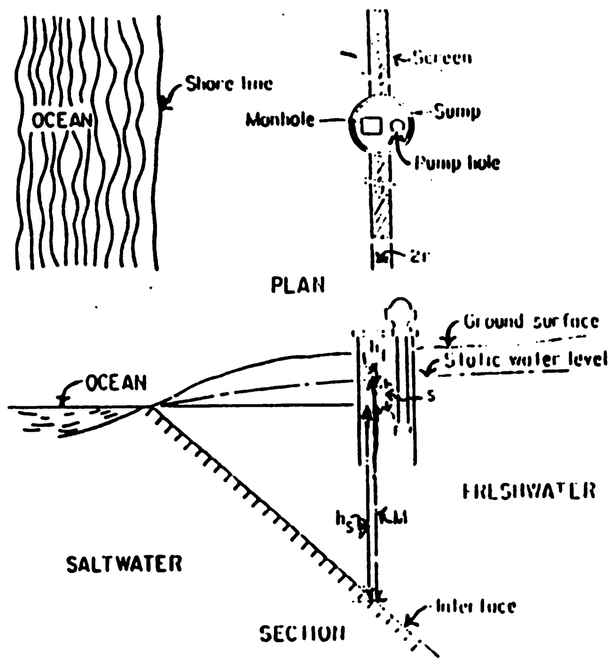
(4). Schematic Section of an Infiltration Gallery Constructed to Obtain Freshwater Near a Seacoast.



epth to the interface is about 30 times the distance water table and mean sea level or the saltwater surface at the point of measurement. For example, if et, the interface would be about 114 feet below the If an infiltration gallery lowered the water table would be 0.5 foot and the saltwater could come up to below the draw down.

ltwater - freshwater interface is not a sharp contact an conditions, but rather a zone of brackish water fresh and saltwater bodies. Approximate saltwater may be determined by installing a piezometer below zone; slowly pump or bail water out of the casing ompletely filled with saltwater, and permit the level . The water table elevation can be determined in a vation well. The shallow freshwater table elevation, evation of the point head of saltwater equal Hf.

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Water Quality Evaluation with Regard to Irrigation

4.16 In determining water availability for irrigation, information is required on both the quantity and quality of the water. Experience in water use has given rise to "degrees" of acceptability which allow an assessment of the suitability of various types of water for a particular use. With sufficient worldwide experience this knowledge has been organized over almost 50 years into guidelines for evaluating irrigation water quality. Ground water often presents quality problems, which can be interpreted by reference to any of the previously established standards. Use of such an approach to the problems involved in diagnosing and controlling water quality implies that there is confidence in the quality standards which have been set.

4.17 The commonly used water standards in the Bahamas are those used by Little et al (1977) to evaluate the groundwater resources for potable water usage. They have determined the thickness of freshwater lenses and recommended abstraction rates based on restricting pumping to sections of the lens that have a chloride content of about 400 ppm. The main problem with such a definition lies with irrigation water standard that use the electric conductivity expressed in total dissolved solids, and not in a single onion such as chloride. Moreover, the standards for irrigation water are based on agricultural concepts that can not be substituted by potable water standards.

4.18 The standards for irrigation water were established in the 1954 Handbook 60, issued by the US Salinity Laboratory, and further refined in 1976 in the FAO Irrigation and Drainage Paper no.29. The standards recommended are:-

Good	0- 700 ppm
Marginal	700-2000 ppm
Hazardous	over-2000 ppm

Also included are standards for alkalinity, as measured by the sodium absorption ratio (SAR), and for toxic elements such as boron, chloride and sodium. In all cases. It is now well known that crops can be grown with much worse water qualities, under certain circumstances. Further move; in the highly permeable calcareous soils in the Bahamas, alkalinity is not a problem. Even the boron standards included in these guidelines were the results obtained from spot trials. It is established that in the field rather higher levels can be tolerated. To illustrate this problem, it is stated in World Bank Paper no.496 (1981) that vegetables were observed on light soils in Pakistan, growing with water of 3000 ppm and that in Bahrain, under arid conditions acceptable crops were growing with water of 7000 ppm. After reviewing worldwide experience in the use of saline irrigation water, Fireman (1968) concluded that "it is clear that there are no absolute critical

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salinity, SAR or any other chemical property of water
e the economic utility of water supply. Within
imits, water of virtually any character can be used for
levelopment of lands."

ugh there is a considerable body of the literature on
there is an urgent need to produce in this report a
'ised standards and technical recommendations for
regimes, so that attempts at groundwater control can
a rational basis. There is no doubt that with poor
y cropping problems can be expected. Special water
ractices will then be required to maintain full crop
. In addition to salinity, other problems result from
r of poor quality. A toxicity problem occurs when
tituents in the water (mentioned before) are taken up
and accumulate in amounts that result in a reduced
ous other problems related to irrigation water quality
with sufficient frequency that they should be
noted.

e white deposits on fruit or leaves due to sprinkler
ith high bicarbonate water.

suitability of a type of water, from a quality
is determined by its potential to cause problems, and
o the special management of irrigation water quality
mally encountered and which materially affect crop
Emphasis should be on the long-term influence of the
ty on the soil-water-plant-system, as it affects crop
d soil and water management. In that regard, several
ve been produced. The ones suggested by Ayers and
), shown in Table (9), are practical and can be used
rigated agriculture, for evaluation of the more common
in underground water. They are intended to cover a
conditions in irrigated agriculture and incorporate
cepts in soil-water-plant-relationships, as recently
However, these guidelines are based on certain
nd they should be adjusted if the water is used under
ons such as those of the drip irrigation used in the

eceding brief discussion and Table ( ) have presented
ols for evaluating the suitability of water for
If a potential problem is predicted, practices may
adopted that will delay, correct, or prevent its
The major objective choosing a management alternative
a salinity problem is to improve soil water
to the crop. Some of the management practices
ating without overpumping-more frequently to maintain
te soil water supply to the crop; applying a method
such as the drip, which will give better salt control

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and planting crops that are tolerant for an existing or potential salinity.

4.22 There is an approximate 10-fold range the in salt tolerance of agricultural crops. This wide choice of crops greatly expands he usable range of water salinity for irrigation, and emphasizes the fact that water quality is specific for the intended use. If a potential water salinity problem is indicated, suitable crops can often be selected that are tolerant to the expected salinity.

Table (9). GUIDELINES FOR INTERPRETATION OF WATER QUALITY FOR IRRIGATION

IRRIGATION PROBLEM	DEGREE OF PROBLEM		
	NO PROBLEM	INCREASING PROBLEM	SEVE[RE] PROBLEM
Salinity-affects water availability to crops ECw in mmhos/cm	<0.75	0.75-3.0	>3.0
Specific Toxicity- affects sensitive crops Sodium 1J2J(adjusted SAR)	<3	3-9	>9
Chloride 1J2J(mg / 1)	<4	4-10	>10
Boron (mg / 1)	<0.75	0.75-2.0	>2.0
Miscellaneous Effects-affects susceptible crops NO 3 -N(or) NH 4- N(mg/1)	<5	5-30	>30
[overhead sprinkler]- HCO 3 (mg/1)	<1.5	1.5-8.5	>8.5
pH	normal range = 6.5 to 8.4		

Note:
1/ Most tree crops are sensitive to sodium and chlorides (use values shown). Most annual crops are not sensitive (use the salinity tolerance tables (Table 10). The adjustment needed to suit the Bahamian conditions can be made after considering the basic assumption used in these guidelines:

(a) Use of water: the climate is semi-arid where effective annual rainfall is low (these guides, therefore, may need adjustment for the Bahamas where high rainfall occurs part of the year). Full production capability of all crops is assumed when the guidelines

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indicate water quality is not a problem. The existence of a potential problem indicates that the use of certain tolerant crops may be necessary to maintain full production capability and does not indicate the water is unsuitable for use on any specific crop.

(b) Method of Timing of Irrigation: irrigation methods which applie water on an "as needed" basis such as sprinklers, are assumed. The guidelines are believed to be too restrictive for drip (trickle) irrigation and high frequency (near daily) sprinkler irrigation.

(c) Degree of Problem: Ordinarily no soil or cropping problem due to water quality would be experienced when using water containing less than the values shown for "No Problem" in Table ( ). On the other hand, if water is used which equals or exceeds the values shown for the "Severe Problem", the water user would commonly experience cropping problems associated with using the poor quality water. With water quality values between these guides, a gradually "Increasing Problem" should be experienced as the water quality deteriorates.

Crop tolerance tables for representative field, vegetable and tree crops that can be grown in the Bahamas are given in Table (10). These incorporate older data from the crop tolerance tables of the US Salinity Laboratory (USDA, 1954), data from Berustein (1964), and data from the University of California Committee of Consultants (1974) that have been updated on the basis of data by Mass and Hoffman (1976), and data by Ayers and Westcot (1977). Table ( ) includes the expected yield reduction of 0, 10, 25 or 50 per cent due to effects of increases in irrigation water salinity (ECw). It must be recognized that actual production, with water of the quality indicated, can range from the full 100 per cent down to 50 per cent, depending upon any one of many factors other than water quality. The values given in Table ( ) represent the maximum production potential for the quality of water, under the assumed conditions of use.

4.23 A toxicity problem is different from the salinity problem. Toxicity occurs within the crop itself, as a result of the uptake and accumulation of certain constituents from the irrigation water, and may occur even though salinity is low. The toxic constituents of concern are sodium, chloride or boron. They can reduce yields and cause crop failure. Not all crops are equally sensitive, but most tree crops and other woody perennial-type plants are. Toxicity problems of sodium and chloride, however, can occur with almost any crop if concentrations are high enough.

4.24 Overhead sprinkling of certain crops can cause special toxicity problems not encountered when irrigation is provided by other methods such as the drip. Excess quantities of sodium and chloride can be dissolved through leaves wet by the sprinkler, causing leaf burn and, in some severe cases, defoliation. This

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occurs primarily during periods of high temperatures and low humidity, and with a rotating type of sprinkler heads. In between rotations of the sprinkler, water evaporates and salts are concentrated. The leaves absorb appreciably more salts during this alternate wetting and drying cycle than if sprayed continuously. Night sprinkling practiced in other countries has been found surprisingly effective in reducing or eliminating the sodium and chloride toxicity due to foliar absorption. Humidity generally rises at night and winds may decrease. Frequent or continuous wetting results in less absorption than intermittent wetting. Increasing the speed of the rotation of sprinkler heads by using heads that rotate at one revolution per minute is recommended.

4.25 From the standpoint of the guidelines shown in Table (9), nitrogen and carbonate may cause specific problems. The management practice which is effective if irrigation water is high in nitrogen is based on the nitrate and ammonium - nitrogen occurring in irrigation water is readily available to crops. Therefore, fertilizer nitrogen rates supplied to crops should be reduced by an amount very nearly equal to that available from the water supply. Ammonium - nitrogen is seldom present at more than one mg per litre unless large amounts of ammonia fertilizer are being percolated to the groundwater. The management practice for correction of the white deposits, if they appear under sprinkler irrigation, would be; (i) to irrigate at night during critical periods, (ii) if sprinklers rotate too slowly, to increase the speed of rotation, (iii) not to sprinkle during periods of very low humidity, and (iv) to change the irrigation method.

Proposed Agricultural Projects in the Bahamas and Their Environmental Impacts

4.26 International financial institutions have been paying more and more attention to environmental issues in agricultural development projects. In a paralell way, but having started earlier, universities and agricultural engineering schools have introduced the subject of environment into the curricula for such areas of study as agronomy, engineering and hydrology. Given the peculiar characteristics of soil and water in the Bahamas, the study of the environmental impact of agricultural practices in the country calls for careful consideration and very specialized treatment, especially when irrigation utilizing groundwater is envisaged.

4.27 The agricultural, engineering and hydrological issues studied in this report lead to the conclusion that the contamination of groundwater by agrochemicals is very unlikely in the project areas,in the northern and the southeastern islands due to the following brief analysis:

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TABLE (10).EXPECTED YIELD REDUCTION FOR THE PARTICULAR CROP DUE TO INDICATED SALINITY OF IRRIGATION WATER

CROPS	Expected Yield Reduction at ECw* Indicated 0%	10%	25%	50%
FIELD CROPS:-				
Soybean (glycine max)	3.3	3.7	4.2	5.0
Sorghum (sorghum bicolor)	2.7	3.4	4.8	7.2
Groundnut (arachis hypogaea)	2.1	2.4	2.7	3.3
Sesbania (sesbania macrocarpa)	1.5	2.5	3.9	6.3
Corn-grain or sweet (zea mays)	1.1	1.7	2.5	3.9
Cowpea (vigna sinensis)	0.9	1.3	2.1	3.2
Beans-field (Phaseolus vulgaris)	0.7	1.0	1.5	2.4
VEGETABLE CROP				
Tomato (lycopersicon esculentum)	1.7	2.3	3.4	5.0
Cucumber (cucumis sativus)	1.7	2.2	2.9	4.2
Cantaloupe (cucumis melo)	1.5	2.4	3.8	6.1
Cabbage (bressica oleracea capitata)	1.2	1.9	2.9	4.6
Potato (solonum tuberosum)	1.1	1.7	2.5	3.9
Sweet potato (ipomea batatas)	1.0	1.6	2.5	4.0
Pepper (capsicum frutescens)	1.0	1.5	2.2	3.4
Lettuce (lactuca sativa)	0.9	1.4	2.1	3.4
Onion (alluim cepa)	0.8	1.2	1.8	2.9
Carrot (daucus carota)	0.7	1.1	1.9	3.1
FRUIT CROPS:-				
Grapefruit (citrus paradisi)	1.2	1.6	2.2	3.3
Orange (citrus sinesis)	1.1	1.6	2.2	3.2
Lemon (citrus limonea)	1.1	1.6	2.2	3.2
Avocado (persea americana)	0.9	1.2	1.7	2.4

*ECw means electrical conductivity of the irrigation water in millions hos per centimeter at 25 degrees celsius.

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- The very low amounts of agrochemicals to be applied on the huge volume of groundwater that could result in a negligible concentration which can not exceed by all means a slight fraction of one part of million.
- The Bahamian groundwater is stored in a limestone aquifer and, as a result,is generally high in CaCO 3 content (generally described as hard-water), as can be observed from Table (12) of the Appendix. The agrochemical inputs reaching groundwater, if any, through rainfall will be subject to changes due to chemical reactions with hard water

- The hydrological characteristics of small oceanic aquifers such as those of the Bahamas are governed by the Ghyben-Hertzberg relation. These aquifers are partially confined, and the water table is affected daily by tidal movements. The effective recharge from rainfall flows downward and outward to the ocean, which will result in no accumulation of agrochemicals.

- The zone of the potential agricultural land to be put under supplementary, unlimited irrigation pumped from groundwater is going to have a relatively lower water table than the surrounding zones, during pumping. That results in an inward groundwater flow (recovery) to reach an equilibrium with the water table in the well field. Agrochemicals, if they exist in ground water, will have no chance for any outward movement. The hydraulic gradient in Darcy's Law governs the movements of solubles as well as suspended chemicals.

- The lense on the northwestern islands, where large scale commercial production is expected, are continuing lenses of an area equal to three times that of the potential agricultural land. The results in more dilution.

- The commercial producers in the Bahamas export their products mainly to the USA. The large-scale farm which have been visited comply with the standards of the US Federal Environmental Agency, which evaluates any contamination in the exported fruits, and they are keep to safeguard the entry of their products.

Water Quality Control with Regard to Irrigation

4.28 Saline water intrusion due to overpumping can be a problem in some coastal regions where sea water has access to an aquifer. Excessive pumping of fresh water causes a wedge of sea water to become even more saline. In many cases, the fear of this occurring is more common than the actual occurrence of the phenomenon, but, nevertheless, the possibility always exists.

4.29 In ideal circumstances, the shape of the intrusion is known as the Ghyben-Herzberg wedge. The extent of the wedge, from an irrigation point of view can be defined in each area through mathematical models. Many advanced models for this purpose have

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been developed recently. Many solutions have been tried in other countries to compact saline intrusion, such as creating a hydraulic potential to hold the wedge back, and balancing the inflow. A suitable possibility to reduce the rate of intrusion is to reduce pumping in the aquifer itself. With the aid of a model, one or a combination of some of these possibilities, may prove to be an economical option.

4.30 Another form of intrusion is the invasion of one aquifer by water of inferior quality from another. This can happen when an aquifer, is over-pumped and the piezometric pressure is seriously reduced, causing the water to move from an adjacent aquifer which was previously in equilibrium before pumping started. Such a situation can occur where water from a lower saline aquifer is up-welling into the overpumped upper aquifers. Again, the use of a model is almost essential to defining the conditions and to testing possible solutions for each island.

4.31 The problem with saline intrusion is that by the time the condition is recognized, the damage has been done. In principle, it is possible to exercise some control to prevent the conditions from spreading. However, often the optimum pumping regime of individual well owners will result in a well field pumping pattern which is so far removed from a socially optimum pattern. Indeed, it can lead to rapid deterioration.

4.32 The matter of aquifer management has been touched on before, comparing the problems involved in the private and public development options. It has been concluded that only the public sector can hope to manage the aquifer. Even at the government level, the problem is expected to be considerable. The institutions are inadequately established, from an irrigation point of view, and the legal framework is non-existent. Hopefully, when the projects are finally in place the situation will be a little better in that the Project Director may have sufficient knowledge and sufficient power to exerciee some control. It is worthwhile to mention here that it is doubtful whether aquifers are really managed effectively anywhere outside the western world, although some attempts have been made after severe problems are encountered. Then, inefficient measures are often adopted, for example, all new well construction is prohibited. However, the more recent deep wells still continue to be pumped and wells continue to be salinized.

B. RECOMMENDED GROUNDWATER INVESTIGATION PROGRAM AS A SOURCE OF IRRIGATION

a. National Master Plan for Land and Water Development Project

4.33 Programs related to land and water development in the Bahamas are being prepared separately by different ministries. As an example, the Water and Sewerage Corporation of the Ministry of

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Consumer Affairs has prepared plans to exploit further reserves for potable water pumping, as shown in the Maps of Potential Agricultural Lands of the Appendix. Many of these reserves can be developed to become prime agricultural land such as those in North Andros, and other, non-potential agricultural land, can be used as potable water reserves. The potable water reserve areas were prepared in a time when agricultural development was not given special attention. Moreover, urban development is extending into all areas, even those that can be developed for agricultural productio. The situation in New Providence Island, where the capital city Nassau is located, is a clear manifestation of the problem.

4.34 Not only government institutions but also some international organizations are coordinating these plans. A clear example is FAO study on forestry that was prepared by only foresters, without any agricultural or engineering participation. The FAO plan was submitted to the government almost two years ago, and is still under review. The prime forest land areas located over the center of the freshwater lenses are considered, from an agricultural point of view, good pine forest soils, which are the easiest to break and prepare. When ground water becomes the only source of irrigation water, the impact of pine trees existing over the center of a lens is expected to be negative due to their high evapotranspiration demands.

4.35 In addition to governmental institutions and international organizations, the private sector has its own plans. For example, the Port Authority Company has leased a major part of Grand Bahama Island for urban development, as well as for some agricultural development allocated to private Bahamian and foreign farmers. Grand Bahama Island possesses all potentialities for agricultural development that can be done paralell to the urban development if being well coordinated.

4.36 Therefore, it is important that the Ministry of Agriculture initiate a master plan for land and water development for the Bahamas. The Master Plan should coordinate and integrate the separate plans of all concerned ministries, after setting development priorities, in order to avoid any conflicts in the future.

b. <u>Investigations Needed for Groundwater and Land Resources</u>

4.37 As mentioned earlier in this report, the major groundwater studies on the Bahama Islands were made some 18 to 20 years ago by Little et al (1977). These studies, were made to the develop the ground water asa souce of potable water, not for irrigation. These studies covered major parts of the islands, but did not includ other areas considered to have potential lenses, such as the southern parts of Andros, Acklins and Eleuthera islands. However, the attainable results have provided very useful information that

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can be used in planning a groundwater investigation program oriented toward irrigation which should be under the supervision of the Ministry of Agriculture as soon as possible.

4.38 An essential idea that should be keptinminal in the study is that a minimal amount of data could satisfy the needs of resource planning for irrigation purpose. It is important to avoid gathering massive data, amounts of a process which is expensive and may provide much useless information. The terms of reference for the studies needed should be severely limited so that only work directly concerned with the objectives of the study - agricultural development - is requested. Specific information should be extracted from the Little et al report, to be studied further, such as, the impact of the low aquifer capacity of Eleuthera island and salinity development, the best development methods for the water lenses of Andros island and to what extent the demands of agricultural and domestic uses can be combined, the possibility of expanding the Deadman's Cay and the feasibility of closing off the saline creak north of the settlement to see if the natural lenses can be enlarged by artificial means, in Long Island, the possibility of introducing infiltration galleries to develop shallow water lenses similar to those of Cat Island, further test drilling to the unexploited areas similar to those located to the west of Hardhill and Andersons in Acklins islands.

4.39 Clear thinking at this stage can save time and money. The question that should be firmly posed is "How can these studies be reduced in time and extent, and yet still meet the objectives?" A detailed knowledge of the potential aquifers more than 40 feet thick on the northwestern islands and more than 20 feet on the southeastern island; thickness, permeability, transmissivity, leakange from overlying and underlying formations, piezometric levels, storage and recharge characteristics, pumping records, and all spatial and temporal variations in these parameters, are needed. Knowledge of water quality for irrigation purposes is essential, and isanissue dealt with elsewhere in this report, where international standards are questioned. Generally, quality varies with depth, and it is necessary to try to define limits for abstraction rates, so that the pumped water is suitable for crop production under either the sprinkler or the trickle irrigation methods.

4.40 Obtaining such information is still considered costly, and involves drilling additional bore holes and taking water samples from all at various depths. It requieres considerable judgement to define the location of such bore holes and sampling intervals, to ensure adequate information. Observations such as detailed lithology, geophysical logs and chemical analysis should be routine. More care in required regard to pump tests, which can become costly if long-term tests are specified, or if aquifer property testing involves drilling a number of piezometers. Generally, these can be avoided if a groundwater system model is

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not required, because often the most important information is the performance of the well.

4.41 Beyond the implementation of the project, there is a need for monitoring. Again it is important to beware of apparently endless data gathering, and only collect that information which can and should be analyzed. This would include the performance of the wells in terms of specific capacity and the quality of products produced. The plan include the following studies:

Topographic Surveys and Maps

4.42 Although topographic maps may not be necessary for all ground water studies, an appreciation and understanding of topography are useful. For some reconnaissance studies, either a good planimetric map or aerial photographs may be used in the field study, instead of a topographic map. However, for more detailed studies, good topographic maps are a necessity. Such maps supply information on surface gradients, and are used as the basis for construction of wells and abstraction pits and maps showing depth to water, water table gradients, contribution of recharge areas, and related features and phenomena. Depending on the type of terrain and the detail required, scales on satisfactory topographic maps range from 1/2-inches to the mile (1:126,700), to 4-inch to the mile (1:15,000). At times, maps with a scale of 1-inch to 400 feet (1:4,000) may be desirable for the detailed study of local phenomena within larger areas of interest. Desirable contour intervals range from 1 fcot in areas of low relief or for large-scale detailed maps, to 25 to 50 feet for rugged areas or small-scale maps.

Water Table Surveys

4.43 Results of water table studies reflect the prevailing balance between the different groundwater recharge/discharge components. As the balance changes, so does the water table level. To what extent the water is permanently or seasonally too close to the ground surface has to be known. The frequency of depth to water table measurements depends on the particular problem being studied, but in general the readings should be made monthly for one full year cycle in rain-fed areas, and daily for two pumping events once in both of the dry and wet seasons. The objective of the measurements should be to establish a record of the water table fluctuations over a period of time that will reflect all factors affecting the water table. In water table surveys, interest is primarily in long-term, seasonal variations (short-term fluctuations after rain or pumping) should be studied separately and should be identified adequately by observations at a few selected sites on key dates.

4.44 Water table levels (Phreatic levels) may be measured in bore

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holes reaching well into the ground water. These observation wells may be placed in a grid or another regular pattern, although the groundwater flow pattern in the area should also be taken into consideration. Groundwater flow will generally be down the slope, toward depressions. A few judiciously located observation wells may give as representative a picture of the phereatic surface as the obtained with a dense grid system. Open water levels in excavated wells are also closely related to the phreatic surface, and, therefore, should be included in the study. During periods of discharge, these (wells tend to be lower than the water tables) in the adjoining land. Only when there is static equilibrium (several hours or a few days after rain) are these levels more or less the same. Water table wells provide no information on potential differences within the groundwater body. Where some differences are expected to occur, piezometers should be used instead. Piezometers measure the pressure in a body of water at the point where its filter is placed. Satisfactor diagnosis and solution of groundwater conditions will require information on the substrata beyond some 6 to 15 feet whereas groundwater extends down to saltwater depths that differ from lens to lens.

4.45 The mere gathering of groundwater data is a needless expense unless it is followed by plotting the data for study and interpretation of the results. Water table data should be analy to provide information on the water table regime, rates and directions of groundwater flow, groundwater sources and sink, regional and temporal trends of change, etc. For this purpose, the available data must be compiled in suitable graphs and maps such as: Hydrography, groundwater table contour maps, depth to groundwater maps, water table profiles, and piezometric profiles.

Water balance Studies

4.46 Generally, enough data and information on groundwater should be collected to draw up a groundwater balance for the area, a distinction should be made between the situation with and without the project. The water balance components to be studied are: - Continuous records of rainfall should be made within the areas oonsidered in this report as potential agricultural lands and a recording type of rainfall should be established and the effective rainfall should be estimated. Recharge by rainwater and the effective rainfall can be deduced from water table records (water table hydrography).

- Recharge by deep percolation losses, if any, from irrigated fields. This component would vary for different soils, irrigation methods and level of farm management.

- Studied possible seepage patterns and seep areas should be undertaken to arrive at quantitative estimates of seepage influx rates. Directions and flow of groundwater to the sea and the

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natural sinks of the area may generally be derived from water table contour maps and water table profiles, together with information on the geological/soil formation underlying the potential groundwater lenses.

- Any occurrence of high concentrations of salts in the ground water in the Bahamas would result from upsetting, via over pumping, the interface between salt water and fresh water of the aquifer. Therefore, the proposed study should determine the current location of the interface under each lens, the expected hazards for future groundwater salinization and the basis of a program for groundwater salinity control. New abstraction rates for pumping have to be established after taking into consideration the irrigation requirements, the irrigation systems, and the crop tolerance. The main diagnostic parameter recommended for classifing the groundwater salinity should be electric conductivity, instead of determining the chloride, as commonly used in the Bahamas.

- Direct evaporation and pumping from groundwater should be studied. The first component becomes significant when water tables are close to the soil surface and orders of magnitude can generally be established by calculation methods. The second component should be determined on the basis of operation surveys and measurements. The contribution of each component, and the balance between recharge and discharge components, may vary in time, as well as per subarea.

iv. Simulation Models

4.47 Simulation models of groundwater systems may be appropriate or not. The main reason for this is that the base data are often inadequate to construct even a sufficiently accurate representation of a static physical system. Historic records of water levels, recharge and discharge are in most circumstances do not come up to the standard needed to provide a reasonable simulation of the dynamic system. It is only by demonstration or validating the model to produce the present water table level patterns (piezometry), using historic inputs and pumping data, that it would be possible to use it confidently as a productive tool with. Where that data base is adequate and good simulation is achieved, a groundwater model is the most powerful analytical tool available.

4.48 A model may be worthwhile because of the understanding of the flow system that the discipline of model construction demands, and the fact that, as further data are gathered, the model can be upgraded. The use of a model for planning purposes depends on the objectives. Broadly, the main objective is to optimize the use of the groundwater resource for irrigation purposes. More specifically, this may involve; estimating, orders of magnitude of groundwater balances, calculating seepage fluxes and predicting changes in water table regime under gaging water balance conditions induced by pumping. It should also involve a restriction to avoid

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salinization of existing wells. It would certainly require the prevention of excessive drawn down in the more intensively developed parts of the aquifer, some degree of controlled mining might be allowed.

All of these conditions can be met by examining various configurations of wells, and applying appropriate economic controls so that undesirable developments is avoided.

v. Recommended Soil Study

4.49 Detailed soil surveys traditionally carried out to identify soil properties are not recommended the for calcareous soils of the Bahamas. The high calcium carbonate contents of these soils exert a strong influence on their physical and chemical characteristics, which can be generalized as limited water holding capacity, high permeability, fixation of phosphorus and low organic matter content.

4.50 What is needed is a reconnaissance soil survey oriented toward agricultural development, which can be conducted by adjusting the existing land capability maps produced by Little et. al., for general development purposes, but not specifically for agricultural development.

c. Preparation of Final Designs

4.51 The areas identified in this report as potential agricultural lands to be put under supplementary irrigation constitute the minimum acreage to start with. A horizontal expansion around these areas should follow, if needed, in the future. The Ministry of Agriculture should delineate priority areas on maps of suitable scale based on socioeconomic issues, made within the framework shown on the Maps established by this report. Next the final designs for each area in each island should be prepared according to the preliminary designs mentioned in this report, and preferably according to the results of the investigation program mentioned before.

d. Land Tenure and Water Legislation Issues

4.52 Irrigation projects should not be limited by traditional rights and legislation. Problems in connection with land tenure should be solved to give security to farmers, so they can carry out the long-term investment needed to develop irrigation projects.

4.53 At present, there is no law or an entity within the different governmental institutions that can plan and monitor groundwater development for irrigation purposes. Therefore, it is advisable that the Ministry of Agriculture initiate the irrigation water rights and legal framework needed for the use of groundwater resources for irrigation. This legislation should give the

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Ministry the power to initiate the by-laws needed to monitor and safeguard pumping operations in the fields, through its extension workers.

e. Project Promotion

4.54 It is good that the government is encouraging investment in large agricultural projects. Such a wise policy has established successful fruit production projects irrigated by modern techniques, and has created linkages to the export markets. It is a policy that should be promoted ever further. It is also equally important to encourage the participation of Bahamian investors, either independently, or jointly, with foreign investors.

4.55 The participation of Bahamian farmers, especially young people who would like to become farmers, deserves to be promoted. The promotion efforts required for this community need considerable time and staff before actual construction of new projects can commence. The best method to follow is to send a community organizer or extension worker from the Ministry of Agriculture to each island to identify the needs of those who might be interested, through discussions with individuals, groups and local leaders. The promoter should be someone from the island who is familiar with the local situation.

4.56 An irrigation scheme for commercial production intended for use by Bahamian small farmers will impose major changes on a community practicing traditional rainfed agriculture, and may initiate a sequence of changes. Factors to be considered are the level of farming knowledge, existing skills in irrigated farming, and attitudes to change. Equally important are the rural way of life, social structure and the sort of mistakes which can be made through ignorance of these things. For example, a farmer who thinks that more water automatically brings better crops, will not hesitate to mine any aquifer in order to obtain it. When there is an intention to introduce new settlers on farms in a project area, the question of compatibility must be considered. The promoter should assist in the establishment of the needed farmer groups, and in their legalization. Once they are established, the promoter will continue to guide and assist them for some time. During the construction period, the promoter should be present to provide any advice or supervision needed.

f. Control of Construction Works

4.57 The construction works needed for clearing land and implementing irrigation projects involves a number of contracts and subcontracts, which must be controlled and coordinated. Therefore, it is recommended that the Ministry of Agriculture consider establishing a body for this type of organization, in order to avoid serious difficulties. Construction programs involve critical timing, and one or two contracts running into trouble can dislocate

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the whole project. The authority to be established can avoid this by careful selection of contractors and by dealing with contractual difficulties rapidly and effectively when they arise especially in small farm projects. It is also necessary to take advantage of a contractor's particular expertise in methods of land clearing and drilling of wells or abstraction pits. The hazards of awarding contracts are an example of the problems involved in the control of a of construction program and demosntrate the need for a decisive administrative body, to be created under the umbrella of the Ministry of Agriculture.

g. Irrigation Research and Rural Extension

4.58 The strengthening of the institutional capacities of the research and extension services of the Ministry of Agriculture has been addressed in other reports of this feasibility study. Due to the special nature of irrigation research and extension, it is strongly recommended that these activities be linked. The best research works on irrigation are those never done in traditional experimental stations or centers that are isolated from farmers fields. By that means, the selected site is constitutes an experimental station/pilot demonstration field free from any charge.

4.59 It is recommended that adaptive irrigation research programs be demonstrated by using the Training and Visit System of Extension (T & V) described by Benor and Baxter (1984). This system has been successfully implemented in many World Bank irrigation projects.

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APPENDIX

STATISTICAL DATA AND FIGURES

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TABLE 1

SUMMARY OF OBSERVATIONS FOR Nassau Airport NEW PROVIDENCE

	TEMPERATURE deg F		VAPOUR PRESSURE mbar	RAINFALL ins Monthly Total	SUNSHINE Hours Daily	WIND Speed	
	Max	Min				kts	mph
JAN	76.91	61.91	19.51	1.53	7.1	8.17	9.40
FEB	77.01	61.98	19.15	1.55	7.7	8.68	9.99
MAR	79.70	64.23	20.32	1.05	8.5	8.82	10.15
APR	81.80	66.70	21.47	2.01	9.2	8.71	10.03
MAY	84.39	70.05	24.87	4.32	8.6	8.24	9.48
JUN	86.94	73.18	28.34	9.56	7.5	7.44	8.56
JUL	87.65	74.59	29.14	6.14	9.0	7.41	8.53
AUG	89.03	74.45	29.46	7.96	8.8	7.25	8.34
SEP	88.08	73.85	29.41	6.68	7.1	6.37	7.33
OCT	85.06	71.61	26.73	7.42	7.0	7.44	8.56
NOV	81.27	67.28	22.58	2.46	7.4	8.29	9.54
DEC	78.05	63.32	20.14	1.81	7.1	7.92	9.12
			Period Total	52.49			

22 Year Monthly Averages (1961-1982) of selected climatic variables.
Prepared by the BAHAMAS METEOROLOGICAL DEPARTMENT - Climatological Section.

TABLE 2

SUMMARY OF OBSERVATIONS FOR Harbour Island ELEUTHERA

	TEMPERATURE deg F		VAPOUR PRESSURE mbar	RAINFALL ins Monthly Total	SUNSHINE Hours Daily	WIND Speed	
	Max	Min				kts	mph
JAN	76.90	66.10	19.89	1.93	7.1	9.80	11.28
FEB	76.70	65.50	19.36	1.84	7.7	9.80	11.28
MAR	78.80	67.20	20.55	1.51	8.5	10.20	11.74
APR	81.20	69.00	21.50	1.39	9.2	10.00	11.51
MAY	83.60	72.10	24.79	4.30	8.6	8.90	10.24
JUN	85.80	75.20	28.64	7.01	7.5	7.90	9.09
JUL	87.60	77.30	29.82	3.96	9.0	8.40	9.67
AUG	88.10	77.40	29.95	4.97	8.8	8.20	9.44
SEP	87.80	76.40	29.65	5.73	7.1	7.40	8.52
OCT	84.90	74.10	27.22	7.72	7.0	9.10	10.47
NOV	81.00	70.60	22.93	2.22	7.4	10.10	11.63
DEC	78.20	67.50	20.20	1.64	7.1	10.00	11.51
			Period Total	44.22			

22 Year Monthly Averages (1961-1982) of selected climatic variables.
Prepared by the BAHAMAS METEOROLOGICAL DEPARTMENT - Climatological Section.

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TABLE 3

SUMMARY OF OBSERVATIONS FOR B A R C NORTH ANDROS

	TEMPERATURE deg F		VAPOUR PRESSURE mbar	RAINFALL ins Monthly Total	SUNSHINE Hours Daily	WIND Speed	
	Max	Min				kts	mph
JAN	75.81	63.76	22.47	3.04	7.3	8.10	9.32
FEB	80.23	62.28	21.59	2.67	7.4	8.20	9.44
MAR	82.46	64.81	23.30	0.86	8.5	8.70	10.01
APR	84.57	67.87	25.23	1.94	8.7	8.90	10.24
MAY	86.64	71.68	27.82	6.45	8.4	7.30	8.40
JUN	87.07	73.96	30.29	7.90	8.0	6.80	7.83
JUL	89.71	75.57	32.02	5.37	8.5	7.30	8.40
AUG	89.33	75.17	31.89	6.47	8.0	7.40	8.52
SEP	89.69	74.05	32.10	7.51	7.5	6.50	7.48
OCT	87.51	73.45	29.13	8.43	6.9	8.00	9.21
NOV	83.31	69.20	25.59	3.41	6.9	9.00	10.36
DEC	81.02	65.46	22.73	1.71	7.0	9.40	10.82
			Period Total	55.76			

22 Year Monthly Averages (1961-1982) of selected climatic variables.
Prepared by the BAHAMAS METEOROLOGICAL DEPARTMENT - Climatological Section.

TABLE 4

SUMMARY OF OBSERVATIONS FOR Mangrove Cay ANDROS

	TEMPERATURE deg F		VAPOUR PRESSURE mbar	RAINFALL ins Monthly Total	SUNSHINE Hours Daily	WIND Speed	
	Max	Min				kts	mph
JAN	75.81	63.76	22.47	1.52	7.3	8.10	9.32
FEB	80.23	62.28	21.59	1.49	7.4	8.20	9.44
MAR	82.46	64.81	23.30	0.86	8.5	8.70	10.01
APR	84.57	67.87	25.23	1.40	8.7	8.90	10.24
MAY	86.64	71.68	27.82	4.53	8.4	7.30	8.40
JUN	87.07	73.96	30.29	7.22	8.0	6.80	7.83
JUL	89.71	75.57	32.02	3.22	8.5	7.30	8.40
AUG	89.33	75.17	31.89	4.82	8.0	7.40	8.52
SEP	89.69	74.05	32.10	6.39	7.5	6.50	7.48
OCT	87.51	73.45	29.13	6.55	6.9	8.00	9.21
NOV	83.31	69.20	25.59	2.53	6.9	9.00	10.36
DEC	81.02	65.46	22.73	1.49	7.0	9.40	10.82
			Period Total	42.02			

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22 Year Monthly Averages (1961-1982) of selected climatic variables.
Prepared by the BAHAMAS METEOROLOGICAL DEPARTMENT - Climatological Section.

TABLE 5

SUMMARY OF OBSERVATIONS FOR West End GRAND BAHAMA

	TEMPERATURE deg F		VAPOUR PRESSURE mbar	RAINFALL ins Monthly Total	SUNSHINE Hours Daily	WIND Speed	
	Max	Min				kts	mph
JAN	75.61	60.90	19.32	2.25	7.0	9.08	10.45
FEB	75.77	60.84	18.96	3.56	7.5	9.03	10.39
MAR	79.29	63.83	20.69	2.58	8.1	9.35	10.76
APR	82.57	66.38	22.47	1.90	8.9	8.79	10.12
MAY	85.30	70.18	26.07	4.06	8.7	7.93	9.13
JUN	87.93	72.25	29.30	6.45	8.1	6.38	7.34
JUL	90.29	73.72	30.97	5.35	8.3	7.30	8.40
AUG	90.42	74.43	30.94	6.80	8.0	5.95	6.85
SEP	88.70	73.65	30.39	7.17	6.9	6.79	7.82
OCT	84.40	70.80	26.77	4.71	6.0	8.77	10.09
NOV	79.60	66.48	22.88	2.16	7.1	8.69	10.00
DEC	76.70	62.79	20.13	2.20	6.7	8.16	9.39
			Period Total	49.19			

22 Year Monthly Averages (1961-1982) of selected climatic variables.
Prepared by the BAHAMAS METEOROLOGICAL DEPARTMENT - Climatological Section.

TABLE 6

SUMMARY OF OBSERVATIONS FOR Green Turtle Cay ABACO

	TEMPERATURE deg F		VAPOUR PRESSURE mbar	RAINFALL ins Monthly Total	SUNSHINE Hours Daily	WIND Speed	
	Max	Min				kts	mph
JAN	75.67	61.53	18.44	2.44	7.5	5.79	6.66
FEB	75.57	61.45	18.33	2.61	7.7	10.37	11.94
MAR	78.82	64.71	20.07	2.24	8.4	10.59	12.19
APR	73.86	68.08	22.31	2.30	9.1	9.80	11.28
MAY	80.61	71.52	25.68	6.13	8.8	9.17	10.55
JUN	86.78	74.19	28.79	8.43	9.1	8.10	9.32
JUL	84.21	76.30	30.43	5.05	9.2	7.40	8.52
AUG	88.88	76.34	30.53	5.62	8.8	7.60	8.75
SEP	83.58	75.16	29.70	7.94	8.3	7.76	8.93
OCT	84.75	72.03	26.73	6.16	7.6	10.18	11.72
NOV	77.29	68.17	22.90	2.90	7.5	9.74	11.21
DEC	77.22	63.29	19.57	2.43	7.3	9.73	11.20
			Period Total	54.25			

22 Year Monthly Averages (1961-1982) of selected climatic variables.
Prepared by the BAHAMAS METEOROLOGICAL DEPARTMENT - Climatological Section.

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TABLE 9

SUMMARY OF OBSERVATIONS FOR The Bight CAT ISLAND

	TEMPERATURE deg F		VAPOUR PRESSURE mbar	RAINFALL ins Monthly	SUNSHINE Hours	WIND	
	Max	Min		Total	Daily	kts Speed	mph Speed
JAN	79.40	64.40	21.80	1.47	7.6	8.10	9.32
FEB	79.70	63.50	21.10	1.44	8.0	8.30	9.55
MAR	81.40	65.20	21.80	0.91	9.0	8.90	10.24
APR	83.10	69.10	23.50	1.49	9.1	8.80	10.13
MAY	85.40	69.50	26.40	3.71	8.7	7.40	8.52
JUN	86.70	72.80	29.20	5.35	8.6	6.80	7.83
JUL	88.30	73.90	30.10	2.38	9.2	7.90	9.09
AUG	89.30	75.10	30.00	4.05	8.7	7.60	8.75
SEP	88.90	73.80	30.10	4.33	8.1	6.80	7.83
OCT	86.30	72.80	28.40	6.89	7.4	8.00	9.21
NOV	83.30	68.70	24.10	2.36	7.2	8.40	9.67
DEC	80.40	66.30	21.70	1.50	7.2	7.90	9.09
			Period Total	35.88			

22 Year Monthly Averages (1961-1982) of selected climatic variables.
Prepared by the BAHAMAS METEOROLOGICAL DEPARTMENT - Climatological Section.

TABLE 10

SUMMARY OF OBSERVATIONS FOR George Town EXUMA

	TEMPERATURE deg F		VAPOUR PRESSURE mbar	RAINFALL ins Monthly	SUNSHINE Hours	WIND	
	Max	Min		Total	Daily	kts Speed	mph Speed
JAN	74.80	67.60	22.30	1.49	7.7	8.60	9.90
FEB	79.40	66.90	21.60	1.06	8.0	8.70	10.01
MAR	81.30	68.30	22.80	1.11	8.8	9.10	10.47
APR	83.20	70.60	23.90	1.37	8.9	9.50	10.93
MAY	85.20	73.00	26.90	5.00	8.6	8.20	9.44
JUN	87.40	75.70	30.20	5.52	8.5	7.80	8.98
JUL	88.70	77.50	32.10	3.16	9.1	8.50	9.78
AUG	89.30	77.60	31.10	3.77	8.8	8.00	9.21
SEP	88.70	76.80	31.20	4.58	8.0	7.10	8.17
OCT	86.10	74.20	29.10	6.33	7.3	7.40	8.52
NOV	82.10	71.80	25.60	2.73	7.0	8.80	10.13
DEC	79.40	68.60	23.20	1.51	7.1	9.00	10.36
			Period Total	37.63			

22 Year Monthly Averages (1961-1982) of selected climatic variables.
Prepared by the BAHAMAS METEOROLOGICAL DEPARTMENT - Climatological Section.

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									[illegible]	[illegible]	[illegible]	63.2	62.6	65.2	[illegible]
...esium (Mg)	1.8	5.3	9.3	3.2	2.7	2.1	2.4	2.6	1.1	1.5	2.4	1.3	2.2	3.0	2.7
...um (Na)	25.9	43.4	68.5	28.8	26.1	20.6	22.6	28.5	16.7	18.2	21.3	14.7	24.1	33.5	[illegible]
...rbonate (HCO_3)	213.5	223.3	236.7	219.6	234.2	201.3	244.0	231.8	176.9	207.4	251.3	202.5	213.5	223.3	[illegible]
...te (SO_4)	0.4	6.6	17.4	4.6	4.9	3.3	1.6	0.6	0.0	0.0	0.0	0.0	0.9	[illegible]	[illegible]
...ride (Cl)	22	61	97	36	28	27	25	33	17.0	22	19	15	30	[illegible]	[illegible]
...ganese (Mn)	0.02-	0.02-	0.02-	0.02-	0.02-	0.02-	0.02-	0.02-	0.02-	0.02-	0.02-	0.02-	0.02-	[illegible]	[illegible]
...l Iron (Fe)	0.1	0.05	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-	0.05-	[illegible]
...a (SiO_2)	5.2	4.0	4.6	2.4	1.8	1.6	2.0	1.8	1.1	1.8	2.0	2.4	2.3	3.6	[illegible]
...ride (F)	0.05-	0.05-	0.05-	0.10	0.15	0.09	0.07	0.05	0.05	0.05	0.04	0.06	0.07	[illegible]	[illegible]
...te (NO_3)	0.07	0.35	0.25	0.02	0.03	0.07	0.13	0.44	0.42	0.10	0.35	0.18	0.17	0.32	[illegible]
...olved Solids (Residue)	234	309	396	252	262	232	263	264	[illegible]	222	255	[illegible]	245	[illegible]	[illegible]
...l Hardness as $CaCO_3$	[illegible]	162	201	174	151	162	158	176	134	162	187	155	156	[illegible]	[illegible]
...ratory pH	7.40	7.45	7.45	7.43	7.42	7.50	7.33	7.55	7.61	7.52	7.33	7.49	7.53	7.45	[illegible]
...ific Conductance (micromhos)	[illegible]	651	877	430	470	418	477	433	344	412	455	379	441	[illegible]	[illegible]
...perature (° F.)	77	77	-	-	-	-	-	-	74	75	-	76	-	76	-

...RCE: GUYTON (1966)

...E: RESULTS EXPRESSED IN PARTS PER MILLION EXCEPT PH AND SPECIFIC CONDUCTANCE.

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FIGURE 2

) R C NORTH ANDROS
l Rainfall & ETo Patterns

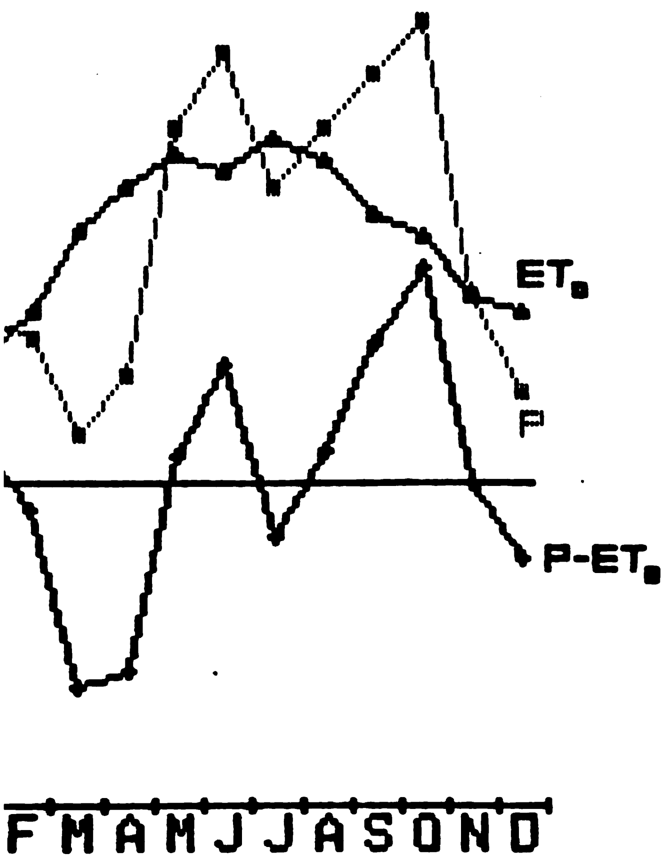

FIGURE 4

u Airport NEW PROVIDENCE
al Rainfall & ETo Patterns

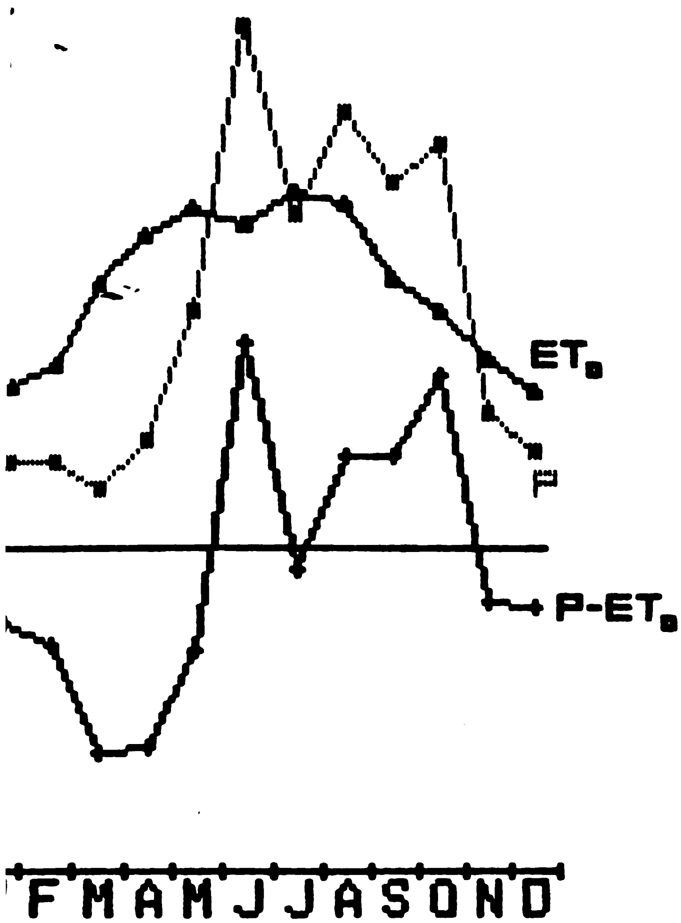

FIGURE 6

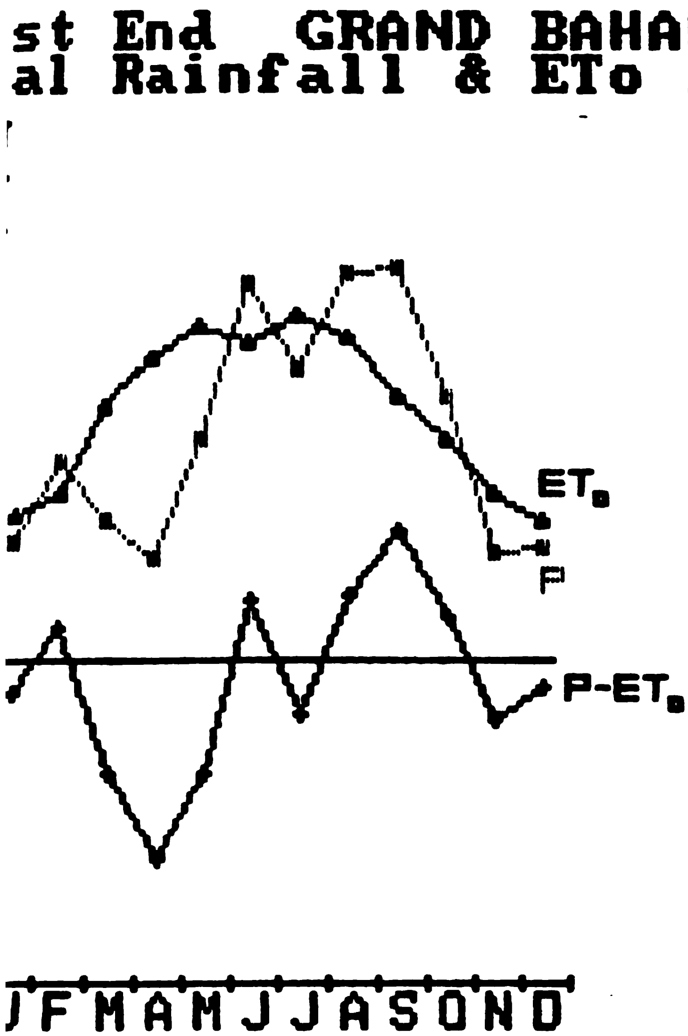

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FIGURE 8

e Bight CAT ISLAND
al Rainfall & ETo Patterns

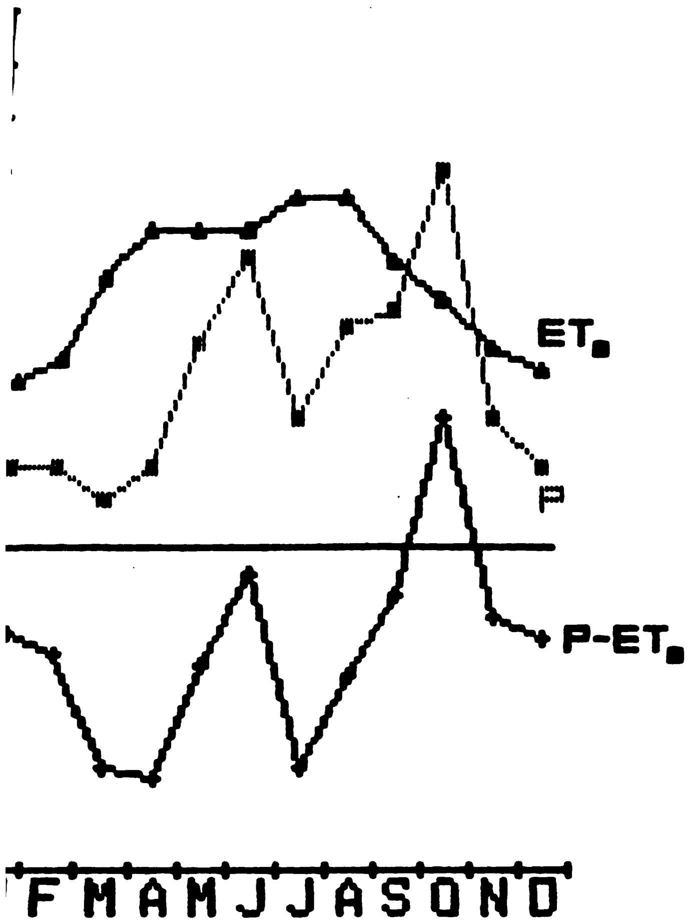

FIGURE 10

KLINS & CROOKED ISLAND
al Rainfall & ETo Patterns

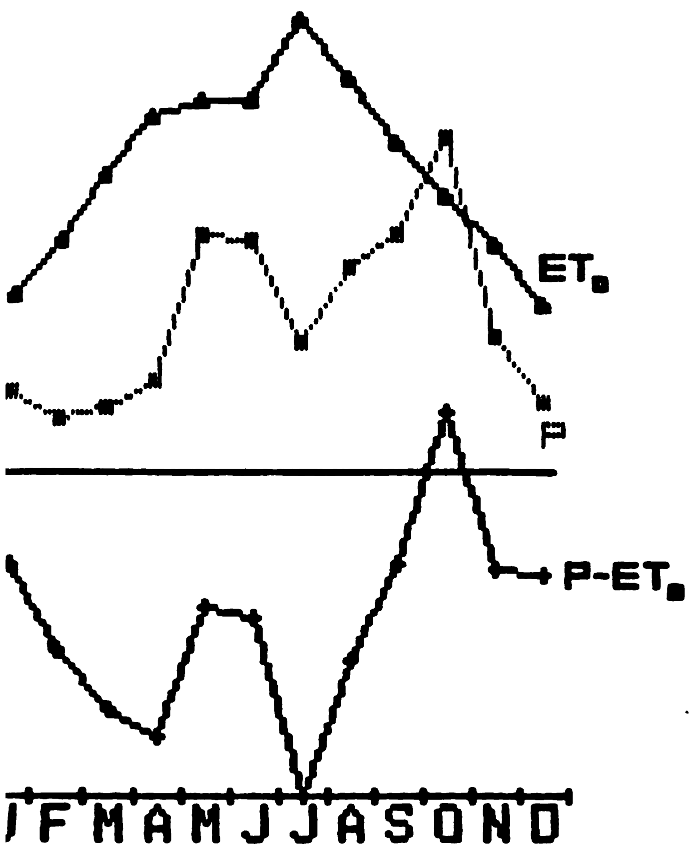

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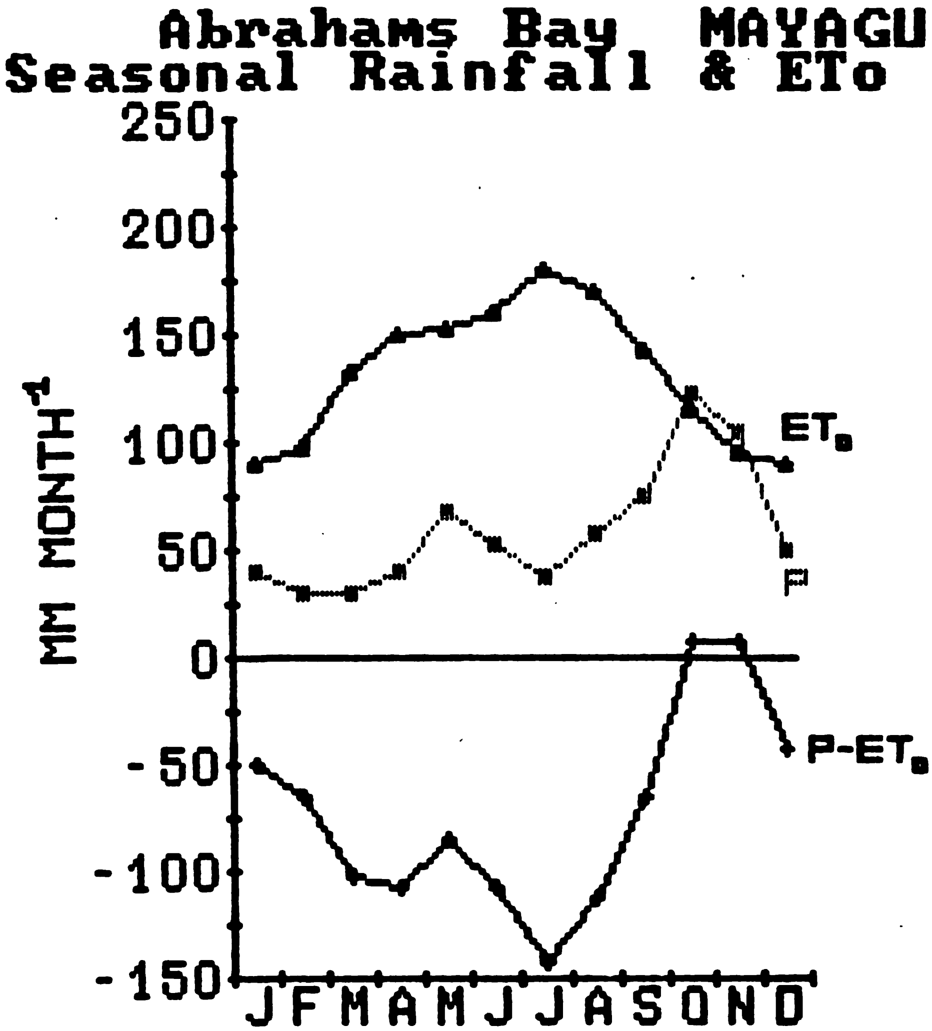
FIGURE 11



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APPENDIX
TABLE 12

(a) Harbour Island ELEUTHERA

WATER BALANCE - SELECTED VEGETABLES (ins/month)

FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1.84	1.51	1.39	4.30	7.01	3.96	4.97	5.73	7.72	2.22	1.64	44.22
4.01	5.54	6.41	6.71	6.18	7.14	6.86	5.52	4.96	4.29	3.95	65.36
1.08	0.24	----	----	----	----	----	----	----	0.55	0.75	
----	0.34	0.74	1.09	1.04	0.24	----	----	----	----	----	
----	----	----	----	----	0.29	0.69	0.95	0.90	----	----	
1.33	1.33	----	----	----	----	----	----	----	2.36	2.97	14.97
----	1.88	4.75	7.32	6.42	1.71	----	----	----	----	----	22.08
----	----	----	----	----	2.07	4.73	5.24	4.46	----	----	16.50
1.33	3.21	4.75	7.32	6.42	3.78	4.73	5.24	4.46	2.36	2.97	53.56
.49	-1.70	-3.36	-3.02	0.59	0.18	0.24	0.49	3.26	-0.14	-1.33	

(b) WATER BALANCE - CITRUS (ins/month)

FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
.84	1.51	1.39	4.30	7.01	3.96	4.97	5.73	7.72	2.22	1.64	44.22
1.01	5.54	6.41	6.71	6.18	7.14	6.86	5.52	4.96	4.29	3.95	65.36
.86	0.81	0.81	0.81	0.75	0.75	0.75	0.75	0.81	0.81	0.81	
.03	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	
.45	4.49	5.19	5.44	4.63	5.35	5.14	4.14	4.01	3.47	3.20	51.79
1.13	5.43	6.29	6.58	6.05	7.00	6.72	5.41	4.86	4.20	3.88	64.45
.61	-2.98	-3.80	-1.14	2.38	-1.39	-0.17	1.59	3.71	-1.25	-1.56	
.29	-3.92	-4.90	-2.28	0.96	-3.04	-1.75	0.32	2.86	-1.98	-2.24	

s have been considered

c) WATER BALANCE - BANANA (ins/month)

FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
.84	1.51	1.39	4.30	7.01	3.96	4.97	5.73	7.72	2.22	1.64	44.22
.01	5.54	6.41	6.71	6.18	7.14	6.86	5.52	4.96	4.29	3.95	65.36
.10	1.10	0.90	0.80	0.40	0.40	0.45	0.50	0.60	0.70	0.85	
.41	6.10	5.77	5.37	2.47	2.86	3.09	2.76	2.97	3.00	3.36	45.95
.57	-4.59	-4.38	-1.07	4.54	1.10	1.88	2.97	4.75	-0.78	-1.72	

as 1st MAY

d) W A T E R S C H E D U L I N G (inches)

EB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
49	1.70	3.36	3.02	----	----	----	----	----	0.14	1.33	14.10
61	2.98	3.80	1.14	----	1.39	0.17	----	----	1.25	1.56	15.23
29	3.92	4.90	2.28	----	3.04	1.75	----	----	1.98	2.24	24.38
57	4.59	4.38	1.07	----	----	----	----	----	0.78	1.72	16.98

MAS METEOROLOGICAL DEPARTMENT - Climatological Section in collaboration
rimation Consultant during the period JULY-SEPTEMBER 1989.

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(a) B A R C NORTH ANDROS

WATER BALANCE - SELECTED VEGETABLES (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	3.04	2.67	0.86	1.94	6.45	7.90	5.37	6.47	7.51	8.43	3.41	1.71	55.76
ETo	2.38	3.17	4.63	5.40	5.98	5.69	6.33	5.91	4.93	4.54	3.45	3.14	55.54
kc:													
Tomato	1.05	1.08	0.24	----	----	----	----	----	----	----	0.61	0.79	
Potato	----	----	0.36	0.76	1.09	1.04	0.24	----	----	----	----	----	
Beans	----	----	----	----	----	----	0.32	0.72	0.95	0.90	----	----	
ETcrop:													
Tomato	2.50	3.43	1.11	----	----	----	----	----	----	----	2.10	2.48	11.62
Potato	----	----	1.67	4.10	6.52	5.92	1.52	----	----	----	----	----	19.73
Beans	----	----	----	----	----	----	2.03	4.25	4.68	4.09	----	----	15.05
ETcrops	2.50	3.43	2.78	4.10	6.52	5.92	3.55	4.25	4.68	4.09	2.10	2.48	46.39
BALANCE:	0.54	-0.76	-1.92	-2.16	-0.07	1.98	1.82	2.22	2.83	4.34	1.31	-0.77	

(b) WATER BALANCE - CITRUS (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	3.04	2.67	0.86	1.94	6.45	7.90	5.37	6.47	7.51	8.43	3.41	1.71	55.76
ETo	2.38	3.17	4.63	5.40	5.98	5.69	6.33	5.91	4.93	4.54	3.45	3.14	55.54
kc:													
no weeds	0.86	0.86	0.81	0.81	0.81	0.75	0.75	0.75	0.75	0.81	0.81	0.81	
weeds	1.03	1.03	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	
ETcrop:													
no weeds	2.05	2.73	3.75	4.37	4.84	4.27	4.75	4.43	3.69	3.68	2.79	2.54	43.90
weeds	2.45	3.27	4.53	5.29	5.86	5.58	6.21	5.79	4.83	4.45	3.38	3.07	54.71
BALANCE:													
no weeds	0.99	-0.06	-2.89	-2.43	1.61	3.63	0.62	2.04	3.82	4.75	0.62	-0.83	
weeds	0.59	-0.60	-3.67	-3.35	0.59	2.32	-0.84	0.68	2.68	3.98	0.03	-1.36	

Matured citrus trees have been considered

(c) WATER BALANCE - BANANA (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	3.04	2.67	0.86	1.94	6.45	7.90	5.37	6.47	7.51	8.43	3.41	1.71	55.76
ETo	2.38	3.17	4.63	5.40	5.98	5.69	6.33	5.91	4.93	4.54	3.45	3.14	55.54
kc	1.00	1.10	1.10	0.90	0.80	0.40	0.40	0.45	0.50	0.60	0.70	0.85	
ETbanana	2.38	3.49	5.09	4.86	4.78	2.28	2.53	2.66	2.46	2.72	2.41	2.67	38.34
BALANCE:	0.66	-0.82	-4.23	-2.92	1.67	5.62	2.84	3.81	5.05	5.71	1.00	-0.96	

Planting date taken as 1st MAY

(d) W A T E R S C H E D U L I N G (inches)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Vegetables	----	0.76	1.92	2.16	0.07	----	----	----	----	----	----	0.77	5.68
Citrus:													
no weeds	----	0.06	2.89	2.43	----	----	----	----	----	----	----	0.83	6.21
weeds	----	0.60	3.67	3.35	----	----	0.84	----	----	----	----	1.36	9.82
Banana:	----	0.82	4.23	2.92	----	----	----	----	----	----	----	0.96	8.93

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(a) Mangrove Cay ANDROS

WATER BALANCE - SELECTED VEGETABLES (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.52	1.49	0.86	1.40	4.53	7.22	3.22	4.82	6.39	6.55	2.53	1.49	42.02
ETo	2.38	3.17	4.63	5.40	5.98	5.69	6.33	5.91	4.93	4.54	3.45	3.14	55.54
kc:													
Tomato	1.05	1.08	0.24	----	----	----	----	----	----	----	0.61	0.79	
Potato	----	----	0.36	0.76	1.09	1.04	0.24	----	----	----	----	----	
Beans	----	----	----	----	----	----	0.32	0.72	0.95	0.90	----	----	
ETcrop:													
Tomato	2.50	3.43	1.11	----	----	----	----	----	----	----	2.10	2.48	11.62
Potato	----	----	1.67	4.10	6.52	5.92	1.52	----	----	----	----	----	19.73
Beans	----	----	----	----	----	----	2.03	4.25	4.68	4.09	----	----	15.05
ETcrops	2.50	3.43	2.78	4.10	6.52	5.92	3.55	4.25	4.68	4.09	2.10	2.48	46.39
BALANCE:	-0.98	-1.94	-1.92	-2.70	-1.99	1.30	-0.33	0.57	1.71	2.46	0.43	-0.99	

(b) WATER BALANCE - CITRUS (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.52	1.49	0.86	1.40	4.53	7.22	3.22	4.82	6.39	6.55	2.53	1.49	42.02
ETo	2.38	3.17	4.63	5.40	5.98	5.69	6.33	5.91	4.93	4.54	3.45	3.14	55.54
kc:													
no weeds	0.86	0.86	0.81	0.81	0.81	0.75	0.75	0.75	0.75	0.81	0.81	0.81	
weeds	1.03	1.03	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	
ETcrop:													
no weeds	2.05	2.73	3.75	4.37	4.84	4.27	4.75	4.43	3.69	3.68	2.79	2.54	43.90
weeds	2.45	3.27	4.53	5.29	5.86	5.58	6.21	5.79	4.83	4.45	3.38	3.07	54.71
BALANCE:													
no weeds	-0.53	-1.24	-2.89	-2.97	-0.31	2.95	-1.53	0.39	2.70	2.87	-0.26	-1.05	
weeds	-0.93	-1.78	-3.67	-3.89	-1.33	1.64	-2.99	-0.97	1.56	2.10	-0.85	-1.58	

Matured citrus trees have been considered

(c) WATER BALANCE - BANANA (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.52	1.49	0.86	1.40	4.53	7.22	3.22	4.82	6.39	6.55	2.53	1.49	42.02
ETo	2.38	3.17	4.63	5.40	5.98	5.69	6.33	5.91	4.93	4.54	3.45	3.14	55.54
kc	1.00	1.10	1.10	0.90	0.80	0.40	0.40	0.45	0.50	0.60	0.70	0.85	
ETbanana	2.38	3.49	5.09	4.86	4.78	2.28	2.53	2.66	2.46	2.72	2.41	2.67	38.34
BALANCE:	-0.86	-2.00	-4.23	-3.46	-0.25	4.94	0.69	2.16	3.93	3.83	0.12	-1.18	

Planting date taken as 1st MAY

(d) WATER SCHEDULING (inches)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Vegetables	0.98	1.94	1.92	2.70	1.99	----	0.33	----	----	----	----	0.99	10.85
Citrus:													
no weeds	0.53	1.24	2.89	2.97	0.31	----	1.53	----	----	----	0.26	1.05	10.78
weeds	0.93	1.78	3.67	3.89	1.33	----	2.99	0.97	----	----	0.85	1.58	17.99
Banana:	0.86	2.00	4.23	3.46	0.25	----	----	----	----	----	----	1.18	11.98

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(a) Nassau Airport NEW PROVIDENCE

APPENDIX TABLE 15

WATER BALANCE - SELECTED VEGETABLES (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.53	1.55	1.05	2.01	4.32	9.56	6.14	7.96	6.68	7.42	2.46	1.81	52.49
ETo	2.93	3.33	4.82	5.68	6.16	5.86	6.51	6.30	4.96	4.31	3.47	2.87	57.19
kc:													
Tomato	1.05	1.08	0.24	----	----	----	----	----	----	----	0.58	0.77	
Potato	----	----	0.36	0.76	1.09	1.04	0.24	----	----	----	----	----	
Beans	----	----	----	----	----	----	0.32	0.72	0.95	0.90	----	----	
ETcrop:													
Tomato	3.08	3.60	1.16	----	----	----	----	----	----	----	2.01	2.21	12.05
Potato	----	----	1.74	4.32	6.72	6.09	1.56	----	----	----	----	----	20.43
Beans	----	----	----	----	----	----	2.08	4.53	4.71	3.88	----	----	15.21
ETcrops	3.08	3.60	2.89	4.32	6.72	6.09	3.64	4.53	4.71	3.88	2.01	2.21	47.68
BALANCE:	-1.55	-2.05	-1.84	-2.31	-2.40	3.47	2.50	3.43	1.97	3.54	0.45	-0.40	

(b) WATER BALANCE - CITRUS (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.53	1.55	1.05	2.01	4.32	9.56	6.14	7.96	6.68	7.42	2.46	1.81	52.49
ETo	2.93	3.33	4.82	5.68	6.16	5.86	6.51	6.30	4.96	4.31	3.47	2.87	57.19
kc:													
no weeds	0.86	0.86	0.81	0.81	0.81	0.75	0.75	0.75	0.75	0.81	0.81	0.81	
weeds	1.03	1.03	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	
ETcrop:													
no weeds	2.52	2.86	3.90	4.60	4.99	4.39	4.88	4.72	3.72	3.49	2.81	2.32	45.22
weeds	3.02	3.43	4.72	5.57	6.04	5.74	6.38	6.17	4.86	4.22	3.40	2.81	56.36
BALANCE:													
no weeds	-0.99	-1.31	-2.85	-2.59	-0.67	5.17	1.26	3.24	2.96	3.93	-0.35	-0.51	
weeds	-1.49	-1.88	-3.67	-3.56	-1.72	3.82	-0.24	1.79	1.82	3.20	-0.94	-1.00	

Matured citrus trees have been considered

(c) WATER BALANCE - BANANA (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.53	1.55	1.05	2.01	4.32	9.56	6.14	7.96	6.68	7.42	2.46	1.81	52.49
ETo	2.93	3.33	4.82	5.68	6.16	5.86	6.51	6.30	4.96	4.31	3.47	2.87	57.19
kc	1.00	1.10	1.10	0.90	0.00	0.40	0.40	0.45	0.50	0.60	0.70	0.85	
ETbanana	2.93	3.66	5.30	5.11	4.93	2.34	2.60	2.83	2.48	2.58	2.43	2.44	39.65
BALANCE:	-1.40	-2.11	-4.25	-3.10	-0.61	7.22	3.54	5.13	4.20	4.84	0.03	-0.63	

Planting date taken as 1st MAY

(d) WATER SCHEDULING (inches)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Vegetables	1.55	2.05	1.84	2.31	2.40	----	----	----	----	----	----	0.40	10.55
Citrus:													
no weeds	0.99	1.31	2.85	2.59	0.67	----	----	----	----	----	0.35	0.51	9.27
weeds	1.49	1.88	3.67	3.56	1.72	----	0.24	----	----	----	0.94	1.00	14.50
Banana:	1.40	2.11	4.25	3.10	0.61	----	----	----	----	----	----	0.63	12.10

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APPENDIX
TABLE 16

(a) Green Turtle Cay ABACO

WATER BALANCE - SELECTED VEGETABLES (ins/month)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
2.44	2.61	2.24	2.30	6.13	8.43	5.05	5.62	7.94	6.16	2.90	2.43	54.25
2.60	3.47	5.09	4.74	5.88	6.41	6.16	6.46	4.88	4.72	3.12	3.08	56.61
1.03	1.08	0.23	----	----	----	----	----	----	----	0.61	0.79	
----	----	0.36	0.78	1.09	1.04	0.24	----	----	----	----	----	
----	----	----	----	----	----	0.31	0.72	0.95	0.90	----	----	
2.68	3.75	1.17	----	----	----	----	----	----	----	1.90	2.43	11.93
----	----	1.83	3.69	6.41	6.67	1.48	----	----	----	----	----	20.09
----	----	----	----	----	----	1.91	4.65	4.63	4.25	----	----	15.44
2.68	3.75	3.00	3.69	6.41	6.67	3.39	4.65	4.63	4.25	1.90	2.43	47.46
-0.24	-1.14	-0.76	-1.39	-0.28	1.76	1.66	0.97	3.31	1.91	1.00	0.00	

(b) WATER BALANCE - CITRUS (ins/month)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
2.44	2.61	2.24	2.30	6.13	8.43	5.05	5.62	7.94	6.16	2.90	2.43	54.25
2.60	3.47	5.09	4.74	5.88	6.41	6.16	6.46	4.88	4.72	3.12	3.08	56.61
0.86	0.86	0.81	0.81	0.81	0.75	0.75	0.75	0.75	0.81	0.81	0.81	
1.03	1.03	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	
2.24	2.99	4.12	3.84	4.76	4.81	4.62	4.84	3.66	3.83	2.53	2.49	44.72
2.68	3.58	4.99	4.64	5.77	6.29	6.04	6.33	4.78	4.63	3.06	3.01	55.78
0.20	-0.38	-1.88	-1.54	1.37	3.62	0.43	0.78	4.28	2.33	0.37	-0.06	
-0.24	-0.97	-2.75	-2.34	0.36	2.14	-0.99	-0.71	3.16	1.53	-0.16	-0.58	

'us trees have been considered

(c) WATER BALANCE - BANANA (ins/month)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
2.44	2.61	2.24	2.30	6.13	8.43	5.05	5.62	7.94	6.16	2.90	2.43	54.25
2.60	3.47	5.09	4.74	5.88	6.41	6.16	6.46	4.88	4.72	3.12	3.08	56.61
1.00	1.10	1.10	0.90	0.80	0.40	0.40	0.45	0.50	0.60	0.70	0.85	
2.60	3.82	5.60	4.26	4.71	2.57	2.47	2.91	2.44	2.83	2.18	2.61	38.99
D.16	-1.21	-3.36	-1.96	1.42	5.86	2.58	2.71	5.50	3.33	0.72	-0.18	

? taken as 1st MAY

(d) WATER SCHEDULING (inches)

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
.24	1.14	0.76	1.39	0.28	----	----	----	----	----	----	----	3.81
----	0.38	1.88	1.54	----	----	----	----	----	----	----	0.06	3.86
.24	0.97	2.75	2.34	----	----	0.99	0.71	----	----	0.16	0.58	8.74
16	1.21	3.36	1.96	----	----	----	----	----	----	----	0.18	6.87

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West End GRAND BAHAMA

WATER BALANCE - SELECTED VEGETABLES (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	2.25	3.56	2.58	1.90	4.06	6.45	5.35	6.80	7.17	4.71	2.16	2.20	49.19
ETo	2.70	3.08	4.63	5.50	6.08	5.76	6.31	5.91	4.84	4.08	3.05	2.58	54.50
kc:													
Tomato	1.05	1.08	0.24	----	----	----	----	----	----	----	0.61	0.78	
Potato	----	----	0.37	0.75	1.09	1.04	0.24	----	----	----	----	----	
Beans	----	----	----	----	----	----	0.32	0.72	0.95	0.90	----	----	
ETcrop:													
Tomato	2.83	3.32	1.11	----	----	----	----	----	----	----	1.86	2.01	11.13
Potato	----	----	1.71	4.13	6.62	5.99	1.51	----	----	----	----	----	19.97
Beans	----	----	----	----	----	----	2.02	4.25	4.60	3.67	----	----	14.54
ETcrops	2.83	3.32	2.82	4.13	6.62	5.99	3.53	4.25	4.60	3.67	1.86	2.01	45.65
BALANCE:	-0.58	0.24	-0.24	-2.23	-2.56	0.46	1.82	2.55	2.57	1.04	0.30	0.19	

WATER BALANCE - CITRUS (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	2.25	3.56	2.58	1.90	4.06	6.45	5.35	6.80	7.17	4.71	2.16	2.20	49.19
ETo	2.70	3.08	4.63	5.50	6.08	5.76	6.31	5.91	4.84	4.08	3.05	2.58	54.50
kc:													
no weeds	0.86	0.86	0.81	0.81	0.81	0.75	0.75	0.75	0.75	0.81	0.81	0.81	
weeds	1.03	1.03	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	
ETcrop:													
no weeds	2.32	2.65	3.75	4.46	4.92	4.32	4.73	4.43	3.63	3.30	2.47	2.09	43.07
weeds	2.78	3.17	4.53	5.39	5.96	5.65	6.18	5.79	4.75	3.99	2.99	2.52	53.70
BALANCE:													
no weeds	-0.07	0.91	-1.17	-2.56	-0.86	2.13	0.62	2.37	3.54	1.41	-0.31	0.11	
weeds	-0.53	0.39	-1.95	-3.49	-1.90	0.80	-0.83	1.01	2.42	0.72	-0.83	-0.32	

Matured citrus trees have been considered

WATER BALANCE - BANANA (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	2.25	3.56	2.58	1.90	4.06	6.45	5.35	6.80	7.17	4.71	2.16	2.20	49.19
ETo	2.70	3.08	4.63	5.50	6.08	5.76	6.31	5.91	4.84	4.08	3.05	2.58	54.50
kc	1.00	1.10	1.10	0.90	0.80	0.40	0.40	0.45	0.50	0.60	0.70	0.85	
ETbanana	2.70	3.38	5.09	4.95	4.86	2.31	2.52	2.66	2.42	2.45	2.13	2.19	37.66
BALANCE:	-0.45	0.18	-2.51	-3.05	-0.80	4.14	2.83	4.14	4.75	2.26	0.03	0.01	

Planting date taken as 1st MAY

WATER SCHEDULING (inches)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Vegetables	0.58	----	0.24	2.23	2.56	----	----	----	----	----	----	----	5.61
Citrus:													
no weeds	0.07	----	1.17	2.56	0.86	----	----	----	----	----	0.31	----	4.97
weeds	0.53	----	1.95	3.49	1.90	----	0.83	----	----	----	0.83	0.32	9.85
Banana:	0.45	----	2.51	3.05	0.80	----	----	----	----	----	----	----	6.81

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(a) Clarence Town LONG ISLAND

WATER BALANCE - SELECTED VEGETABLES (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	2.01	1.43	1.04	1.94	4.17	4.41	2.32	3.28	4.01	7.57	3.45	2.61	38.24
ETo	3.69	3.96	5.38	4.54	6.24	6.18	7.04	7.02	5.59	4.70	4.09	3.84	62.25
kc:													
Tomato	1.05	1.08	0.24	----	----	----	----	----	----	----	0.54	0.76	
Potato	----	----	0.33	0.73	1.09	1.04	0.24	----	----	----	----	----	
Beans	----	----	----	----	----	----	0.29	0.72	0.95	0.90	----	----	
ETcrop:													
Tomato	3.87	4.27	1.29	----	----	----	----	----	----	----	2.21	2.92	14.56
Potato	----	----	1.78	3.31	6.80	6.42	1.69	----	----	----	----	----	20.00
Beans	----	----	----	----	----	----	2.04	5.05	5.31	4.23	----	----	16.63
ETcrops	3.87	4.27	3.07	3.31	6.80	6.42	3.73	5.05	5.31	4.23	2.21	2.92	51.20
BALANCE:	-1.86	-2.84	-2.03	-1.37	-2.63	-2.01	-1.41	-1.77	-1.30	3.34	1.24	-0.31	

(b) WATER BALANCE - CITRUS (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	2.01	1.43	1.04	1.94	4.17	4.41	2.32	3.28	4.01	7.57	3.45	2.61	38.24
ETo	3.69	3.96	5.38	4.54	6.24	6.18	7.04	7.02	5.59	4.70	4.09	3.84	62.25
kc:													
no weeds	0.86	0.86	0.81	0.81	0.81	0.75	0.75	0.75	0.75	0.81	0.81	0.81	
weeds	1.03	1.03	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	
ETcrop:													
no weeds	3.17	3.40	4.36	3.67	5.05	4.63	5.28	5.26	4.19	3.81	3.31	3.11	49.26
weeds	3.80	4.08	5.27	4.44	6.11	6.05	6.90	6.88	5.47	4.60	4.00	3.77	61.39
BALANCE:													
no weeds	-1.16	-1.97	-3.32	-1.73	-0.88	-0.22	-2.96	-1.98	-0.18	3.76	0.14	-0.50	
weeds	-1.79	-2.65	-4.23	-2.50	-1.94	-1.64	-4.58	-3.60	-1.46	2.97	-0.55	-1.16	

Matured citrus trees have been considered

(c) WATER BALANCE - BANANA (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	2.01	1.43	1.04	1.94	4.17	4.41	2.32	3.28	4.01	7.57	3.45	2.61	38.24
ETo	3.69	3.96	5.38	4.54	6.24	6.18	7.04	7.02	5.59	4.70	4.09	3.84	62.25
kc	1.00	1.10	1.10	0.90	0.80	0.40	0.40	0.45	0.50	0.60	0.70	0.85	
ETbanana	3.69	4.35	5.92	4.08	4.99	2.47	2.82	3.16	2.79	2.82	2.86	3.27	43.22
BALANCE:	-1.68	-2.92	-4.88	-2.14	-0.82	1.94	-0.50	0.12	1.22	4.75	0.59	-0.66	

Planting date taken as 1st MAY

(d) WATER SCHEDULING (inches)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Vegetables	1.86	2.84	2.03	1.37	2.63	2.01	1.41	1.77	1.30	----	----	0.31	17.53
Citrus:													
no weeds	1.16	1.97	3.32	1.73	0.88	0.22	2.96	1.98	0.18	----	----	0.50	14.90
weeds	1.79	2.65	4.23	2.50	1.94	1.64	4.58	3.60	1.46	----	0.55	1.16	26.10
Banana:	1.68	2.92	4.88	2.14	0.82	----	0.50	----	----	----	----	0.66	13.60

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(a) The Bight CAT ISLAND

WATER BALANCE - SELECTED VEGETABLES (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.47	1.44	0.91	1.49	3.71	5.35	2.38	4.05	4.33	6.89	2.36	1.50	35.88
ETo	3.06	3.41	4.94	5.76	5.85	5.81	6.44	6.38	5.23	4.50	3.64	3.21	58.24
kc:													
Tomato	1.05	1.08	0.24	----	----	----	----	----	----	----	0.58	0.77	
Potato	----	----	0.37	0.77	1.09	1.04	0.24	----	----	----	----	----	
Beans	----	----	----	----	----	----	0.31	0.71	0.95	0.90	----	----	
ETcrop:													
Tomato	3.22	3.68	1.19	----	----	----	----	----	----	----	2.11	2.47	12.66
Potato	----	----	1.83	4.44	6.37	6.04	1.55	----	----	----	----	----	20.23
Beans	----	----	----	----	----	----	2.00	4.53	4.97	4.05	----	----	15.55
ETcrops	3.22	3.68	3.02	4.44	6.37	6.04	3.54	4.53	4.97	4.05	2.11	2.47	48.45
BALANCE:	-1.75	-2.24	-2.11	-2.95	-2.66	-0.69	-1.16	-0.48	-0.64	2.84	0.25	-0.97	

(b) WATER BALANCE - CITRUS (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.47	1.44	0.91	1.49	3.71	5.35	2.38	4.05	4.33	6.89	2.36	1.50	35.88
ETo	3.06	3.41	4.94	5.76	5.85	5.81	6.44	6.38	5.23	4.50	3.64	3.21	58.24
kc:													
no weeds	0.86	0.86	0.81	0.81	0.81	0.75	0.75	0.75	0.75	0.81	0.81	0.81	
weeds	1.03	1.03	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	
ETcrop:													
no weeds	2.63	2.93	4.00	4.67	4.74	4.36	4.83	4.79	3.92	3.65	2.95	2.60	46.07
weeds	3.16	3.51	4.84	5.65	5.73	5.69	6.32	6.26	5.13	4.41	3.57	3.15	57.40
BALANCE:													
no weeds	-1.16	-1.49	-3.09	-3.18	-1.03	0.99	-2.45	-0.74	0.41	3.24	-0.59	-1.10	
weeds	-1.69	-2.07	-3.93	-4.16	-2.02	-0.34	-3.94	-2.21	-0.80	2.48	-1.21	-1.65	

Matured citrus trees have been considered

(c) WATER BALANCE - BANANA (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.47	1.44	0.91	1.49	3.71	5.35	2.38	4.05	4.33	6.89	2.36	1.50	35.88
ETo	3.06	3.41	4.94	5.76	5.85	5.81	6.44	6.38	5.23	4.50	3.64	3.21	58.24
kc	1.00	1.10	1.10	0.90	0.80	0.40	0.40	0.45	0.50	0.60	0.70	0.85	
ETbanana	3.06	3.75	5.44	5.19	4.68	2.32	2.58	2.87	2.62	2.70	2.55	2.73	40.48
BALANCE:	-1.59	-2.31	-4.53	-3.70	-0.97	3.03	-0.20	1.18	1.71	4.19	-0.19	-1.23	

Planting date taken as 1st MAY

(d) WATER SCHEDULING (inches)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Vegetables	1.75	2.24	2.11	2.95	2.66	0.69	1.16	0.48	0.64	----	----	0.97	15.65
Citrus:													
no weeds	1.16	1.49	3.09	3.18	1.03	----	2.45	0.74	----	----	0.59	1.10	14.83
weeds	1.69	2.07	3.93	4.16	2.02	0.34	3.94	2.21	0.80	----	1.21	1.65	24.02
Banana:	1.59	2.31	4.53	3.70	0.97	----	0.20	----	----	----	0.19	1.23	14.72

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(a) George Town EXUMA

WATER BALANCE - SELECTED VEGETABLES (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.49	1.06	1.11	1.37	5.00	5.52	3.16	3.77	4.58	6.33	2.73	1.51	37.63
ETo	2.95	3.83	5.27	6.09	6.37	6.27	6.81	6.72	5.54	4.56	3.76	3.32	61.50
kc:													
Tomato	1.05	1.08	0.24	----	----	----	----	----	----	----	0.58	0.77	
Potato	----	----	0.37	0.75	1.09	1.04	0.24	----	----	----	----	----	
Beans	----	----	----	----	----	----	0.32	0.72	0.95	0.90	----	----	
ETcrop:													
Tomato	3.10	4.13	1.27	----	----	----	----	----	----	----	2.18	2.56	13.23
Potato	----	----	1.95	4.57	6.94	6.52	1.63	----	----	----	----	----	21.62
Beans	----	----	----	----	----	----	2.18	4.84	5.26	4.11	----	----	16.39
ETcrops	3.10	4.13	3.22	4.57	6.94	6.52	3.81	4.84	5.26	4.11	2.18	2.56	51.25
BALANCE:	-1.61	-3.07	-2.11	-3.20	-1.94	-1.00	-0.65	-1.07	-0.68	2.22	0.55	-1.05	

(b) WATER BALANCE - CITRUS (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.49	1.06	1.11	1.37	5.00	5.52	3.16	3.77	4.58	6.33	2.73	1.51	37.63
ETo	2.95	3.83	5.27	6.09	6.37	6.27	6.81	6.72	5.54	4.56	3.76	3.32	61.50
kc:													
no weeds	0.86	0.86	0.81	0.81	0.81	0.75	0.75	0.75	0.75	0.81	0.81	0.81	
weeds	1.03	1.03	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	
ETcrop:													
no weeds	2.54	3.29	4.27	4.94	5.16	4.70	5.11	5.04	4.15	3.70	3.04	2.69	48.64
weeds	3.04	3.94	5.17	5.97	6.24	6.15	6.67	6.59	5.43	4.47	3.68	3.25	60.61
BALANCE:													
no weeds	-1.05	-2.23	-3.16	-3.57	-0.16	0.82	-1.95	-1.27	0.43	2.63	-0.31	-1.18	
weeds	-1.55	-2.88	-4.06	-4.60	-1.24	-0.63	-3.51	-2.82	-0.85	1.86	-0.95	-1.74	

Matured citrus trees have been considered

(c) WATER BALANCE - BANANA (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.49	1.06	1.11	1.37	5.00	5.52	3.16	3.77	4.58	6.33	2.73	1.51	37.63
ETo	2.95	3.83	5.27	6.09	6.37	6.27	6.81	6.72	5.54	4.56	3.76	3.32	61.50
kc	1.00	1.10	1.10	0.90	0.80	0.40	0.40	0.45	0.50	0.60	0.70	0.85	
ETbanana	2.95	4.21	5.80	5.49	5.10	2.51	2.72	3.03	2.77	2.74	2.63	2.82	42.76
BALANCE:	-1.46	-3.15	-4.69	-4.12	-0.10	3.01	0.44	0.74	1.81	3.59	0.10	-1.31	

Planting date taken as 1st MAY

(d) WATER SCHEDULING (inches)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Vegetables	1.61	3.07	2.11	3.20	1.94	1.00	0.65	1.07	0.68	----	----	1.05	16.38
Citrus:													
no weeds	1.05	2.23	3.16	3.57	0.16	----	1.95	1.27	----	----	0.31	1.18	14.88
weeds	1.55	2.88	4.06	4.60	1.24	0.63	3.51	2.82	0.85	----	0.95	1.74	24.83
Banana:	1.46	3.15	4.69	4.12	0.10	----	----	----	----	----	----	1.31	14.83

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(a) ACKLINS & CROOKED ISLAND

WATER BALANCE - SELECTED VEGETABLES (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.50	0.97	1.14	1.70	4.36	4.23	2.40	3.73	4.36	6.06	2.42	1.24	34.11
ETo	3.21	4.26	5.46	6.48	6.83	6.84	8.30	7.18	5.99	4.98	4.17	3.10	66.79
kc:													
Tomato	1.05	1.08	0.24	----	----	----	----	----	----	----	0.54	0.76	
Potato	----	----	0.33	0.73	1.09	1.04	0.24	----	----	----	----	----	
Beans	----	----	----	----	----	----	0.27	0.68	0.95	0.90	----	----	
ETcrop:													
Tomato	3.37	4.60	1.31	----	----	----	----	----	----	----	2.25	2.36	13.88
Potato	----	----	1.80	4.73	7.45	7.11	1.99	----	----	----	----	----	23.09
Beans	----	----	----	----	----	----	2.24	4.88	5.69	4.48	----	----	17.29
ETcrops	3.37	4.60	3.11	4.73	7.45	7.11	4.23	4.88	5.69	4.48	2.25	2.36	54.26
BALANCE:	-1.87	-3.63	-1.97	-3.03	-3.09	-2.88	-1.83	-1.15	-1.33	1.58	0.17	-1.12	

(b) WATER BALANCE - CITRUS (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.50	0.97	1.14	1.70	4.36	4.23	2.40	3.73	4.36	6.06	2.42	1.24	34.11
ETo	3.21	4.26	5.46	6.48	6.83	6.84	8.30	7.18	5.99	4.98	4.17	3.10	66.79
kc:													
no weeds	0.86	0.86	0.81	0.81	0.81	0.75	0.75	0.75	0.75	0.81	0.81	0.81	
weeds	1.03	1.03	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	
ETcrop:													
no weeds	2.76	3.66	4.42	5.25	5.54	5.13	6.22	5.38	4.49	4.03	3.38	2.51	52.78
weeds	3.31	4.38	5.35	6.35	6.70	6.70	8.13	7.03	5.87	4.88	4.09	3.04	65.83
BALANCE:													
no weeds	-1.26	-2.69	-3.28	-3.55	-1.18	-0.90	-3.82	-1.65	-0.13	2.03	-0.96	-1.27	
weeds	-1.81	-3.41	-4.21	-4.65	-2.34	-2.47	-5.73	-3.30	-1.51	1.18	-1.67	-1.80	

Matured citrus trees have been considered

(c) WATER BALANCE - BANANA (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.50	0.97	1.14	1.70	4.36	4.23	2.40	3.73	4.36	6.06	2.42	1.24	34.11
ETo	3.21	4.26	5.46	6.48	6.83	6.84	8.30	7.18	5.99	4.98	4.17	3.10	66.79
kc	1.00	1.10	1.10	0.90	0.80	0.40	0.40	0.45	0.50	0.60	0.70	0.85	
ETbanana	3.21	4.68	6.00	5.84	5.47	2.74	3.32	3.23	2.99	2.99	2.92	2.64	46.01
BALANCE:	-1.71	-3.71	-4.86	-4.14	-1.11	1.49	-0.92	0.50	1.37	3.07	-0.50	-1.40	

Planting date taken as 1st MAY

(d) WATER SCHEDULING (inches)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Vegetables	1.87	3.63	1.97	3.03	3.09	2.88	1.83	1.15	1.33	----	----	1.12	21.90
Citrus:													
no weeds	1.26	2.69	3.28	3.55	1.18	0.90	3.82	1.65	0.13	----	0.96	1.27	20.69
weeds	1.81	3.41	4.21	4.65	2.34	2.47	5.73	3.30	1.51	----	1.67	1.80	32.90
Banana:	1.71	3.71	4.86	4.14	1.11	----	0.92	----	----	----	0.50	1.40	18.35

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(a) Abrahams Bay MAYAGUANA

WATER BALANCE - SELECTED VEGETABLES (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.61	1.23	1.20	1.59	2.70	2.09	1.44	2.27	3.00	4.87	4.12	1.92	28.04
ETo	3.55	3.84	5.21	5.86	6.02	6.28	7.07	6.70	5.56	4.56	3.78	3.59	62.02
kc:													
Tomato	1.05	1.08	0.24	----	----	----	----	----	----	----	0.58	0.75	
Potato	----	----	0.34	0.80	1.09	1.04	0.24	----	----	----	----	----	
Beans	----	----	----	----	----	----	0.27	0.69	0.95	0.90	----	----	
ETcrop:													
Tomato	3.73	4.14	1.25	----	----	----	----	----	----	----	2.19	2.69	14.01
Potato	----	----	1.77	4.69	6.56	6.53	1.70	----	----	----	----	----	21.25
Beans	----	----	----	----	----	----	1.91	4.62	5.28	4.11	----	----	15.92
ETcrops	3.73	4.14	3.02	4.69	6.56	6.53	3.60	4.62	5.28	4.11	2.19	2.69	51.18
BALANCE:	-2.12	-2.91	-1.82	-3.10	-3.86	-4.44	-2.16	-2.35	-2.28	0.76	1.93	-0.77	

(b) WATER BALANCE - CITRUS (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.61	1.23	1.20	1.59	2.70	2.09	1.44	2.27	3.00	4.87	4.12	1.92	28.04
ETo	3.55	3.84	5.21	5.86	6.02	6.28	7.07	6.70	5.56	4.56	3.78	3.59	62.02
kc:													
no weeds	0.86	0.86	0.81	0.81	0.81	0.75	0.75	0.75	0.75	0.81	0.81	0.81	
weeds	1.03	1.03	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	
ETcrop:													
no weeds	3.05	3.30	4.22	4.75	4.87	4.71	5.30	5.03	4.17	3.70	3.06	2.91	49.07
weeds	3.66	3.95	5.11	5.74	5.90	6.16	6.93	6.57	5.45	4.47	3.70	3.52	61.15
BALANCE:													
no weeds	-1.44	-2.07	-3.02	-3.16	-2.17	-2.62	-3.86	-2.76	-1.17	1.17	1.06	-0.99	
weeds	-2.05	-2.72	-3.91	-4.15	-3.20	-4.07	-5.49	-4.30	-2.45	0.40	0.42	-1.60	

Matured citrus trees have been considered

(c) WATER BALANCE - BANANA (ins/month)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL	1.61	1.23	1.20	1.59	2.70	2.09	1.44	2.27	3.00	4.87	4.12	1.92	28.04
ETo	3.55	3.84	5.21	5.86	6.02	6.28	7.07	6.70	5.56	4.56	3.78	3.59	62.02
kc	1.00	1.10	1.10	0.90	0.80	0.40	0.40	0.45	0.50	0.60	0.70	0.85	
ETbanana	3.55	4.22	5.73	5.27	4.81	2.51	2.83	3.02	2.78	2.74	2.65	3.05	43.16
BALANCE:	-1.94	-2.99	-4.53	-3.68	-2.11	-0.42	-1.39	-0.75	0.22	2.13	1.47	-1.13	

Planting date taken as 1st MAY

(d) WATER SCHEDULING (inches)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Vegetables	2.12	2.91	1.82	3.10	3.86	4.44	2.16	2.35	2.28	----	----	0.77	25.81
Citrus:													
no weeds	1.44	2.07	3.02	3.16	2.17	2.62	3.86	2.76	1.17	----	----	0.99	23.26
weeds	2.05	2.72	3.91	4.15	3.20	4.07	5.49	4.30	2.45	----	----	1.60	33.94
Banana:	1.94	2.99	4.53	3.68	2.11	0.42	1.39	0.75	----	----	----	1.13	18.94

Prepared by the BAHAMAS METEOROLOGICAL DEPARTMENT - Climatological Section in collaboration with the I.I.C.A. Irrigation Consultant during the period JULY-SEPTEMBER 1989.

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APPENDIX

TABLE- 23

SPECIFICATIONS AND ESTIMATED COSTS (US$, F.O.B.BAHAMAS) OF THE GUN-SPRINKLER SYSTEM RECOMMENDED FOR A 35 ACRES MODEL FARM (FRUIT, VEGETABLES OR FORAGE CROPS) DESIGNED FOR THE NORTHWESTERN ISLANDS OF THE BAHAMAS, IN US$ (F.O.B.BAHAMAS)

	UNITS	PRICE/UNIT	YEARS 1	2	3-10	11	12-20
INVESTMENT COSTS AND SPECIFICATIONS:							
Wells [10,20-30' deep] [10 years depreciation]	18.0	200.0	3,600.0	-	-		-
Pump [400-600 gpm,diesel engine, Gun-sprinkler and trailor] [10 years depreciation]	1.0	12,000.0	12,000.0	-	-		-
TOTAL INVESTMENT COSTS			15,600.0			15,600.0	
DEPRECIATION OF TOTAL INVESTMENT COSTS [10 years depreciation]				1,560.0	1,560.0	1,560.0	1,560.0
OPERATION & MAINTENANCE COSTS							
Diesel Fuel [379 pumping hours, 5.0 gal/hr, US$ 1.75/gal]				3,335.2	3,335.2	3,335.2	3,335.2
Oil [9.5 gal, US$ 10.0/gal				95.0	95.0	95.0	95.0
Repair [US$ 50/100 hrs]				189.5	189.5	189.5	189.5
Labors [two labor per hour] for 4 acres, US$ 2.75/ hr/labor]				521.2	521.2	521.2	521.2
TOTAL ANNUAL OPERATION & REPAIR COSTS				4,140.9	4,140.9	4,140.9	4,140.9

NOTE:

Accounting Conversion: Investments takes place at the end of the investment period.

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APPENDIX

TABLE- 24

SPECIFICATIONS AND ESTIMATED COSTS OF THE DRIP IRRIGATION SYSTEM RECOMMENDED FOR A 40 ACRES MODEL CITRUS FARM DESIGNED FOR THE NORTHWESTERN ISLANDS OF THE BAHAMAS, IN US$ (F.O.B.BAHAMAS)

INVESTMENT COSTS & SPECIFICATIONS:	UNITS	PRICE/UNIT	1	2	YEAR 3-10	11	12-20
Wells [10" diameter, about 20-30'deep] [10 years straight line depreciation]	4.000	200.000	800.000	-	-		-
Pump [200 gpm, diesel engine, 9hp, '200 TDH, Flow Meter] [10 years straight line depreciation]	1.000	2,420.000	2,420.000	-	-		-
Filters [48", Sand Media] [10 years straight line depreciation]	1.000	2,165.000	2,165.000	-	-		-
Fertigation Unit [Injector, 314"x0.75", tank] [10 years straight line depreciation]	1.000	190.000	190.000	-	-		-
Intake Line [4", 120 psi, schedule 40, 960'] [10 years straight line depreciation]	960.000	1.060	1,017.600	-	-		-
Mains Self Coupling [120 psi, schedule 40, 4", 1000-50x20' lengths-, 2 valves, 2 concrete stay at "T" junction] [10 years straight line depreciation]	1,000.000	1.060	1,060.000	-	-		-
Submains [120 psi, schedule 40, 3" I.D. ,1744, 8 valves 3"] [10 years straight line depreciation]	1,744.000	0.670	1,168.480	-	-		-
Laterals [Polyvinyl, 0.58" I.D. of 69,600] [10 years straight line depreciation]	69,600.000	0.045	3,132.000	-	-		-
Emitters [Button drippers BARBED type of 1 gphr = 4640 emitters] [10 years straight line depreciation]	4,640.000	0.180	835.200	-	-		-
Pressure guages [0.25" male, thread 0-100 psi] [10 years straight line depreciation]	10.000	12.000	120.000	-	-		-
Trenching [18"x8"] [10 years straight line depreciation]	2,744.000	0.800	2,195.200	-	-		-
TOTAL INVESTMENT COSTS			15,103.400			15,103.400	
DEPRECIATION OF TOTAL INVESTMENT COSTS [10 years straight line depreciation]				1,510.400	1,510.400	1,510.400	1,510.400

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CONTINUED

APPENDIX

TABLE- 24

INSTALLATION LABOR COST:	Total reg.hrs	Rate/hr	1	2	3-10	11	12-20
Pluming of 4 wells [900'+60' Intake Pipe" + Ts" + foot valves]. 8hrs/well	8.0	7.5	60.0				
Construction of concrete slap [4'x8'x" for pump and filters]	13.0	7.5	97.5				
Plumbing of pump & filter	13.0	7.5	97.5				
Mains self coupling [1000'-50x20' lengths]	8.0	7.5	60.0				
Installation of 2x4" valves & 2 concrete stays at "T" junction	2.0	7.5	15.0				
Installation of submains self coupling [1744'-88x20' lengths + 8 valves]	14.0	7.5	105.0				
Installation of 72 risers [drilling and connectionss]	24.0	7.5	180.0				
Installation of laterals [69,600, 0.58" I.D,20 min/lateral]	48.0	7.5	360.0				
Installation of drippers [4,640 emitters]	77.0						
TOTAL LABOR INSTALLATION COSTS [10 year depreciation]	207.0		975.0			975.0	
OPERATION & MAINTENANCE COSTS:							
Diesel Fuel [624 operation hrs,0.5 gal/hr,$1.76/gal]		549.12	549.12	549.12	549.12	549.12	549.12
Oil [5 gal/year,US$ 10.0/gal]		50.00	50.00	50.00	50.00	50.00	50.00
Repairs [US$ 20/100 hrs of operation]		124.80	124.80	124.80	124.80	124.80	124.80
Labor [one labor for 40 acres,8 hr/day,$4.0/hr]		9,984.00	9,984.00	9,984.00	9,984.00	9,984.00	9,984.00
TOTAL INSTALLATION LABOR COSTS [10 years depreciation]			10,707.92	10,707.92	10,707.92	10,707.92	10,707.92

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APPENDIX

TABLE- 25

SPECIFICATIONS AND ESTIMATED COSTS (US$ F.O.B.BAHAMAS) OF THE DRIP IRRIGATION SYSTEM RECOMMENDED FOR A 32 ACRES MODEL VEGETABLE FARM DESIGNED FOR THE NORTHWESTERN ISLANDLS OF THE BAHAMAS, IN US$ (F.O.B.BAHAMAS)

	UNITS	PRICE/UNIT	YEARS 1	2	3-10	11	12-20
INVESTMENT COSTS & SPECIFICATIONS:							
Wells [10" diameter, about 20-30'deep] [10 years straight line depreciation]	4.00	200.00	800.00	-	-		-
Pump [600gpm, diesel engine, 29hp, 200 RPM, Flow meter, mounted on a trailer] [10 years straight line depreciation]	1.00	11,020.00	11,020.00	-	-		-
Filters [36", sand media] [10 years straight line depreciation]	2.00	1,744.58	3,489.16	-	-		-
Fertigation Unit [Injector 3/4"x0.9" plus a tank of 15 gallons] [10 years straight line depreciation]	1.00	500.00	500.00	-	-		-
Intake Line [6",120psi, schedule 40, 960] [10 years straight line depreciation]	960.00	2.35	2,256.00	-	-		-
Mains seff coupling [120psi, schedule 40 ,1500', 6", 3"x6" gate valves, 2 concrete stays at "T" junction] [10 years straight line depreciation]	1,500.00	2.35	3,525.00	-	-		-
Submains [120psi, schedule 40, 2800 ,3" I.D., 140x20' lengths, 16 valves 3"] [10 years straight line depreciation]	2,600.00	0.67	1,876.00	-	-		-
Trenching [18"x8"] [10 years straight line depreciation]	4,300.00	0.80	3,440.00	-	-		-
Pressure guages [0.25" male, thread 0-100psi] [10 years straight line depreciation]			100.00				
TOTAL INVESTMENT COSTS			27,006.96			27,006.96	
DEPRECIATION OF TOTAL INVESTMENT COSTS [10-years straight line depreciation]				2,707.70	2,707.70	2,707.70	2,707.70

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APPENDIX

TABLE- 25

CONTINUED

	Total reg	Rate/hr	1	2	3-10	11	12-20
INSTALLATION LABOR COSTS:	hrs						
Plumbing of 4 wells [900'+60' Intake pipe +"Ts" and foot valves] 2hrs/well	8.0	7.5	60.0	-	-		-
Construction of concrete slap [4'x8'x4" for pump and filter	13.0	7.5	97.5	-	-		-
Plumbing of pump and filter	13.0	7.5	97.5	-	-		-
Main self coupling [1500-6", 3x6" gate valves, 2 concrete stays at "T" junction	11.0	7.5	82.5	-	-		-
Submains [2800', 3" I.D., 140x20' lengths, 16x3" valves]	26.0	7.5	195.0	-	-		-
Installation of 464 risers	77.0	7.5	577.5	-	-		-
Installation of laterals [32 rolls of 232,320']	309.0	7.5	2,317.5	2,317.5	2,317.5	2,317.5	2,317.5
TOTAL INSTALLATION LABOR COSTS [10 year depreciation for all activities except laterals]			3,427.5			3,427.5	
OPERATION & MAINTENANCE COSTS:	Per Season	Per year[3 Seasons assumed]					
Diesel Fuel [156 hrs/season, 4 gal/hr, US$ 1.76/gal]	1,098.24	3,294.72		3,294.72	3,294.72	3,294.72	3,294.72
Oil [9 gals per season, US$ 10.0/gal]	11.25	33.75		33.75	33.75	33.75	33.75
Repairs [US$ 30/100 hrs/season]	46.88	140.63		140.63	140.63	140.63	140.63
Labor [one labor for 32 acres for 8 hours per day, US$ 40.0 per hour]	2,080.00	6,240.00		6,240.00	6,240.00	6,240.00	6,240.00
*Laterals [poly vinyl with in-line emitters; ,39 rows of 7260 ech/acre; 232,320 risers 464'-0.5" Flexible P.V.C]		7,552.00	7,552.00	7,552.00	7,552.00	7,552.00	7,552.00
TOTAL ANNUAL OPERATION AND MAINTENANCE COSTS	3,236.37	17,261.10	7,552.00	17,261.10	17,261.10	17,261.10	17,261.10

* Lateral are parts of the equipment needed but their costs are included under O&M costs because they are replaced annually.
** Accounting Convension: Investments take place at the end of the investment period.

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APPENDIX

TABLE- 26

SPECIFICATIONS AND ESTIMATED COSTS (US$, F.O.B.BAHAMAS) OF THE SPRINKLER SYSTEM RECOMMENDED TO PROVIDE LIMITED IRRIGATION FOR ONE ACRE MODEL MIXED CROPS FARM DESIGNED FOR THE SOUTHEASTERN ISLANDS.

	UNITS	PRICE/UNIT	YEARS 1	2	3-10	11	12-20
INVESTMENT COSTS AND SPECIFICATIONS:							
Abstraction pit [9'x9' and extending about 3' below water table] [10 year straight line depreciation]	1.0	400.0	400.0	-	-		-
Pump [1.5" suction], 1.5" discharge to be reduced to 0.75", 100 gpm discharge, 50 psi 3 hp motor 3600 RPM] [10 year straight line depreciation]	1.0	400.0	400.0	-	-		-
Rain bird sprinkler [0.75"] [10 year straight line depreciation]	4.0	12.5	50.0	-	-		-
Garden Hose [0.75", 50' length] [10 year straight line depreciation]	6.0	25.0	150.0	-	-		-
P.V.C Pipe [0.75", 20' length] [10 year straight line depreciation]	2.0	6.0	12.0	-	-		-
Couplings [0.75"x0.75"] [10 year straight line depreciation]	4.0	1.0	4.0	-	-		-
Elbows [0.75"] [10 year straight line depreciation]	4.0	1.0	4.0	-	-		-
Home-made tripoids [10' height] [10 year straight line depreciation]	2.0	25.0	50.0	-	-		-
TOTAL INVESTMENT COSTS			1,070.0			1,070.0	
DEPRECIATION OF TOTAL INVESTMENT COSTS [10 years depreciation]				107.0	107.0	107.0	107.0
OPERATION & MAINTENANCE COSTS:							
Gasoline Fuel [one gal/h, 20 hrs pumping time per year, US$ 2.0/gal.of fuel]				40.00	40.00	40.00	40.00
Oil [0.75 gal, US$ 12.0 gal]				9.00	9.00	9.00	9.00
Repairs [US$ 0.15 per hour]				3.00	3.00	3.00	3.00
Labor [one labor per hour per acre, US$ 2.75/hr]				2.75	2.75	2.75	2.75
TOTAL ANNUAL OPERATION AND MAINTENANCE COSTS				54.75	54.75	54.75	54.75

NOTE:

Accounting Convension: Investments take place at the end of the investment period.

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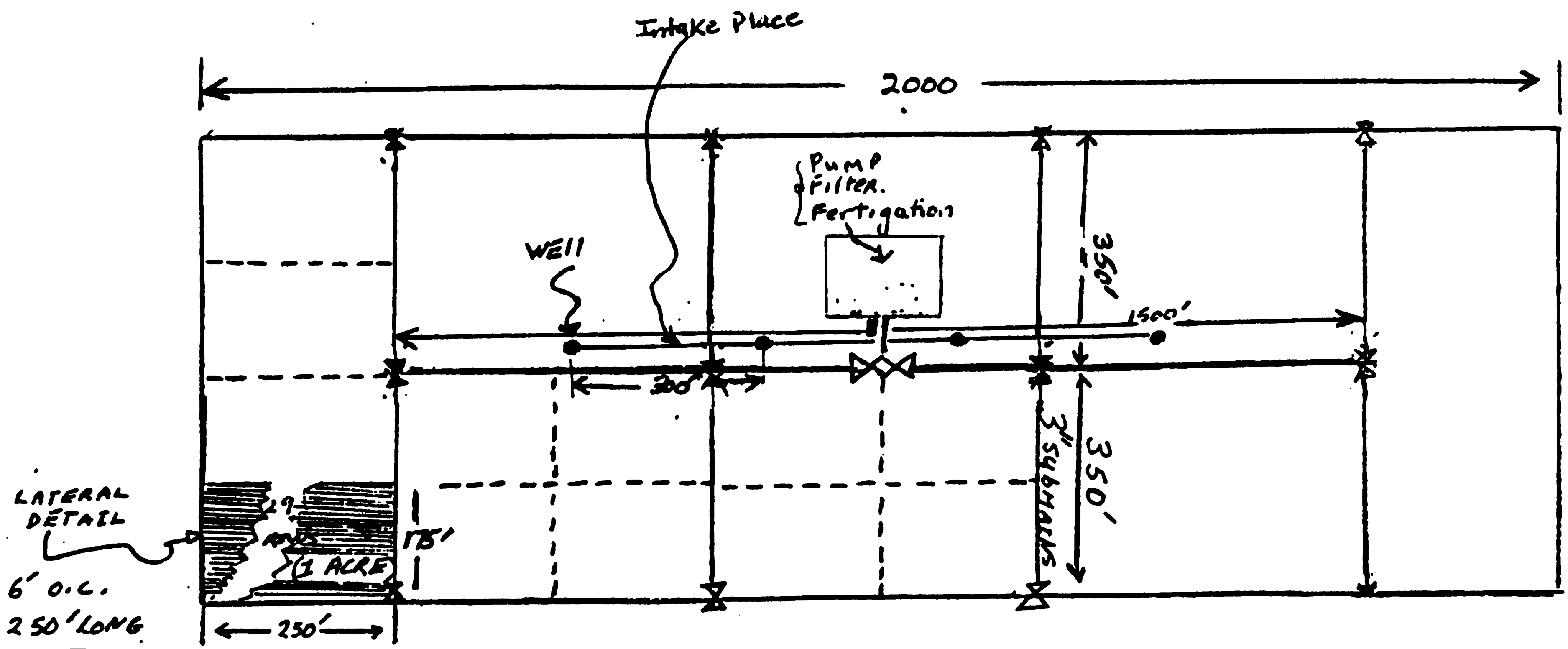
LAYOUT OF A DRIP IRRIGATION SYSTEM DESIGNED FOR A 40 ACRES MODEL CITRUS FARM



RISERS - - -464
GATE VALVES
3" - - - - 16
GATE VALVES
6" - - - - 3
FOOT VALVES 4
6"

SLIP X MALE THREAD 3" 24
SLIP X MALE THREAD 6" 15
REDUCERS 6" X 3" 4

6" MAINS 1500'
3" SUBMAINS 2800'
0.58" LATERALS 232,000'
1/2 gph @ 12" SPACING
INTAKE 6" 960'

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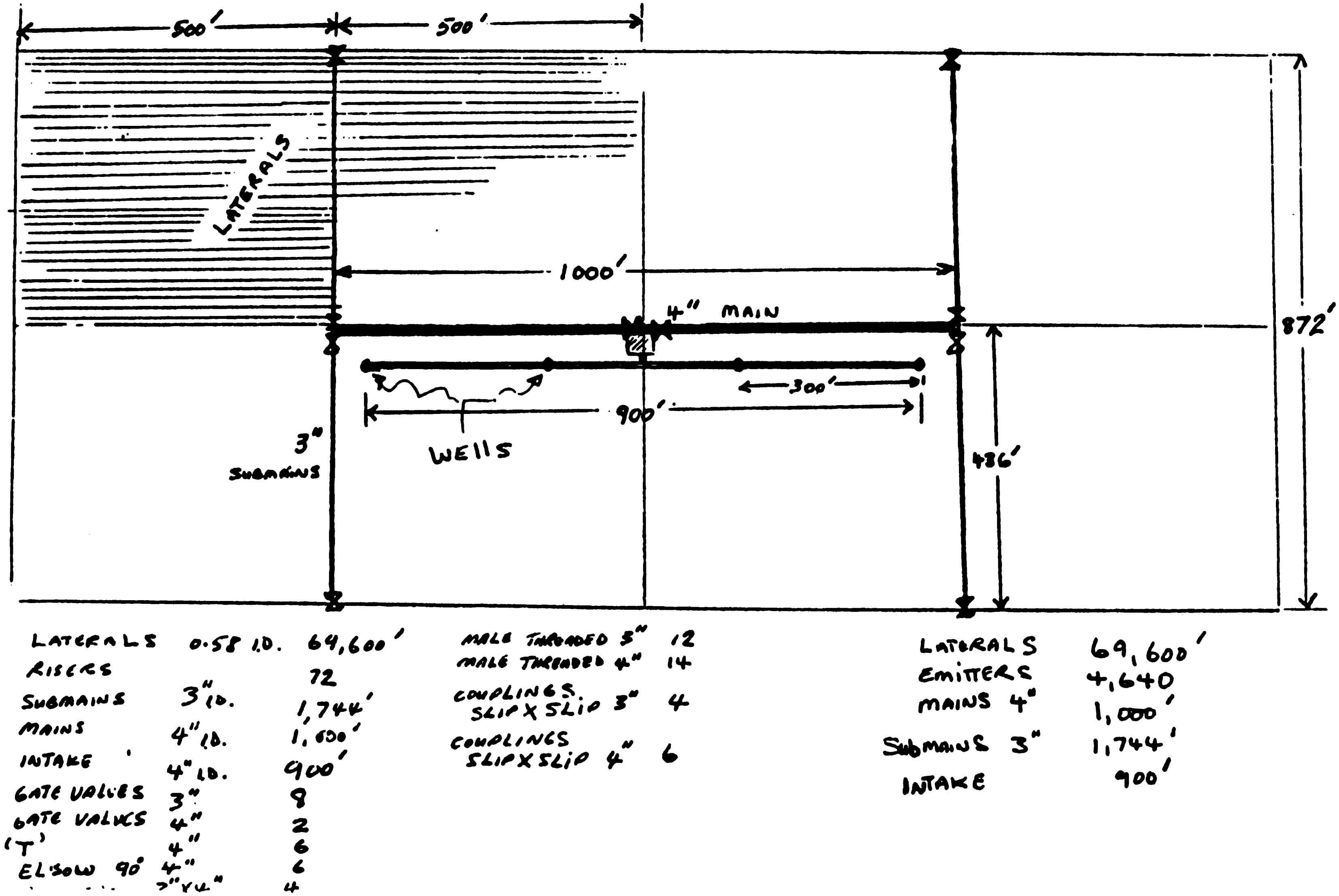
LAYOUT OF A DRIP IRRIGATION SYSTEM DESIGNED FOR A 32 ACRES MODEL VEGETABLE FARM



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THE BAHAMAS

AGRICULTURAL SERVICES DEVELOPMENT PROJECT

(BH-0011)

ANNEX 4

AGRICULTURAL MARKETING SUBPROJECT

This report was prepared by Dr. Luis A. Ampuero, assisted by Mr. Elvis Rolle (counterpart) and Mr. Joao Bosco Monnerat, IICA Project Coordinator

INTER-AMERICAN INSTITUTE FOR COOPERATION ON AGRICULTURE

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I. INTRODUCTION

t of The Bahamas supports development of the agricultural sector to achieve structural economy, save foreign exchange, and consolidate farming in the Family Islands. To it will encourage the production of crops, orchards and livestock and will strenghten the reting system. For this purpose, in 1989 the Agricultural Services Development (ASD) ulated, with the technical cooperation from the Inter-American Institute for Cooperation CA).

roduction generated by the implementation of the ASD Project, it is necessary to inghten the Produce Exchange system. This requires upgrading the existing Produce cilities in Nassau and packhouses in the Family Islands, an improvement of "mailboat" rvices, a new approach to foodstuff retailing, and the establishment of a market m and an agricultural export promotion capacity.

'ed agricultural marketing system is centered around a major wholesale facility located assau, that serves as the country's main collection point for produce originating in New ı a network of seven packing houses in the Family Islands. Transportation services ly Islands and Nassau are provided by "mailboats", which use Potter's Cay for landing.

of the ASD Project recommended that the Produce Exchange at Potter's Cay be that a new facility be constructed at Soldier's Road. However, as the original version ct was reviewed by Bahamian government officials, the concept and high cost of PE were seriously challenged. It became clear that for implementation of the ASD be necessary to reduce investment costs and find less expensive alternatives for duce Exchange system.

udy

this document to redesign the agricultural marketing component of the ASD Project, uidelines indicated by the Bahamian Government. Specifically, this study will evaluate iovating the Produce Exchange at Potter's Cay, as well as the construction of a new e site or at another location in New Providence Island. Current operating and ires of the current system will be assessed and recommendations formulated.

nalize the physical and operating characteristics of packhouses in the Family Islands, ovation and equipment needs, and how these should be integrated with the Produce iendations will be made in reference to changes in management procedures and

e conducted of "mailboat" services currently providing inter-island transportation of ctual relationships between the Produce Exchange and "mailboat" operators will be lyhood of boat operators improving their services with project implementation.

between the Produce Exchange system and the agricultural market information the ASD Project will be indicated, and the need to establish a market information :ed.

and Organization

d employed for the study included a review of existing secondary information and ocuments provided by the Ministry of Agriculture, Trade and Industry (MATI), IDB with MATI authorities, senior technical staff of IDB and IICA, PE executives and ctor operators in the retail and wholesale marketing of fruits and vegetables,

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equipment suppliers, packhouse managers, "mailboat" operators, and private farmers; and a series of site visits to the PE at Potter's Cay, retail outlets in Nassau, and the packing house located in North Andros.

Field work was conducted during a period of three weeks in The Bahamas. Preparation of the study was completed in three weeks at IICA headquarters in San José, Costa Rica.

Chapter II evaluates the current Produce Exchange system and describes its physical and operating characteristics. The operating and physical modifications recommended for the Produce Exchange system are presented in Chapter III. An estimation of four investment alternatives associated to the rehabilitation and renovation of the Produce exchange is conducted in Chapter IV. The main bibliographical sources are listed in Chapter V, and Chapter VI includes a series of relevant complementary information materials.

D. Acknowledgements

Elaboration of this document has been possible with the colaboration of persons in The Bahamas and in Costa Rica, Mr. Joao Bosco Monnerat, Project Mr. Freddy Revilla, institutional and credit analyst, and Mr. Nelson Espinoza coordinator of IICA, have provided permanent support and encouragement. Mr. Elvis Rolle, economic analyst of the Ministry of Agriculture, assisted with the collection of information and was an invaluable guide in interviews and field visits in Nassau and Andros. Messrs. Robert Douglas, David Marshall and Belville Edwards, architect and engineer from the Ministry of Works and Utilities, furnished the various layout alternatives for the Produce Exchange. Messrs. Tyrone North and Earl Bastian, Manager and Assistant Manager of the Produce Exchange, contributed with information and insights about system operation.

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II. ASSESSMENT OF THE PRODUCE EXCHANGE SYSTEM

A. Antecedents

This section analyses the main characteristics of the state-owned agricultural marketing system in The Bahamas, which includes the Produce Exchange (PE) facility and retail outlets in Nassau, and the packing houses in the Family Islands. The "mailboats", which provide inter-island transport services of produce from the packing houses to the Produce Exchange, are also analyzed.

The Produce Exchange (PE) at Potter's Cay was established in 1966, with cold storage and produce handling facilities and equipment, to spearhead marketing activities of fruits, vegetables and field crops produced by farmers in New Providence and other islands in the country. Subsequently, the Government sponsored the construction of packhouses in several islands, which were assigned the task of purchasing produce from local farmers, and grade, pack and ship it to the PE.

The PE system includes two retail outlets in Nassau, located in Kemp Road and Jumbey Village. Retail sales are also conducted at the PE's Potter's Cay site.

A vital element of the agricultural marketing system are the "mailboats", which provide transport services from the packhouses in the Family Islands to the PE in New Providence. Participation of these boats, which receive a government subsidy to provide weekly mail transport services, is essential to assure regular produce shipments from the islands to Nassau. These boats have traditionally used the Potter's Cay port facilities.

B. The Produce Exchange (PE) at Potter's Cay

1. Physical Location

The Produce Exchange (PE) building is located at a site named Potter's Cay, under the causeway connecting New Providence to Paradise Island. As Fig. 1 shows, the facility is located, in the midst of a port facility and various government-owned buildings. The PE is favourably located, as it is the focal point for "mailboats" traffic linking Nasau and the Family Islands.

Boats docking at Potter's Cay transport a diverse assortment of commodities from Nassau to the Family Islands, because it is the cheapest transportation mode available. Frozen meats, cooking oil, furniture, vehicles, cement and construction materials, dry goods and foodstuffs and mail are regularly shiped to the islands. Farmers in the islands can also obtain fertilizer, insecticides, seeds, and horchard supplies in the Fish and Farm Stores located across the PE, on the East side of the Paradise Island causeway.

At Potter's Cay, boats unload agricultural goods and produce originating in the Family Islands. Being the most important return load, agricultural produce contributes to sustain the economic viability of "mailboat" services connecting Nassau with other island in The Bahamas.

The position of Potter's Cay as point of arrival for a variety of fresh produce has induced the formation of a retail market along the main entrance road, where some 80 to 100 retail stalls have been set up. This, in addition to the stato-owned Marine Products Market located on the south side of the PE, where there are 24 retail stalls for 48 fish vendors. Along the driveway under the causeway, there are at least two smaller produce wholesalers selling fruits and vegetables off their refrigerated trucks.

Fig. 1

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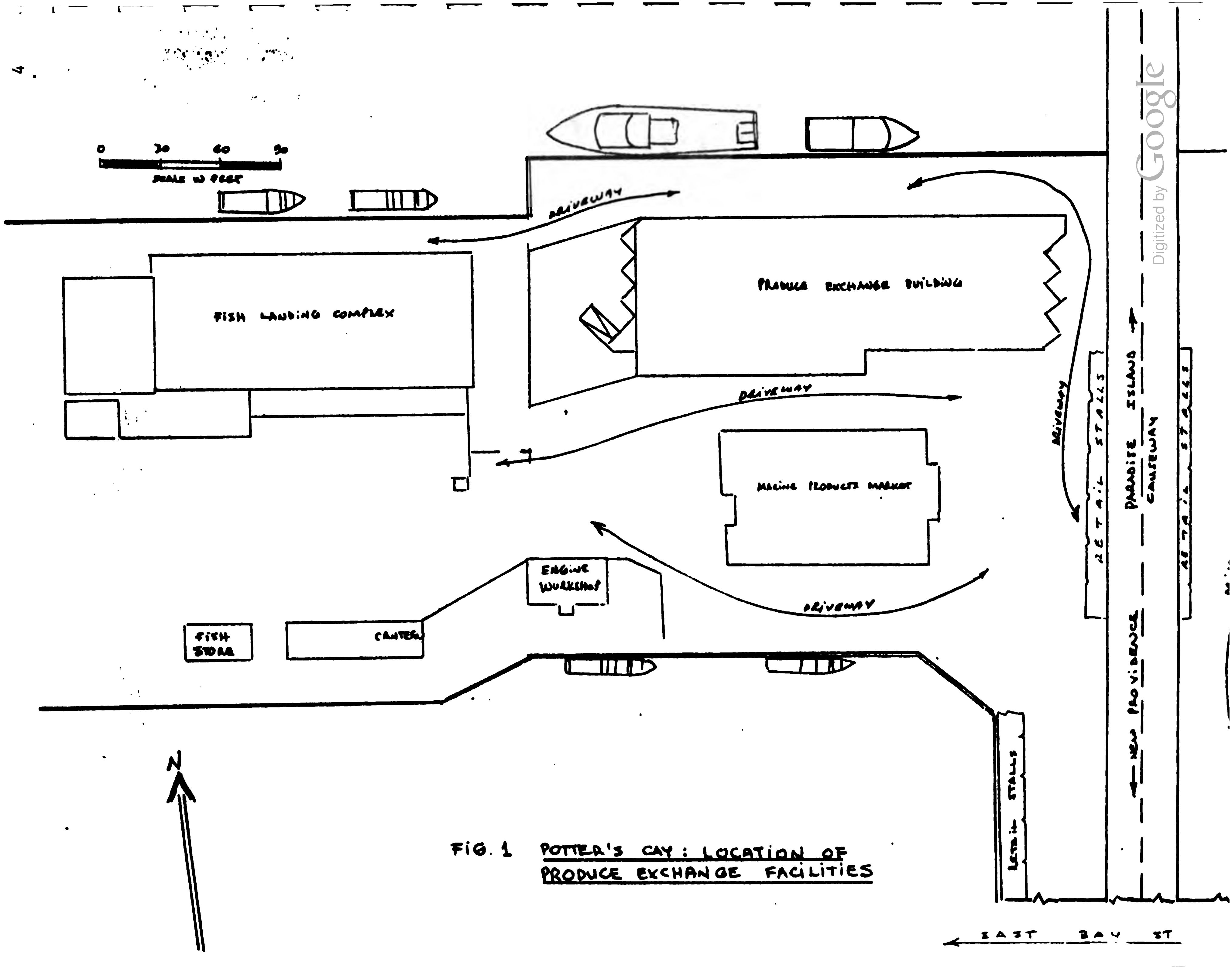

FIG. 1 POTTER'S CAY: LOCATION OF PRODUCE EXCHANGE FACILITIES

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Because of the presence of these vendors, the vehicle flow along the causeway and the traffic to downtown Nassau, during certain hours of the day, there exists a traffic congestion on the intersection connecting Potter's Cay and East Bay Street.

For PE customers, the site occupied by the wholesale facility is quite favourable. Being located on the periphery of downtown Nassau, it is easily accesible to consumers and institutional clients in New Providence and Paradise Islands. From Potter's Cay, produce deliveries can be readily made to customers throughout the city. The site at Potter's Cay is particularly valuable as it is the center of operations for "mailboat" traffic connecting Nassau with rural and farmer communities in other islands. The PE's location at Potter's Cay minimizes trans-shipment costs of produce from boats to the PE.

However, from an urbanistic standpoint, the establishment of produce and fish collection and wholesaling activities, and fish and farm supply outlets, in close proximity to Paradise Island, one of the country's leading tourist resort areas, is not optimal. Regardless of how well it is managed and controlled, operation of wholesale facilities handling perishable products generate unpleasant odours and garbage, and attract low-income and destitute individuals, as well as retail vendors of foodstuffs, who should operate in non-tourist areas.

2. Layout

The PE is schematically presented in Fig. 2 and consists of the following:

a. External perimeter, enclosing a site of approximately 90 ft by 200 ft. Most of the site is occupied by the main building, with the exception of the docking area in the West end. This docking area is enclosed with a chain link fence that does not offer adequate protection.

   The facility is surrounded by public driveways and other state-owned buildings. It has no areas for future expansion. The North side faces a public driveway along the port, which is generally congested by people and vehicles handling cargo. The West side is next to a driveway separating the PE from the Fish Landing Complex. The South side faces a driveway separating the PE from the Marine Products retail market, and the East side faces the driveway connecting Potter's Cay with East Bay St., and separating the PE building from the columns sustaining the causeway.

b. Product loading and unloading areas, on the West and East sides of the building. The loading area on the West end has been constructed to serve four vehicles and has an area of approximately 5.800 square feet. However, the area for maneuvering is so narrow that it is difficult for two medium-sized vehicles to unload at a time. It would be difficult to unload a 20 feet container on the West end dock.

   The loading area on the East side has facilities for docking three vehicles simultaneously. The maneuvering area in this side is larger than the one at the other end, yet it lacks the necessary security and protection to inhibit the presence of intruders and bystanders. A 20 ft container could use the East end dock, yet it would block the driveway in front of the PE.

   Both loading areas have a height of approximately 3 ft 2" and are suitable for unloading produce transported in large and heavy vehicles. This is unfortunate as presently most vehicles unloading and loading cargo at the PE are of medium and small size. None of these vehicles can adequately use the current docking facilities.

Fig. 2

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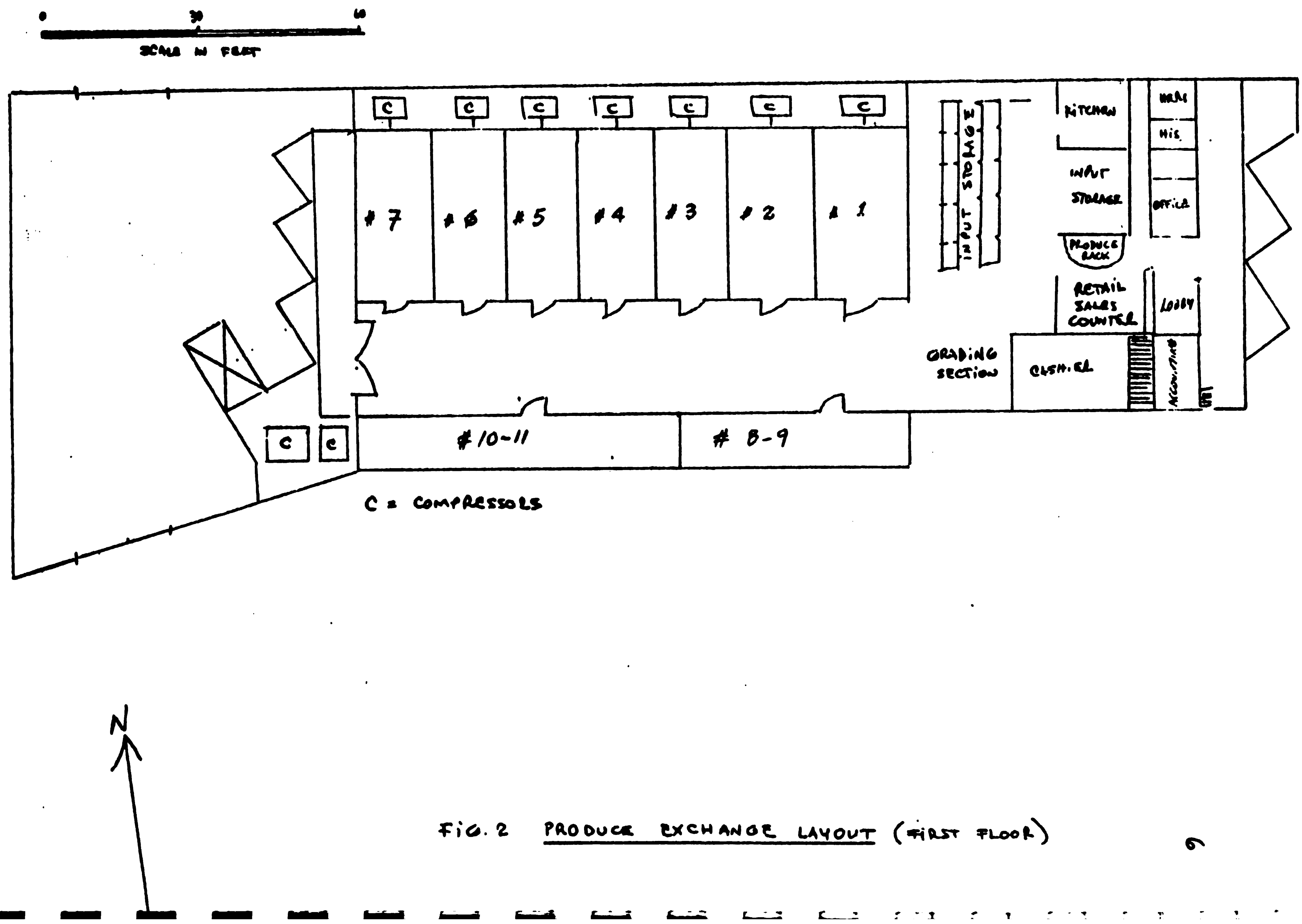

FIG. 2 PRODUCE EXCHANGE LAYOUT (FIRST FLOOR)

two loading bay areas do not offer protection from natural elements to incoming or rgo. This is detrimental to product quality as vehicles in use generally lack covered

n of having loading and unloading areas on the two extremes of the facility, together (of fences and a security system, is one more cause for pilferage.

g area, consisting of approximately 13.000 square feet of constructions, including the rts:

Storage rooms- on the North side of the building, there are seven cold rooms in line, one measuring 14 ft 10" wide, 38 ft 8" long, and 9 ft 8" high. Doors leading to these s have a standard size of 7 ft 2" by 4 ft 8". These chambers have a refrigerating volume proximately 40.000 cubic feet, sufficient to refrigerate 10 metric tons of produce per ber.[1]

cordance to the original building plan, these cold storage chambers were to be used lows:

ıber # 1 (East end):	Spare storage
ıber # 2:	Vegetable storage
ıber # 3:	Vegetable storage
ıber # 4:	Orange storage
ıber # 5:	Orange storage
ıber # 6:	Onion storage
nber # 7 (West end):	Onion storage

/ years ago, a gas ripenning room for tomatoes and bananas was installed in Chamber The installation has not been completed.

Storage Rooms- on the South side of the building, four cold rooms were originally tructed. Some years ago, dividing walls of two of these rooms (# 8 and 9) were taken to form one single chamber. In addition, the wall dividing chambers # 10 and # 11 was ved, and one door was eliminated (# 11), to install a gas ripening room for bananas tomatoes. A local company completed the installation of this gassing room but did not any operating manuals nor anybody trained to run it. At present, none of these nbers (# 8 through 11) is in operation.[2]

groups of cold chambers are separated by a 21 ft 6" wide corridor. This is too wide resents a waste of space.

0 per cent of the aluminum louvers installed to protect the outside refrigeration panels nbers # 8 through # 11 is lost. This has occurred because these panels face a public ion area and has no type of fencing to protect it from vandals. The loss of louvers will panel lives, and will also increase operation costs due to refrigeration losses.

capacity, it is assumed that produce boxes are stored up to a maximum level of 8 rows, in pallets placed Pallets are assumed to be handled with manually driven lifts, leaving a 6 ft. central corridor for access. If this ated, storage capacity could be increased to 15 metric tons per chamber.

Maintenance office of MATI, the services of a Miami expert (Mr. Robert J. Malia, of Thermo Air Inc., P.O. Box Fla.) have been recently contracted to assess the condition of rippening facilities in Chambers # 7 and # rt was expected to have an estimated rehabilitation cost by late September 1990.

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iii. Product Selection and Grading area- this is located between the sales and input storage areas. Originally a machine for the processing of tomatoes, potatoes, oranges and grapefruits was installed in this area. Some months ago, this machine broke down and was removed for maintenance. Its current where abouts are unknown. Hence, PE personnel employ a rudimentary wooden table for grading and sorting.

The location of the grading area is not appropiate as it is adjacent to the sales and administration area. It is also small as it occupies less than 1.200 square ft. During the peak season, the processing area is a bottleneck to product flows from cold storage chambers to the sales area. Even during the low production season corresponding to the time this study was conducted, personnel and product congestion were observed as a result of the limited space currently assigned to product grading and packing activities.

iv. Input storage area- this is positioned across the grading area. It is completely open and it permits unrestricted access by PE personnel and customers. Because of its closeness to the grading area, packing materials come in close contact with discarded, spoiled and rotting produce. After working hours, the area does not prevent contacts of pests and insects with packing materials. In times of increased seasonal production, as produce accumulates throughout the exchange, it becomes difficult to access input storage areas.

In addition to the problem of using an inappropriate area for the storage of packing inputs, the existing area is improperly utilized, as a result of insufficient shelving. This explains why cardboard boxes are "stored" in the second floor, on the kitchen roof, and under the West side dock of the PE, in several rooms of the Fish Landing Complex, and in the Jumbey Village Retail outlet.

v. Sales and accounting area- this is located in front of the PE and consists of a cashier's office, front desk, retail display room, employee kitchen and accounting office. Two other rooms in the East front of the facility are presently not being utilized. This sales area is predominantly employed to conduct retail sales to consumers and small retail vendors, rather than being used for wholesale transactions. This sales and accounting area is adjacent to the processing/grading section, with no physical division or separation of any kind. The kitchen and bathroom areas, pressumably for the use of plant employees, is directly accesible from the produce processing/input storage area.

vi. Electrical Control Board- located between a presently unused office and the employee bathrooms.

vii. Employee bathrooms- for men and women, located in the North-East corner of the building, adjacent to the electrical control board and next to the kitchen.

viii. Administrative offices- located in a second floor and forming an "L" along the East and South fronts of the building, on top of the sales area and grading section. These offices include those of the General Manager, Assistant Manager, Secretary, Accounting Section, and Purchasing Section. There are also three bathrooms, one kitchen, one storage room, and two vacant offices.

d. Compressor Areas are located on two sections of the PE. One along the North side, next to the seven cold chambers in line, and other in the South-West corner of the building. The group of seven compressors facing the dockside is protected by a roof and a chain link fence, without any measure of security nor protection from vandalism and salty ocean waters. The refrigeration machinery on the South-West corner is in the open and lacks any protection from natural elements and ocean salt.

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e location of compressors facing the dock needs to be remarked. These delicate
ninery, which have copper coils and pipes, are specially affected by ocean salt and
tected in every possible way.[3] Moreover, these compressors are at the mercy of
ng the public port driveway. (Reportedly, compressors are vandalized on weekends
when PE personnel is gone, to prevent refrigeration of a given chamber, and assure
of abundant spoiled products on Monday).

Vehicles

__Rooms__

rincipal drawbacks of the refrigeration system in the PE refers to the fact that it
Freon 12, as most refrigeration facilities in The Bahamas. Because Freon 12 is an
chlorofluorocarbon (CFC), it has a negative effect upon the ozone layer, and is being
sed out. In accordance to an international agreement, by the year 2.000 Freon 12 will
used for industrial purposes.

s of the eight cold rooms presently existing in the PE are presented in Table 2.1. All
rs in service have 7.5 HP motors and the same dimensions.

TABLE 2.1.
PE: CHARACTERISTICS OF COLD STORE FACILITIES

CHAMBER #	HP	GAS TYPE	DIMENSIONS FT)
1	7.5	FREON 12	14'10"X38'8"X9'8"
2	7.5	FREON 12	14'10"X38'8"X9'8"
3	7.5	FREON 12	14'10"X38'8"X9'8"
4	7.5	FREON 12	14'10"X38'8"X9'8"
5	7.5	FREON 12	14'10"X38'8"X9'8"
6	7.5	FREON 12	14'10"X38'8"X9'8"
7			14'10"X38'8"X9'8"
8-9			11'5" X43'7"X9'8"
10-11			11'5" X58'7"X9'8"

Gas ripening facilities have been installed in rooms # 7 and # 10-11.

mbers exhibit deficiencies which prevent their proper utilization and maintenance, as

s doors have a height of 7 ft 2" and do not permit the use of existing forklift, which is
igh;

ooms are so narrow (14 ft 10") that, even if the forklift could enter, it would be able to
produce along one wall only;

ber heights are low (9 ft 8") so that only one row of pallets can be stored. Use of at
two-level metal racks would require a minimum height of 16 ft. (allowing 4 ft for air
lation and for installation of evaporators);

igeration specialists in The Bahamas, the damaging effect of ocean salt upon the PE 's refrigeration
t be over-emphasized. It reduces equipment life from one-half to one-third of its normal period of service,
costs are significantly increased.

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(iv) rooms are poorly illuminated;

(v) all doors lack plastic curtains to prevent refrigeration leakages; and

(vi) there is not an adequate drainage system to permit regular washing of the chambers and eliminate condensation fluids.

b. Grading and Handling Equipment and Machinery

The PE has one fuel-driven, counterbalance Clark forklift, a manually operated forklift, and a box stapling machine. There is no other type of produce grading, processing or handling equipment. The only grading machine of the PE broke down several months ago and has not yet been repaired. Consequently, all produce grading, sorting, cleaning and boxing is presently done by hand. The processing area is not air conditioned.

c. Ripening Rooms

Two former cold chambers (# 7 and # 10-11) have been converted to gas rippening rooms. However, the installation was incomplete and these rooms have never operated. Due to lack of maintenance and control, some pieces of equipment are missing.

d. Office Equipment and Furniture

The PE has the mimimum office equipment and furniture to operate, and consists of a typewriter and desk calculators, desks, chairs and file cabinets. The facility lacks a computer system.

e. Vehicles

The PE has two vehicles to serve its customers in Nassau, including a van, which can load up to 2200 lbs. of produce, and a truck, with a loading capacity of 8.800 lbs. None of these vehicles has refrigeration.

f. Plumbing, Sewage, Drainage and Electrical Installations

Existing plumbing, sewage, drainage and electrical installations are generally inadequate, as indicated in the analysis made my Ministry of Works personnel (see Annex D).

C. Retail Outlets in Nassau

In Nassau, in addition to the wholesale facility at Potter's Cay, the Produce Exchange system operates three retail outlets. Without exception, these outlets present a poor image of state management. Due to overstaffing and limited sales volume, these outlets are deficitary operations.

1. **The Potter's Cay Outlet**

The retail outlet at Potter's Cay operates on the sales area on the East end of the PE building. In this section, retail sales are conducted paralell to wholesale activities, serving small vendors and consumers. This retail activity occupies several PE employees and is the entity's principal source of clients.

Products sold in this outlet consist mainly of over-ripe produce. Even though there exist minimum volume requirements to sell in this outlet, these were observed to be quite flexible. Produce are

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lisplay table directly from the grading area. They are packaged and boxed in a attractive way. Product assortment is limited to those products handled by the PE. played in a flat wooden table on the back of the counter. The sales area has no ipment for produce or display racks. It lacks air conditioning, although it is well

l Outlet

at Kemp Road occupies the ground floor of a private residence. The facility has n front to accomodate four cars. The principal sales area has approximately 500 an open 12 ft-long refrigerated rack for produce display, a sales counter, a cash cale. Neither of the two existing air conditioning units operates, as both of them broke not been repaired.

able refrigeration chamber on the South side of the building, with an approximate) cubic ft, sufficient to manually store 2.5 tons of produce. However, as with most ilities in the system, this two-year old chamber ceased to operate one year ago and repaired since. Even though the chamber itself is in relative good condition, the t has been disassembled. Both the chamber and its compressor were assembled on ve no protective walls nor roof, being completely exposed to the sun, wind and rain

a presents a poor aspect, with a limited produce volume, narrow assortment, play and packaging, in addition to a general lack of hygiene and cleanliness. As in ne mix of products offered consisted only of products handled by the PE. The sign on the outlet's name has lost its colors and has fallen to the ground.

no independent system to remove spoiled products and garbage. When requested, a rented truck may take from one to three weeks to remove the garbage.

one manager plus four employees. These employees include two sales ladies, one ne clerk. As in the Potter's Cay facility, employee morale was observed to be low. The ployees and current payroll costs to operate this outlet are excessive for its size and rations.

Village Outlet

llage outlet also operates in association with the PE. It is located on Blue Hill Road and o buildings, each having approximately 3.000 square ft., one of which is rented to etailers and the other is used for sales to retailers and consumers.

on the West side has eight stalls which have been rented to private vendors. It seems that all or some of these vendors pay no rent. At least one of these vendors ity to store products and packaging materials, having installed his outlet at a more e nearby. Other stalls have simply been abandoned. A few of the existing retailers elatively good produce mix and volume, only part of which was bought from the PE uilding across the driveway.

o the East side building, one half of it has been converted to a sales area, while the used to store PE cardboard boxes. Illumination is extremely poor. Due to lack of rnishings, wooden display racks have been turned around and converted into a sales

to equipment, this outlet lacks a refrigeration chamber, and has only one 60 lb. scale, culator, and one desk.

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Reportedly, these buildings will be shortly abandoned, and the outlet moved to another location. This is appropiate as the East side building shows evident signs of structural decay, with several cracked walls.

This outlet is also staffed with five persons. As in the case of the Kemp Road store, this number of employees and payroll costs are excessive.

D. "Mailboat Services"

1. Relationship with the PE

"Mailboats" play a critically important role in transporting produce from field packing houses to the PE. Without these services, there could be no production of fresh fruits and vegetables in the islands. On the other hand, as recognized by boat operators themselves, the viability of their business is also dependent upon the successful operation of the PE, as produce is one of the few return loads from the islands. This situation reveals the level of mutual interdependence existing between the PE and boat operators.

In spite of their interdependence, however, there is virtually no formal relationship between boat operators and the Ministry of Agriculture or the Produce Exchange. The relationship between "mailboats" and the Government of The Bahamas, including subscription of service contracts and negotiation of subsidies, is channeled through the Ministry of Transport. So far, these negotiations have not addressed issues concerning the transportation of produce.

2. Principal Features

Tables 2.2a and 2.2b in Annex A show the main features of boats currently transporting poduce to the PE. About one-half of these boats have cranes or lifts to facilitate loading and unloading operations. Most boats lack refigeration facilities. This implies that produce must travel either on the deck, completely exposed to the sun, or in non-refrigerated compartments in the hull. Both of these forms of transportation are detrimental to product quality. Reportedly, temperatures in the hull can get as high as 150 degrees Farenheit!. It should not be surprising that entire shipments have been spoiled as a result of completely inadequate transportation conditions.

Only one-third of the boats curently transporting produce to the PE have refrigeration chambers. Refrigeration capacities are not distributed in proportion to outputs flowing to packing houses to the PE: three boats with refrigerated compartments operate in the Eleuthera-Nassau route, with an aggregate capacity of 25 MT; 2 boats serve the Andros-Nassau route, with a capacity of 4.8 MT; and 1 boat serves each of the routes from Abaco, Cat Island, and Grand Bahama to Nassau.

Refrigerated chambers in "mailboats" are of variable dimensions and storage capacities. Equipment and installations are non-standardized. No chamber has plastic curtains to inhibit refrigeration leakages, nor temperature/humidity controls. Thermographs are not employed. All chambers require use of manual storage methods.

3. Frequency of Service and Tariffs

With the exception of Eleuthera and Andros, packhouses have only one boat per week to ship produce to Nassau. This requires coordinated actions between the packhouse, the boat operator and farmers to avoid delays.

Tariffs for non-refrigerated transportation of produce to the PE in Nassau are equal for all the islands, Bh$ 1 per box. This rate increases to Bh$ 2 per box, for all islands, when transportation is in refrigerated compartments. This pricing mechanism penalizes the profitability of transport services from the more distant locations.

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f seven packhouses, located in the islands of Andros (North Andros Packing
rth Eleuthera, Hatchet Bay, and Green Castle Packing houses), Cat Island (Smith
Exuma (Mt. Thompson Packing House), and Long Island (North Long Island
se facilities follow a standard design in terms of building shape, sizes and
s, with the exception of the facilities at Green Castle in the island of Eleuthera and
hown in Table 2.3, most packing houses have building sizes of 2.400 square feet,
f the facility in North Andros which has 4.000 square ft. Facilities consist of
of 28' x 85', and 36' x 110' in North Andros. These buildings have access doors on
es.

nouses has 2.880 cubic feet of refrigerated storage, with the exception of the facility
leuthera that only has 1.980 cubic ft. Cold chambers have been attached to the
of the longer sides. These chambers have two doors, one to communicate with the
one facing the outside, to off load produce.

TABLE 2.3.
CHARACTERIS|ICS OF FIELD PACKING HOUSES

TION	BUILDING SIZE (SQ.FT.)	COLD STORAGE CAP.(ft3)	REFRIGERATION. CAPACITY (MT)	VOLUME * PACKED (MT)
EUTHERA	2.400	1.980	4.8	80
EUTHERA	2.400	2.880	7.2	555
ELEUTHERA	2.400	2.880	7.2	701
N ANDROS ISLAND	4.000	2.880	7.2	772
SLAND	2.400	2.800	7.2	176
MA	2.400	2.800	7.2	195
D, LONG ISLAND	2.400	2.880	7.2	514

es refer to 1989. Volumes of produce handled by each packing house vary markedly. As
le 2.3, those having the largest volumes in 1989 were the plants in North Andros and
These are followed by the facilities in Hatchet Bay and North Long Island. The plants
t outputs are those in Exuma, Cat Island and Green Castle.

o the largest of the Packing Houses, located in Andros, the following features have

igure 3, the plant in North Andros is a rectangular building 36 ft wide, 110 ft long, and
floor is at ground level, hence product handling is manual. Two entrances on the
are used for reciving produce from farms. A cold storage chamber has been attached
wider sides. Offices for administrative personnel, in addition to an input storage room
s have been constructed inside the building. The facility is not fenced, being accesible

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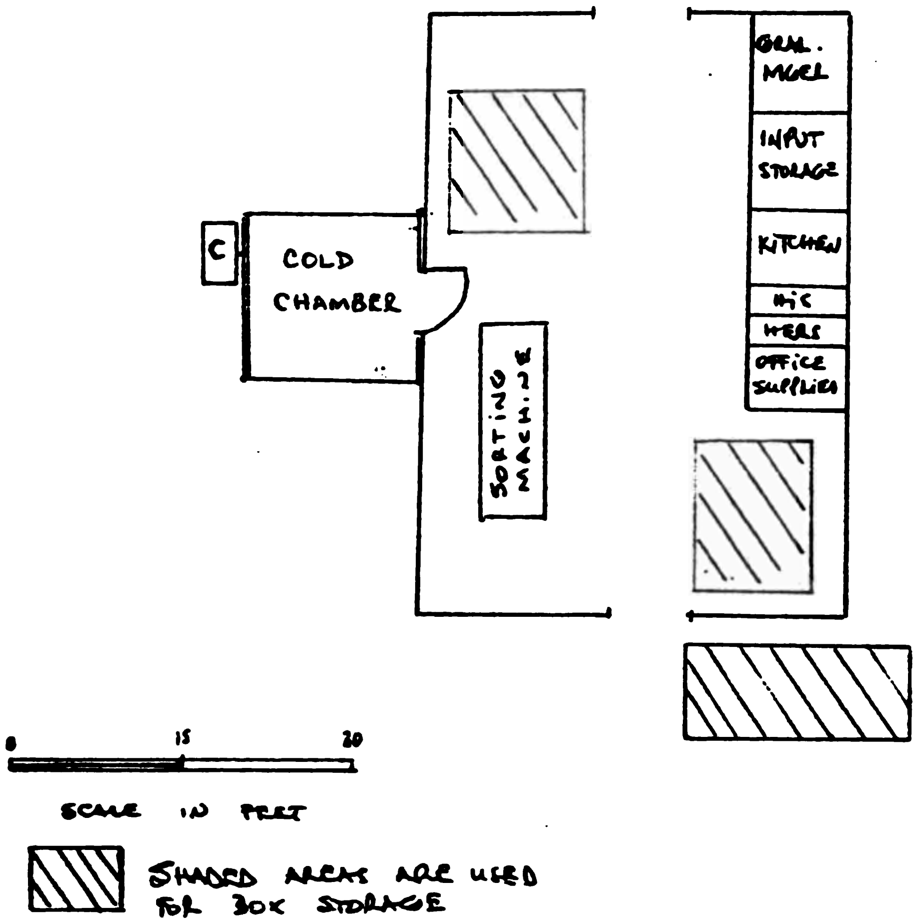

FIG. 3 LAYOUT OF NORTH ANDROS PACKING HOUSE

2. **Cold Storage**

The panels of the cold storage chamber are in good condition. However, the compressor has not been operating properly. About one year ago a new compressor and evaporator were purchased to replace the existing ones. This equipment has been at the packing house since May 1989 but has not yet been installed.

As in other cold storage facilities of the system, the chamber in North Andros lacks thermometers, humidity controls and plastic curtains. The compressor has been installed above the groung and is well protected from rain, but not from salty air and vandals. One corner of the roof was broken some months ago and has not yet been repaired.

3. **Equipment**

The packing house has a 16"-wide grading and sorting machine for processing tomatoes, sweet peppers, potatoes end cucumbers. Reportedly, it has a capacity to process 1.5 MT of produce. This capacity is considered to be inadequate as during the peak production season there is a need to process up to three times that figure.

The existing grading and sorting machine consists of a receiving station, a washer, a drier, a pre-sizer, and a sorting mechanism for six produce sizes. This machine is quite old and its make is unknown. Certain parts of the sorting mechanism are broken or have been lost. The facility also has a hand-lift to move pallets, a 60 lb scale, and a box stapling machine.

4. **Input Storage**

Existing space for storage of packing inputs is too small, eben considering the 40 ft container parked next to the facility which is used for box storage. Cardboard boxes occupy several areas, reducing procesing and circulation space. Lack of control, misuse and losses of packing inputs are evident.

5. **Processing Area**

The packing house has a processing area of approximately 2.860 square ft. However, due to the use of certain sections for circulation and storage of cardboard boxes, and equipment layout, the usable area for grading is no larger than 1.200 square ft.area. It is reported that during the peak production season, the facility is overwhelmed with production.

F. <u>Operating Practices</u>

1. **Accountability**

A series of operating features observed in the course of visits made to the PE and Andros packink house, and conversations with its executives and line personnel indicate that it is not run effectively. This conclusion is supported by the following facts: no person seems to be responsible or held accountable for pilferage, shrinkage, breakage and spoilage losses; nobody seems to have the motivation to prevent waste, unnecessary expenses, and pilferage, nor have the authority to adopt corrective measures. This situation will continue as long as the PE's principal executive is not made responsible for the entity's losses, and there is not an organizational structure to exert proper supervision over the General Manager.

2. **Quality and Weight Control**

The above situation also applies to the relationship betweem the PE end the field Packing Houses in the islands and the "mail boats". No quality control is exercised by the PE to assure that packing

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houses in the islands comply to a set of strict purchasing, grading, processing, storage and handling standards. It is reported that a significant volume of sub-standard, over-ripe, and inadequately graded produce is purchased by the packing houses and shipped to the PE. This produce generally cannot be sold, or has to be sold at discount prices, yet the government and the PE have paid full purchasing, packing end boat transportation costs.

Even though products shipped in "mailboats" have a bill of landing describing the number and weight of units transported, boat operators are not held accountable for differences. Specifically, it has been observed that broken watermelons arriving to Nassau were thrown away directly from the boat to the ocean, no record being made by PE personnel.

The PE currently lacks the capacity to weigh loads of produce above 500 pounds. Hence shipments of heavy and bulky products like watermelons cannot be weighed on arrival to the PE. Because of the antiquated type of 500 lbs. scale currently in use for receiving products, it is pressumed that at peak production times, PE personnel avoid weighing of arriving shipments.

3. **Measurement of Losses**

No system is in place to detect, identify and measure the extent of losses experienced by the PE, hence essential information is missing for the adoption of remedial measures and the measurement of progress. It is pressumed that the largest losses occur during peak production periods, as a result of the lack of a continuous cold chain and the existence of transportation bottlenecks. It is reported that operating losses principally occur as a result of pilferage by boat crews, truckers, and PE bystanders and intruders.

4. **Personnel**

The PE system is overstaffed, overpaid, and the employment policy runs counter to profitability. Aggregate payroll costs of the PE, the packing houses and the retail outlets (excluding the one in Freeport) equal Bh$ 1.124.266. Assuming that the PE charged a 15% broker fee, if it only had personnel costs, it would have to sell produce for about Bh$ 7.5 million! to reach a break even point. Because sales are lower than Bh$ 2 million, the large payroll and high salaries cannot be justified on economic grounds.

Tables 2.4A, 2.4B, and 2.4C in Annex A present a listing of permanent personnel currently employed in the PE, the retail outlets and the field packing houses. This information includes salary levels and seniority. These employees are of two types: permanent and casual. Permanent employess have acquired such status after 3-5 years, have higher montly salaries, and are the most difficult to remove. Casual employees have been working less than the mimimum 3-5 years with the PE, have lower weekly salaries, and do not enjoy many of the benefits associated with permanent tenure.

As observed in Table 2.4A, the PE has 37 employees, of which 23 are permanent and 14 are casual laborers. The monthly payroll is equal to Bh$ 28.480, of which Bh$ 20.600 correspond to permanent employees and Bh$ 7.880 to casual laborers. Given the significantly higher costs of permanent versus casual employees, it is noteworthy that the PE would employ such a high proportion of the former, to perform tasks requiring limited skills.

Eleven persons work in the two PE retail outlets in Nassau, as presented in Table 2.4B, with a total payroll cost of Bh$ 124.330 per year. There are 78 persons working in the packing houses, at a yearly cost of Bh$ 639.721, as detailed in Table 2.4C.

Reportedly, political factors play a major influence in appointing PE personnel. This bypasses the authority of the principal executives and reduces their managerial effectiveness, as certain employees consider to be the protegees of persons of higher rank. Reportedly, because of political influences, it is hard to get employees to work, and it is even harder to fire them if they do not work.

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The type of PE activities, in the areas of product handling and grading, generally requires the services of relatively young personnel. It is important to mention that PE personnel in these capacities are not young and in several cases are approaching the age for retiring.

It can be noted that the large permanent PE staff, in Nassau and the packing houses, bears no relationship to the seasonal nature of agricultural production in the country. Likewise, in spite of the large numbers of personnel employed in the system, no employee is qualified in the critical areas of marketing and merchandising or maintenance.

None of the persons currently occupying executive positions in the PE has had any formal training in warehouse management or wholesale marketing. Moreover, they have never benefitted from the provision of specialized technical assistance. PE management still lacks the necessary level of professional development. The facility at Potter's Cay lacks a Plant Manager with understanding of cold storage and produce handling.

5. **Security and Controls**

There is no security system in place at the PE facility in Potter's Cay. West-side chain link fences are easy to trespass, and the wooden back door on the West end of the PE building has no lock. In addition, there is no guard on duty to inhibit the presence of intruders. No system is in place to regularly take inventories, weigh arriving shipments, or check the correctness of produce deliveries.

No cold chamber has thermometers nor humidity controls, hence there is way to periodically assess refrigeration conditions. Because of this, the PE is experiencing product losses as a result of inadequate refrigeration conditions.

Random and end-of-period inventories are not regularly taken, to assess the validity of purchases, shipments, and sales reports.

6. **Financial Operating Indicators**

a. PE Produce Purchases

The pattern of PE purchases corresponds to the seasonal nature of agricultural production in The Bahamas. As Table 2.5 shows, in 1988 the bulk of PE produce purchases took place in the first quarter of the year (49%), followed by the second quarter (21%), the fourth (20%), and finally the third (10%). Bananas, watermelons and cucumbers were the only products purchased by the PE in significant volumes throughout the year. Local production and PE purchases of tomatoes, pineapples, onions, Irish potatoes, cabbages and sweet peppers is markedly seasonal.

During 1989, as presented in Table 2.6, seasonal PE produce purchases were more stable than the previous year, fluctuating between 703 and 928 MT per quarter. In this year, fruit purchase represented between 450 and 550 MT and field crops between 34 and 54 MT per quarter. Vegetable purchases, on the other hand, were quite variable among quarters. In terms of value, fruit purchases accounted for 55 per cent of all PE purchases in 1989, vegetables for 38 per cent and field crops for 7 per cent. In terms of quantities, fruits represented 64 per cent of the total, vegetables 30 per cent and field crops 6 per cent.

During the first quarter of 1990, the PE purchased the volumes of produce indicated in Table 2.7. The value of produce purchased by the PE during the first quarter of the year was equal to Bh$ 736.000. Monthly purchase values ranged between Bh$ 223.240 in the month of February to Bh$ 279.228 in January. Quantities purchased in the same period ranged between 116 tons in March to 464 tons in February. In terms of value, the largest component corresponds to vegetables (77%), followed by fruits (20%) and field crops (2%).

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During the first quarter of 1990, a few products made up most of the fruit volumes purchased by the PE. For example, in January bananas, oranges, Persian limes and grapefruits represented 88%; in February, bananas, oranges and watermelons totalled 82% of purchases; and in March, bananas and oranges represented 93% of total purchases. During the quarter, orange purchases were the most important fruit purchased, representing almost 40% of the total, and being concentrated in the month of January.

TABLE 2.5.
SEASONAL PATTERN OF PE PURCHASES
(TONS - 1988)

PRODUCT	I QTR. JAN-MAR	II QTR. APR-JUN	III QTR. JUL-SEP	IV QTR. OCT-DIC	TOTAL
BANANAS	215	92	107	248	662
TOMATOES	398	171	0	127	696
PINEAPPLES	5	2	0.5	0.5	8
ONIONS	113	49	0.5	0	162.5
IRISH POTATOES	137	59	0	0	196
CABBAGES	231	99	0	16	346
SWEET PEPPER	1	0.5	0	0	1.5
WATERMELONS	27	11	122	50	210
CUCUMBERS	12	5	8	11	36
TOTALS	1139	488.5	238	452.5	2318
%	(49)	(21)	(10)	(20)	(100)

TABLE 2.6.
QUARTERLY QUANTITIES AND VALUES
OF PRODUCE RECEIVED BY THE PE - 1989
(TONS AND THOUSANDS OF B$).

	I QTR.		II QTR.		III QTR.		IV QTR.	
	QTTY.	VALUE	QTTY.	VALUE	QTTY.	VALUE	QTTY.	VALUE
FRUITS	456	250	451	267	583	280	551	286
VEGETAB.	418	254	252	266	70	73	214	161
FIELD CROPS	54	37	34	35	50	40	46	32
TOTALS	928	541	737	568	703	393	811	479
(%)	29	27	23	29	22	20	26	24

With respect to vegetables, the largest commodity group purchases, more than 90% corresponds to three products, namely cabbages, peppers, and tomatoes. Tomatoes amounted to 95% of PE vegetable purchases in January, 34% in February, and 25% in March. Cabbage purchases equalled 62% of vegetable purchases in February and 49% in March.

b. Packing House Produce Purchases

As Table 2.8 shows, volumes and values of produce purchased in each island during 1989 were quite varied. More than one-half of all purchases were made by the packing houses in Eleuthera and one-fifth by the packing house in Long Island.

Peak production in each island were spread among quarters. They occurred in the first quarter occur in Eleuthera and Cat Island, in the second in Exuma, in the third in Andros, and in the fourth in Long Island.

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TABLE 2.7.
QUANTITY AND VALUE OF PRODUCE RECEIVED BY THE PE
FIRST QUARTER 1990
(TONS AND THOUSANDS OF BH$).

	JANUARY		FEBRUARY		MARCH		TOTAL	
	QTTY.	VALUE	QTTY.	VALUE	QTTY.	VALUE	QTTY.	VALUE
FRUITS	186	99	83	34	7.8	15.5	277	149
VEGETAB.	200	170	375	186	106.0	214.0	721	570
FIELD CROPS	12	9	6.5	3.7	1.6	3.3	20	16
TOTALS	398	279	464	223	116	233	1018	736

Table 2.9 presents the value of produce purchases in the first quarter of 1990 by a group of four packing houses in Andros and Eleuthera. Purchases by the North Andros packing house are larger than the other three combined. Total produce purchases for the quarter equalled Bh$ 838.511. This figure is larger than the amount reported by the PE in Nassau, being presumed that the difference corresponds to produce purchased by the packing houses but not sold to the PE.

Considering the largest purchase items by the North Andros packing house, during the month of January, tomatoes represented 45% of all purchases, and cabbages 12%. In February, tomatoe purchases amounted tc 14% and cabbage to 72%. In March, purchase percentages for these two products were equal to 25 and 39, respectively.

With respect to packing houses in Eleuthera, in Hatchet Bay, watermelons represented the largest purchase item. In Green Castle, products purchased vary markedly each month. In North Eleuthera the largest purchases corresponded to oranges and tomatoes.

c. PE Produce Sales

Sales made by the PE, either directly at Potter's Cay or through the existing retail outlets at Kemp Road and Blue Hill, are significantly lower than purchased volumes. As Table 2.10 indicates, for the first quarter of 1990, sales equalled Bh$ 496.961, which is 68 % of purchases during the same period. This implies that in the first quarter of 1990, losses attributable to shrinkage, breakage, pilferage and spoilage amount to Bh$ 239.039!. A portion of these losses, a sum equal to Bh$ 142.828 corresponding to the first quarter of the year, is taken as spoilage and "donations" in Table 2.11. These charitable donations usually consist of over-ripe, unsaleable produce. Consequently, during this quarter, shrinkage, breakage and pilferage losses are estimated to equal Bh$ 96.211.[4]

TABLE 2.10.
PRODUCE SALES: PE AND RETAIL OUTLETS
(1ST. QTR. 1990)

	1989	1989	1990
JANUARY	164.043	142.202	189.957
FEBRUARY	173.479	144.193	162.389
MARCH	153.412	102.560	144.614
TOTALS	490.934	388.955	496.960

Source: Produce Exchange

[4] Economic losses, corresponding to sale of products at lower prices due to loss of quality, are also disguised in these figures.

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d. Balance Sheets and Income Statements

There exists no established system to generate financial information on the PE system. No office has been commissioned to perform this task, and PE executives lack the necessary financial and accounting background. This is complicated by the diversity of PE operations, the lack of a computerized control system and the fragmentation of PE comnponents among several government offices in at least three Ministries.

Because PE system components are embedded in several government organizations. It is difficult to view it as a separate enterprise. The lack of centralized operating control system deprives PE management of one of the most useful tools for informed decision-making. Sales receipts of the PE and retail outlets are deposited directly to a bank account in the national Treasury, salaries and operating expenses are paid from MATI's budget, and maintenance requirements must be funded from MATI's overall maintenance account.

7. Functional Performance

a. Ordering and Receiving

The concept of the PE performing a guiding role in production planning and scheduling for farmers, in accordance to identified market opportunities has been lost. The PE plays no active role in production planning. On the contrary, the role performed by the PE is passive, adjusted in response to volumes delivered by farmers to field packing houses in other islands or directly to the PE by producers in New Providence.

The PE does not plan ahead volumes to be purchased and marketed. Its operation becomes erratic, tuned in response to volumes of produce collected by the field packing houses. At no point in time does the PE have a precise idea of produce volumes that will be supplied by farmers. PE executives predict product arrivals based on production seasonality but not on the grounds of a planned production programme. The PE is "pushed" by supply forces rather than leading production activities in accordance to "demand pull" signals.

It appears that the PE is playing a useful role for farmers, as these have the opportunity to check other sale options before delivering their products to the PE. The sad part of this is that the PE receive only those shipments that cannot be sold more profitably elsewhere.

b. Grading

The OE has established a series of grades and standards for its produce purchases. These grades are based on size. There are two grades for cabbage, watermelons, grapefruit, bananas and cucumbers, three for onions, pineapples, oranges and persian limes, and four for tomatoes. According to PE clients, enforcement of these grades is not strict. There is not a system of penalties imposed on packing houses for deviations from norms. When improperly graded produce arrives to the PE, it is simply regraded. Product or price losses are not accounted for and nobody is held responsible for grading deficiencies. In general, "operating" losses accrue to the Produce Exchange.

It has been reported that, occasionally, some farmers will take to the PE produce rejected by private buyers. There are no penalties in place to prevent or discourage these situations to take place.

c. Handling and Transportation

In accordance to qualified sources, more than one half of post-harvest produce losses, presently confronted by the PE, occur beyond the field packing houses. During this study, data has been found that indicates spoilage rates of 13 to 32 per cent for produce handled by the PE in the first

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three months of 1990, as is presented in Tables 2.7 and 2.10. These losses were due to poor loading into the mail boats, inadequate transportation, defficient unloading at Potter's Cay, in addition to the absence of a continuous cold chain.

(i) From the Farms to the Packing Houses

Harvesting times are determined in accordance to scheduled "mailboat" departure times. Harvesting activities do not take advantage of the most appropiate temperature and humidity conditions. Farmers use their own trucks or rented vehicles to take produce in bulk - generally in fertilizer sacs- from their farms to packing houses. The PE takes posession of the product at the packing house, assuming all the post-harvest and economic losses that may occur in subsequent marketing stages, including all product handling, packing and transportation costs.

At the packing house, products are unloaded, classified and packed in carton boxes or jute bags by hand. For some products, such as watermelons, cardboard boxes are not used. In some cases it is reported that box supplies are insufficient, hence produce must be handled in bulk. Inadequate cardboard packing supplies cause that boxes labelled with the name of one product (e.g. tomatoes) be used for a variety of products.

(ii) From the Packing Houses to the "Mailboat"

After grading and packing, produce is loaded into "mailboats". In most cases this is done by hand as only one-third of the boats have cranes or lifts and loads are usually not containerized nor palletized.

When done by hand, loading operations take several hours. Loading hours are selected strictly in accordance to the convenience of boat operators, not being associated to what is more appropiate for fresh produce. Hence, the adverse effects of high temperatures are not minimized.

Table 2.12 shows truckage costs paid by the Produce Exchange system for transporting goods from the packhouses to the "mailboats" in the islands, for the year 1989. Note that the largest expenses correspond to the facility in North Eleuthera (60 % of the total).

(iii) Transportation of Produce in "Mailboats"

Contractual conditions between the PE and boat operators do not establish the fulfillment of any handling nor refrigeration requirements. Boat operators are not responsible for produce breakage and spoilage or pilferage occuring during transportation. In general, the perishable nature of produce has not yet been taken into account in the elaboration of transportation agreements.

(iv) Unloading at Potter's Cay

Boats arriving to Potter's Cay generally dock in established areas, independently of the location of the PE. In many cases this causes that produce must travel up to 1/2 mile from the boat to the PE. No attempt has been made to organize unloading operations so as to minimize produce exposure to the sun and trans-shipment costs.

In spite of the fact that many boats arrive at Potter's Cay during the night hours, unloading operations begin after 9:00 a.m. and extend through the morning. Because PE employees start work at 8:00 a.m., produce is exposed to detrimental temperature end humidity levels during several hours.

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The PE has not established mimimum handling and transportation patterns for boat operators to comply, including a determination of unloading hours, docking operations, minimum temperatures for arriving produce, nor minimum refrigeration infrastructure.

(v) **From the "Mailboat" to the PE**

When produce boxes arrive in bins or pallets, it would be possible to employ the PE's forklift. In most cases, however, products arrive to Potter's Cay in bulk or in non-palletized boxes and must be transferred to a vehicle for transportation to the PE. To accomplish this task, in spite of having two vehicles of its own, the PE employs the services of independent truckers. For this purpose, during the first quarter of this year, the PE paid out Bh$ 2.526.00.

In many cases, the smaller and less equipped boats may take several hours, even an entire morning to off-load a shipment of produce. Naturally, this is detrimental to the maintenance of produce quality and is one of the main contributing factors to large spoilage rates. However, under the present system, there are no incentives nor penalties to motivate proper product handling and transportation by boat operators.

d. **Receiving and Cold Storage**

There are serious technical deficiencies in the operation of cold rooms in the PE, as there are no temperature and humidity controls. Similarly, there exist no polar plastic curtains in cold room doors to prevent refrigeration leakages.[5]

None of the cold chambers has thermometers to measure temperatures, hence it is not possible to determine their adequacy to refrigerate different types of produce. Moreover, temperature levels are fixed by maintenance personnel. Nobody in the PE is capable of adjusting them in accordance to the needs of produce.

Door sizes of cold storage chambers are not appropiate. They are too low to permit fork-lift operation. Consequently, costly and slow manual labor must be used to store produce, a strenous and time-consuming cost.

Even though there is a large area dedicated to cold storage, there is not a temperature-controlled staging area, to prepare outgoing shipments. Hence, product deliveries are staged in the main alley or grading section, none of which has controlled temperatures, and causing traffic congestion and control difficulties.

e. **Grading, Selection and Packing**

The PE has a grading, selection and packing section of its own, to handle produce brought in by farmers in New Providence Island, as well as to reprocess, regrade, separate over-ripe and spoiled products, and repack produce arriving from other islands. These operations are a result of deficiencies occuring throughout the marketing chain, from farms to the PE, as has been described above.

f. **Pricing and Account Collection**

Pricing of different types of produce is performed by a special agricultural marketing commitee housed at MATI. This committee meets every Monday to assess local supplies and import permits. Prices are adjusted according to market conditions.

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[5] These losses can be significant. The refrigeration loss resulting from the openning of a door during a few minutes -when plastic curtains are not in place- is recovered after several hours of continued operation.

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The lack of a properly established and operating information system, prevents this committee to have the necessary production and consumption data for proper decision-making.

There is not an established policy on marketing margins or wholesale markups by the PE. Sale prices are established at levels that the market will bear, without reference to operating costs of the system. Because of the sizable spoilage and pilferage losses, current sale prices do not even cover the costs of purchasing the commodities in the Family Islands.

g. **Payments to Farmers**

Because the PE depends on government funds to make payments to farmers, it generally takes at least two weeks before producers can collect their payments. This delay can be longer during the peak production season. This is naturally a desincentive to farmers supplying produce to the PE.

In accordance to traditional public disbursement patterns in The Bahamas, payments to farmers selling produce to packhouses in the Family Islands are made by the national Treasury, channeled through the Chief Commissioner's office. This situation inhibits the PE to develop a commercial relationship with farmers.

h. **Merchandising, Promotion and Publicity**

The PE does not execute any planned promotion or publicity strategy. What is worst, it has adopted a passive sales attitude. Several retailers have complained that the PE does not call on them, to inform about produce availabilities and promotions. This is noteworthy when consideration is given to the large number of permanent employees working in the PE.

To date, the PE has not followed a consistent marketing strategy. Specifically, there has never been an effort to establish its own trademark, seeking to develop a measure of brand loyalty and goodwill that may subsequently permit a price differential.

The PE's sales history during the recent months clearly points out its lack of a regular and wide product assortment. These characteristics do not enable it to become a regular and reliable supplier to any type of client, leaving the field open for the establishment of other more efficient private sector operators.

The fact that the PE relies exclusively on local produce prevents it from having a complete product mix throughout the year. Without a capacity to import certain products during specific periods of the year when no local production is available, the PE cannot have the wide assortment of fruits and vegetables required by retailers, and therefore cannot play the role of a competitive, consistent and regular wholesale supplier.

i. **Market Information**

Neither the PE nor MATI have been successful in establishing an agricultural market information service. Information collected is not complete, is inadequately processed and is not disseminated properly. Published information is not user oriented, and accomplishes little in terms of guiding production and marketing planning by private sector operators.

8. Other Issues

a. **Maintenance**

The PE system confronts a serious maintenance problem. In Family Island packhouses, only one cold chamber is operating, and even this chamber operates with dificulties. Several pieces of equipment have been purchased to replace defective components, yet they have not been installed (e.g. North Andros packing house, compressors, and evaporators for chambers # 8-9 in

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the PE). Installation of other machines or systems has not been completed (ripening rooms in the PE at Potter's Cay). Other cold storage chambers cannot operate because key components have been disassembled and not repaired (compressor of chamber at Kemp Road). There is no preventive maintenance program in place. Maintenance activities are strictly of a remedial nature, directed to fix brokendown machines. Actual repair can take several days end weeks.

These problems are a consequence of a series of factors. Dependence of the PE system on MATI maintenance services, in terms of personnel and budget, is a major factor causing poor maintenance of equipment. MATI maintenance personnel have a series of tasks and duties to fulfill, in addition to those related to the PE. Spare parts for PE equipment must be purchased with MATI maintenance funds, which are generally scarce. Use of these funds requires authorization from several offices, a task which is not only time-consuming but is often frustrated as approval is not granted.

b. **Managerial Authority**

PE managers lack authority to exert personnel supervision and control. There exists a degree of "independence" on the part of certain employees that render fruitless the well-intentioned efforts of managers. For example, several employees do not report to work at 8:00 a.m., the established hour to initiate activities. Other employees simply do not carry out activities that they consider to be outside their duties (e.g. the drivers do not want to assist in unloading produce from boats).

Personnel working in the grading section at the Potter's Cay facility work at their own rhythm. The manager expressed his inability to command a given type of performance from these workers. To motivate a specific type of behaviour, he is required to request so politely and hope he receives support. This is a result of the fact that personnel working in this and other sections are permanent rather than casual, that is, they know they cannot be removed, and that their salaries and tenure are in no way associated to productivity or performance.

c. **Vehicle Operation**

After business hours, as well as during weekends and holydays, drivers take home both PE vehicles as the PE currently lacks a garage. This is an inconvenient practice, specially when there is no established system to control vehicle use by the drivers.

G. Conclusions

The PE system exhibits several crippling deficiencies that prevent it from playing a meaningful role in the promotion of agriculture and originate increasing financial loses. This can be appreciated by focusing on the system as a whole and on each of its principal components, as presented below:

1. Overall Deficiencies

The wholesale and retail facilities that compose the system are not properly managed. There exists no decision-making body to overview their operation. Managerial and administrative functions are dispersed in different offices in several Ministries. Executives have limited responsibilities and authority. Throughout the system, there is a lack of accountability, supervision and controls.

The system does not play a guiding role for agricultural production in the country. It merely receives what farmers produce. This situation is detrimental to farmers who lack guidance for production planning, and for the government, which has to buy whatever is produced.

There are no incentives to achieve operating eficiency, reduce spoilage and pilferage, and increase system profitability.

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Activities are conducted without an analysis of their financial implications. Sale prices and marketed volumes are insufficient to cover the high operating costs of the facilities.

The high marketing risks associated with perishable commodities are falling only on the government. This is one of the major sources for persistent losses.

There exists a serious staffing problem. Most personnel is overpaid and sub-employed most of the time. There are no people qualified to perform various critical tasks. Employee morale and productivity are invariably low. Employees lack appropiate training and technical assistance to increase their productivity.

Political influences play a role in staffing, product purchasing, grading, and collection of payments. The system is viewed as an employment agency for unskilled persons.

2. Specific Aspects

a. The Produce Exchange

The facility at Potter's Cay is affected by the problems indicated above. It is overstaffed in certain areas and understaffed in others.

It lacks its own maintenance department, and has no sales personnel. As a result, it experiences serious maintenance problems and plays a limited merchandising and sales function.

Both wholesale and retail functions are conducted at Potter's Cay. This reduces concentration on wholesaling, and inhibits the PE from playing a meaningful role with respect to the development of the retail sector.

The physical infrastructure of the Pe exhibits several constraining factors, such as the limited cold storage space, and the lack of an apropriate packing input storage area. Due to design deficiencies the facility does not permit adequate control and traffic.

b. The Retail Outlets

The three existing outlets in Nassau perform a limited role, with low sales volumes, narrow assortment, and high operating costs. They present a poor image of state-owned facilities, and play a marginal role in serving consumers.

c. The Packing Houses

The packing houses face the same problems observed at the Produce Exchange. Plants present layout deficiencies with respect to lack of input storage areas, absence of maintenance, overstaffing and low employee morale.

d. The "Mailboats"

"Mailboats" operate independently of the PE. They have no contractual agreements with the PE or the Ministry of Agriculture, hence they are not required to comply with any condition for the transportation of produce.

Inter-island transportation of produce is seasonally variable, hence boat operators view as a marginal activity. This leads boat operators to treat produce as any other type of cargo.

Boat operators are not held responsible for pilferage, spoilage or breakage loses occuring to produce during transportation.

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Only one-third of the vessels transporting produce has refrigeration equipment, and one-half has lifts or cranes. Consequently, produce is often transported improperly, and loading/unloading operations are difficult to perform.

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III. PROPOSED SYSTEM REFORMS

A. Introduction

This section outlines the modifications required to enhance the developmental role and operating efficiency of the agricultural marketing system, including the wholesale and packing facility at Potter's Cay, the retail outlets selling PE products, the "mailboats" providing inter-island transportation services, and the packing houses in the Family Islands. It is assumed that this system can be more effective and financially viable by clarifying its development role, the specific functions to be played by each component, and the manner in which these components are inter-related. To improve overall system efficiency, it is also necessary to undertake the physical modification of existing warehouse and processing facilities, replace equipment as well as refurbish inter-island transport vessels.

B. Role of the Marketing System

1. Objectives

a. Assist Growers end Serve Consumers

The agricultural marketing system will have two principal objectives, (i) to assist Bahamian farmers in marketing fruits end vegetables required to satisfy local market demand, and (ii) provide a wide produce assortment to urban consumers in the principal cities. For these purposes, the system will promote crop diversification and year-round production, through the provision of essential services to farmers.

As an state-owned or mixed entity, the PE system will emphasize the pursuit of the above objectives, while encouraging the participation of small farmers in production activities, and focusing on the attention of low-income consumer needs.

By seeking the above objectives, the project will contribute to save foreign exchange and reduce the country's dependence of foreign foodstuff supplies, consolidate farming in the Family Islands as a viable economic activity, and improve the structural balance of The Bahamian economy.

PE relationships and contacts with farmers will be carried out through the packing houses, while those with consumers will be executed through retailers and institutional clients.

b. Promote Import Substitution and Exports

The system will also assist Bahamian farmers in exploiting import substitution and export opportunities for produce. In the latter case the emphasis would be on medium-sized and large farmers.

Advances towards this purpose will also result in additional foreign exchange earnings or savings and an improvement of the country's structural economic balance.

c. Support Development of Marketing Institutions

The system will support the development of a Market Information Service to conduct market research end guide production. Local foodstuff marketing institutions will also be supported, particularly the retailer organizations serving large low-income consumers in urban areas.

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d. Seek Financial Self-sufficiency

The PE system will strive to attain financial self-sufficiency, moving away from the high government subsidies and operating losses that characterize present conditions.

e. Generate Productive Employment

The system will strive to generate productive employment in farming and marketing. This will be done by performing its functions efficiently. As the marketing system operates with increased efficiency, it will lower marketing costs and margins, hence reducing the prices paid by consumers. This increases the real income of consumers, which in turn motivates an expansion of the demand for foodstuffs and other commodities. As demand increases employment opportunities arise in farming and throughout the marketing chain.

2. **Functions**

a. Demand Forecasting and Production Planning

The PE at Nassau will be the center of the system, becoming the "eyes and ears" of the market, in permanent contact with local and foreign buyers of Bahamian produce. It will maintain updated information of volumes traded and prices for fresh fruits and vegetables, and forecast consumption and market trends for these products.

Based on projected consumption levels and historical production patterns, the PE can assign production quotas to each island. Or, alternatively, given the aggregate marketable volume, farmers may offer specific volumes or acreages. Allocation of production quotas to farmers would be conducted in coordination with, and through the network of packing houses. The process will count on the participation of each island's extension agents and research institutions, as well as agricultural credit and production input suppliers. The timely and coordinated supply of all these services are critical to assure project success.

Under the project, planting and production decisions will be adopted in accordance to predicted market conditions. This is the only way to prevent the seasonal market gluts that cause sizable loses to farmers and the PE alike. It is also the logical procedure to mitigate seasonal shortages, by programming local production and imports.

This approach entails a major deviation from current activities played by the PE. The system will no longer "attempt" to sell what is produced and delivered to it, but it will rather guide and assist producers to take advantage of well-identified market opportunities.

b. Wholesaling

With respect to farmers in each island, the PE will act as a commission wholesaler or broker, not taking tittle to the commodities traded, but solely providing an intermediary marketing service to growers and buyers. The PE will perform only wholesale functions, buying in quantity, grading and sorting, boxing and hiring transportation services, and selling to other wholesalers, retailers, and institutional clients.

The PE will sell produce to local and export buyers, deducting a 10-15 % commission to cover its operating costs as broker.

The system will not continue to rely on a precarious and uncontrollable "mailboat" system, but will promote the development of a more efficient and reliable inter-island transportation system. It is essential that a permanent working relationship be established between the marketing system and "mailboat" operators, formalized by written contracts.

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In performing its wholesaler functions, the system will promote development of foodstuff retail institutions, such as neighbourhood stores, market stall vendors, and consumer commissary stores. It will not engage in retailing activities. The existing outlets at Kemp Road and Jumbey Village should be closed down or transferred to the private sector. It is recommended that the PE system sponsors a **voluntary retailer chain** to increase overall distribution efficiency of produce in The Bahamas.

To perform an effective wholesale function and establish a loyal voluntary retail chain, the PE system must be prepared to import, during certain periods of the year, those items that Bahamian producers cannot produce in sufficient quantities.

c. Packing and Storing

The PE system, through the packing houses in the Family Islands and the PE facility in Nassau, will provide packing and cold storage services to local produce growers.

3. **Management and Ownership**

Under more favourable conditions, the PE and the packing houses should be run by private sector operators, under government regulation and control, to minimize government expenses and assure increased efficiency. However, the existence of geo-political and social goals, in the project as well as its high initial investment costs, suggest. That the Government will have to continue to have a strong participation in the system, at least while it achieves a minimum level of efficiency to be able to attrack private sector interest. Therefore, the system will start by being operated by a special unit inside MATI.

a. Establishment of a Public Corporation

It is suggested that, in a near future, as soon as the conditions allow it a public corporation should be established (or refurbished) and be managed by a quasi-private Board. One-hundred per cent of the shares would be initially held by the government (e.g. MATI). The Board of Directors, however, would have no less than five members and no more than seven. These members would be predominantly drawn from the private sector. A high-level public official (i.e. the Minister of Agriculture) would be the **de facto** Chairman of the Board, but all other members would be private sector businessmen and professionals, with expertise in key areas of interest to the PE system.

This Board should be provided with an operating charter, with the social and financial objectives of the project clearly spelled out, and should be granted operating independence and the necessary funding. Having been established, this Board should be responsible for implementing the project and hiring the required staff.

b. Gradual Transfer of Shares

In time, as the new corporation proves its worth and builds up its public image, its shares could be gradually transfered to its principal users (e.g. farmers, retailers, or associative groups). This concept is important so that the government role may shift from that of promoter in the beginning and initial stages of the process, to that of partner during the project's stage of maturity.

User participation in ownership and management should be sought at every level of the system, at the PE and packing house levels. Packing houses should be turned into public corporations and their shares gradually transfered to users, via discounts on payments made to farmers. The same discount procedure could be adopted to sell PE shares to packing houses.

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c. Professional Management

The whole system should be operated by highly qualified professionals.

4. Staffing

Under the project, it will be necessary to rationalize current staffing of PE and packing houses, to reduce costs and increase efficiency. Tables 3.1 and 3.2A, 3.2B, and 3.2C show proposed staffing for the PE and packing houses. It is proposed that PE staff be reduced from 36 to 28, and the annual payroll lowered from Bh$ 360.215 to Bh$ 254.832. The retail outlets in Kemp Road and Jumbey Village would be closed down or transfered to the private sector. Hence, personnel working in these outlets would be taken out from the PE payroll. Packing house staff would be reduced from 78 to 70, decreasing payroll costs from Bh$ 639.721 to Bh$ 505.512. These changes will save a total of Bh$ 363.922 in salary expenses.

Packing house staffing will also be rationalized by establishing three levels, depending on the volume of operation. Plants in North Andros and North Eleuthera are assigned the staffs listed in Table 3.2A, with a yearly payroll of Bh$ 72.216. Plants in Hatchet Bay and North Long Island are assigned staffs of 7 persons, with annual payroll costs of Bh$ 58.440, as indicated in Table 3.2B. Plants in North Long Island, Exuma and Green Castle are staffed as shown in Table 3.2C, with 5 employees and a payroll expense of Bh$ 39.552 per year.

These tables also show the new functional composition of PE staff, with increased personnel in sales, maintenance, and control. Personnel in grading and produce handling operations are all casual laborers, year-round or seasonal, and receive the lowest salaries (Bh$ 132.60/week).

5. Technical Assistance and Training

Successful project implementation will require the provision of an integral technical assistance and training package during the initial phase of the project. This package will be geared to strenghten the managerial efficiency of the system. For this, it is proposed that two expatriate professionals be contracted, to serve in the positions of PE general manager and plant manager, for the first two years of the project. During the first year of implementation, two local persons should be selected as management-trainees, to replace the expatriate personnel when they complete their contract terms.

The expatriate professional contracted to serve as general manager of the system should have an academic background in business administration or agricultural marketing, at least five-years experience managing foodstuff wholesale/retail operations, and capacity to train personnel. The expatriate to serve as plant manager should have at least five years of practical work in produce marketing organizations, and be proficient in warehousing, refrigeration, and product handling operations. He should also have experience and capacity to handle PE personnel.

During the first two months of project implementation, the general manager will select the individuals to be hired as packing house managers, who will depend directly on him. During the first six months, the general manager will select the individuals to be contracted as management trainees for the positions of general manager and plant manager. All the individuals contracted will receive a mix of on-the-job and classroom training provided by the expatriate personnel and by short-term consultants. The short-term consultants, both local and expatriate, will be contracted to assist PE executives and train personnel in the areas of accounting, inventory and personnel management, marketing and merchandising, information collection.

C. Renovation of PE Facility at Potter's Cay

Physical renovation of the wholesale Produce Exchange facilities at Potter's Cay can be viewed as a complete range of actions. On the one hand, renovation can be viewed as upgrading the existing building as it is, without any significant layout changes nor product/traffic flow modifications Even

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though this would be the least costly option, it would also be the one with the most physical constraints and deficiencies.

Renovation of the PE can also be seen as the construction of a new facility at Potter's Cay, after tearing down the existing constructions. This is the more expensive investment option, and is directly comparable to the alternative of constructing a new facility at a different site.

Between these two extremes stand a series of intermediate renovation alternatives, in which parts of the existing building are renovated, while other sections are demolished to erect new constructions and facilities. These intermediate options permit to adjust the costs of renovation to investment levels that, being financially feasible, are acceptable to decision-makers in The Bahamian government.

1. **Recommended Layout Modifications**

Several layout modifications are necessary to optimize operation of the PE facility at Potter's Cay. These modifications seek to satisfy traffic and product flow principles.

The main sections of a plant such as the PE consist of areas dedicated to product handling, cold storage, shipment staging, input storage and assembly, complementary and auxiliary installations, and an administrative section. The administrative section includes a front office to attend clients and visitors, and office space for executives, sales and purchasing staff, and accounting personnel.

A produce handling end storage facility should have a separate vehicle and pedestrian entrances and circulation routes, through a guarded gate. The administrative and processing sections should be clearly separated. Plant sections should be arranged so as to minimize product movement and facilitate handling.

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TABLE 3.1.
PRODUCE EXCHANGE: PROPOSED STAFFING

POSITION	NUMBER OF PERSONS		MONTHLY SALARY	ANNUAL COST
	YEAR-ROUND	SEASONAL	(BH$)	(BH$)
GENERAL MANAGER	1		1.800	21.600
PRODUCTION SUPERVISOR	1		1.500	18.000
SECRETARY	1		800	9.600
CHIEF ACCOUNTANT	1		1.200	14.400
ASSISTANT ACCOUNTANT	1		800	9.600
CASHIER	1		713	8.556
MAINTENANCE CHIEF	1		1.200	14.400
ASS. MAINTENANCE OFFICER	1		900	10.800
SALES CHIEF	1		1.000	12.000
SALESPERSON (*)	3		574+	20.664
DRIVER	2		713	17.112
FORKLIFT OPERATOR	1		713	8.556
GRADING AND PACKING	2		574	13.776
		4	574	27.552
PRODUCT UNLOAD/LOAD	2		574	13.776
		2	574	13.776
GUARD	3		574	20.664
TOTALS	22	6		254.832

(*) These employees should receive sales commissions (between 1/2 to 1%) in addition to suggested salaries.

TABLE 3.2A. PACKING HOUSES: PROPOSED STAFFING PER PLANT (LARGE VOLUME)

POSITION	NUMBER OF PERSONS		MONTHLY SALARY	ANNUAL COST
	YEAR-ROUND	SEASONAL	(BH$)	(BH$)
GENERAL MANAGER	1		1.200	14.400
ASST. ACCOUNTANT/CASHIER	1		800	9.600
GRADING AND PACKING	2		574	13.776
		2	574	13.776
PRODUCT UNLOAD/LOAD	1		574	6.888
		2	574	13.776
TOTALS	6	4		72.216

TABLE 3.2B. PACKING HOUSES: PROPOSED STAFFING PER PLANT (MEDIUM VOLUME)

POSITION	NUMBER OF PERSONS		MONTHLY SALARY	ANNUAL COST
	YEAR-ROUND	SEASONAL	(BH$)	(BH$)
GENERAL MANAGER	1		1.200	14.400
ASST. ACCOUNTANT/CASHIER	1		800	9.600
GRADING AND PACKING	2		574	13.776
		1	574	6.888
PRODUCT UNLOAD/LOAD	1		574	6.888
		1	574	6.888
TOTALS	5	2		58.440

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TABLE 3.2C. PACKING HOUSES: PROPOSED STAFFING PER PLANT (LOW VOLUME)

POSITION	NUMBER OF PERSONS		MONTHLY SALARY	ANNUAL COST
	YEAR-ROUND	SEASONAL	(BHS)	(BHS)
GENERAL MANAGER	1		1.000	12.000
ASST. ACCOUNTANT/CASHIER				
GRADING AND PACKING	1		574	6.888
		1	574	6.888
PRODUCT UNLOAD/LOAD	1		574	6.888
		1	574	6.888
TOTALS	3	2		51.552

a. Product Handling and Processing Section

(i) **External Perimeter, Entrance and Circulation**

To eliminate the current lack of security, disorder, and widespread pilferage at the PE facility, it is advisable to install a fence encircling the plant's perimeter. In this manner, it will be possible to establish one entry point for all vehicle and pedestrian traffic entering the facilities. This entry will be controlled by a permanent guard. Ideally, the enclosed perimeter will also include the dockside on the North part of the PE building, eliminating the existing public driveway.

(ii) **Docking Area**

Optionally, as is more traditionally done in plant layouts, there could be only one loading/unloading area, to handle all arriving and departing produce shipments. This would be the case if the PE is integrated with the Fish Landing Complex, which already has such a docking area. However, if such integration is not carried out, one of the two existing docking areas in the PE could be eliminated. Alternatively, as is the current trend in designing warehouse facilities, point-of-use docks could be established to handle each type of incoming or outgoing shipments. Given the elongated shape of the PE site, this appears to be the most attractive option, as it would permit to minimize product handling and movement.

(a) Local Trade

With respect to Bahamian produce, the selected area should have the capacity to handle products arriving from two separate sources: packing houses in the Family Islands, and farms in New Providence Island. The former would arrive in "mailboats" and the latter in medium-sized pick-ups and light trucks. The docking area should also be capable of handling shipment of produce to institutional clients in Nassau, using the PE's vehicles or rented trucks, as well as the vehicles owned by the clients themselves. Most of these vehicles are refrigerated medium-sized (20 ft long) trucks or vans.

In relation to produce arriving in "mailboats" from the Family Islands, the receiving area would have to be as close as possible to the dock, to minimize trans-shipment delays. Unloading of produce could be further facilitated by employing a movable conveyor of the type suggested by Canadian Fishery Consultants for use in the Fish Landing Complex, which is graphically presented in Figure 4. Preferably, roofs should be constructed above conveyor areas, to protect products and machines from the elements.

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To permit rapid unloading of produce from boats, it is recommended that a section of Potter's Cay dock be assigned for the exclusive use of the PE. Boats would use this port section exclusively for the unloading/loading of produce, but once these operations have been completed, they would move elsewhere in the dock to handle other types of cargo. Implementation of these measures would facilitate the installation and operation of movable conveyors and minimize trans-shipment delays. It would also eliminate current transport costs to move produce from the boats to the PE.[6]

The PE also must have unloading facilities to receive fruits and vegetables arriving from farms in New Providence Island. For this, a docking area accessible to medium-sized vehicles and light trucks needs to be in place. These facilities can be used to load shipment for PE institutional clients in Nassau and New Providence Island. Dock heights of these facilities should be adequate to the types of vehicles used by farmers and Nassau clients, preferably from 2 ft to 3 ft 2".

(b) International Trade

Docking areas at the Potter's Cay facility should also have the capacity to handle produce imports and exports, which are generally carried out in roll on - roll off (Ro-Ro) 40 ft containers. If the PE is integrated with the FLC, the existing dock is adequate for handling these containers. However, if such integration does not take place, new docking facilities would have to be set up.

(iii) **Produce Processing Area**

A separate section for product preparation, grading, sorting and packing has to be established, preferably adjacent to the receiving area and the cold storage section. This section should be refrigerated or air conditioned, to enhance employee performance and minimize product losses. Floors should be easily washable, and the entire area should be well illuminated. Whenever possible, employees in this section should have separate bathrooms, with showers and lockers.

The size of this section depends on the volume of products to be processed by the plant. This in turn will depend on the production volumes brought by New Providence farmers and the volumes of ungraded or improperly graded, or unpacked produce arriving form the Family Islands.

A minimum processing capacity of 3 MT per hour is recommended to satisfy local market needs. This is based on historical purchasing patterns (1987 and 1988), during the peak first-quarter production season, in which the plant can receive up to 500 tons of produce per month, or up to 25 tons per day. Assuming that 90 per cent of this volume is received from the Family Islands and 10 per cent from New Providence, and that the PE will need to reprocess up to 50 % of the produce arriving from the later and process 100 % of the produce originating in the former, to satisfy local market demand, the PE should have sufficient space to process up to 14 tons of produce end three types of crops per day. Five hours of effective machine operation are assumed per day.

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[6] Preliminary conversations regarding the feasibility of this conversion have been informally sustained with a high-level official in the Ministry of Transport, who indicated that they are feasible in principle. Nevertheless, there is a need for MATI to carry on the necessary official requests and negociations with the Ministry of Transport to formalize this matter.

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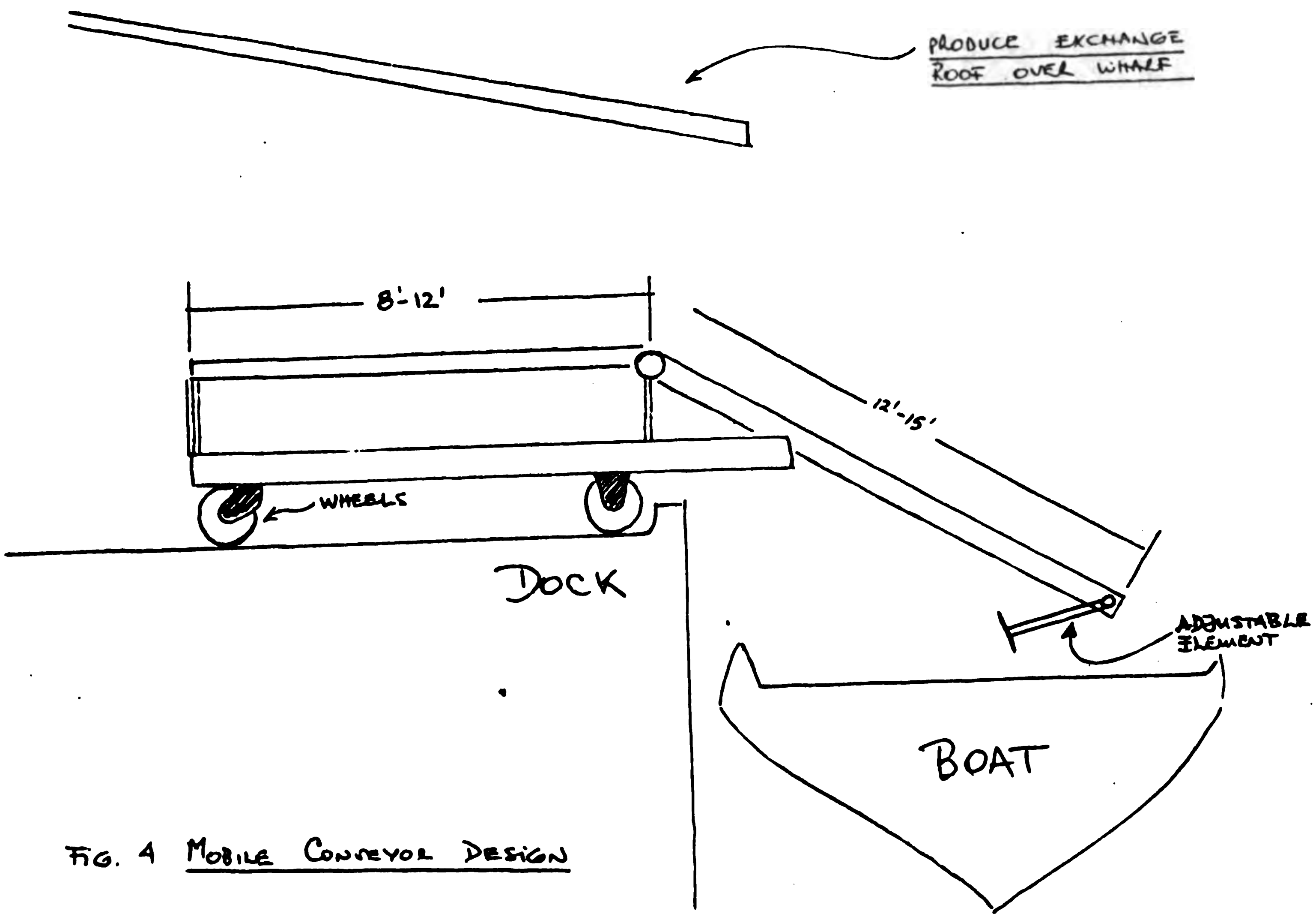

FIG. 4 MOBILE CONVEYOR DESIGN

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To satisfy packing requirements of produce exports, a minimum capacity of 3 MT per hour is suggested. It is considered that the PE would have to pack products during the months of October to April, when Bahamas enjoys a comparative advantage to supply the U.S. market.

An area equal to 6.000 square feet is required for produce grading, packing and boxing operations. Based on the volumes expected to arrive at the PE, for both local and foreign consumption, it is considered that the facility should have a minimum area of 3.000 square ft to install produce grading and sorting machinery. It is recommended that an additional 1.000 square feet of space be reserved for holding ungraded produce and preparing pallets of boxed products and circulation.

b. Cold Storage Section

One of the most important sections of the plant consists of the cold storage chambers. These rooms should be capable of providing adequate refrigerated storage to the different types of produce arriving to the PE. Temperature and humidity levels should be fully measurable and controllable at all times by the PE staff.

With respect to chamber size, it should be designed to facilitate product handling while most efficiently using available storage space. Given the limited area available, the rather large volumes of produce that will be stored in the PE, and the relative high cost of labor in The Bahamas, it is recommended that chamber doors and rack layout permit utilization of fork-lifts.

(i) Modification of Existing Chambers

If existing PE cold chambers are renovated, they can be improved by enlarging their doors to a minimum height of 8 ft 2", to enable operation of the forklift which requires an 8 ft clearance. In addition to this, if possible, they should be joined in groups of two (# 1 and #2, #3 and #4, and #5 and #6), to allow forklift operation and shelving on the sides. These modifications leave chamber heights unchanged at the current level of 9 ft 8 ", which only allows one-tier storage. Consequently, the maximum volume of produce that could be stored with a fork-lift in the renovated existing chambers would be 30 tons of produce.

However, with non-mechanical storage methods, these chambers can be used to store up to 100 tons of produce. For this, it is assumed that no access corridors are left and all available refrigerated space is used to stock products in a single 5 ft-high level. Naturally, this storage system is not compatible with the operation of a modern and efficient warehouse facility.

(ii) Construction of New Chambers

(a) Chamber Size

If new chambers are built, or the existing ones are subject to a major modification, recommended chamber sizes are: 20 or 40 ft wide, 25 or 34 ft long and 20 ft high. The smallest chamber (20'x25'x20')would have a capacity to store 21 MT tons of produce, while the larger size (40'x34'x20') would hold 56 MT.

Cold chamber widths should have a minimum of 20 feet, to permit stocking on both sides of the walls and the operation of a fork-lift along an 11 ft corridor to facilitate

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manuevering. If there is sufficient space, width can be increased in multiples of 20 ft, replicating the same rack layout pattern, as is presented graphically in Fig. 5.[7]

With respect to chamber lengths, these can be as long as desired, even though as the rooms have increased lenghts, it becomes more difficult to assure uniform refrigeration and they become less efficient from the perspective of construction costs. Minimum recommended length is 25 ft, to allow for installation of three metalic rack beys, each one with the capacity to store two pallets per tier. Length has to be increased in multiples of 100", the dimension of each additional bay.

Finally, 20 ft high chamber heights are recommended, to install three-tier shelving, and allow sufficient space for air circulation and evaporator installation. Modern warehouse facilities are being designed with 20 and 24 ft heights, to make optimum use of building area. Height is generally the least expensive expansion option. Utilization of chambers of these heights necessarily requires the use of pallets and fork-lifts. Twenty feet-high ceilings allow for the installation of three-tier metal racks, while 24 ft-high ceilings enable four-tier storage.

(b) Number of Chambers

The facility should have four chambers to satisfy temperature, humidity and compatibility requirements of different groups of fruits and vegetables, which are presented in Table 3.1.

Fig. 5

[7] It would be possible to use corridors as narrow as 9 ft. However, the recommended width facilitates fork-lift operation and reduces the likelyhood of accidents.

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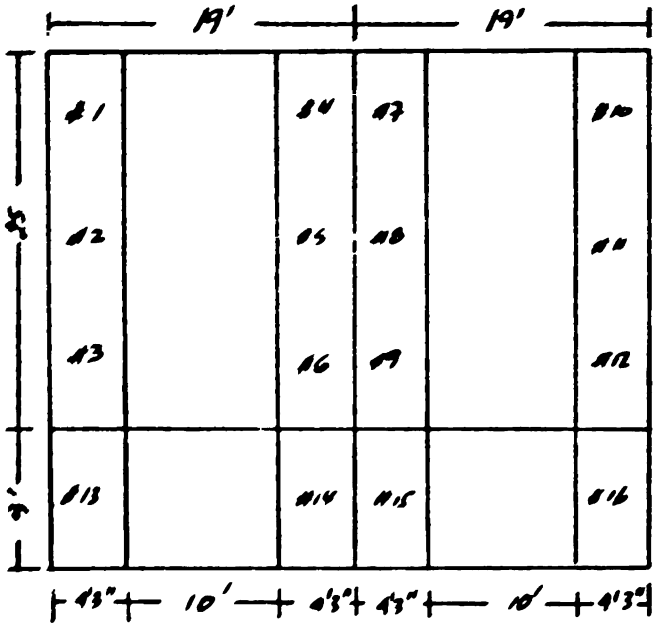

SIZE A : 19' × 25'
BAYS #1 - #6

SIZE B : 38' × 25'
BAYS #1 - #12

SIZE C : 38' × 34'
BAYS #1 - #16

FIG. 5 RECOMMENDED COLD STORAGE ROOM DIMENSIONS

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TABLE 3.1.
TEMPERATURE AND HUMIDITY REQUIREMENTS FOR DIFFERENT TYPES OF PRODUCE

PRODUCT NAME	RECOMMENDED TEMPERATURE (F)	RECOMMENDED HUMIDITY (%)	EXPECTED VOLUME (MT)
HIGH TEMPERATURE/MEDIUM HUMIDITY			
GREEN TOMATOES	65-70	85-90	2.409
RIPE TOMATOES	55-65	90-95	
IRISH POTATOES	55-60	85-90	4.496
AVOCADO	55-60	85-90	133
BANANAS	55-60	85-90	3.627
MANGOES	55-60	85-90	9
GRAPEFRUITS	55-60	85-90	449
PINEAPPLES	55-60	85-90	16
SUB-TOTAL			11.139
SWEET POTATOES (*)	65-70	85-90	1.105
WATERMELONS (*)	65-70	85-95	180
SUB-TOTAL			1.285
MEDIUM TEMPERATURE/MEDIUM HUMIDITY			
SWEET PEPPERS	50	85-90	388
CUCUMBERS	50	85-90	156
OKRA	50	85-90	30
SUBTOTAL			574
LOW TEMPERATURE/HIGH HUMIDITY			
BROCCOLI	32-36	95-100	290
CABBAGE	32-36	95-100	126
GREEN ONIONS	32-36	95-100	671
LETTUCE	32-36	95-100	1.301
PEAS	32-26	95-100	196
ORANGES	32-36	90-95	2.003
ZANAHORIAS	32-36	95-100	453
FRUTILLA	32-36	90-95	1.103
CAULIFLOWER	32-36	95-100	313
SUBTOTAL			6.456
MELONS	40	90-95	389
TANGERINES	40	90-95	118
SUBTOTAL			507
TOTAL			19.961

(*) Should not be stored with bananas and tomatoes.

(c) Recommended Sizes and Numbers

Four large cold chambers (40 ft x 34 ft x 20 ft) should be constructed. These chambers would have an aggregate capacity to store 224 MT of produce, and would satisfy the requirements of compatibility, temperature, and humidity of different products.

The proposed capacity would be adequate to store expected volumes of produce. As indicated in Table 3.1, annual produce consumption of The Bahamas in 1988 was equal to 19.961 MT. This is the maximum level of store that would have to be provided in the country to satisfy local consumption needs. Considering that this volume is uniformly

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distributed throughout the year, monthly consumption is equal to 1.663 MT, of which the PE handles about 30 % at the local peak production season.

The recommended cold storage capacity has been obtained assuming that the PE facility at Potter's Cay can increase its market share to 50 per cent of local produce consumption. This is equal to 831 MT per month, or 192 MT per week.

c. Gas Ripening Section

The facility requires a gassing room for ripening bananas and tomatoes with a capacity to gas 20 MT loads. This capacity is estimated considering that the 30 per cent of the products marketed require ripening, which equals 1.810 MT per year, or 150 MT per month; and assuming that the ripening room can process 8 loads per month.

If it is decided that the PE will be refurbished with the existing layout, installations should be completed to have a gas ripening room in chamber # 10-11. It is recommended that chamber # 7 be turned back to store products, as chamber # 10-11 would offer sufficient gassing capacity. A definitive action should wait for the recommendations to be formulated by the consultant contracted by MATI to evaluate the condition and repair costs of the PE gassing equipment.

Construction of a gas ripening facility at the PE has been strongly recommended by several middlemen, as there is none in the country. Such facility would permit the PE to better adjust produce supplies to market demand.

d. Shipment Staging Section

It is recommended that a separate refrigerated area for staging outgoing produce shipments be established. In this manner, it can be prevented that this activity be carried out in the cold chambers or in an unrefrigerated area, as is being presently done.

If there is a simple renovation of the PE, it would be possible to locate this pre-shipment area in a section of the corridor between the cold chambers. This area would be separated from other plant sections with plastic polar curtains and properly air conditioned. If a major renovation is conducted, this area needs a mimimum of 320 square ft, to allow circulation of a fork-lift (11' corridor) and sufficient room for four pallets. The staging area should be located midway between the cold chambers and the dock.

e. Input Storage Section

The facility requires one warehouse with the capacity to store a three-month supply of packing materials, 61.000 units. For this, is is assumed that the PE could handle up to 50 per cent of the local produce consumption, and that produce is packed in 30 lb. units. The required warehouse should have the following dimensions: 34 ft long, 40 ft wide and 20 ft high, to install four rows of three-tier metalic shelving, with 100" bays, and a capacity to store two pallets per bay.

One of the principal requirements of the current facility is to establish a separate area for the storage of packing inputs, composed principally of cardboard boxes. This area should be locked and readily accesible from processing and shipment areas. It should permit the installation of three or four-tier metalic racks to fully utilize storage space. Ideally, this section should be adjacent to the product processing area, and connected to it by a window through which assembled boxes would be passed.

f. Complementary Constructions and Installations

In addition to the above requirements, the following aspects should be considered in designing a modified or new PE facility:

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Compressor areas: all refrigeration machinery on the periphery should be adequately protected from the elements and vandals. Such protection, however should not inhibit adequate ventilation of refrigeration equipment. Preferably, however, all delicate machinery should be placed at places as distant as possible from the ocean, to protect them against salt water and air.

Drainage and water installations: all areas, including the cold storage chambers should be easily washable. Water faucets for the connection of rubber hoses should be located at convenient sites, to facilitate washing of each plant section and cold storage chamber. Every one of these sections should have a drainage system to allow efficient removal of liquids utilized in washing operations.

Illumination: there is a need to improve illumination of cold chambers.

Maintenance: a room should be constructed to set up a maintenance workshop.

Garage: a covered garage, for a minimum of two PE medium-sized vehicles should be constructed.

Parking area: a visitor's and employee's parking area, for persons visiting the facility but not loading or unloading produce should be designated.

Garbage disposal system: there is a need to establish a waste and garbage disposal system, involving the use of closed containers.

g. Administrative Section

Administrative areas should be separated from other PE sections. There should only be a connection between these areas and the Production Manager office. The general public should only have access to the administrative area. Administrative and plant personnel should use separate bathrooms. One room in the administrative section should be designated for the installation of computer equipment.

2. **Equipment and Installations**

a. Grading Machinery

The PE requires a processing and sorting machine to replace the one that broke down. The new machine requires a processing capacity of 3 MT per hour to satisfy local market requirements. Such capacity would have to be doubled if the PE is to process fruits and vegetables for the export market.

The required machine consists of a receiving station, a trash separator, pre-sizer, washer, water eliminator and waxer, drier, selection table and sizer. It is essentially the same type as the grading machine currently in operation in the North Andros packing house, but of a greater procesing capacity. At this stage, given the volumes to be processed and the diversity of the crops, it is considered that automatic box fillers would not be necessary.

It is assumed that the receiving station would be located as close as possible to the dock for produce arriving in trucks from New Providence farms and in "mailboats" from packing houses in the Family Islands. To speed-up processing, conveyor belts could be installed from the docks to the receiving station.

This machine, if installed along a straight line, requires an area of 3.000 square ft (100'x30'). If a "U"-shaped machine layout is adopted, 3.200 square ft are required (80'x40').

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b. Pallet-Handling Equipment

It is necessary that the facility be provided with an electrical fork-lift of the counterbalance type. This vehicle should have a capacity to lift mimimum loads of 2.000 lbs and to reach at least 12 ft high. The fuel-driven fork-lift presently owned by the PE could be used for outdoor operation or in well-ventilated areas, but it should not be used inside cold storage chambers.

The counterbalance-type fork-lift is recommended as opposed to the straddle-type, as the former is generally cheaper, easier to maintain and -specially- operate.

c. Electrical Generator

To prevent losses associated to power cut-offs, it is recommended that an auxiliary electrical generator be installed. It is reported that blackouts occur regularly in the PE, last several hours, and impede continuos operation of refrigeration equipment. This situation has to be prevented as it can cause sizable loses to the PE.

d. Scales

In order to randomly check pallets of produce, it is recommended that the PE be provided with a cell floor scale, specially designed for heavy-duty warehouse applications, with a capacity to weight a minimum of 1.000 pounds.

e. Computer System

In order to allow the establishment of a computerized inventory control and accounting system, it is recommended that a computer system be installed at the PE. Given the level of operations, it is considered that an IBM or compatible equipment, with 640 K and a hard-disk of 30 MB, plus a printer and appropiate software, would be required.

f. Metalic Racks

To optimize use of cold-storage and input storage facilities, it is recommended that three-tier metal racks be acquired. These racks areof the same type presently employed to store packing inputs by the PE. Rack bays should be 99" apart, to allow shelving of two pallets per bay.

g. Other Equipment and Vehicles

The PE requires at least one and preferably two refrigerated vehicles, with a 3.5 MT load capacity, to make deliveries in Nassau.

A maintenance workshop needs to be installed at the PE. It should be equipped with all the necessary accesories to carry out welding of refrigeration system components, minor electrical repairs, and regular maintenance of grading and produce handling equipment.

Fixed thermometers should be installed in every cold chamber. Portable produce thermometers should also be acquired for executive and supervisory personnel.

A personnel stamp clock is required to control employee attendance.

D. Integration of PE with the Fish Landing Complex

This section analizes a possible integration of the PE facilities at Potter's Cay with the adjacent Fish Landing Complex.

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1. Antecedents

The Fish Landing Complex (FLC), also known as Fish Terminal, is the result of a development project identified by the United Nations Development Program (UNDP) back in 1972. The project was implemented over a period of several years, being completed by 1983, with the technical support of the Food and Agriculturai Organization of the United Nations (FAO), and a loan from the Inter-American Development Bank.

After considering several possible locations for the project's plant, a site at Potter's Cay, adjacent to the Produce Exchange was selected. This selection was made because Potter's Cay was considered to have the best safe haven and approach characteristics, adequate depth for safe vessel maneuvering, mimimum initial dredging costs, and an ideal strategic location for fish landing and marketing activities.

The project was ambitious and intended to fill a major need of the local fishing industry. Its cost has been estimated at Bh$ 4.841.113.[8] It sought to promote development thorough the provision of essential landing and marketing services to small and medium-sized fishermen. These services were associated to the landing, freezing, storing, and wholesaling of fish and fishery products. In addition, the project was expected to support the daily maintenance and operation of the fishing fleet, by supplying toilet and cafeteria facilities, retail stores, electrical supplies, sheltered space for the repair of nets, traps, and lines, fuel and water for berthed vessels, and ice to some 200 fishing vessels and 700 fishermen.

2. Implementation and Operating Difficulties

Layout of the FLC is presented in Fig. 6. The facility partially operated in 1983-84, was shut down in March 1984 due to operating and maintenance deficiencies. It was re-openned in 1985 and partially operated for a year. The plant ceased operations indefinitely in August 1986. Even though a complete analysis to explain the project's failure has not yet been undertaken, the following contributing factors are cited:

Fig. 6

• Information for this section has been predominantly taken from a consulting report recently presented to the government of The Bahamas by Canadian Fishery Consultants Ltd.

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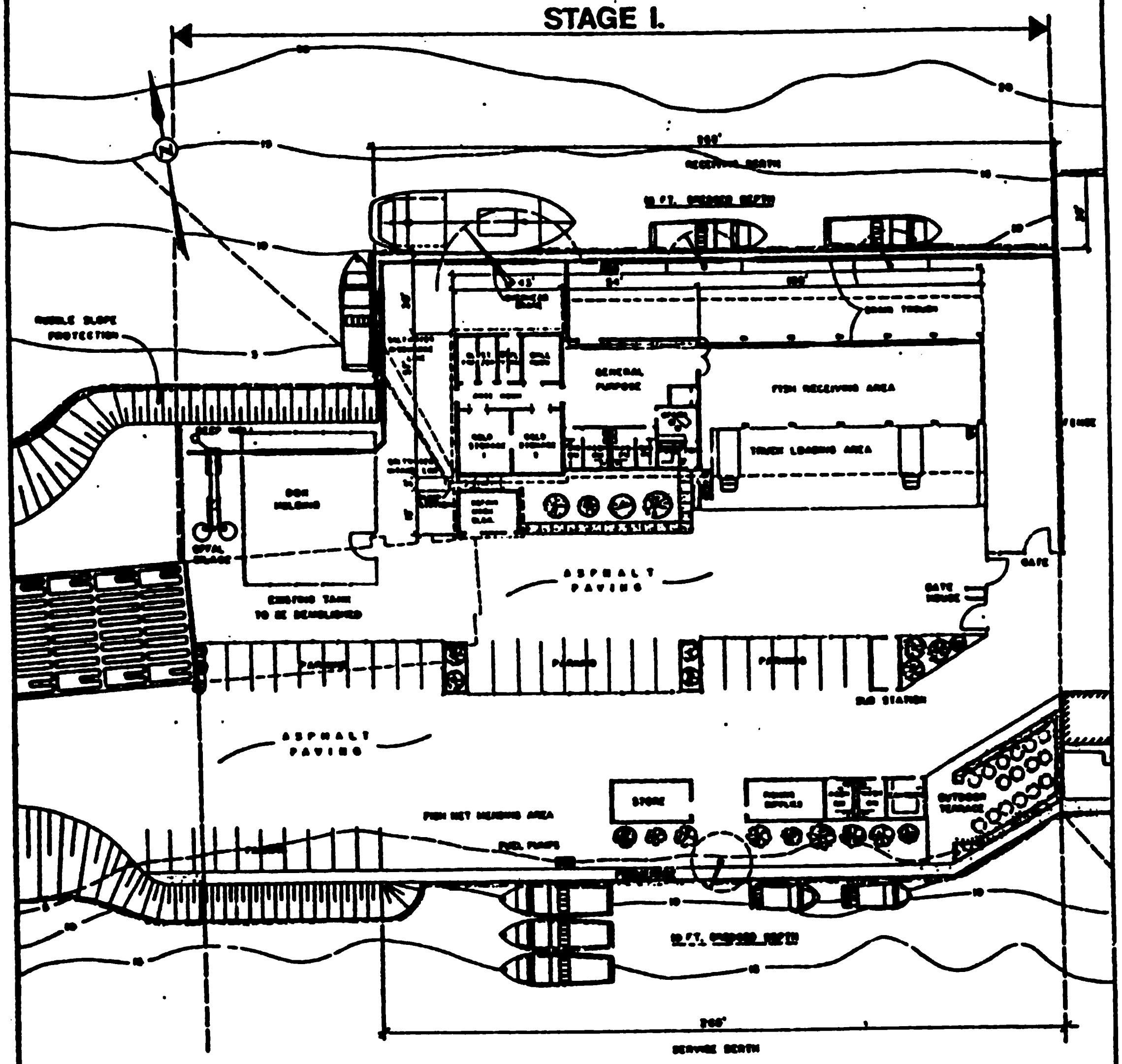

Plan

STAGE-I

Fig. 6 FISH LANDING COMPLEX

POTTERS' CAY NASSAU N.P. BAHAMAS

STEVENSON HARDTKE ASSOCIATES LIMITED

J.B. KOPPERNAES ENGINEERING LTD.

GEORGE V. COX & PARTNERS

30 15 0 30 60 90

SCALE IN FEET

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(a) cost over-runs amounting to 79% of the originally planned investment;

(b) inability to execute complementary project activities to increase fish landings;

(c) management deficiencies, arising from operation of the facility by the Department of Fisheries, an entity dependent of the Ministry of Agriculture, Trade and Industry (MATI). These deficiencies can be better understood if it is considered that FLC management by MATI has been conducted in a manner similar to the Produce Exchange; and

(d) serious equipment maintenance and operation problems, principally associated to the plant's ammonia refrigeration system. These problems have been of a recurrent nature; in every case remedial actions were not taken for months, and adopted solutions generally turned out to be inadequate.

3. **Rehabilitation Initiatives**

Over the years, the government of The Bahamas, the IDB, and the Ministry of Agriculture have made several attempts to solve the implementation and operating constraints confronted by the FLC. To date, all these efforts have been unsuccessful. Last year, a consulting firm, Canadian Fisheries Consultants Ltd. (CFC), was contracted to evaluate the status of the facility and recommend possible action courses. This report is still being evaluated and no decisions as to the future of the FLC have been made yet.

The work done by CFC reveals many of the same problems faced by the PE, in terms of operating, maintenance, and bureaucratic problems. It also points out the existence of major construction and installation deficiencies in the ammonia refrigeration system.

4. **Feasibility of Integrating the FLC with the PE**

a. Advantages

Based on the above factors, the principal advantage resulting from an integration of the FLC to the PE is refered to the resulting area expansion and lower investment levels. It would not be necessary to construct new loading/unloading facilities at the PE for both "mailboat" and truck off-loading and loading of produce shipment to Nassau, as those belonging to the FLC are excellent. Use of the docking and loading/unloading areas of the FLC would mitigate the critical problem of insufficient area currently faced by the PE, freeing areas in the PE for installation of produce grading, processing and storage, and reducing investment levels in new PE facilities.

Specifically, the former fish landing area can be used for all produce loading and off loading operations. The former fish processing room, located to the West of the landing area, could be used for storage of packing inputs or produce processing. The only FLC section that would not be readily utilized by the PE refers to the cold chambers and ice factory.

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b. **Disadvantages**

Integration of the PE and FLC facilities presents the following negative aspects:

(i) as it stands, the FLC entails an investment of over Bh$ 4 million, which has yet to prove it usefulness in supporting the development of the country's fishing industry. By integrating this facility with the PE, such investment and its intended benefits would be lost. This would not be desirable as the FLC seemss to have the potential to be rehabilitated;[9]

(ii) the refrigeration chambers and ice factory of the FLC, which have been built to store frozen fish are not the most adequate for stering produce and have a series of problems that have not been solved in more than eight years. In addition, these chambers are not sufficiently large to substitute the need for new chambers at the PE;

(iii) integration of the facility to the PE would postpone indefinitely the FLC project, as presently it does not seem feasible to mix produce and fish in the same facility; and

(iv) the IDB and the GoBh are currently exploring various alternatives to rehabilitate or find an alternative use for the facility. Integration of the FLC to the PE, even though for a purpose distinct from the originally planned one, would serve to mitigate the adverse public image created by an inactive and closed-down FLC. Moreover, as the new PE system is established, it could consider possible expansions to handle certain fish products and provide an increasing range of services to fishermen. Such expansion would be possible because successful establishment of the new PE system will require the creation of an efficient institutional and managerial structure.

5. **Conclusion**

It would be advisable to integrate the FLC with the PE if this results in a significant reduction of renovation costs and in a clear improvement in overall layout. Otherwise, it seems more appropriate to maintain both facilities separated, and independently pursue rehabilitation of the FLC.

E. Investment and layout Alternatives

Four investment and layout alternatives for the establishment of an improved PE facility have been prepared in collaboration with technical personnel from the Ministry of Works and Utilities. Site and building layouts corresponding to these options are presented in Figs. 7, 8, 9, 10a, and 10b. Layout features and estimated construction costs are shown in Table 3.5.

1. **Refurbish the Existing Facility without Layout Modifications**

It would cost approximately Bh$ 510.000 to refurbish the existing facility at Potter's Cay, without making any modification in layout. This sum includes: Bh$ 260.000 to renovate the building, Bh$ 150.000 for repairing and improving the electrical system, and Bh$ 100.000 for repairing and refurbishing the cold storage and ripening facilities.

The layout proposed for this option, shown in Fig. 7, removes the input storage area to make room for sorting and packing activities, and chamber #8-9 is assigned for ripenning while all chambers on the North side of the building are devoted to cold storage.

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9 According to Canadian Fishery Consultants, Ltd. with the rehabilitation of the machinery and equipment and the replacement of damaged cold store insulation, the FLC has an excellent potential to achieve its initial objectives (Op. cit., 1989, p. 53).

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Even though this would be the least expensive option, it would confront all the drawbacks and deficiencies that have been indicated in Chapter II, associated mainly to insufficient cold storage space, lack of perimetral protection, and inadequate docking facilities. In addition, to make-up for the lack of storage capacity to keep packing supplies, it would be necessary to rent a facility elsewhere.

2. **Upgrade and Expand the Existing Facility with Layout Modifications**

It would cost approximately Bh$ 1.750.000 to carry out a major modification and expansion of the present facility. The layout plan for this option, presented in Figs. 8A and 8B (Unit 1), entails an expansion and a substantial modification of the building at Potter's Cay, constructing a new input storage area on the West and, eliminating the existing cold storage chambers to install packing and sorting activities on the North side and the loading dock for trucks on the South side. New cold storage chambers of the dimensions recommended in Chapter III would be installed in the area presently used for grading. Employee bathrooms and offices would be constructed on the Northeast corner of the building.

Most of the serious drawbacks observed at the present facility would be resolved with this investment alternative. Cold storage capacity for produce would be augmented to the levels recommended in this study. The cold storage section consists of a goup of four large chambers facing a central corridor, following a pattern similar to the ene observed in the Fish landing Complex. Separate and adequate input storage space would be provided next to the packing and sorting area. Loading and off-loading operations would be concentrated at the center, elliminating both existing docks. A new truck loading dock would be constructed on the South side. One ripening room would be constructed between the produce packing area and the cold storage section.

Fig. 7

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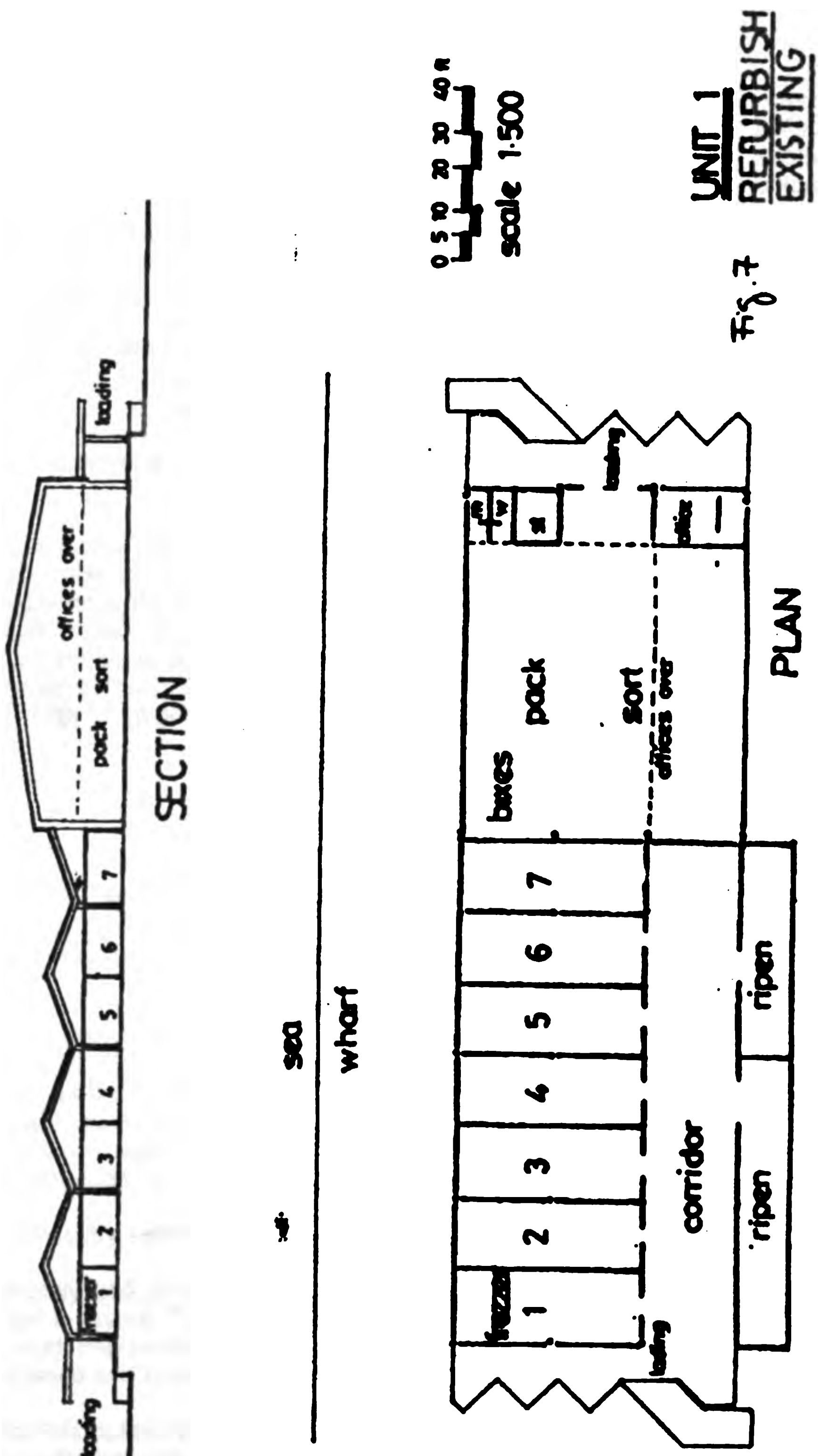

Fig. 7

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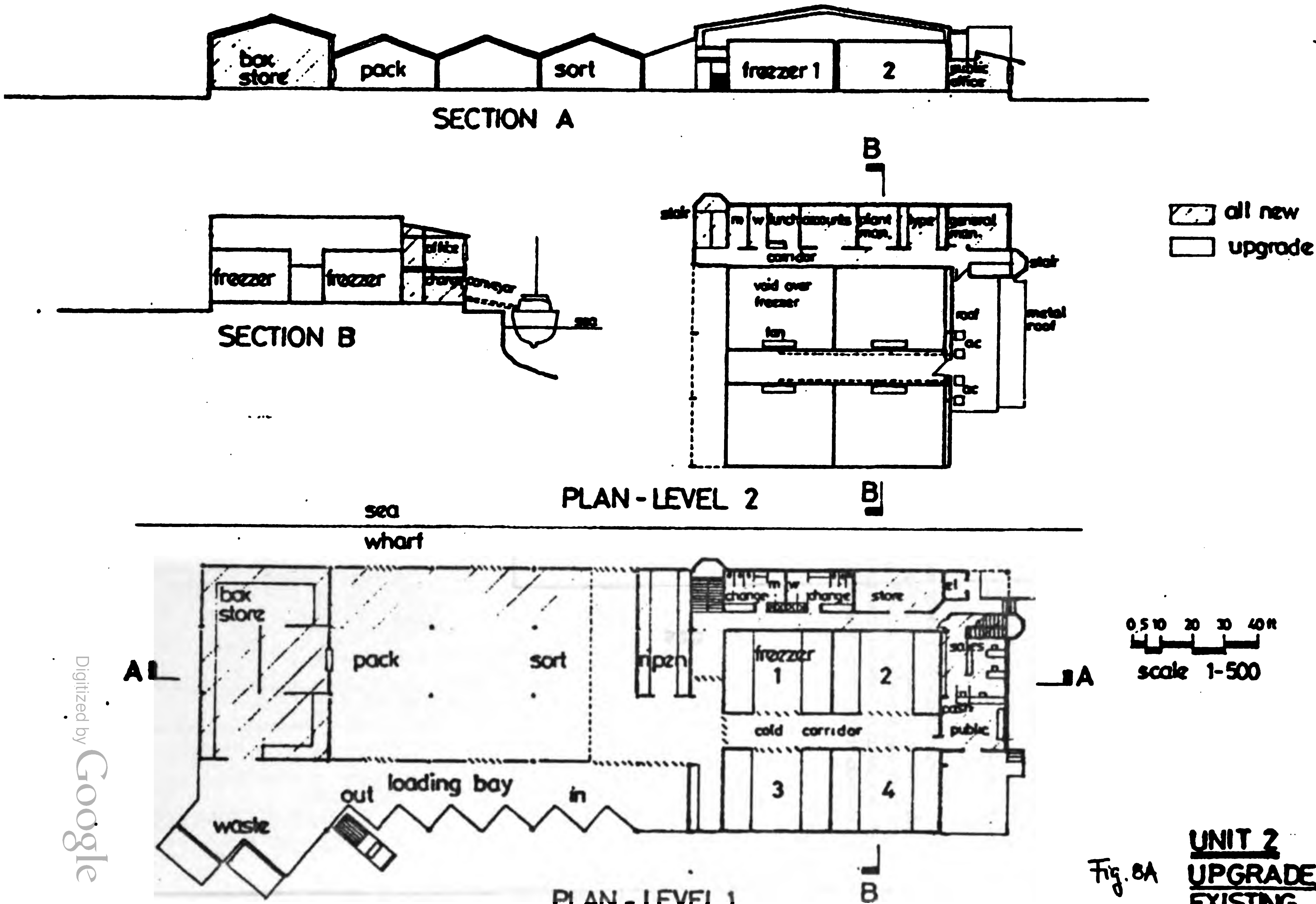

Fig. 8A **UNIT 2 UPGRADE/EXPAN EXISTING**

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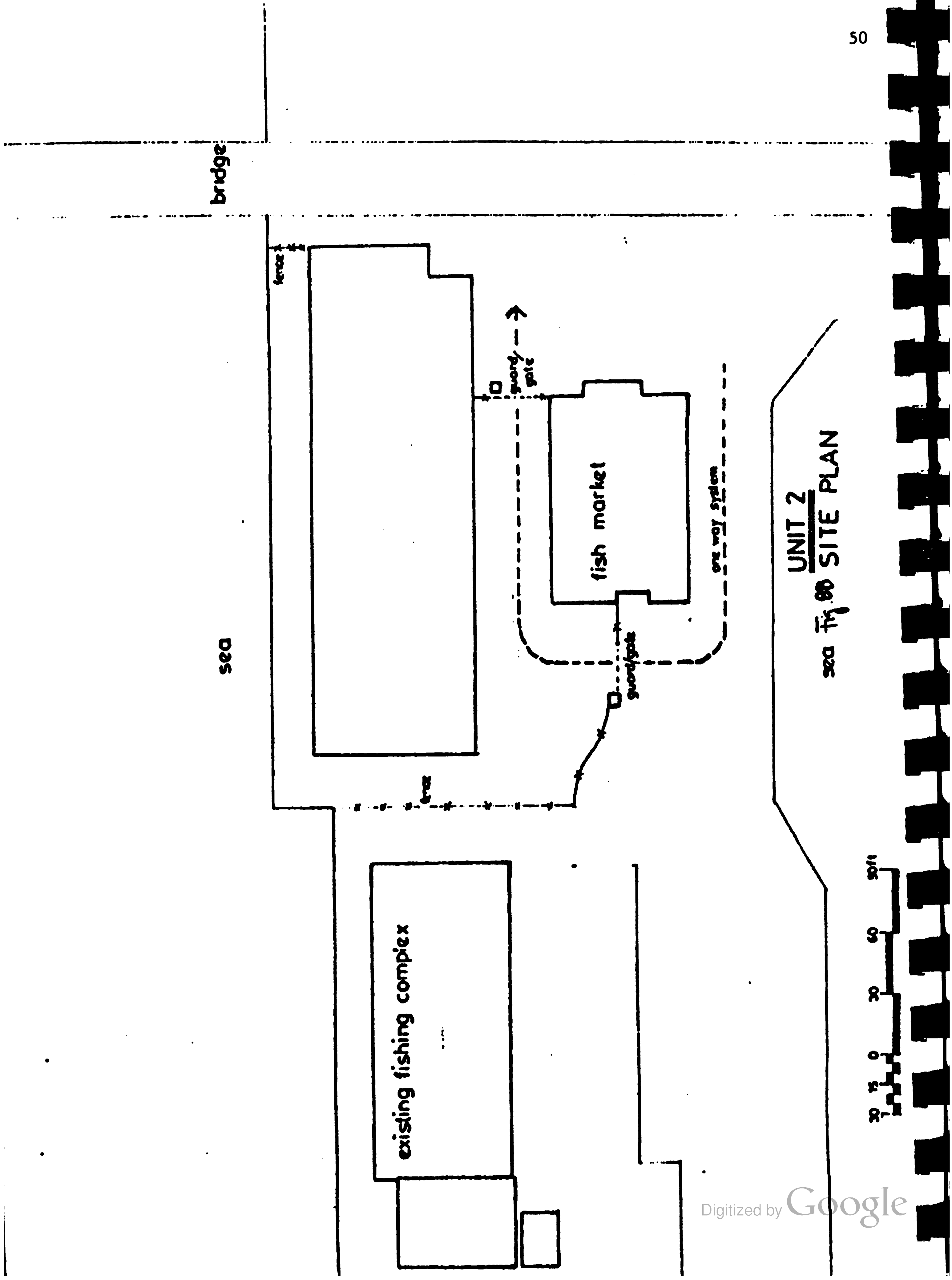

UNIT 2

fig. 80 SITE PLAN

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ıal remaining problem refers to the lack of a sufficient perimetral area to establish a ence and a controlled traffic system for vehicles and pedestrians, and provide for ample ulation and parking. The facility would have limited possibilities for future expansion.

nd Expand Existing facility and integrate it with Fish Landing Complex

f upgrading and expanding the present facility and integrating it with the adjacent Fish omplex is equal to Bh$ 1.600.000. The layout for this option is presented in Figs. 9A and 9B v a new cold storage section would be constructed between the existing buildings. There two separate packing and sorting areas, on both sides of the cold chambers, one in the he other in the PE. Docking areas would be expanded about four times the existing size. ing rooms would be installed next to the cold chambers. Two box storage room would be ed, one at the present grading station, and another at the FLC. Offices would follow a similar option 2.

t offers the required refrigeration facilities, and has ample space dedicated to sorting and input storage, and ripening. Even though layout is not optimal because of the elongated the building, and division of packing and sorting and input storage areas in two separate this option offers the capacity of incremental additions to expand refrigeration capacities. As ther options, this facility would also lack the necessary perimetral fencing, orderly circulation rolled entrance.

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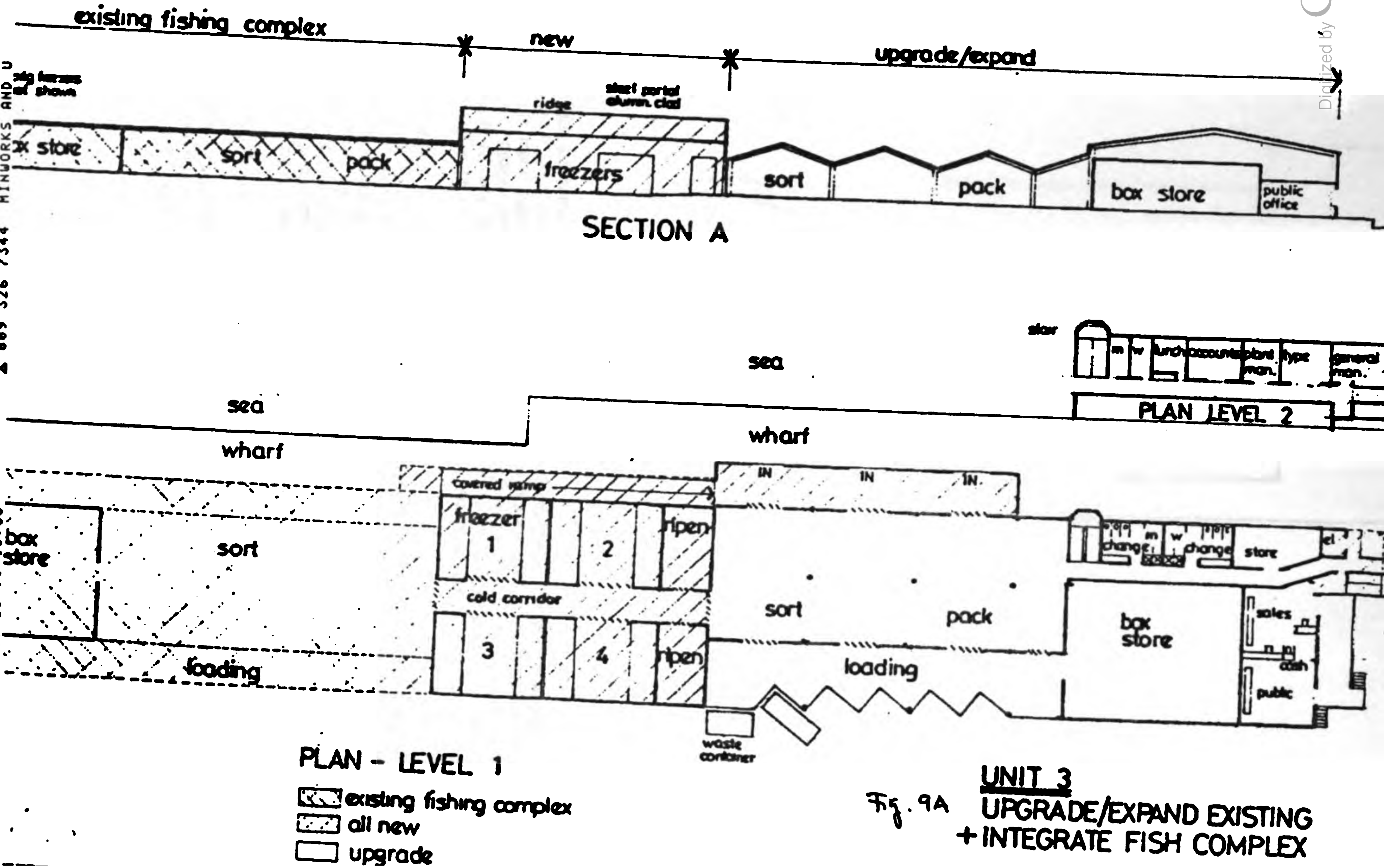

Fig. 9A

UNIT 3
UPGRADE/EXPAND EXISTING
+ INTEGRATE FISH COMPLEX

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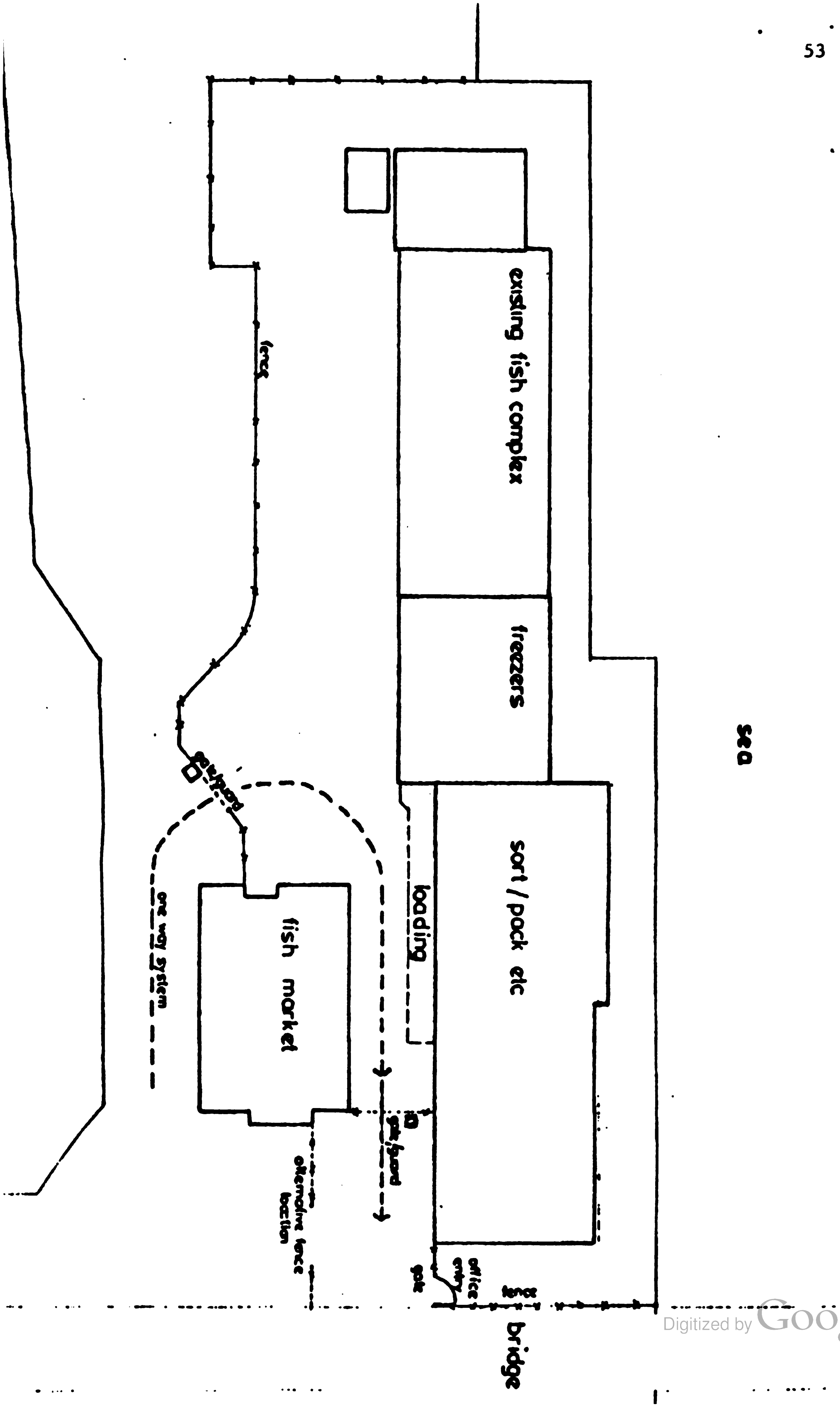
existing fish complex
freezers
sea
sort / pack etc
loading
fish market
fence
one way system
alternative fence location
office entry
gate
fence
bridge

4. **Construct a New Facility at a Different Site**

The cost of a new facility at a different site is equal to Bh$ 2.750.000. This facility, shown in Figs. 10a and 10b, meets all the requirements recommended in this document. This facility requires 10 per cent less land area than the one in option 3, because of better distribution of plant sections. It would have to be built at a diferent site as there is not sufficient area at Potter's Cay, unless part of the Marine Products Market was appropiated.

5. **Conclusions and Recommendations**

The previous analyses lead to the conclusion that the most attractive option is Option 2, Upgrading and Expanding the Existing Facility with Layout Modification. This alternative solves the serious cold storage, produce handling, and input store restrictions that characterize option 1. Adoption of option 2 offers an adequate size and capacity, without utilizing the Fish Landing Complex, hence this facility if released for implementation of another project. Investment savings realized by integrating the FLC to the PE are not sufficiently large to justify integration of the facilities. Even though the chosen layout is not as convenient as in option 4, a new facility, option 2 reduces the required investment by Bh$ 1 million.

F. Retail Outlets in Nassau

It is recognized that both the Kemp Road and Jumbey Village outlets play a limited role in the marketing of produce. Considering the reduced sales volumes, limited product assortment, overstaffing and sizable payroll costs, it is evident that both outlets are money-losing operations. In addition to representing a burden on public finances, these outlets are a poor example of produce retailing and present a negative image of state management.

TABLE 3.5.
INVESTMENT AND LAYOUT ALTERNATIVES FOR IMPROVED PE FACILITIES

CONCEPT	OPTION 1	OPTION 2	OPTION 3	OPTION 4
COST (BH$000)	510	1.750	1.600	2.750
SITE AREA (FT2)	24.533	24.533	41.400	31.166
COLD STORAGE				
- AREA (FT2)	4.100	3.822	3.822	4.200
- VOLUME (FT3)	39.975	77.640	77.640	84.000
- CAPACITY (MT)				
* MANUAL	90			
* FORK-LIFT	30	173	173	187
SORT/PACK-AREA (FT2)	4.400	4.391	10.108	6.363
RIPENNING (FT2)	1.365	667	866	1.500
INPUT STORAGE AREA (FT2)	-----	2.528	3.915	1.750
LOADING (FT)	126	216	478	50

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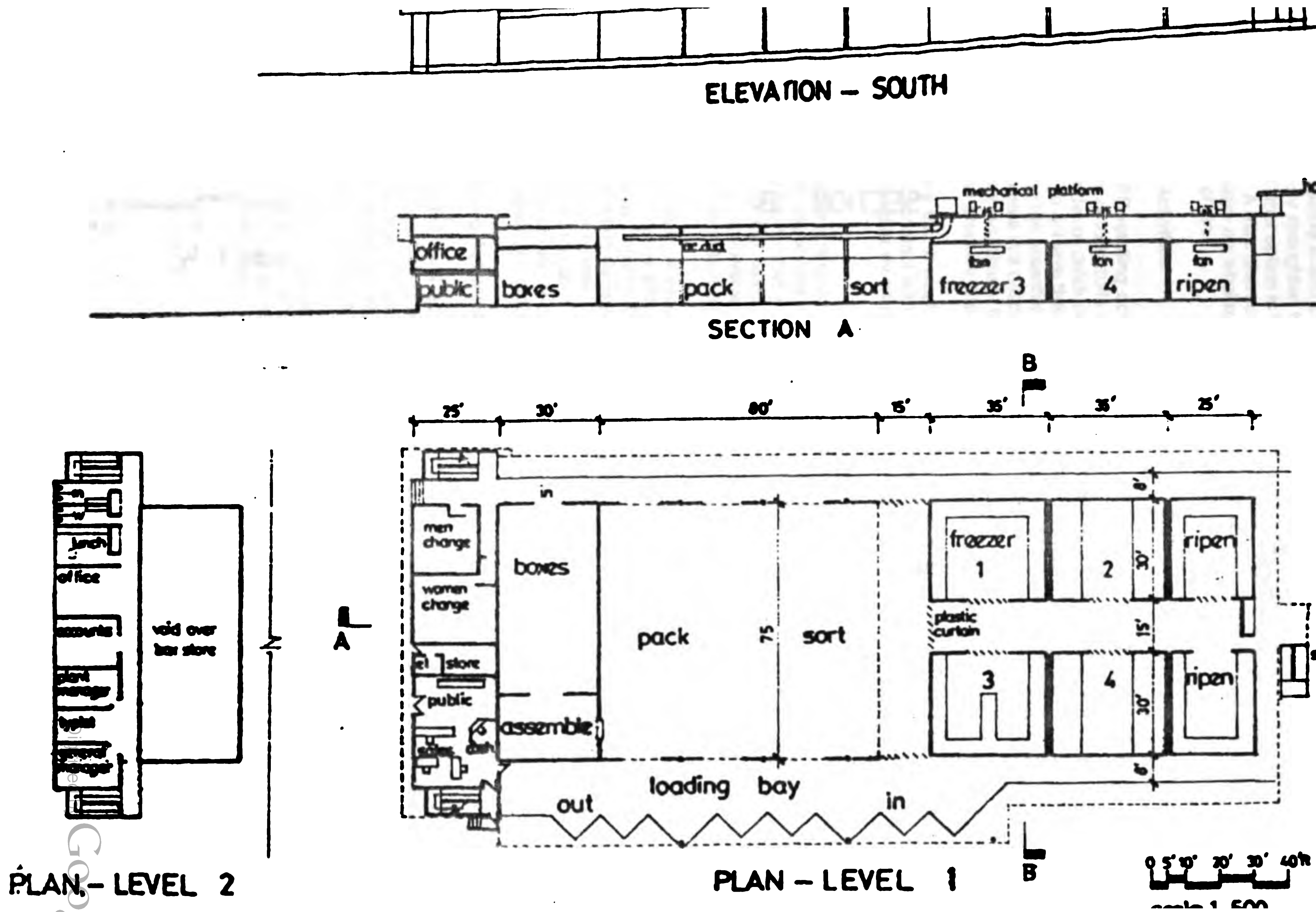
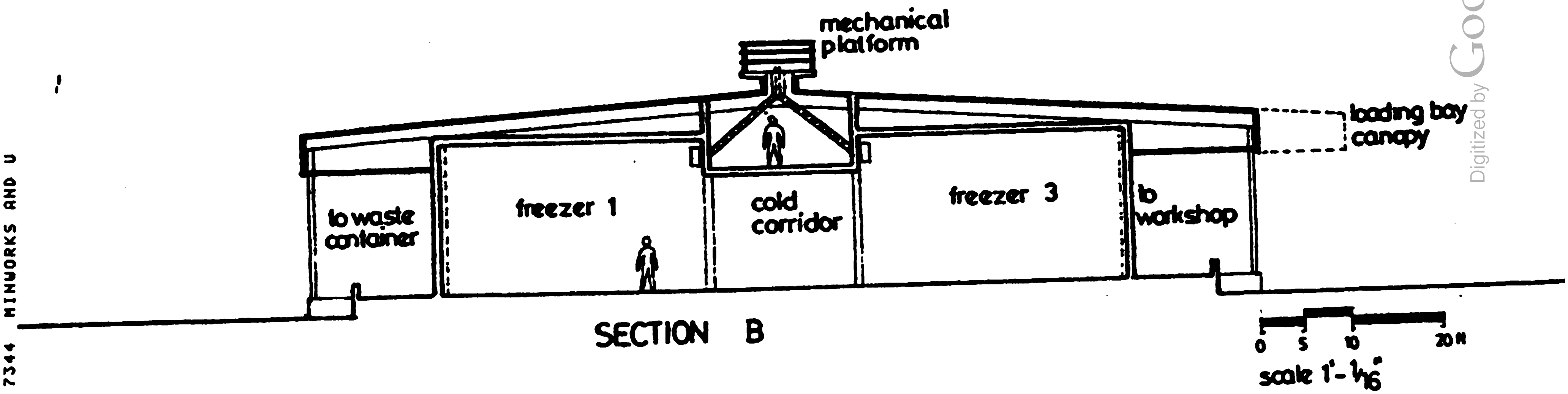
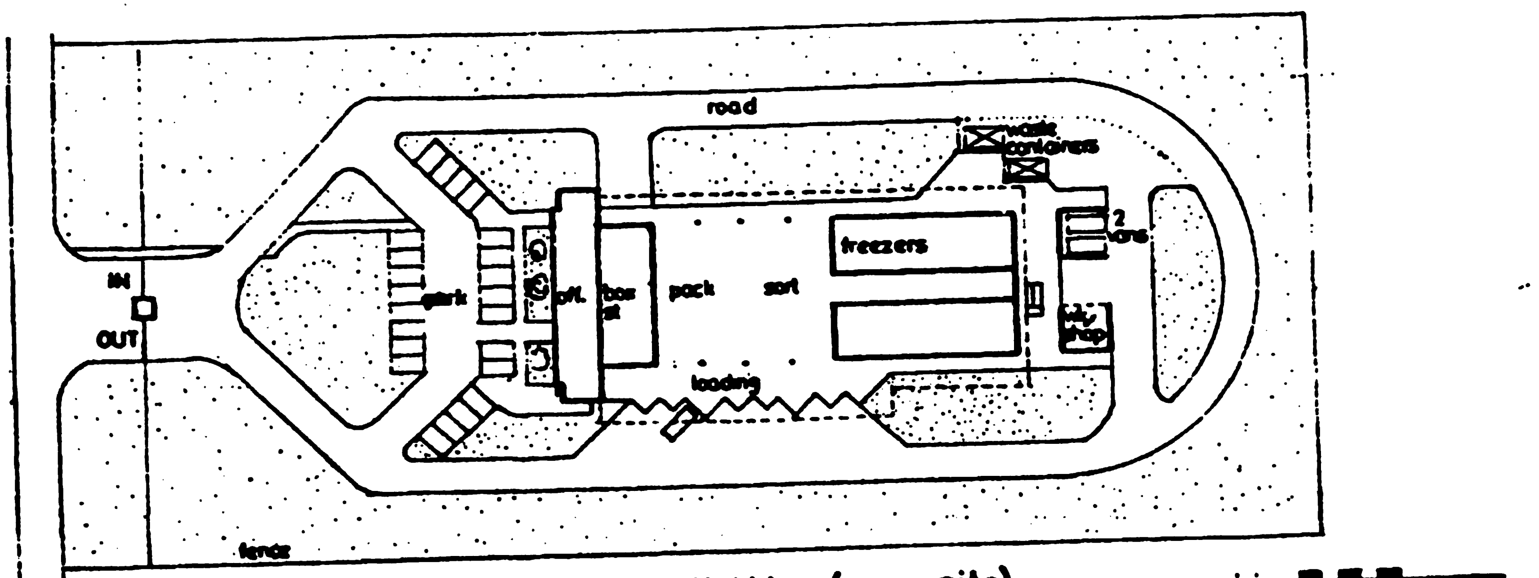


FIG. 10A
UNIT 4
ALL NEW



SECTION B



SITE PLAN – (new site)

Fig. 10B

UNIT 4
ALL NEW

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Consequently, there are three possible action courses that may be followed with respect to PE retailing activities. One option is to properly strenghten this activity so that effective and meaningful state-owned retailing actions are carried out. Other option is to abandon retailing altogether, concentrating PE system efforts on wholesaling functions. A third alternative involves a combination of the previous two, namely, the concentration of the PE system on wholesaling, the privatization of existing retail outlets, and the formation of a voluntary retailer chain.

1. **Strenghtening of Retailing Activities**

It is possible to strenghten PE retailing activities, so that they play a meaningful role in terms of: supplying a broad assortment of foodstuffs at the lowest possible prices to the consumer population; providing a management model of produce-handling retail outlets; and promoting consumption of locally produced foodstuffs. To achieve these objectives, it would be necessary to properly staff and manage each outlet, providing the essential equipment, technical assistance and training. In addition, each outlet would have to operate in a descentralized fashion, with the freedom to procure from other wholesalers those supplies not available at the PE. Only in this manner would the retail outlets be able to carry the broad year-round produce line necessary to succeed in this line of business.

Advantages of this option are that it would enable the government to have a direct intervention in retailing, and maintain a direct contact with this business sector. This contact would provide valuable information on price determination mechanisms, operating costs, the competitive environment and consumer behaviour.

The above advantages, however, are countered by several disadvantages associated with this option. There are incremental costs associated to equipping the retail facilities, providing the necessarv operating capital to provide each outlet with an adequate volume and assortment of products, and supplying the necessary technical assistance, training, supervision and control to assure proper establishment and operation. Involvement in retailing would also detract the PE system from concentrating in the critically important area of wholesaling, its major area of responsibility.

Direct public sector involvement in produce retailing would introduce a series of inefficiencies associated with running small stores with employees earning fixed salaries, working on established schedules, and receiving fringe benefits. Generally, such stores can be run more efficiently through independent operators, who obtain no fixed salaries, no fringe benefits, charge no overtime, and who can enlist unpaid supplementary family labor whenever necessary. The need for a decentralized method of operation in terms of foodstuff imports and purchases from other wholesalers, as well as the highly personalized nature of retailer-consumer relationships, clearly point out the advantages of independent private sector operators in this line of business.

2. **Concentration on Wholesaling Activities**

Another possible action course involves the concentration on wholesaling, closing down all the existing retail outlets. By concentrating on a specific set of wholesaling functions, the PE system would have a greater probability of success. As retail depots are liquidated, operating costs and losses associated to retail operations would be immediately reduced. Projected investment costs would also be diminished as it would not be necessary to re-equip the retailing facilities.

One disadvantage with this option relates to the permanent staff working in the stores, for whom the government may be unable to find employment elsewhere. By liquidating its retail stores the government would also be deprived of direct contacts with the retail trade. The PE would also lose access to a set of retailers with whom a series of concerted actions can be undertaken.

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3. **Privatization and Formation of Voluntary Chain**

It is possible to follow an intermediate solution course by privatizing the existing retail outlets and establishing a voluntary chain promoted by the PE. This alternative would enable the government to obtain many of the advantages associated to the other alternatives, without experiencing the drawbacks connected with each of them.

Privatization of the outlets would cut operating losses and reduce the need for additional investment funds. The PE system would be free to concentrate its attention on the performance of wholesale functions. Existing permanent employees of the PE system could be given priority in acquiring/leasing the facilities, which would also address the need to find alternative productive employment for existing staff. As presently state-owned retail outlets are transfered to independent operators, they could benefit from a series of advantages associated to this form of ownership, such as increased effort to serve the consumer, minimum staff, longer work days, absence of holydays and weekends, and use of unpaid family labor. All these factors would contribute to improve profitability of these operations.

As a complement to privatization of retail outlets, the PE system could sponsor the formation of a voluntary chain, which would affiliate the newly privatized outlets as well as other independent retailers. The principles of this type of organization consist in a simple agreement or contract subecribed between a wholesaler (the PE) and each independent retailer. In such document, the wholesaler offers to supply a range of products to the retailer at the lowest possible prices. In turn, the retailer agrees to buy such products only from the wholesaler. As a result, a mutually beneficial bond is created between the wholesaler and the retailer. The retailer is assured of a constant and reliable supply of products at adequate prices, and the wholesaler develops a loyal market for his products.

This organizational model has been successfully established in several countries, such as Mexico and Brazil. In both cases, the government has created institutions that affiliate retailers located in lower income neighborhoods. The experience obtained shows that in this manner, the government can play a significant role in promoting the development of the retail sector, as the voluntary chain becomes a conduit for channeling technical assistance and training to the retail trade. It has been found that the voluntary chain plays a key role in removing many of the obstacles that inhibit development of retail businesses managed by independent operators. By so doing, the government of The Bahamas can promote the establishment of retail outlets in selected lower-income neighborhood in Nassau and in the islands.

In assisting the development of the retail sector serving the lower income groups, it is possible to increase real incomes of consumers, as foodstuff prices are competitively lowered, and improve nutrition, and foostuff consumption increases as a result of rising real incomes. In turn, increased foodstuff consumption expands the market for agricultural sector products.

4. **Project Proposal**

It is proposed that the Government proceed to privatize the existing retail outlets and establish a voluntary chain. To implement this, resources have been programmed in the project to provide the necessary technical assistance and training to PE personnel in charge of chain management. It is also assumed that affiliated retailers will have access to development credit lines.

G. "Mailboat" Transportation Services

"Mailboats" play an essential role in the transportation of produce from the Family Islands to Nassau. However, these services are deficient and originate sizable economic losses to the PE as a consequence of produce spoilage, breakage and pilferage. These losses must be prevented for the PE system to become financially viable.

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1. **Contractual Terms**

To assure the provision of adequate transport services by mailboat" operators, it is proposed that, under the project, the PE establishes a contractual relationship with each one of them, as is presently done by the Ministry of Transport in the case of mail. Such contractual relationships will have a set of incentives for proper product handling and storage, as well as penalties for deviation from required conditions.

Boats operators must assume responsibility for produce transported in their vessels. Specifically, operators should be responsible for providing adequate storage conditions (temperature and humidity) to prevent product spoilage. They should also be held accountable for any products received from packing houses and not delivered to the PE in Nassau, to prevent pilferage and thievery. Boat operators should also assume responsibility for the provision of appropiate produce handling, to discourage rough treatment and prevent breakage and bruises.

To assure proper storage conditions in vessels, it is proposed that, with each shipment, a thermograph be installed inside the refrigerated chamber. This device registers room temperature every hour, so as to determine increases that can damage the product. Boat operators would be responsible for delivering the produce at the PE at temperatures within a certain range. Significant deviations from this range should penalize the operator. If the product is proven to have been transported under inadequate storage conditions, and is not saleable, the boat operator should reimburse its full value to the packing house.

It is recommended that an arbiter be designated to solve conflicts arising from transportation contracts between the PE and boat operators.

2. **Organizational Aspects**

Produce handling and transport conditions could be improved by promoting a series of organizational changes in "mailboat" operation. For example, scheduled days and hours of boat arrivals to Potter's Cay should take into consideration PE operating hours. It would be in the interest of the PE to discourage arrival of boats during non-working hours, holydays or weekends.

To minimize trans-shipment costs from boats to the PE, docking regulations could be established, reserving the dock next to the PE exclusively for produce loading and unloading operations. Produce could only be unloaded from boats in the specifically designated dock section. Once a boat completes produce unloading operations. she would have to move elsewhere in Potter's Cay to unload other commodities. The same would apply to loading operations.

Boats would be motivated to unload at the specifically designated area by the possibility of unloading at a faster pace, as this area would be served by a movable conveyor belt. Hence operators wouls be assured that temperatures of produce being delivered would fall within the required range.

3. **Incentives for Change**

The above recommendations are grounded on the assumption that boat operators will install refrigerated storage facilities in their vessels, to provide the temperature and humidity conditions required by fresh fruits and vegetables. This assumption has been tested in a series of conversations with "mailboat" operators landing in Potter's Cay, having reached the conclusion that they will invest provided that they are given the necessary incentives.

These incentives are principally associated to the capability of the PE to assure regular produce flows and/or carry out the initial investment. In addition to this, investments by boat operators could be further encouraged by the provision of credit under preferential development conditions, technical assistance, and regulations.

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a. <u>The Need for Sustained Produce Volumes</u>

Nothing seems to motivate boat operators more than the assurance of a sustained volume of cargo throughout the year. Precisely, one reason why operators have not yet shown much interest in upgrading their facilities for produce transportation is referred to the erratic and seasonal nature of agricultural production. At the present time, neither the PE nor anybody can assure boat operators that they will obtain a convenient return if they invest in adequate cold storage facilities. Nobody can even assure boat operators of a mimimal quantity of produce throughout the year. It should be not a surprise, consequently, that boats have shown limited interest in upgrading their vessels.

As the PE identifies market opportunities, and enlists farmer production, it can have a good estimate of produce quantities and volumes to be transported from each island. This would provide the essential information for negotiating contracts with boats serving each island.

The existence of mimimum regular cargo volumes is considered to be a greater incentive than increasing currrent prices. A number of boat operators have installed refrigerated chambers with the existing price of Bh$ 2 per box of produce, even when cargo availability is restricted to certain periods of the year. An increased transport price would not necessarily motivate operators to install cold chambers, as they would still not have the assurance of a regular volume of cargo.

During project implementation, attention will be paid to the utilization of refrigerated transport capacities in the return trips of boats to the islands. Such capacities could be partly utilized by coordinating the transportation of fresh produce or other perishables. This activity would be facilitated by the establishment of a voluntary retailer chain, and the existence of affiliated retailers in the islands. Each one of these retailers would demand a variety of foodstuffs, which could be supplied through the PE in Nassau.

b. <u>Investment Support</u>

Boat owners will need investmant support to carry out the necessary upgrading of their vessels. The Department of Agriculture, together with the Ministry of Transport, will enter into negotiations with boat owners as to the type and extent of such improvements. Boat owners will be assured of sufficient cargo from "his" particular island, given the increased crop production to take place under the project.

Loans for boat upgrading will come from the Bahamas Development Bank (BhDB), through a specific fund that the bank borrowed from the Inter-American Development Bank (IDB) for investments of this nature. Given the nature of the upgrading - installation of refrigerated chambers with their accompanying equipment -, loans will not be large and the boat itself will serve as collateral.

If boat owners resist making the loans or mortgaging their vessels, there is still the possibility that the Produce Exchange provide the refrigerated chambers, which would be gradually paid back by the boat operator. This could be accomplished by deducting a given sum per box of produce transported from the going price (for example, Bh$ 0.10 per box). The greater the volume transported, the faster the value of the chamber would be paid. In this manner, refrigerated transport would be initially available, without additional investment risks assumed by the boat operator. The risk would be assumed by the project, which has the capacity to promote production volumes.

The rationale for recommending project involvement in boat equipping is well grounded. It is in the interest of the PE system that inter-island transportation of fresh produce be carried out in refrigerated conditions from the start of the project. It simply makes no sense to spend in costly refrigerated chambers in the packing houses and in the PE at Nassau, if produce is going to travel in non-refrigerated conditions. The cold chain must not be broken under any circumstance.

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Similarly, the project cannot wait a long period of time until boat operators decide to make their own investments in refrigerated facilities.

c. Other Incentives

(i) **Technical Assistance**

The PE should be in the capacity to provide technical assistance to boat operators transporting produce from the islands, to assist them in refrigeration equipment selection, installation, operation, maintenance and repair. This could be done through the PE's plant manager or the person in charge of sevicing the facility's refrigeration chambers.

(ii) **Regulations**

The Ministry of Health should not authorize inter-island transportation of fresh fruits and vegetables in non-refrigerated conditions. The PE should not subscribe contracts with boat operators that cannot offer refrigerated transport.

Based on the incentives to be established by the project for boat refurbishing, it is considered that operators will be willing to borrow funds and install the necessary refrigerated chambers. However, if the incentives and regulations are not sufficient to motivate a positive response from boat operators, the PE should be prepared to install refrigeration chambers in selected boats

H. Packing Houses in the Family Islands

The packing houses in the Family Islands play an essential role in the collection, grading, sorting and boxing of produce sent to the PE. As such, the packing houses in the islands are the vital linkage connecting the PE system and the market with the farmer population. In addition to this, it is proposed in this project that they become the centers of a series of services to produce growers. Specifically, it is proposed that the existing packing house structures be convert to **agricultural service centers**, providing a series of auxiliary services to farmers.

1. **Existing Facilities**

a. Physical Modifications

Based on the volumes of produce handled by existing packhouses, which was presented in Table 2.3, it is considered that two facilities justify a 1.000 ft2 expansion in processing area (North Andros and North Eleuthera). The other five plants are handling produce volumes which can be adequately handled in the existing area. All building expansions should be constructed with heights of at least 16 ft. to allow for proper ventilation and provide versatility.

Plants in North Andros, North Eleuthera, Hatchet Bay, and North Long Island will be provided with new input storage rooms, of the following dimensions: 30 ft long, 30 ft wide, and 12 ft high, to store packing supplies using hand-lifts on wooden pallets. In the other plants, Mt. Thompson, Smith Bay, and Green Castle, input storage rooms will be installed of the following dimensions: 15 ft long, 15 ft wide, and 12 ft high. All these rooms will be attached to existing facilities, as close as possible to the produce sorting section.

The blueprint for an improved and expanded prototype packing house is presented in Fig. 11. A new building area has also been attached to each of the existing installations, to make room for the complementary services to be provided to farmers. Specifically, the expanded facilities have an office for the provision of agricultural credit, and a technical assistance and agricultural extension office. It is assumed that marketing information will be provided by the packing house manager.

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b. Equipment

Grading and sorting equipment in the North Andros and North Eleuthera packhouses should be replaced with new machinery, while those in the other five should be repaired. The existing new cold room equipment should be installed in the North Andros packhouse. New compressors and evaporators need to be purchased for the other six facilities.

2. **New Facilities**

a. Physical Facilities

Four new packinghouses should be built in the following locations:

* Mayaguana
* Long Island
* South Andros
* Crooked Island

Fig. 11

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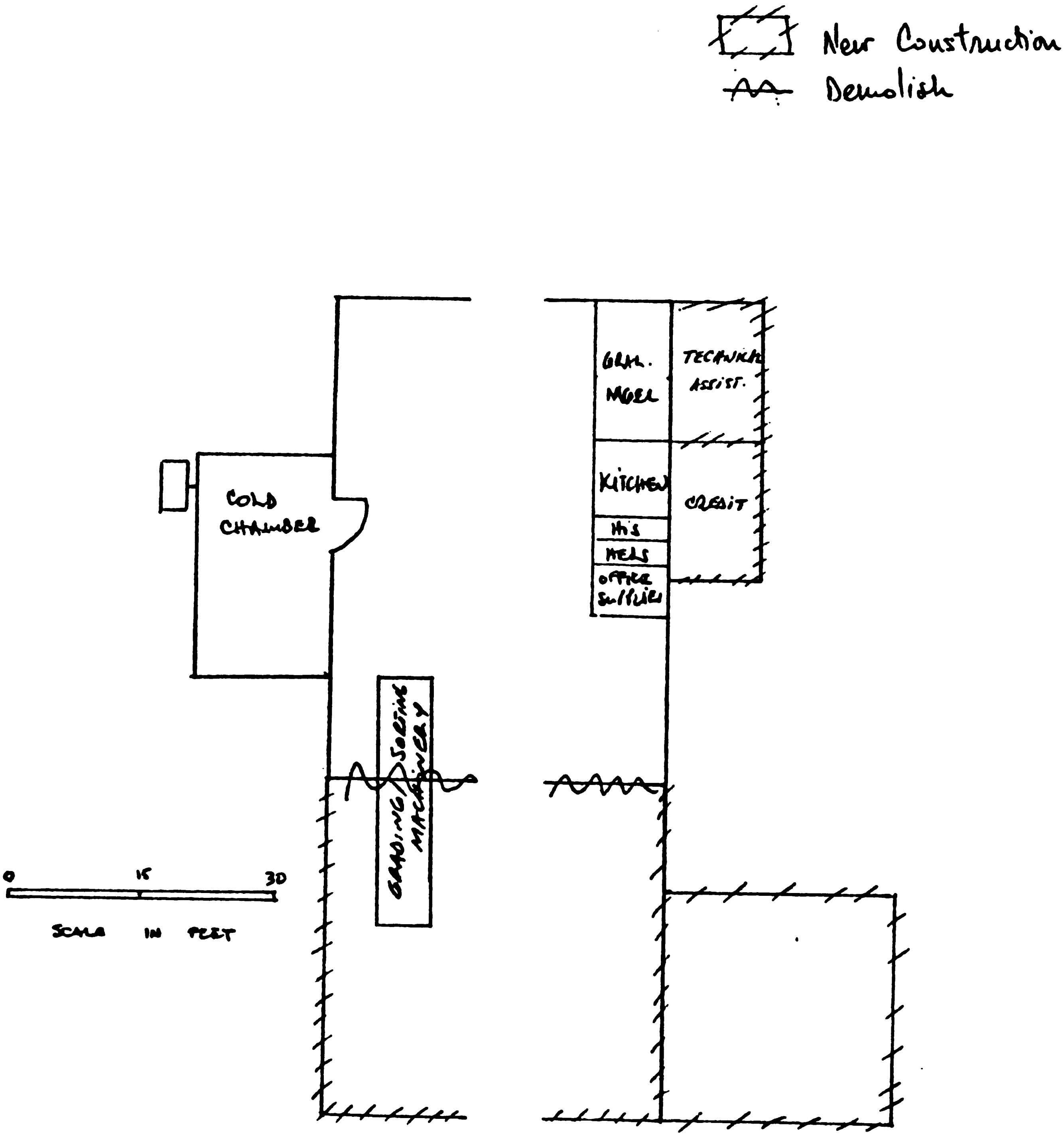

FIG. 11 EXPANDED AND IMPROVED PACKINGHOUSE: PROPOSED LAYOUT

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Each of the four recommended packing houses should have a design similar to the one shown in Fig. 3, consisting of one sorting/packing area of 2.380 ft2 (28 ft wide by 85 ft long), with a minimum height of 12 ft. There should also be an input storage room of at least 225 ft2. The administrative area, with separate offices for the manager, assistant accountant, extension agent, and agricultural credit staff, a small kitchen, and bathrooms for personnel should also be constructed.

b. Equipment

Each packing house should be provided with the mimimum necessary equipment, including: one produce grading and sorting machinery, one hand-lift for pallet handling, 100 wood pallets, two 60-lb scales, one box stapler machine, office furniture and supplies.

3. Operating Procedures

a. Decentralized Management

Even though the packing houses and the PE in Nassau are both components of the same system, each packhouse should be viewed as a separate enterprise, receiving products from farmers and marketing them through the PE. Packing house managers should be selected with the approval of the General Manager of the PE in Nassau, but should have a level of autonomy in selecting and firing personnel working in their facilities, and the methods to meet its production quotas. Each packing house manager should be provided with incentives to increase operating efficiency, by reducing operating costs and spoilage.

Separate consideration of each packing house is essential for sound financial monitoring of performance. PE system executives need to know how is every packhouse doing, and have the capacity to analize each situation separately, to adopt corrective measure of identify additional investment opportunities or requirements.

b. Prices and Margins

The PE detects market opportunities in The Bahamas or abroad, and estimates mimimum prices to be paid to farmers. These prices would be obtained by estimating mimimum sale prices by the PE, deducting a fixed percentage commission (usually 10 % and no more than 15 % in this line of business), and substracting "mailboat" transport costs (Bh$ 2 per box).

The PE is Nassau communicates minimum price and estimated saleable volumes of each produce item to the packing houses in the Family Islands, which in turn communicate it to farmers.

Once products are actually marketed and sold, and final sale prices are determined, the prices to be paid by the PE to packing houses would have to be calculated. When the sale price is higher than the estimated mimimum, the PE would pay packing houses the corresponding differential. If sale prices were to be lower than the mimimum, the PE wouold absorb the loss, hence the need to carefully estimate mimimum prices.

Packing houses should establish a margin per box to cover their operating costs. Based on current prices charged by private sector packers in Florida, such margin should range between Bh$ 2 and 4 per box. This price, multiplied by the number of boxes processed and shipped, provides the gross income of the packing house, from which operating costs have to be deducted.

I. Market Information Services

Establishment of an agricultural market information service is a necessary element to assure successful project implementation. This service has to provide the folowing types of market news:

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* Acres planted per crop, expected yields and harvesting periods, for each island;

* Demand forecast per month for the coming quarter, for each crop and island, broken down by types of consumers;

* Wholesale and retail prices for each crop per week, at Nassau, Freeport and Miami;

* Volumes marketed in each island during the previous week;

* Volumes expected to arrive to each island in the coming week, either from local sources or from a foreign supplier.

The fact that the above are news imply that they have to be readily available to users, predominantly wholesalers (i.e. the PE), retailers, institutional consumers and farmers. It is recommended that these news be disseminated with daily and weekly frequency, via bulletins and radio. A large board containing relevant price information could also be placed at a visible location in the PE and at the packing houses.

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MARKETING - Technical Assistance and Training

The overall requirements for technical assistance and training in marketing under the project are summarized in Table 3.3 below. As recommended by the project, both the general manager and the plant manager of the Produce Exchange will be expatriate personnel. They will provide training to the two local trainees who will be hired for that purpose by the Exchange and whose salaries are already included in the Exchange's budget. Because of this, such training will have no cost to the project. The costs of the component are the following:

	$	
Technical Assistance		
General Manager of PE (24m/m x $10,000):	240,000	(Local Funds)
Plant Manager of PE (24m/m x $ 8,000):	192,000	(Local Funds)
SUBTOTAL LOCAL FUNDS	432,000	
Other Tech.Assist. ...(43m/m x $ 9,000):	387,000	
Training by Expatriate Experts........(7m/m x $ 9,000):	63,000	
Training by Local Experts.............(21.5m/m x $ 5,000):	107,500	
SUBTOTAL FOREING FUNDS	557,500	
T O T A L	989,500	

Table 3.3 Technical Assistance and Training Requirements (man/months)

AREA	YEARS			
	1		2	
TECHNICAL ASSISTANCE				
GENERAL MANAGEMENT	12		12	
PLANT MANAGEMENT	12		12	
FINANCIAL ANALYSIS	3			
COMPUTER PROG. & OP.	3			
FINANCIAL AUDIT	1			
MAINTENANCE	1			
POST-HARVEST TECHNOLOGY	2			
FOODSTUFFS RETAILING	2			
VOLUNTARY CHAIN ORG.	2			
INFORMATION SYSTEMS	3			
GRADING	2			
EXPORT PROMOTION				
TOTAL TECH. ASSISTANCE	43		24	
TRAINING	FOR	BAH	FOR	BAH
GENERAL MANAGER 1/	6			
PRODUCTION SUPERVISOR 1/	6			
CHIEF ACCOUNTANT		3		3
SALES CHIEF	3		1	
PACKING HOUSE MGRS.		1		1
GRADING PERSONNEL		1		
MAINTENANCE PERSONNEL	1	1		
FORK-LIFT OPERATOR		0.5		
COMPUTER OPERATOR		3		1
INFORMATION COLL.&ANALYSIS	2	3		3
TOTAL TRAINING	6	12.5	1	9

1/ Without cost to the project will be trained by the general manager and the plant manager, respectively.

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'. FINANCIAL ANALYSIS OF INVESTMENT ALTERNATIVES

; a financial analysis of the marketing component of the ASD Project, assuming that **upgrade and expand the existing facility with Layout modifications**, is selected. d by comparing the situation with the project with the present condition without it.

ject

; the financial feasibility of investment option 2, which is recommended in this study.

put

umed to reach the project's facilities are indicated in Table 4.1. During the project's ımed that the packing houses and PE handle approximately 30 per cent of the consumption. Over a four-year period, this volume is estimated to double, reaching : Consequently, when this level of throughput is attained, the project would be ıately 40 per cent of the local produce consumption.

and Working Capital

qual Bh$ 4.496,400, as detailed in Tables 4.2A, 4.2B, 4.2C, and 4.3. The largest y corresponds to investments in the PE at Potter's Cay (Bh$ 2.486.947), followed :isting packing houses (Bh$ 989.387), establishment of new packinghouses in 4 100). A sum of Bh$ 779.212 is for operating capital. The amount required for ıs been set to cover the major operating costs during a two-month period. The rovided with an operating capital fund to make it independent from the national

ɔsts for the project equal Bh$ 5.157.336 in year one, and rise gradually to Bh$), as is shown in Table 4.4. These costs include produce purchasing costs, the estimate purchasing costs, the amount paid to farmers, a price of Bh$ 723 per ed.

nd transportation costs, it is considered that boat operators will gradually provide t services. The asumed rate of adoption is shown in Table 4.1, which affects the or this concept. Rates for refrigerated transport equal Bh$ 2/box of 30 lbs, and efrigerated.

e with staffing recommendations formulated in Chapter III, and include personnel ay, the seven existing packing houses and the four new ones to be established.

ts costs have been estimated at 2% per year for buildings, and 4% for the other existing ones as well as the ones to be constructed or acquired..

efer to cardboard boxes, acquired at an estimated unit price of Bh$ 1, including and fuel to operate the auxiliary generator to be acquired for Potter's Cay, the he fork-lifts.

de electricity, water and communications at Potter's Cay and at the packing

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Spoilage and pilferage costs have been eliminated, assuming that they will have to be the responsibility of the farmers, the system's personnel, or the boat operators, but not the PE nor ther packing houses. This is a critical element to assure the financial viability of the project.

Costs for transporting produce from the packing houses to ports in the islands correspond to actual levels.

4. **Annual Revenues**

Project revenues are of two types: grading and packing charges by the Packing Houses, and brokerage fees by the Produce Exchange, as presented in Table 4.6A. The former have been set at Bh$ 4 per box of produce graded and boxed, and the second at 15 per cent of product price at the PE. These figures correspond to produce industry patterns.

The PE commission should be calculated over the sale price received for the product. This commission is net after produce purchasing, transport, grading and boxing, and product handling costs have been paid. For this analysis, the commission has been estimated up from the price paid to the farmer. In practice, this commission is deducted from the price of sale to retailers.

Table 4.6B presents a practical pricing exercise, according to the procedure indicated in this analysis. For the three commodities analyzed, prices that would be obtained by the farmer are higher than those actually paid in the month of the study.

5. **Debt Service**

As presented in Table 4.6, two loans have been considered to fund the project, one of Bh$ 4.470.434 for investment capital, and one for Bh$ 779.212 for operating capital. In both cases, a 15-year term for repayment, a 5-year grace period, and a 12 per cent annual rate of interest have been assumed.

6. **Net Benefit Before Financing** - The stream of net benefit before financing represents the return to all resources engaged in the operation of the marketing system, without any consideration of financing. The Financial Internal Rate of Return (FIRR) is calculated for the 'with project' situation and is equal to 13%. The Net Present Value (12%) is equal to $373,600. The calculation of the FIRR and NPV for the incremental net benefit would have to take into account the situation 'without project', which represents an annual loss of about $2.5 million. Such amount would have to be added to the stream of benefits 'with project', making both the rate of return and the net present value extremely high (in fact, they would be equal to 103.3% and $19,406,400, respectively). The exercise, therefore, would be ludicrous if it did not provide a strong argument in favour of the financial and economic worth of the project.

7. **Financing** - A loan for a total value of $5,280,000 will be provided in order to cover investment costs ($4,496,400) and incremental operating costs of $780,000. The latter will cover operating expenditures for two months. The loan will be provided for a period of 15 years, with a 5-year grace period. The annual interest rate is 12%.

8. **Net Benefit After Financing** - The stream of net benefit after financing represents the return to the resources engaged by the Marketing System (Produce Exchange) in the subproject, or the amount of money the system is going to receive per year for participating in the project. Again, for the same reasons mentioned above, the exercise is conducted only for the 'with project' situation, without taking into account an incremental flow of benefits. The FIRR is 19% and the NPV(12%) is equal to $386,600.

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C. Situation Without the Project

The above analysis does not take into consideration the resources that are being presently lost as a result of inadequate physical infrastructure, and absence of the conceptual and operating system proposed in this document. These losses are substantial, being estimated that the existing system is losing **Bh$ 2.518.961** per year. This is supported by the financial analysis presented in Tables 4.1, 4.2, and 4.3 in Annex A. This analysis has been undertaken on the assumption that conditions observed during the last three years, and reported in this study, will remain unchanged. Losses are high not only because the system experiences sizable spoilage and pilferage losses, but also because its revenues are not sufficient to cover the value of the fresh products paid to farmers. Consequently, all operating costs, including salaries, packing materials, transportation, storage and handling are all net losses.

D. Conclusion and Recommendation

Project implementation is feasible and advisable. It not only offers attractive financial returns, but permits to eliminate the large losses being absorved by the government to operate the system.

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VI ANNEXES

Annex A. Supporting Tables

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ANNEX A. SUPPORTING TABLES
TABLE 2.2A. CHARACTERISTICS OF "MAILBOATS" TRANSPORTING PRODUCE

NAME OF BOAT	CARGO CAPACITY (TONS)	REFRIG. CAPACITY (MT) (3)	ISLAND SERVED	FREQUENCY
CURRENT PRIDE	88	7.2	N ELEUTHERA	1/WK(T)
HARLEY & CHARLEY	91	6.0	C ELEUTHERA	2/WK(F)
DAYBREAK III (1)		12.0	N/S ELEUTHERA	2/WK(SW)
CAPTAIN MOXEY II	132		S ANDROS	1/WK(W)
LISA J (1)		2.4	N ANDROS	1/WK (T)
LADY CALVISSE			N ANDROS	SEASONAL
LADY MARGO		2.4	N ANDROS	1/WK(F)
CENTRAL ANDROS EXPRESS	62		C ANDROS	1/WK(T)
GLORIA	94		S ANDROS	1/WK(F)
SEA HAULER (1)		2.4	S CAT ISLAND	1/WK(T)
CAT IS. SPECIAL (2)	98	2.4	N CAT ISLAND	1/WK(TH)
MAY DEAN (2)	146		N LONG IS.	1/WK(TH)
GRAND MASTER (1)	214	9.0	EXUMA	1/WK(F)
DEBORAH "K"	204	3.6	C/N ABACO	1/WK(T)
CHAMPION II	90		S ABACO	SEASONAL
MARCELLA III (1)	350	5.4	G. BAHAMA	1/WK
BIMINI MACK	247		BIMINI	1/WK(S)
WINDWARD EXPRESS	95		ACKLINS, CROKED IS., LONG CAY	
LADY MAGIC				SEASONAL

NOTES: (1) Indicates that boat has a crane, and (2) a lift. Letters in parenthesis in frequency column refer to day of arrival to potter's cay dock.
(3) See table 2.2B for estimation procedure

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TABLE 2.2B
ESTIMATED "MAILBOAT" REFRIGERATION CAPACITIES

ME OF BOAT	CHAMBER DIMENSIONS	CUBIC FT.	MT
RENT PRIDE	22' X 16' X 5'	1.760	7.2
LEY & CHARLEY	8' X 24' X 5'	960	6.0
'BREAK III	20' X 25' X 6'	3.000	12.0
A J	10' X 10' X 8'	800	2.4
ORAH "K"	12' X 10' X 6'	720	3.6
HAULER	10' X 10' X 8'	800	2.4
CELLA III	15' X 15' X 8'	1.800	5.4
IS. SPECIAL	8' X 12' X 5'	480	2.4
ND MASTER	14' X 24' X 8'	2.688	9.0
DEAN	12' X 12' X 6'	864	5.4

TABLE 2.2C.
ARACTERISTICS OF "MAIL BOATS" TRANSPORTING PRODUCE TO THE PE

OF T	ISLAND SERVED	TRAVEL TIME (HOURS)	DEPARTURE DAY/TIME	ARRIVAL DAY/TIME
PRIDE	N ELEUTHERA	5 1/2	TH,06:00	M,17:00
CHARLEY	C ELEUTHERA	5 1/4	M, 19:00	T,19:00
III	N/S ELEUTHERA	8		S,
MOXEY II	S ANDROS	5 1/2	M, 11:00	W,20:00
	N ANDROS	5 1/2	W, 18:00	T,13:00
VISSE	N ANDROS	5 1/2	--------	-------
GO	N ANDROS	5 1/2		
ANDROS				
S	C ANDROS	6		
	S ANDROS	5		
R	S CAT ISLAND	16		T
SPECIAL	N CAT ISLAND	14		TH
	N LONG ISLAND	15	M,	TH,20:00
	S LONG ISLAND	23		
TER	EXUMA	15	T,14:00	F, 20:00
K"	C/N ABACO	6		T,
II	S ABACO		TH,06:00	S, 11:00
III	G BAHAMA	12	W,16:00	B, 22:30
CK	BIMINI	16		
EXPRESS	ACKLINS, CR.	23	M, 14:00	TH,
C			--------	--------
CEPHAS	RUGGED ISLAND	21		

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TABLE 2.4A
PE: EXISTING PERSONNEL - POTTER'S CAY

NAME	POSITION	AGE	SENIORITY	ANNUAL
TYRONE NORTH	GENERAL MANAGER	38	1975	21.600
EARL BASTIAN	ASSIST. MANAGER	35	1986	18.000
JOHN FERGUSON	SR. ATTENDANT	38	1972	15.600
ANNIE WARD	SR. CLERK	44	1975	15.600
MERLENE DEAN	SR. ATTENDANT	63	1969	14.400
DEBBIE EVANS	SR. ATTENDANT	37	1974	14.400
MAVIS JOHNSON	SR. ATTENDANT	47		14.400
CIEVA SWEETING	SR. ATTENDANT	42	1973	14.400
NAGEL SMITH	DRIVER	47	1968	14.400
ESTHER THOMPSON	SECRETARY	36		14.400
CARMITA CASH	ATTENDANT	36	1977	9.600
GEORGE MACKEY	ATTENDANT	48		9.600
ERIC MAJOR	ATTENDANT	65	1980	9.600
ELSWORTH MUNNINGS	ATTENDANT	60	1979	9.600
PATRICIA PATTON	ACCOUNTANT	28		9.600
INEZ TAYLOR	ATTENDANT	56		9.600
GLORIA WILLIAMS	ATTENDANT	56	1973	9.600
VAN DYKE BUTLER	ATTENDANT	27	1982	8.400
CHRIS CARTWRIGHT	ATTENDANT	25	1981	8.400
KEITH MAYCOCK	ATTENDANT	27	1981	8.400
JERRY STRACHAN	LAB. TECHNICIAN	33		8.400
BETTY CHARLTON	ATTENDANT	44	1979	7.200
EDDIE THURSTON	ATTENDANT	32	1979	7.200
ARTHUR ARMBRISTER	CASUAL LABORER	33	1989	6.755
VERNITA BAIN	CASUAL LABORER	22	1988	6.755
SHANE DEVEAUX	CASUAL LABORER	21	1988	6.755
ROSETTA DUNCOMBE	CASUAL LABORER	23	1988	6.755
EMILY FERGUSON	CASUAL LABORER	42	1987	6.755
ARTHUR HIGGS	CASUAL LABORER	37	1988	6.755
MARIA JOHNSON	CASUAL LABORER	23	1987	6.755
CORNELIUS MACKEY	CASUAL LABORER	26	1988	6.755
ISMAEL NEWBOLD	CASUAL LABORER	28	1987	6.755
ARABELLA ROLLE	CASUAL LABORER	24	1987	6.755
LUCINE ROLLE	CASUAL LABORER	26	1987	6.755
TREVOR SMITH	CASUAL LABORER	19	1989	6.755
VIENA THOMPSON	CASUAL LABORER	43	1987	6.755
TOTAL				360.215

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TABLE 2.4B

PE: EXISTING PERSONNEL - KEMP ROAD AND JUMBEY VILLAGE

	POSITION	SENIORITY	SALARY (BH$)	ANNUAL (BH$)
:HER	GENERAL MANAGER	1970	1.300/MO	15.600
:NEIL	SR. ATTENDANT	1970	1.200/MO	14.400
'ERGUSON	SR. ATTENDANT	1975	1.200/MO	14.400
ITH	CASUAL LABORER	1987	130/WK	6.754
LIE	CASUAL LABORER	1987	130/WK	6.754
L				57.908
LAGE				
NA	ATTENDANT			10.800
SON	ATTENDANT			9.400
UNDERS	ATTENDANT			10.650
IN	ATTENDANT			11.072
OOPER	ATTENDANT			12.100
AJOR	ATTENDANT			12.400
				66.422
				124.330

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TABLE 2.8.
QUARTERLY KUANTITIES AND VALUES OF PRODUCE PURCHASED
BY FIELD PACKING HOUSES - 1989

	I QTR.		II. QTR.		III QTR.		IV QTR.	
	QTTY.	VALUE	QTTY.	VALUE	QTTY.	VALUE	QTTY.	VALUE
NORTH ANDROS								
FRUITS	12	6	20	13	76	44	30	14
VEGETAB.	17	16	8	10	15	19	11	11
FIELD CR.	32	24	30	25	91	64	43	26
SUB-TOTAL	61	46	58	48	182	127	84	51
LONG ISLAND								
FRUITS	47	20	144	85	141	63	154	53
VEGETABLES	6	4	3	4	0.2	0.6	4	4
FIELD CR.	60	28	152	94	142	65	159	59
SUB-TOTAL	113	52	299	183	283	128	317	117
ELEUTHERA								
FRUITS	362	203	238	138	267	136	245	185
VEGETAB.	29	21	71	67	13	20	59	50
FIELD CR.	404	231	318	213	284	158	316	241
SUB-TOTAL	795	455	627	418	564	314	620	446
EXUMA								
FRUITS	4	2	10	4	38	11	18	3
VEGETAB.	27	15	60	71	29	18	6	6
FIELD CR.	32	17	70	76	68	30	25	9
SUB-TOTAL	63	34	140	151	135	59	49	18
CAT ISLAND								
FRUITS	12	2	6	11	4	2	28	2
VEGETAB.	108	51	2	6	0.4	1	2	11
FIELD CR.	119	58	19	31	6	4	31	15
SUB-TOTAL	239	111	27	48	10	7	61	28
TOTAL	1.271	698	1.151	848	1.174	635	1.131	660

SOURCE: DEPARTMENT OF AGRICULTURE, 1989 AGRICULTURE SECTOR REPORT.

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TABLE 2.11.
SPOILAGE AND CHARITY DONATIONS (FIRST QUARTER 1990)
(BhS)

:RIOD	SPOILAGE	DONATIONS	TOTAL
ARY			
· 10TH	12.488	853	13.341
- 17TH	8.711	1.611	10.322
- 24TH	16.234	1.506	17.740
- 31ST	9.357	1.258	10.615
: - TOTAL	46.790	5.228	51.018
JARY			
· 7TH	12.055	2.782	14.837
· 14TH	3.260	1.070	4.330
- 21ST	932	1.688	2.620
- 28TH	1.127	2.486	3.613
- TOTAL	17.374	8.026	25.400
H			
- 7TH	19.240	1.795	21.035
- 14TH	1.322	24.340	25.662
- 21ST	1.138	11.292	12.430
- 28TH	4.972	1.311	6.283
B - TOTAL	26.672	38.738	65.410
TAL	90.836	51.992	142.828

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TABLE 2.9.
VALUE OF PRODUCE PURCHASED BY FIELD PACKING HOUSES IN ANDROS AND ELEUTHERA (1ST. QUARTER 1990)

	JANUARY	FEBRUARY	MARCH	TOTAL
NORTH ANDROS				
FRUITS	12.065	3.644	-------	15.709
VEGETAB.	199.464	182.325	190.039	571.828
FIELD CR.	5.795	2.085	509	8.389
SUB-TOTAL	217.324	188.054	190.548	595.926
HATCHET BAY - ELEUTHERA				
FRUITS	11.171	13.957	13.637	38.765
VEGETAB.	2.165	4.566	1.692	8.423
FIELD CR.	474	79	14	567
SUB-TOTAL	13.810	18.602	15.343	47.755
GREEN CASTLE - ELEUTHERA				
FRUITS	6.059	1.920	1.147	9.126
VEGETAB.	10.051	1.479	3.961	15.491
FIELD CR.	1.543	1.635	2.312	5.490
SUB-TOTAL	17.653	5.034	7.420	30.107
NORTH ELEUTHERA				
FRUITS	79.926	33.090	15.217	128.233
VEGETAB.	29.317	5.508	1.608	36.433
FIELD CR.	14	6	37	57
SUB-TOTAL	109.257	38.604	16.862	164.723
TOTAL	358.044	250.294	230.173	838.511

SOURCE: PRODUCE EXCHANGE

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Table 4.1
Situation with the Project - Estimated Produce Throughput (Bh$)
ALTERNATIVE 2: Refurbish and Expand Existing Facility

CONCEPT	1	2	3	4	5	6	7	8	9	10
LOCAL PRODUCE OUTPUT (MT) a/	12000	13440	15000	16500	17800	18900	19700	19700	19700	19700
PRODUCE VOLUME (MT)	4000	6000	6000	8000	8000	8000	8000	8000	8000	8000
I-I TRANSPORT										
Refrigerated b/	75%	85%	90%	100%	100%	100%	100%	100%	100%	100%
Non-refrigerated c/	25%	15%	10%	0%	0%	0%	0%	0%	0%	0%

Notes: a/ Taken from Table I-A, Annex 1
b/ Refrigerated transport (Bh$/box): 2
c/ Non-refrigerated transport (Bh$/b 1

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Table 4.2A
Situation with the Project: PE Investment Costs (Bh$)
ALTERNATIVE 2: Refurbish and Expand Existing Facility

PHYSICAL FACILITIES		1650000
Physical Infrastructure (PE)	1500000	
Final Design	150000	
REFRIGERATION FAC.		250000
Refrigerated Chambers (PE)	250000	
EQUIPMENT		416947
Computer system	40000	
Electrical generator	60000	
Metalic racks	30000	
Ripening Room	35000	
Grading/sorting machinery	251947	
VEHICLES		170000
Refrigerated vehicles	100000	
Two fork-lifts	70000	
TOTAL		2486947

Table 4.2C
Situation with the Proyect - Investment Cost Summary (Bh$)
ALTERNATIVE 2: Refurbish and Expand Existing Facility

CONCEPT	AMOUNT
PRODUCE EXCHANGE (Table 4.5A)	2486947
PACKING HOUSES (Table 4.5B)	2009487
TOTAL	4496434

Table 4.2B
Situation with the Project: Packhouse Investment Costs (Bh$)
ALTERNATIVE 2: Refurbish and Expand Existing Facility

1. RENOVATION/EXPANSION EXISTING FACILITIES			989387
a. CONSTRUCTIONS		280995	
Process. Areas (1000 ft2*2*$30/ft2)	60000		
Input storage (900ft2*4*$30/ft2)	108000		
Input storage (225ft2*3*$30/ft2)	20250		
T.E. & Credit off.(240ft2*7*$40/ft2)	67200		
Final Design	25545		
b. EQUIPMENT		638392	
Two new grading/sorting machinery	503892		
Repair five grading/sorting mach.	75000		
Box staplers	3500		
Scales	7000		
Office equipment	35000		
Hand pallets	14000		
c. REFRIGERATION		70000	
Repair chambers and equipment	70000		
2. ESTABLISHMENT NEW FACILITIES			
a. CONSTRUCTION		386100	1,020
Process. Areas (2380ft2*4*$30/ft2)	285600		
Input storage (225ft2*4*$30/ft2)	27000		
T.E. & Credit off.(240ft2*4*$40/ft2)	38400		
Final Design	35100		
b. EQUIPMENT		514,000	
Grading/sorting machinery	480000		
Hand pallets	8000		
Scales	4000		
Box staplers	2000		
Office equipment	20000		
c. REFRIGERATION		120000	
Chambers plus accesories	120000		
TOTAL			2,00

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Table 4.[illegible]
Situation with the Proyect - Operating Capital (Bh$)
ALTERNATIVE 2: Refurbish and Expand Existing Facility

CONCEPT	AMOUNT
PRODUCE PURCHASES	2892000
LABOR EXPENDITURES	793008
I-I TRANSPORTATION	513333
PRODUCTION MATERIALS	422933
UTILITIES	54000
TOTAL PER YEAR	4675275
TOTAL FOR TWO MONTHS	779212

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Table 4.4
Situation with the Proyect - Operating Costs (Bh$)
ALTERNATIVE 2: Refurbish and Expand Existing Facility

CONCEPT		1	2	3	4	5	6	7	8	9	10
COST OF SALES											
Purchasing Costs		2892000	4338000	4338000	5784000	5784000	5784000	5784000	5784000	5784000	5784000
INTER-IS.TRPTN. COSTS											
Refrigerated		440000	748000	792000	1173333	1173333	1173333	1173333	1173333	1173333	1173333
Non-refrigerated		73333	66000	44000	0	0	0	0	0	0	0
Sub-total	42778	513333	814000	836000	1173333	1173333	1173333	1173333	1173333	1173333	1173333
SALARIES											
Potter's Cay	21236	254832	254832	254832	254832	254832	254832	254832	254832	254832	254832
Existing Packing Houses											
Large (2)	12036	144432	144432	144432	144432	144432	144432	144432	144432	144432	144432
Medium (2)	9740	116880	116880	116880	116880	116880	116880	116880	116880	116880	116880
Low (3)	9888	118656	118656	118656	118656	118656	118656	118656	118656	118656	118656
New Packing Houses											
Low (4)	13184	158208	158208	158208	158208	158208	158208	158208	158208	158208	158208
Sub-total	66084	793008	793008	793008	793008	793008	793008	793008	793008	793008	793008
MAINTENANCE AND PARTS											
Buildings	4544	49660	49660	49660	49660	49660	49660	49660	49660	49660	49660
Refrigeration	2023	21880	21880	21880	21880	21880	21880	21880	21880	21880	21880
Equipment & Vehicles	1656	64934	64934	64934	64934	64934	64934	64934	64934	64934	64934
Sub-total	8224	136473	136473	136473	136473	136473	136473	136473	136473	136473	136473
PRODUCTION MATERIALS											
Cardboard Boxes		293333	0	0	0	0	0	0	0	0	0
Fuel	10800	129600	129600	129600	129600	129600	129600	129600	129600	129600	129600
Sub-total	10800	422933	129600	129600	129600	129600	129600	129600	129600	129600	129600
UTILITIES											
Electricity	3000	36000	36000	36000	36000	36000	36000	36000	36000	36000	36000
Water	1000	12000	12000	12000	12000	12000	12000	12000	12000	12000	12000
Communications	500	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
Sub-total	4500	54000	54000	54000	54000	54000	54000	54000	54000	54000	54000
AUXILIARY SERVICES											
Spoilage Disposal	0	0	0	0	0	0	0	0	0	0	0
Transportation Port-PE	0	0	0	0	0	0	0	0	0	0	0
Transportation PH-Port		100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
Sub-total	0	100000	100000	100000	100000	100000	100000	100000	100000	100000	100000
SUB-TOTAL	132385	4911748	6365081	6387081	8170415	8170415	8170415	8170415	8170415	8170415	8170415
Misc. e Imprev.(5%)		245587	318254	319354	408521	408521	408521	408521	408521	408521	408521
TOTALS		5157336	6683336	6706436	8578936	8578936	8578936	8578936	8578936	8578936	8578936

Note: Produce Purchasing Price (Bh$): 723

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Table 4.5A
Situation with the Project - Annual Revenues (Bh$)
ALTERNATIVE 2: Refurbish and Expand Existing Facility

CONCEPT	1	2	3	4	5	6	7	8	9	10
Grading and Packing	770000	1155000	1155000	1540000	1540000	1540000	1540000	1540000	1540000	1540000
Brokerage Fees	5036533	7603200	7627400	10234400	10234400	10234400	10234400	10234400	10234400	10234400
TOTALS	5806533	8758200	8782400	11774400	11774400	11774400	11774400	11774400	11774400	11774400

Packing charges (Bh$/box): 3.50
Brokerage Fees: 0.10

Table 4.5B
Price and Margin Analysis - Selected Products
ALTERNATIVE 2: Refurbish and Expand Existing Facility

CONCEPT	TOMATOES	POTATOES	CABBAGE
Retail Price a/	1.85	0.70	0.79
Retail margin b/	0.65	0.25	0.28
Price to retailer	1.20	0.46	0.51
PE Broker Fees c/	0.12	0.05	0.05
Price CIF Nassau	1.08	0.41	0.46
I-I Transport	0.03	0.03	0.03
Packing Cost d/	0.12	0.12	0.12
Producer Price	0.93	0.26	0.31
% of retail price	0.50	0.37	0.40
Ave. PE Price e/	0.28	0.24	0.20

Notes: a/ City Market prices (Sept 5.90)
b/ Retailer margin: 35%
c/ PE broker fee: 10%
d/ Packing cost per box: Bh$ 3.5
e/ Taken from Dept. of Ag., 1989 Ag. Sector Report

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Table 4.6
Situation with the Project - Debt Service (Bh$)
ALTERNATIVE 2: Refurbish and Expand Existing Facility

CONCEPT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
INVESTMENT															
Inicial Balance	4470434	4470434	4470434	4470434	4470434	4470434	4023390	3576347	3129304	2682260	2235217	1788174	1341130	894087	447043
Interest costs	536452	536452	536452	536452	536452	536452	482807	429162	375516	321871	268226	214581	160936	107290	53645
Amortization	0	0	0	0	0	447043	447043	447043	447043	447043	447043	447043	447043	447043	447043
Total payment	536452	536452	536452	536452	536452	983495	929850	876205	822560	768914	715269	661624	607979	554334	500689
Outstanding balance	4470434	4470434	4470434	4470434	4470434	4023390	3576347	3129304	2682260	2235217	1788174	1341130	894087	447043	[illegible]
OPERATING CAPITAL															
Inicial Balance	779212	779212	779212	779212	779212	779212	701291	623370	545449	467527	389606	311685	233764	155842	77921
Interest costs	93505	93505	93505	93505	93505	93505	84155	74804	65454	56103	46753	37402	28052	18701	9351
Amortization	0	0	0	0	0	77921	77921	77921	77921	77921	77921	77921	77921	77921	77921
Total payment	93505	93505	93505	93505	93505	171427	162076	152726	143375	134025	124674	115323	105973	96622	87272
Outstanding balance	779212	779212	779212	779212	779212	701291	623370	545449	467527	389606	311685	233764	155842	77921	0
TOTAL PAYMENT	629958	629958	629958	629958	629958	1154922	1091926	1028931	965935	902939	839943	776948	713952	650956	587960

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TABLE 48 - MARKETING SUBPROJECT: BUDGET OF THE MARKETING SYSTEM ($'000)

	WITHOUT PROJECT 1/	YEARS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17-20
INFLOWS																		
BASIC VALUE OF PROD. 2/	2,250.0	3,505.3	5,252.0	5,274.0	7,067.3	7,067.3	7,067.3	7,067.3	7,067.3	7,067.3	7,067.3	7,067.3	7,067.3	7,067.3	7,067.3	7,067.3	7,067.3	7,067.3
GRADING + PACKING 3/		770.0	1,155.0	1,155.0	1,540.0	1,540.0	1,540.0	1,540.0	1,540.0	1,540.0	1,540.0	1,540.0	1,540.0	1,540.0	1,540.0	1,540.0	1,540.0	1,540.0
BROKERAGE FEES (16%) 4/		525.8	787.9	791.1	1,048.6	1,048.6	1,048.6	1,048.6	1,048.6	1,048.6	1,048.6	1,048.6	1,048.6	1,048.6	1,048.6	1,048.6	1,048.6	1,048.6
TOTAL INFLOWS	2,250.0	4,801.1	7,194.9	7,220.1	9,655.9	9,655.9	9,655.9	9,655.9	9,655.9	9,655.9	9,655.9	9,655.9	9,655.9	9,655.9	9,655.9	9,655.9	9,655.9	9,655.9
OUTFLOWS																		
INVESTMENT																		
PRODUCE EXCHANGE		2,486.0					170.0				} 2,153.3	170.0						
EXIST.PACK.HOUSES		989.4																
NEW PACK.HOUSES		1,020.1																
TOTAL INVESTMENT 5/		4,496.4					170.0				2,153.3	170.0						
INCREM. WORK. CAP. 6/		780.0																
OPER. EXPEDITURES																		
PRODUCE PURCHASE 7/	2,060.0	2,892.0	4,330.0	4,330.0	5,784.0	5,784.0	5,784.0	5,784.0	5,784.0	5,784.0	5,784.0	5,784.0	5,784.0	5,784.0	5,784.0	5,784.0	5,784.0	5,784.0
INTER-IS. TRANSP.	242.0	513.3	814.0	836.0	1,173.3	1,173.3	1,173.3	1,173.3	1,173.3	1,173.3	1,173.3	1,173.3	1,173.3	1,173.3	1,173.3	1,173.3	1,173.3	1,173.3
SALARIES	1,906.0	793.0	793.0	793.0	793.0	793.0	793.0	793.0	793.0	793.0	793.0	793.0	793.0	793.0	793.0	793.0	793.0	793.0
MAINT. + PARTS	30.0	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5	136.5
INPUTS + FUEL 8/	192.0	422.9	129.6	129.6	129.6	129.6	129.6	129.6	129.6	129.6	129.6	129.6	129.6	129.6	129.6	129.6	129.6	129.6
UTILITIES	51.6	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0
AUX. SERVICES	88.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
SUBTOTAL	4,569.6	4,911.7	6,366.1	6,387.1	8,170.4	8,170.4	8,170.4	8,170.4	8,170.4	8,170.4	8,170.4	8,170.4	8,170.4	8,170.4	8,170.4	8,170.4	8,170.4	8,170.4
MISCELL. (5%)	228.5	245.6	318.3	319.4	408.5	408.5	408.5	408.5	408.5	408.5	408.5	408.5	408.5	408.5	408.5	408.5	408.5	408.5
TOTAL OPER.EXP.	4,798.1	5,157.3	6,683.4	6,706.5	8,578.9	8,578.9	8,578.9	8,578.9	8,578.9	8,578.9	8,578.9	8,578.9	8,578.9	8,578.9	8,578.9	8,578.9	8,578.9	8,578.9
TOTAL OUTFLOW	4,798.1	10,433.7	6,683.4	6,706.5	8,578.9	8,578.9	8,748.9	8,578.9	8,578.9	8,578.9	10,732.2	8,748.9	8,578.9	8,578.9	8,578.9	8,578.9	8,578.9	8,578.9
NET BENEFIT BEFORE FINANCING																		
TOTAL 9/	(2,548.1)	(5,632.6)	511.4	513.6	1,077.0	1,077.0	907.0	1,077.0	1,077.0	1,077.0	(1,076.3)	907.0	1,077.0	1,077.0	1,077.0	1,077.0	1,077.0	1,077.0
FINANCING																		
LOAN RECEIPTS 10/		5,280.0																
INTEREST 12%			633.6	633.6	633.6	633.6	633.6	633.6	570.2	506.9	443.5	380.2	316.8	253.4	190.1	126.7	63.4	
PRINCIPAL								528.0	528.0	528.0	528.0	528.0	528.0	528.0	528.0	528.0	528.0	
NET FINANCING		5,280.0	(633.6)	(633.6)	(633.6)	(633.6)	(633.6)	(1,161.6)	(1,098.2)	(1,034.9)	(971.5)	(908.2)	(844.8)	(781.4)	(718.1)	(654.7)	(591.4)	
NET BENEFIT AFTER FINANCING																		
TOTAL 11/		(352.6)	(122.2)	(120.0)	443.4	443.4	273.4	(84.6)	(21.2)	42.1	(2,047.8)	(1.2)	232.2	295.6	422.3	422.3	485.6	1,077.0

Table 4.8 - MARKETING SUBPROJECT: BUDGET OF THE MARKETING SYSTEM

N O T E S

1. Situation Without Project - In this column, the figures for 'Basic Value of Produce at PE' and 'Produce Purchase' represent a four-year average, from 1986-89. This was done to minimize some strong variations in these two items observed in the last two years. All other cost figures are updated information on costs incurred by the system.

2. Basic Value of Produce at the Produce Exchange - In the situation 'without project', this represents the actual volume of sales of the Exchange (average of four years, 1986-89). In the situation 'with project', this represents the cost of purchasing the produce from the farmer, plus inter-island transportation (by boat), and plus auxiliary services (transportation of produce from Packing House to boat and from boat to the Exchange).

3. Grading and Packing - The Packing Houses will charge $4 per box of produce graded and boxed.

4. Brokerage Fees - The Produce Exchange will charge a brokerage fee of 15% over the product 'price' (basic value of produce at PE). Both the brokerage fees and the grading and packing fees correspond to produce industry patterns. For this analysis, the comission was estimated up from the price paid to farmers; in practice, it is deducted from price of sale to retailers.

5. Total Investment - Investments in Years 6 and 11 represent replacement of vehicles. Investment in Year 10 translates the replacement of cold storage chambers at the PE and Packing Houses.

6. Incremental Working Capital - The figure of $780,000 represents two months of operations in the 'with project' situation, according to Table 4.3.

7. Produce Purchase - It is assumed that in Year 1 the volume of produce purchased would remain basicaly the same as in the situation without project. The figure is the result of multiplying 4,000 tons by $723, the basic value of one ton of produce.

8. Inputs and Fuel - The figure falls from Year 1 to Year 2 because, starting in Year 2, the cost of the boxes provided by the system will be included in the grading and packing fees charged to farmers (the system will charge $4/box, and a box costs approximately $1).

9. Net Benefit Before Financing - The stream of net benefit before financing represents the return to all resources engaged in the operation of the marketing system,-without any consideration of

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financing. The Financial Internal Rate of Return (FIRR) is calculated for the 'with project' situation and is equal to 13%. The Net Present Value (12%) is equal to $373,600. The calculation of the FIRR and NPV for the incremental net benefit would have to take into account the situation 'without project', which represents an annual loss of about $2.5 million. Such amount would have to be added to the stream of benefits 'with project', making both the rate of return and the net present value extremely high (in fact, they would be equal to 103.3% and $19,406,400, respectively). The exercise, therefore, would be ludicrous if it did not provide a strong argument in favour of the financial and economic worth of the project.

10. Financing - A loan for a total value of $5,280,000 will be provided in order to cover investment costs ($4,496,400) and incremental operating costs of $780,000. The latter will cover operating expenditures for two months. The loan will be provided for a period of 15 years, with a 5-year grace period. The annual interest rate is 12%.

11. Net Benefit After Financing - The stream of net benefit after financing represents the return to the resources engaged by the Marketing System (Produce Exchange) in the subproject, or the amount of money the system is going to receive per year for participating in the project. Again, for the same reasons mentioned above, the exercise is conducted only for the 'with project' situation, without taking into account an incremental flow of benefits. The FIRR is 19% and the NPV(12%) is equal to $386,600.

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Table 4.9
Situation without the Proyect
Operating Costs (Bh$)

CONCEPT	MONTHLY	ANNUAL
COST OF SALES	237500	2850000
INTER-IS.TRPTN. COSTS	20219	242623
SALARIES		
Potter's Cay		
Permanent	20600	247200
Casual	7880	94560
Kemp Road Outlet		
Permanent	3700	44400
Casual	1126	13508
Jumbey Village		
Permanent	5535	66422
Packing Houses	53310	639721
Sub-total	92151	1105811
MAINTENANCE AND PARTS		
- Potter's Cay		
Buildings	874	10485
Refrigeration	833	10000
Forklift	83	1000
Vehicles	183	2200
- Packhouses		
Buildings	920	11040
Refrigeration	357	4280
Sub-total	3250	39005
PRODUCTION MATERIALS		
Cardboard Boxes	15553	186633
Fuel	500	6000
Sub-total	16053	192633
UTILITIES		
Electricity	3000	36000
Water	1000	12000
Communications	300	3600
Sub-total	4300	51600
AUXILIARY SERVICES		
Spoilage Disposal	421	5052
Transportation PH-boat	6500	78000
Transportation boat-PE	417	5000
Sub-total	7338	88052
SUB-TOTAL	380811	4569725
Miscelaneous (5%)	19040	228486
TOTALS	399851	4798211

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10
n without the Project
tion Costs (Bh$)

	AMOUNT
s	26906
Chambers	35700
	5000
	11000
S	78606

11
on without the Project
ow (Bh$)

	AMOUNT
ues	
oduce Sales	2250000
s	
erating	4798100
ncial Costs	0
Flow	-2548100

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ANNEX B. NOTES TO ANALYSIS WITHOUT THE PROJECT
(Tables 4.9, 4.10, and 4.11)

1. **Purchasing Costs and Sales Revenues**

Information regarding produce purchasing and sales represents a four - year average, from 1986-89. This was done to minimize some strong variations observed in the last two years.

2. **Inter-island Transportation Costs**

Inter-island transport costs are estimated by assuming that 30 percent of the produce is transported in refrigerated chambers, while the remainder travels on deck or in non-refrigerated compartments. Transport costs equal Bh$ 1 per box with no refrigeration, and Bh$ 2 per box with refrigeration. Considering that the volume transported during the first quarter of 1990 equals 1.018 tons (40%), then a total of 2.545 tons will reach the Produce Exchange during the year. Of this total, 1.781 tons will travel non-refrigerated and 764 tons with refrigeration.

3. **Salary Expenditures**

Annual salary expenditures amount to Bh$ 1.105.811. They represent the largest operating cost cathegory after purchasing costs. Reported figures correspond to figures reported by PE executives and MATI officials and include personnel presently working at the facility in Potter's Cay, the retail outlets at Kemp Road and Jumbey Vilage, and the associated seven packing houses in the Family Islands, as detailed in Tables 2.4a, 2.4b, 2.4c, and 2.4d.

4. **Asset Values and Maintenance and Depreciation Costs**

To estimate maintenance and depreciation costs, the existing building structure at Potter's Cay has been valued at Bh$ 524.250 (17.475 ft2 x Bh$ 30/ft2). The value of refrigeration facilities is estimated to equal Bh$ 250.000 (5.000 ft2 x Bh$ 50/ft2). It is assumed that no investment is made to refurbish these facilities. The vales of the forklift, the truck and the van used by the PE are equal to Bh$ 25.000, Bh$ 40.000, and Bh$ 15.000, respectively.

The value of the seven packing houses in the Family Islands has been estimated at Bh$ 552.000 (18.400 ft2 x Bh$30/ft2). The value of cold storage facilities in these packhouses has been set equal to Bh$ 107.000 (2.140 ft2 x Bh$ 50/ft2).

Annual maintenance costs are assumed to represent 2 per cent of the value of buildings, and 4 per cent for refrigeration facilities, forklift and vehicles.

To estimate depreciation costs, life of the buildings has been set at 40 years, while the life of all other assets is established at 5 years.

6. **Production Material Costs**

Cardboard boxes are the principal production input employed by the PE at Potter's Cay and the packing houses in the islands. Unit costs of boxes are valued at Bh$ 1, with 30-lbs. capacity. The costs of transporting these inputs from Potter's Cay to the packing houses has not been considered.

Fuel consumption costs, associated to operation of the forklift, truck and van, have also been considered.

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7. Public Utility Expenses

Annual public utility expenses for the facility at Potter's Cay have been estimated at Bh$ 30.000 for electricity, Bh$ 12.000 for water and Bh$ 3.600 for communications. Costs for the seven packing houses have been assumed to equal those of the PE at Nassau.

8. Auxiliary and Miscelaneous Expenses

Costs associated to disposal of spoiled products and produce trans-shipment costs from packing houses to boats in the Family Islands and from boats to the Produce Exchange facility at Potter's Cay are considered as auxiliary expenses. All figures used in the analysis corespond to actual expenses reported by system executives for recent months.

Miscelaneous expenses have been set at 5 % of overall operating costs of the PE system.

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Table 2.12
Packing House Disbursements for Truckage (1989 -

SOURCE	TRUCKAGE COSTS
North Andros	
Green Castle	1749
Hatchet Bay	3741
North Eleuthera	46825
Long Island	11430
Cat Island	3570
Exuma	9362
TOTAL	76677

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ANNEX C. Persons Interviewed

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I.P. Minister of Agriculture, Trade and Industry

Financial Secretary

Permanent Secretary, Ministry of Agriculture, Trade and Industry. (MATI)

Acting Director of Agriculture, MATI

Technical Advisor, MATI

Acting Assistant Director of Agriculture, MATI

MATI

Chief Maintenance Officer, MATI

Manager; Kemp Road Retail Outlet, Nassau

ers Senior Administrative Assistant Bahamas Development Bank

Director of Public Works; Ministry of Works and Utilities

Chief Engineer; Ministry of Works and Utilities.

,

Ministry of Works and Utilities Nassau, Bahamas

The Bahamas

, Representative
Deputy Representative
es Sectoral Specialist.

tor Operators

Purchasing Agent, Crystal Palace P.O. Box N-8306, Nassau, Bahamas Tel.(800) 453-5301

President; JAGAR Ltd. Wholesaler's Fresh Produce, P.O. Box N7794, Oakes Field Nassau, Bahamas Tel. (809) 326-0105

on "Lady Margo", Boat, Potter's Cay Port, Nassau, Bahamas

Manager; Harding's Food Store, Wulff Road, Nassau, Bahamas Tel. 393-6423

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"Government of The Bahamas"

Mr. Calvin Balfour	Assistant Secretary, Ministry of Transport Nassau, Bahamas
Mr. Everet Harris	Chief Commissioner, Andros Island, Bahamas

Equipment Suppliers

Mr. Jim Maxwell	Lift Systems, Inc. 3775 NW 81st St. Miami, Florida 33147. Phone No. (305) 693-5322
Mr. Gordon Pinder.	Phil's Refrigeration, Electric Motor & Plumbing Co., Ltd., Nassau - Bahamas, Ph. 393-3763.
Mesrs. Mario Machin and Raul Montes	Ram Freezers and Coolers Mfg., Inc. 1395 E 11th Ave. Miami, Florida 33010, Phone No. (305) 887-1000.
Mesrs. Thomas Gneeda and Brady Pyburn	Executive Vice President Sales Engineer. American Machinery Corporation. 2730 Eunice Ave. Orlando, Florida 32802. Phone No. (407) 295-2581.

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ANNEX D. BUILDING SURVEYOR'S REPORT ON PE FACILITIES AT POTTER'S CAY

SURVEY AT PRODUCE EXCHANGE - NASSAU

DATE OF SURVEY: 30TH. AUGUST, 1990

AGE OF BUILDING: APPROXIMATELY 25 YEARS OLD

DESCRIPTION OF BUILDING

A single storey building of steel frame construction with steel sheeting cladding the walls and roof, on a mass concrete floor, with a mezzanine floor in the south eastern corner housing the office portion of the building.

An extension to the building on the south elevation was cladded with aluminum louvers most of which were missing.

Condenser units are housed on a concrete platform to the north elevation and enclosed by P.V.C coated chain link fencing under a recently constructed lean to roof.

There are loading bays to the east and west elevations under steel framed lean to roofs.

Internally the building is divided as follows:-

Refrigerated store rooms food ripening store rooms, food grading areas, storage racks, public bathrooms on the main ground floor area and offices and ctaff bathrooms on the mezzanine floor.

EXTERNAL

MAIN ROOFS

The main roof is covered with steel sheeting and although the sheeting appeared in good condition, I was informed that the

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roof leaked in numerous areas during heavy rain.

There was evidence of repairs to the top of the roof in the form of mastic or bituminous patching around the tops of screw heads fixing the steel sheets to the roof structure.

No access was available for close examination of the roof sheeting, however, it is suspected that rain is entering the building via screw tops where water tightness is defective, (ie missing or deteriorated washers under screw heads) close examination of the roof sheeting is required and repairs carried out as necessary by specialist steel roofing contractor.

Some Hopper outlets on the north elevation of the main roof did not have any down pipes fitted.

LEAN TO ROOFS OVER LOADING BAYS - EAST AND WEST ELEVATIONS

These roofs are constructed of steel sheeting supported on "Z" section steel beams and circular steel columns. The steel columns appeared to be in satisfactory condition, but the "Z" section beams were severely corroded and in some areas completed deteriorated. The steel sheeting to these roofs leaked in numerous areas. Both lean-to roofs should be renewed completely.

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WALLS NORTH ELEVATION

This wall is of steel frame construction and cladded with steel sheeting supported on a solid concrete base forming the floor and loading bays. The steel cladding to the wall appeared in good condition and was recently painted, except for two or three sheets that showed signs of corrosion at ground floor level.

Windows are of metal frame with metal louvers to the outside face and steel security bars to the inside. The window frames are supported on timber cills, all of these timber cills were severely rotted and needed renewing. The metal windows and louvers were in satisfactory condition, though a few louvers were missing and should be replaced.

WALLS EAST ELEVATION

Windows to this elevation as north elevation but without timber cills.

Metal cladding around main entrance doors were severely dented and should be renewed to improve appearance.

The mass concrete loading bays showed no signs of settlement or other structural defect, but a small portion where the metal angle protecting the top edge of the concrete was missing, and

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the concrete edges in that area was broken and needed making good.

Rubber buffers which is assumed was attached to protruding steel bolts near the top edges of the loading bay were missing. Buffers should be replaced to prevent further damage by motor vehicles in this area.

WALLS SOUTH ELEVATION

Wall and cladding to right side of southern wall were similar in construction and condition as northern wall, including rotten timber cills.

Wall cladding was in satisfactory condition but steel sheets installed to cover unused window openings contained four large holes (approximately 2' x 2') and boarded over with plywood from the inside which is unsatisfactory, because the plywood will rot in the near future. Plywood was also used for covering a disused opening where an air conditioning unit was installed above a disused window.

The corner where the main produce building meet the rear addition was stained with mould growth. It appeared that a rain water downpipe above that corner was leaking and causing the above mentioned stain to the steel sheeting.

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A water storage tank at ground floor level was over flowing and flooding the ground in front of the building. The over flow valve in the tank should be overhauled or renewed.

The left side of the south elevation wall was constructed of aluminium framing and cladded with aluminium louvers. Many of these louvers were missing, they were not screwed or bolted to the frame. They were supported on angle brackets, and therefore easy for vandals to remove.

The edge of the concrete cill supporting the framing to this elevation was cracked and broken exposing the steel reinforcing bars.

WALLS WEST ELEVATION

The masonry wall to the right side of this elevation had many cracks in the plaster and gaps where plaster was missing and needed making good.

The top section of a wall to the right side of the purchasing office appeared to be live and sliding away from the main structure. This section of the wall should be taken down and rebuilt with adequate ties for lateral restraint to the main building.

The steel cladding to the main wall was slightly damaged and dented and could be repaired, but otherwise in satisfactory

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condition.

INTERNAL

INTERNAL DECORATION

Internal decoration was generally in poor condition and should be redecorated throughout.

CEILINGS

The front portion of the building had a suspended ceiling. A few ceiling tiles were missing, but the remaining ceiling tiles were dark and dusty and should all be renewed with tiles to match existing.

The ceilings above the offices in the mezzanine floor were of insulation boading. These ceilings were in satisfactory condition except for a stained ceiling in one of the offices due to the leaking roof above.

The plasterboard ceiling to the purchasing room was warped and falling away from the ceiling joists due to the leaking roof above.

There was no ceiling above the grading area. Cob webs and corroded metal from lattice beams above the grading area could fall onto the floor below. It is advised that a ceiling be installed above this area.

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INSULATION

Insulation over the rear portion of the building was in poor condition. The wrapping around the insulation quilts were torn in numerous areas exposing the fibre glass insulation.

Insulation in this area should be renewed and possibly a false ceiling installed to this area at the rear of the building.

BATHROOMS GROUND FLOOR

The male bathroom was in very poor condition. There was no artificial lighting and no washing facilities. There were two W.C's one of these did not function on the date of the survey.

The ladies bathroom was in similar condition to the gents including a lack of washing facilities.

Walls to the bathrooms were tiled with ceramic wall tiles, many of which were missing and should be replaced.

BATHROOMS MEZZANINE FLOOR

The ladies bathroom contained two W.C's and these were not separated from each other with cubicle partitions, which is most undesirable. The bathroom area is too small to house two bathroom cubicles.

The gents bathroom contained one W.C and a urinal and these were not separated for the same reason as in the ladies bathroom

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EF ROOMS

/ere cooking facilities in staffrooms in the ground ne levels but both were in very poor condition. on the mezzanine floor did not have any openable other means of ventilation.

e enclosed an area to the west elevation. This fence n link and metal poles. The fence was in reasonable xcept the north west corner where three sections of ils were missing and should be renewed to secure the nat area.

get estimate to correct the above mentioned defects 1 the region of $260,000.00.

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THE BAHAMAS

AGRICULTURAL SERVICES DEVELOPMENT PROJECT

(BH-0011)

ANNEX 5

ENVIRONMENTAL ISSUES OF THE BAHAMAS

This report was prepared by Mr. Christopher M.R. Pastakia, assisted by Dr. Maurice Isaacs and Mr. Egbert Wallace (counterparts)

INTER-AMERICAN INSTITUTE FOR COOPERATION ON AGRICULTURE

November, 1989

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COMMONWEALTH OF THE BAHAMAS
MINSTRY OF AGRICULTURE, TRADE AND INDUSTRY

AGRICULTURAL SERVICES DEVELOPMENT PORJECT
ENVIRONMENTAL ASPECTS

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APPENDIX III

CRITERIA FOR PROJECT IMPACT ASSESSMENT

ECONOMIC/ECOLOGICAL MAPS (SEPARATE)

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EXECUTIVE SUMMARY

The present agricultural situation in the Bahamas is one where commercial development is isolated in a few of the nothern islands, with artisanal agriculture in the south-eastern islands. Irrigation is limited to about 7310 acres. There is a relatively low level of agrochemical use in the artisanal sector; and information has not been provided by most commercial farms.

The institutional aspects of environmental management are poor. There are a number of Ministries and Departments associated with various aspects of environment, natural resources and public health. At present there is little coordination between these bodies.

Human resources, both in terms of agricultural workers, andas for the control of environmental and public health matters, are limited. There is a need to consider the manpower required for development (in all sectors), the drift to New Providence and Grand Bahama, and improved training and data collection/analysis for adequate planning and management.

Infrastructure in terms of roads and inter-island transport for produce requires improvement. Concern is expressed at the poor state of the Produce Exchange, Nassau, in respect of public health risks and the large quantities of solid waste produced by the present facility.

The project seeks to consider an improvement in commercial and artisanal agriculture by the introduction of irrigation: total irrigation the northern islands of Andros, Grand Bahama, Abaco and Eleuthra; whilst the remaining islands would benefit by partial irrigation to supplement a present rain-fed situation. Improvement in agrochemical use and extension services, infrastructure, together with appropriate credit facilities would encourage the growth of the agricultural sector.

The environmental impact of these proposals relate, in the main, to the considerable expansion of agricultural land under irrigation. The irrigation project design considers some 50,962 acres capable of irrigated agricultural development. Such an expansion will bring with it considerable land clearance and preparation; road construction; and upgrading of infrastructure and marketing facilities; increase in agrochemical use; and conflict with other land uses and natural resource development.

To mitigate against the more serious impacts of these proposals, the environmental assessment of the project proposes a number of actions that both reduce the negative impacts and allow for a practical and realistic agricultural development project.

The area expansion for irrigation has been reduced. This reduction takes account of the use of some areas for alternative production, especially for forestry. Further reductions have been made to

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remove agricultural development from over those areas which overlie water reserves and wellfields. Some areas have been removed to allow for conservation areas for flora and fauna to be protected.

Further reductions in area expansion have been made by consideration of only those acreages that are presently under government control. Private lands are uncontrolled in terms of land use, and it is considered that the project should reflect investment into those areas which are under government control, with credit and extension available to the private sector (should it be required).

Such reductions have brought the overall project area under irrigated development to a total (full and partial irrigation) of 27,881 acres. A further 3,637 acres of private land are identified as being potentially available for such agricultural development. Grand Bahama, New providence and Long Island have been removed from the project area, as none contain suitable Crown Lands.

To further improve the development prospects, it is proposed that the project bee considered in three phases. These can be summarized as follows:

	Crown Lands	Private Lands
PHASE 1 (0 - 5 years)	7022 acres	---
PHASE 2 (5 - 10 years)	10430 acres	1819 acres
PHASE 3 (10 - 20 years)	10429 acres	1818 acres

This phased development will allow a mix of commercial and artisanal development, whilst at the same time allowing the improvement of the extension, institutional, legal, and infrastructural aspects of the project.

The impact of agrochemicals is hard to determine, given the lack of data on existing resource reserves, and the proposals for future agricultural use. At present few pesticides are used in the Family Islands, and any increase in their use must place some hazard on the aquifers in these islands. These aquifers are used for local family and community water supplies; and such multiple use brings a risk that it is prudent not to dismiss. There is a further potential risk in the long term accumulation of fertilizer and pesticide residues in the soils and aquifers under intensive irrigated agriculture. It is recommended that a pesticide control law and regulations be rapidly developed and enacted. To improve the extension services and to provide a greater measure of control of agrochemical use and pest control, it is recommended that extension officers be allowed training as Public Health Inspectors. Improvement in the Public Analyst's service will be needed if agrochemical residues are to be a component part of future environment and public health management.

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Road construction damage can be largely mitigated by the use of unsurfaced secondary and tertiary roads, together with adherence (as far as possible) to the existing forest road network.

Salinization is unlikely to be a problem, unless there is an excessive use of water for irrigation, or abstraction from the halocline or saline zone. This must be controlled by adequate forms of licensing, pump sizes and continuing checks on abstraction rates and quantities.

Conservation areas have been protected by removing agricultural development from these localities, and it is recommnded that two major conservation reserves (Maidenhead, Andros and Crossing Rocks/Hole in the Wall, Abaco) be created.

To improve the institutional situation there are proposals for specific actions that can be immediately implemented by the Government of the Bahamas. These include the appointment of a conservation officer within the Ministry of Agriculture; the formation of a system of inter-departmental liaison; the setting up of an Environmental Affairs Committee under the Ministry of Health; and the setting up of a Cabinet Committee of Ministers to supervise the phased development of a national land use policy.

Water quality monitoring will be needed. This should be undertaken by cooperation between the agricultural extensions service and the Public Analyst. To provide the necessary data on which a continuous programme can be devised an initial exercise is recommended. This exercise could be put into effect with some upgrading of equipment and staff training.

A specific agrochemical study of the water supplies to the major citrus farms in Abaco is recommended. This would require the upgrading of equipment suggested above, and the manpower requirements suggest that the project is bets executed as a technical assistance project. To allow for the agrochemical study, upgrading of equipment and the water quality (initial study) to be executed it is considered that these three programmes could be integrated into a single technical assistance programme.

Project proposals for technical assistance from the IDB for forestry and coastal protection are already under consideration. Suggestions for the improvement of the environmental terms of reference of these projects are made.

A short-term technical assistance project is recommended for a consultancy to consider the possible re-use systems for solid wastes. To improve the possibilities of using guano, and reducing the costs of fertilizers and soil conditioners to the artisanal farmers of the Family Islands, an estimation of the existing and potential use of bat guano should be undertaken.

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ACKNOWLEDGEMENTS

It would not have been possible to complete this mission without the support and assistance I recieved from my colleagues, counterparts and others in the Bahamas.

I am indebted to the professional assistance and cooperation given to me by my colleagues in the IICA Consultant Team, particularly Mr. J. Monnerat, the Team Leader; and I thank all of them for their friendship which contributed greatly to the enjoyment and success of our collaboration. Similarly, I thank my two counterparts Dr. Maurice Issacs and Mr. Egbert Wallace.

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Many others have helped me to gain a deeper insight of the country, and to make my stay in the Bahamas professionally and personally rewarding, and to all I give my best wishes and thanks.

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1 INTRODUCTION

1.1 Terms of Reference

This report considers the environmental aspects of the the Feasibility Study for the Agricultural Services Development of the Commonwealth of the Bahamas, on the basis that development should proceed without damage to the fragile environment and the limited natural resources of the islands.

For agricultural development to take place in a sustainable manner it is to be consider not merely spatial requirements, but also a timescale that allows for controlled development phases. The Terms of Reference for the Environmental Aspects require the integration of agriculture with other natural resources, in particular forestry, groundwater reserves and the coastal environment. The Terms of Reference for this sector of the project are reproduced in Appendix I.

The report considers the present capability of national institutions to monitor and control environmental problems and natural resources; together with assessing the direct impact of the project proposals on the environment of the project islands.

1.2 Methodology applied

Data collection for the project was undertaken with the assistance of local counterparts. Visits were made to all the islands within the Study group, with the exception of Andros and Grand Bahama, due to time constraints. Opinions were obtained from farmers in the South-East Island Group; and meetings were held with representatives (at technical and senior management level) of governmental and non-governmental organizations, and individuals, (Appendix II), to obtain a broad understanding of the complexity of the institutional and management problems that exist.

It should be noted that in the environmental sector technical data is very scarce, generally out-of-date, and in some sectors (water quality in the Family Islands) effectively non-existent.

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2 THE PRESENT SITUATION

2.1 Environment of the Project Area

The environment of the Project Area has been described by a number of previous workers. The landform and landscapes of the areas have been characterized by Little et al (1976), and by Sealey (1985). The Caribbean Pine (Pinus caribaea) forests in the Northern islands have been described by Henry (1974); and the natural history of the islands is documented by the Bahamas National Trust, and outlined by Campbell (1978).

The freshwater resources of the islands were studied by Little et al (1976). Sealey (1985), also provides a concise summary of this field. The nature and theory of the hydrology of the forms of freshwater lenses found on the islands is obtainable in Ward (1975).

In considering the project area, the South-East Island group: Eleuthera, Long Island, Cat Island, Crooked Island and Acklins Island, and Mayaguana, have been considered together. These islands show a general similarity in their environment, and economic potential. The Northern group: Andros, Abaco, Grand Bahama and New Providence, show similarities in their general environmental characteristic, but because of their economic and development potential, are considered separately.

The coppice lands of the South-East islands have not been recently studied. Campbell (1978), provides a description of the general vegetation, both past and present, for these lands. Most primary hardwoods are now scarce, and the existing cover is a low-canopied, secondary scrub. The range of shrubs includes braziletto (Caesalpinia vesicaria), species of Acacia, haulback (Mimosa bahamensis) Commercial species are much reduced, including mahogany (Swietenia mahogani), wild tamarind (Lysilomas bahamensis), and horseflesh (Lysilomas sabicu). On Crooked Island and Acklins Island, and on isolated nearby cays, cascarilla (Croton cascarilla) is found, the bark still being collected and dried for export.

The Northern islands are dominated by a self-sustaining forest of Caribbean Pine (Henry, 1974). In most islands there has been introduction of exotic (non-native species) of which two species of Australian pines (Casuarina litorea & C. cunninghamiana) are now common, and scattered throughout the islands. Orchids, especially Bromeliads, are found in isolated areas.

Conservation issues within the project area are relatively few, though one species calls for special attention. The only species of psittacid in the Bahamas, the Bahamian Parrot (Amazona leaucephala bahamensis) is found now only on Abaco and Inagua, though historically widespread in the islands (Snyder, King & Kepler, 1981). Gnam has continued research on the populations and predation of the Abaco parrots, and has indicated (personal

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communication) that the behavioral habits of the Abaco and Inagua species are now sufficiently different to consider these to be distinct varieties.

2.2 The Institutional situation

Management and control of environment, natural resources and conservation rests with a number of governmental and non-governmental organizations. The major problem is a lack of formal communication between these bodies for integrated planning or concerted action. Figure 1 provides a summary of the responsibilities of the various organizations concerned.

The need for institutional strengthening in this area is immediate. The Bahamas is fortunate in having enabling legislation which will allow a relatively speedy improvement to made through the enactment of Ministerial regulations. It is thus possible to consider the development of mechanisms for environmental and natural resource monitoring and management within the existing legal and responsibility framework.

In respect of the responsibility of environmental monitoring an control, the Ministry of Health (specifically the Department of Environmental Health Services) is empowered to control this sector under the Environmental Health Services Act, 1987. This Act will be used to recommend actions to be taken with respect to inter-governmental liaison and agrochemical control.

Conservation is the responsibility of the Ministry of Agriculture, and a Conservation Officer is designated within the Department of Agriculture. This post is vacant at the moment, and requires considerable strengthening if the Ministry's responsibilities are to be effectively executed. With the increasing international focus on conservation issues; the potential for wildlife tourism and research; and the proximity of the Bahamas to the North American ecological lobby, it is prudent to ensure that the Ministry of Agriculture can not merely execute its conservation role, but substantially improve the present, poor conservation image of the Bahamian public sector.

The Bahamas National Trust was created in 1959. It is charged with the duty to promote " the permanent preservation ... of lands and tenements (including buildings) and submarine areas of beauty or natural or historic interest...". A non-governmental organization (NGO), the Trust is dependent on private donations and subscriptions, and is limited by these financial constraints.

Natural resources fall under various Departments. Water supply is now the responsibility of the public Water & Sewerage Corporation (formerly part of the Ministry of Works) which liaises with the Ministry of Consumer Affairs. Forestry is a department under the Department of Lands & Surveys, which also has the responsibility for the allocation of Crown Lands. The Department of Fisheries is

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under the Ministry of Agriculture. Overall planning is the responsibility of the department of Physical Planning, Ministry of Works. Solid waste disposal is presently controlled (in New Providence) by the Department of Environmental Health Services, but it is proposed to make this service into a public corporation along the lines of the Water & Sewerage Corporation (Tonettil & Norton, 1988).

2.3 Natural Resources

Consideration of the environmental situation in the Bahamas requires and understanding of both the fragility of the ecosystems and the natural resources on which the country is ultimately dependent. The natural resources of the Bahamas can be summarized as follows:

2.3.1 Land: Limited in this archipelago, and under considerable development pressure especially in the coastal zone for tourism. Future agricultural development will increase this pressure.

2.3.2 Forests: Mainly secondary, and presently consist of Caribbean Pine (*Pinus caribaea*) in the islands of Andros, Grand Bahama, Abaco and New Providence. The other Family Islands are dominated by secondary scrub, from which most commercial hardwoods have been removed.

2.3.3 Minerals: With respect to the project the possibility of using bat guano could be locally important, though reserves have been historically mined. Salt is produced from sea water, but mainly in Inagua (outside the project area), although small-scale production continues in Exuma and Cat Island. Aragonite (oolitic sand) is presently mined in Bimini, although concessions are held in north Andros (Joulter Cay), Eleuthera (Schooner Cay), and in the southern part of the 'Tongue of the Ocean'. Petroleum exploration has indicated that the Bahamas may hold economic reserves of deep oil. Limestone is the base rock of the islands and is used for building and road construction.

2.3.4 Freshwater: Found in varying amounts as freshwater 'lenses', usually in areas of young, porous limestone. These areas are invariably the most suited for all forms of development, and in the Northern islands are covered by stands of pine forest.

2.3.5 Rainfall: The northern islands have the heaviest annual rainfall (and large, deep freshwater lenses) averaging about 50-60 ins/yr. Eleuthera and Central and Southern Andros average between 40-50 ins/yr, whilst the other Family Islands (considered in the project) average only 30-40 ins/yr.

2.3.6 Coastal Zone & Marine Resources: A major area of exploitation within the country, the coastal zone is under development pressure

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from tourism. The value of the mangrove areas in terms of coastal productivity is little understood. The marine resources are a major source of food and export income.

These resources are in the main renewable, although the mineral deposits should be considered as finite resources. All areas of resource are under pressure from development, primarily tourism, and within the context of the project from increased agricultural activity. The inter-action of the resources and the pathways of negative impacts are summarized in Figure 2.

2.4 Land ownership

The problems of natural resource management in the Bahamas are further complicated by the forms of land ownership found within the country. The Bahamas allows relatively wide scope, particularly on the Family Islands, for development of all lands, other than Crown and Government lands (which can have use conditions applied to any leases made on these lands). In brief there are five forms of land ownership:

Crown land: which is land owned by the country and administered by the Department of Lands and Surveys, in the Ministry of Works.

Government Land: which is owned by the Government, and administered by the Treasury.

Commonage Land: being land held in 'common' within a community in the islands and is controlled by the members of that community.

Generation Land: being private land available for use by members of certain family groups.

Private Land: held as freehold or unconditional leasehold property by private citizens or organizations.

There is no land use policy or regulations to control the development of land in the Family Islands. Land owners and commage users, have complete control over their lands. Thus any government controlled development of land can only proceed on Crown and Government Lands.

2.5 Present agricultural status

2.5.1 GeneraL

Consideration of the potential for agricultural development must see the South-East islands as a group. Here constraints on transport and freshwater, together with the problems of soil development, indicate that an up-grading of artisanal, rainfed agriculture is most sustainable. Minimal irrigation is possible in

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some cases, although in both southern Cat Island, and northern Eleuthera, irrigated agriculture on a larger, commercial scale is feasible.

The greater abundance of rainfall, and the deeper water lenses in the Northern islands, allows considerable potential for irrigated agriculture. However these islands also possess considerable stands of natural pine forest, and are under further development pressure from housing and tourism. The impact of agriculture on these islands will vary from location to location.

Agriculture has had a poor history in the Bahamas. There has been little in the way of sustained development, given the potential areas that exist. In the South-East, agriculture is partly a form of subsistence living, and here there is remarkable achievement, given the conditions of poor soil and water. Commercial exploitation has been less successful. There is today about 7310 acres under intensive, irrigated agricultural development. Anecdotal evidence indicates a general indifference by the commercial growers to the extension service of the Ministry of Agriculture. This is in part due to the independence of action that the commercial growers enjoy as well as a reflection on the poor state of the agricultural extension service. In the South-East islands is effectively non-existent.

2.5.2 Agrochemical usage

Agrochemical use is not monitored in the Bahamas. Anecdotal evidence in the South-East Islands suggests that farmers use little (if any) pesticides, and relatively small amounts of fertilizers. Supplies are usually from the Fish & Farm Store in Nassau (Table 1), though private traders may also supply such chemicals.

It is not possible to obtain a true picture of pesticide imports. If a permit for duty-free importation is requested, it is sometimes possible for the Department of Agriculture to refuse the request (and effectively ban that consignment). Some farmers said it was easier to pay the duty on agrochemicals, claiming the Department's procedures were too slow for their intensive operations.

Extension workers admitted that they had no rights to inspect agrochemical stores or monitor use on-farm, and most of the commercial farms visited would give no details of their pesticide use.

Water quality data on agrochemical contamination is lacking, and so it is not possible to assess whether there has been any impact on the freshwater reserves in the islands. It would seem unlikely that there is any serious contamination to the reserves in the South-East islands. Table 2, reproduces water quality data from Andros (Little et al., 1976), which shows a high level of nitrate in some of the samples analyzed. Whether this is a reflection of

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agrochemical use is impossible to judge, but it does indicate that in some freshwaters reserves the thresholds may be lower than expected.

2.5.3 Roads

Farm roads in many cases are in very poor condition. Such roads are effectively cleared and level tracts of compacted limestone. This is an adequate form of construction, providing adequate side drainage is maintained. Maintenance is the responsibility of the farmer, and in many cases this is poor. Some farmers claimed that they preferred to have poor roads, as this deterred thieves and improved the security of their land (particularly where livestock was concerned).

Primary roads through the islands are generally surfaced by tarmacadam, though maintenance is generally poor, with many areas badly pitted and unsurfaced. Aggregate for these roads is by a series of borrow pits of hard limestone, usually excavated along the length of the road to ease transport costs. As a result there are a number of off-road areas that are barren, prone to water-logging and so becoming a potential breeding ground for mosquitoes, as well as being use for fly-tipping (adding to their general nuisance and public health risk).

2.5.4 Land use conflicts - Forestry & Conservation

Presently there is little land use conflict between forest development in the Northern Islands and agriculture; though there is little inter-departmental cooperation to alleviate conflicts should they arise.

The Department of Forestry has, through IDB/FAO Assistance, proposals for a Management Plan for the pine forests (Allan, 1986), and for a new Forestry Law (McHenry, 1987). Both these initiatives have been carefully thought out, with the objective of the sustainable development of the forestry sector. Under the proposals for a Forestry Law, three types of reserve are defined:

Forest Reserves being areas of Crown land to be managed as a permanent forest estate for the sustained yield of timber and other forest produce.

Protected Forests being areas for Crown land to be managed in the same manner as forest reserves until the land is required for agriculture, industry, residences or other development.

Conservation Forests being areas of Crown land to be managed to protect wildlife and to preserve areas of special scientific interest and scenic beauty.

Given the land available in the Bahamas, the human resources, the need to conserve water reserves and wildlife, these proposals seem

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wholly justified, and do not (in themselves) provide any conflict in land use with other forms of development. It is recommended therefore the enactment of a Forestry Law, and the Forest management Plan, be fully supported.

Two areas of Conservation Forest have been proposed by the Department of Forestry, and a request sent to the Ministry of Agriculture for these areas to be so set aside from any development. The areas are:

Maidenhead reserve, Staniard Creek, Andros which has been proposed as a reserve for orchids and a general wildlife reserve, especially for waterfowl.

Crossing Rocks & Hole in the Wall, Abaco which are two areas to conserve the breeding and nesting grounds of the endangered Bahamian parrot Amazona leucocephala bahamensis.

The Andros reserve is shown on Map AN/E/3A, and it is recommended that the Ministry allow this reserve to be created.

In the case of the Abaco reserves, Gnam (personal communication) has indicated that the range of these colonies has increased near the highway, partly as a response to predation by feral cats. The initial conservation reserve was designed to be part of a larger forest reserve, but with the possibility of development and the increase in range, it is recommended here that the conservation area be increased to the size shown on Map AB/E/3C, and the reserve created accordingly.

It should also be noted that the Department of Agriculture has no trained conservation wardens, or field operatives that could act as wardens in either reserve. The Department of Forestry has forest rangers, and it is recommended that, through the Conservation Officer, the two Department collaborate in the wardening and administration of these conservation areas, rather than delay these conservation initiatives any further.

2.5.5 Salinization

The present state of the freshwater reserves is generally good. However the study by Little et al (1976) showed that excessive pumping in some areas had resulted in salinization of some of the shallower lenses. This is particularly noticeable in the Hatchet Bay area of Eleuthera, where previously freshwater wells were then (1975) recorded as brackish or saline. This part of Eleuthera will now depend on piped water from the Bogue wellfield and proposed water reserve in the north of the island.

Salinization could also occur if, for any reason, brackish or saline water was taken from deeper layers of the lenses, and returned via ground percolation. This would result in the

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freshwater layer becoming increasing saline, especially if pumping was on a regular basis.

2.5.6 Marketing infrastructure

A further impediment to agricultural development are the difficulties encountered in marketing farm produce. Farmers (in some islands) sell their produce to local Packing Houses,where it is packed and shipped for distribution in Nassau. The Packing Houses are in a poor state of maintenance, with refrigerated rooms out of order and little in the way of appropriate packing material or continuing infrastructural support. Produce is shipped via the island mail boats, and in many cases the transport of produce is a secondary consideration. As a result the produce, on arrival in Nassau, is often unsuitable for further distribution or consumption. The Produce Exchange, Nassau, is the government clearing centre for produce from the Family Islands to retail outlets in Nassau.

The complete system of produce distribution is highly inefficient, resulting in some 55% wastage of produce from producer to consumer. Whilst initial problems exist in the individual packing houses on the islands, and much wastage is due to inefficient forms of storage and transport by the mail boats, the Produce Exchange wastes 50% of the produce it receives.

Tonnages through the Produce Exchange vary between 3905 tons (1987) to 5117 tons (1984), averaging 4553 tons between 1984-1987. Thus the Produce Exchange wastes an estimated 2270 tons of produce per annum.

Conditions within the Produce Exchange give some cause for concern about public health. Waste produce is stored alongside fresh, saleable fruit and vegetables. The cold stores are only partly functional, and not all can be accessed by fork-lift trucks. Produce appears to rot where it is stored, and is then piled in any convenient spot before being taken to a truck for dumping.

The Environmental Health Services inspect the Produce Exchange by visual examination at monthly intervals. Pest infestation is commonplace, with cockroaches, flies and rats being the main problem organisms. No sprays are used for pest eradication, due to the proximity of unprotected fresh produce, so control is by poison baits and fly papers.

Waste is not collected by the municipal waste disposal system, but is taken by Department of Agriculture to the Gladstone Road Agriculture Centre (GRAC) for disposal in a small landfill site. One vehicle serves both as a garbage truck as well as being used to move produce from the Produce Exchange to the retail outlets. The system is inefficient, and causes both a pest problem and a potential groundwater hazard at GRAC.

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3 ENVIRONMENTAL IMPACT OF THE PROJECT

3.1 Introduction

The project has been designed and defined by the irrigation, agricultural and marketing experts of the Consultant Team. The project design has been based on the criteria of suitable land and available water for agriculture only, rather than incorporating other land uses, considering environmental impact (except for consideration of water reserves) or land ownership. This section therefore considers the proposals for irrigated agriculture in the light of the wider Terms of Reference required by the environmental aspects. Consideration of the detailed impact of agrochemicals, has been restricted due to lack of data and knowledge of the conclusions of the agricultural and livestock experts of the Consultant Team.

This section will consider the likely impacts of the project as seen against the perspectives of such impacts on the natural and human resources of the Bahamas; the expansion of the agricultural frontier; and the impact with respect to wildlife and conservation; followed by individual assessment of the proposed areas. Criteria have been developed to assess the environmental impact, and to subsequently advise on mitigating measures against negative impacts. These criteria are detailed in Appendix III.

3.2 Expansion of the agricultural frontier

Presently irrigated agriculture in the Bahamas covers some 7,310 acres. The project proposes to increase this area both for commercial production (for export) and to improve the farming regime of artisanal and small farmers in the Family Islands.

Consideration as to areas that can benefit from irrigation has used two main criteria: the availability of groundwater supplies, and the land capability (in respect of development of suitable agricultural soils). Secondary considerations have been the proximity of roads systems, and the Crown ownership of land (to permit governmental control of land distribution).

Using hydraulic considerations for water supply, some 50,962 acres in the northern islands of Andros, Abaco, Grand Bahama and Eleuthera, have been defined for unlimited irrigation.
This represents a substantial increase of irrigated land in these

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islands (Table 3). Tables 4 & 5 reproduce the details of the proposed irrigated areas for each island, as defined by the Irrigation Engineer.

For the south-eastern Family Islands a limited form of irrigation is proposed which will supplement an essentially rain-fed form of agriculture. This system relies on the farmers adhering to the irrigation schedules, and pump sizes, proposed by the Project. If implemented this limited form of irrigation will be bring into production some 7,809 acres.

The proposals for irrigation alone will extend the agricultural frontier for by between 589% - 804%. Such an increase will impact on the development of other natural resources and on conservation areas, though the actual impacts will vary with the individual location.

3.3 Land clearance, preparation and roads

The problems of land clearance and ground preparation in the Bahamas will vary with each location. The proposed areas have taken into account the land capability as defined by Little et al., and such areas are likely to have the most easily preparable soils.

Land clearance does however depend on the type of vegetative cover that needs to be removed. In the northern islands much of the proposed irrigated land is presently covered by commercial stands of Caribbean Pine (*Pinus caribaea*). The Department of Forestry considers that the timber value of this land should be accounted for when the land is cleared, and recommends a charge to the developer of BAH$ 80/acre. In environmental terms this charge is justified, representing as it does a 'one off' charge for the loss of a sustainable and self-generating natural resource.

In the south-eastern islands the vegetative cover is mainly secondary coppice scrubland with little commercial value. These lands are easier to clear (presently burning being extensively used by artisanal farmers).

In a few cases irrigation areas are proposed on abandoned farmland, that has historically been cleared and prepared. These areas should be considered as prime sites for agricultural development, and represent a positive environmental impact on otherwise useless land; except where such areas overlie a designated water supply wellfield or reserve.

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In most areas of the north-western islands, the proposals make use of the existing forest road system. The systems of road development (Section 2.4.3) should not cause any major impact, providing that care is taken to ensure adequate drainage.

3.4 Natural resource conflicts : Forestry

Commercial stands of Caribbean Pine (*Pinus caribaea*) are found on Andros, Abaco and Grand Bahama. These are mainly secondary growths, but are self-seeding (in most areas) and hence represent a self-sustained natural resource. The Forestry Management Plan that this report recommends be enacted (Section 2.5.4) would allow for the commercial development of these reserves on a sustainable basis. The value of this resource must be considered against the value, and practicability, of agricultural development.

The FAO Report (1987) gives projections for the commercial quantities of timber in various areas. The projections for sawlog in Andros and Abaco ranged from 1,012,000 bd.ft. in 1987 to 30,867,000 bd.ft. in 2017; for cordwood and waste the totals were 100,900 tons in 1987 rising to 208,100 tons in 2017. The value of the forest products has been assessed by Gordon-Puller (1986). The wholesale price (in Florida) for sawlogs of Southern (Caribbean) Pine ranged between US$ 484 -754/1000 board feet (bd.ft). Cordwood and sawmill waste are worth US$ 3/ton. This represents a potential annual income from forest products of US$ 929,128 rising to US$ 19,730,973.

It is considered that the Forest Reserves, being the areas of prime commercial timber, should be protected from destructive development (Appendix III, 3.4). Agricultural development is thus best in the Protected Forest reserves, which are considered to be less productive for timber.

In addition to timber production, the forest reserves are being considered for dendrothermal electricity generation. Funds have been requested from the IDB to develop such plants at Morgan's Bluff, Andros and Marsh Harbour, Abaco. The forest reserves will provide the necessary fuel in the form of growing stock, thinnings, forest residues and saw mill waste.

These proposals should also be considered in respect to the irrigated areas proposed for these islands.

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considerable lack of data which technical judgements require. Therefore the EIA criteria require no development within a water reserve (Appendix II, 1). This requirement applies also to existing wellfields.

A further concern is the use of a limited irrigation system in the south-eastern islands. In these islands water resources are generally scarce, and the shallow lenses are used for all water requirements, including potable supply. It is not uncommon for agricultural small-holdings to be merely a few hundred yards away from individual household pumps, or even surrounding settlement water supply points. Under these circumstances the increase in the use of agrochemicals to improve yields is likely to have a much more immediate, localised impact on water supplies than the more intensive systems proposed for the north-western islands.

3.6 <u>Water resources : Salinization</u>

Salinization of water lenses is also of importance, and this aspect has been taken into account in the irrigation design, and abstraction rates for the various islands recommended. Little et al. (1976) have dwelt in detail on the nature of and the problems of abstraction from the aquifers. The Gyben-Hertzberg relationship holds for the aquifers in the Bahamas, but Little et al.(1976) note that the depth to the freshwater/saltwater inferface (halocline) generally given as 40 x head of water above sea level is only approximate. "The freshwater lenses are in a state of dynamic equilibrium...any reduction in water level as a result of pumping or a lack of recharge will permit further saline intrusion of the aquifer..". Little further notes that by using the equation of Todd (1959) the depth to the halocline can be measured, and that this is dependent on: the amount of rainfall that recharges the aquifer; the permeability of the aquifer; and the size of the isalnd. This is important when considering multiple water use in the thin sections of the south-eastern islands.

Canter, Knox and Fairchild (1987) note that " saltwater intrusion into coastal aquifers is a concern in those areas where ground water pumpage is excessive...The total dissolvedsolids can also be increased by irrigation practices...". In determining the possible occurrence of salinization the recommended abstraction rates for the project must be considered. On abstraction rates, Little et al.(1976) have noted the effect on the aquifer: (for Abaco) the abstraction rate when fully developed would ..."reduce a 60ft. lens to 30 ft. At the same rate a 30 ft. lens would be reduced to 15 ft...".

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In view of these comments, the project abstraction rates will be compared with those recommended by Little et al (1976).

3.7 Impact on Human resources

The proposed increase for the northern islands presumes that most of this land will be developed for commercial, export driven agriculture. In a country with a small overall population, spread through a number of scattered islands, such commercial development will place a considerable strain on the relatively small pool of labour available to the agricultural sector; and has wide ranging implications, in social, economic and political terms.

The major export crop at present is citrus, and from discussions with commercial farmers on Abaco, citrus development requires one skilled agricultural worker per 140 acres, on a full-time basis. In addition there is work for a variable number of part-time labourers. Given that 40,005.8 acres of Crown land have been defined for irrigated development in the northern islands, this would relate to a requirement of some 290 skilled farm workers.

This human resource need must be seen in a context of abandonment of farming as a profession. In Abaco alone the requirement would be for 106 new farm workers. The 1978 census put the full-time farmer population of this island at 300, but the present farmer population (outside of the commercial farms) is now said to be 33.

Together with the farm workers, is the need to consider the families that full-time workers would bring with them. On an average of 5 persons per household housing and social infrastructure for some further 1450 persons would be needed to support these commercial ventures. In Abaco, there would be an increase of 530 persons (7% of the population: 1980 census).

The source of such labour should also be considered. Intra-island migration would further deplete the farmers and overall population of the Family Islands. This could radically affect the development of agriculture (as proposed by the project) in these islands. However, with farm labourers being paid between BAH$ 20 - 25/day, it is questionable whether farmers might find it worthwhile to migrate to the north, rather than develop their own lands.

If intra-island migration to satisfy the proposed labour requirements is not possible, an alternative would be to encourage immigrant labour from neighbouring countries. This would continue the trend for immigration by Haitian and Jamaican workers. This

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option must however be left to the political judgement of the Bahamian Government.

3.8 Conservation issues

In respect of conservation of wildlife, the problem is one of the impact of agriculture development on conservation areas, including the effect of agrochemicals on non-target organisms. This would be of particular importance to the avifauna of the islands, and to insect pollinators (bees).

There are two main areas (within the project) that are of importance with respect to conservation issues, the Maidenhead Reserve, Staniard Creek, Andros and Crossing Rocks & Hole in the Wall, Abaco (Section 2.5.4). Proposed irrigation areas IX & X (Andros) and area X (Abaco) are close to these conservation areas.

The Abaco areas are of importance with respect to the potential environmental impact. The Bahamian Parrot (Amazona leucocephala bahamensis) may well be threatened by the use of agrochemicals in the adjacent agricultural area. Of equal importance to the success of agriculture is the possibility of the parrots invading the crops as a source of food. It would be a major irony if this highly endangered species were to become a major agricultural pest as a result of the proposed location of irrigated areas.

3.9 Consideration of individual islands

This section will consider the impacts of the individual areas proposed for irrigated agriculture in each island, with respect to the points discussed above. The areas are numbered according to the proposals and maps provided by the Irrigation Engineer.

3.9.1 Abaco

AREA I This area will have a major impact on forestry. The area is in a Forest Reserve, which is shortly to be leased for timber production in conjunction with the reserve on Little Abaco. It is understood that the reserve around Area I will be thinned at a rate of 600 acres/year, whilst timber is felled on Little Abaco at 300 acres/year. On a 40 year production cycle, the timber in Area I will be ready for felling in 15-20 years. Additionally to its forestry impact, this area would considerably increase the use of agrochemicals in an area dominated by the commercial Bahama Star citrus farm.

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AREA II This area is privately owned, and although within a Forest Reserve, there are no major impacts.

AREA IV This area is within a Forest Reserve, which would be necessary for the proposed dendrothermal plant at Marsh Harbour. It is also adjacent to the main wellfield for this town.

AREAS These areas represent agricultural development on V-VII mainly abandoned sugar cane land. There are some stands of timber within these areas, but overall these areas represent the most suitable, and least environmentally damaging within the project in the northern islands, except for the areas proposed to lie over the existing wellfield above Lake City.

AREA This area lies within Protected Forest Reserves, VIII and as such could be considered for agricultural development.

AREA IX This area lies within the Forest Reserve, and as such must have an impact on future forestry development.

AREA X This area lies south of thewater reserve and adjacent to the proposed conservation reserve for the Bahama Parrot. In respect to the latter, some predation and crop destruction by the parrots must be accepted. Prescribed destruction of the parrots (as an agricultural pest) would not be acceptable. The area also lies within the largest Forest Reserve on Abaco, and this timber reserve will provide a valuable resource within the next 20-40years.

The proposed rate of abstraction on Abaco the same as recommended by Little et al (1976).

3.9.2 Andros

AREA I This area lies within the Forest Reserve in an area that has already considerable development. If forestry is developed in north Andros, together with dendrothermal generation at Morgan's Bluff (to the north-east) this area of forest is likely to be part of the extractable lumber land.

AREAS These areas lie within Protected Forest Reserves II - IV and can be considered for irrigated agriculture.

AREAS These areas lie within the Forest Reserves of V - VIII central Andros. Area VI lies close to one of the & XI & XIII Andros Blue Holes. In conjunction with the other proposed irrigation areas over this major water lens, considerable impact must occur in

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respect to forestry development. Areas VII, VIII, XI and XIII lie over the deepest part of the lens, and would represent much a more reduced risk of any groundwater contamination.

AREAS IX - X These areas lie adjacent and close to the proposed Maidenhead Conservation Area, Staniard Creek, and would present a threat to this reserve (which is essentially for botanical and wildfowl conservation).

AREA XII This proposed area lies within a major single stand of Forest Reserve.

It is noted that the recommended maximum abstraction rate is 620 gpd/acre against a recommended rate by Little et al.(1976) of 570 gpd/acre.

3.9.3 Grand Bahama

AREAS I-V All these areas are set within existing timber concessions in Forest Reserves, and as such represent a conflict in landuse. Little et al.(1976) are cautious about the water supplies of Grand Bahama due the under-exploitation of resources at that time (except around Freeport), and the effect of losses due to the Lucayan Waterway. No recommended rate is given in their Confidential Annex.

3.9.4 Eleuthera

AREAS I - V These areas lie adjacent to the Bogue wellfieldand water reserve. Whilst Cant (1981) notes that this water reserve will be required to meet future demands "...to the whole area and as far southwards as Savannah Sound...", it is felt that the scale of proposed development in this area should not affect the water reserves.

AREA VI The proposed irrigation area is set within a 20' deep lens, and such departs from the criteria laid down for full irrigation, and could represent a potential threat to water supplies around the Tarpum Bay Settlement.

Abstraction rates for Eleuthera are the same as recommended by Little et al.(1976).

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3.9.5 Cat Island

The proposed area north of Frankfort Creek, although designed for abstraction pit irrigation, lies directly over the designated Water Reserve on this island. The proposed area at Tea Bay Settlement lies over a very small water lens, which represents the water supply for this area; and localised contamination of the supplies is highly likely.

Little et al.(1976) note that "...the aquifer on Cat Island is very variable...". They recommend a range of abstraction rates between 360-460 gpd/acre. Whilst within this range, the abstraction rate recommended (450 gpd/acre) is set towards the higher range of the Little et al. figure, which should apply mainly to the development of the Devil's Point lens.

3.9.6 Exuma Islands

Proposed irrigation areas are over the best lenses in the Great Exuma, which are also used for public supply. The Calvin Bay lens area does not seem to cause any major negative impact. Little et al.(1976) recommend an abstraction rate "...limited to about 400 gpd/acre...". The maximum recommended rate of 440 gpd/acre would seem close to the earlier recommendation.

3.9.7 Long Island

Proposed agriculture at Deadmans Cay & Burnt Ground, and Stella Maris are in areas of existing wellfields. Little et al. (1976) point to the limited water reserves on this island, as well as the expense of providing public supplies. Many areas are reliant on roof catchments and small shallow lenses. Little et al. note that the aquifer is variable, and recommend that abstraction "...should not exceed 300 gpd/acre.", although the agricultural recommendation is set higher at 310 gpd/acre.

3.9.8 Acklins Island

The proposed areas in Acklins Island are over reasonably large lenses, where the public supply is relatively low. Little et al.(1976) recommend an abstraction rate at about 250 gpd/acre, against an the recommended rate of about 276 gpd/acre. Both recommendations say these rates would reduce the lens thickness by 33.3%.

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3.9.9 Crooked Island

The proposed partially-irrigated area lies within the only significant lens in the island. The recommended abstraction rate is 273 gpd/acre against 290 gpd/acre recommended by Little et al.(1976); both rates likely to reduce the lens thickness by 33.3%.

3.9.10 Mayaguana

The proposed area is over the best lens in the island, but (at present) no public supplies are drawn from this lens due to the extensive piping that would be required. Little et al.(1976) recommend a rate not exceeding 300 gpd/acre, and the recommended rate of 276 gpd/acre falls within this figure.

3.10 Other issues

The impact of the construction or rehabilitation of Packing Houses, storage facilities and jetties for the mail boats to improve the domestic marketing infrastructure is unlikely to have a major impact, particularly with regard to the coastal zone.

The problem of solid waste disposal, both on individual islands and the Nassau Produce Exchange does remain. If the Produce Exchange is either refurbished, or re-located in a new site, it will be important to consider the disposal of waste from this facility.

Agricultural effluents from intensive livestock operations are a further source od groundwater pollution. The porosity of the soil means that the use of unlined slurry pits (effectively simple 'soak aways') provides a concentrated pollution load on the aquifer. It is important to ensure that such operations find some alternative form of effluent treatment (eg: high-rate filtration). Improvement in the grading capabilities of the Packing Houses, and the refusal of unmarketable produce may well lead to an increase in the waste disposal of rejected produce in the islands. This is a relatively small problem overall, but should be considered for its much larger impact on the local community's public health. The problems of fly and rodent infestations are always likely, and landfill (even with subsequent burning) is not an adequate answer to this problem.

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4 MITIGATION OF NEGATIVE PROJECT IMPACTS

4.1 Introduction

The preceding section has dealt with the probable impacts of the project, and this section will provide suggested solutions to reduce the negative impacts.

It is accepted that agricultural development is sufficiently advantageous to the future social and economic of development of the Bahamas for the project concept to be acceptable.

4.2 Solutions to land-use conflicts

The main negative impact relates to the scale of the proposed development. This represents a considerable increase in the existing capacity, and as has been shown, will require more human resources than are presently available. This section will therefore seek to mitigate these effects of scale, as well as addressing the other issues raised in the preceding section.

The proposed design considers that there is a minimum of 50,962.2 acres available for full irrigated development. Development to this level must take a considerable number of years, and will require careful market analysis as well as investment. It is considered that the project should concern itself with that land that can be reasonably put into production, given existing markets, investment and manpower.

Furthermore the national development must be a consideration in project design, and the development of other sectors taken into account. The criteria (Appendix III) do so in particular relation to forestry, and human resources. Additionally, the constraints imposed by land ownership (Section 2.4) need to be considered, to ensure a realistic development project.

The availability of land should also be considered, and Tables 4 & 5 indicate that such concerns have been taken into account. These tables show "Areas that can be considered for irrigation in the 1st. phase", and cover mainly those areas that are ungranted Crown Lands.

The term "1st. phase" is somewhat misleading for no timescale for the development of the proposed irrigated areas has been proposed, and this section will consider a phased approach to allow agricultural development to proceed in an environmental sensitive manner. The timescale proposed herein will cover three phases over a twenty year period, which will allow for both natural resource use and future development, as well as being a suitable for period for training and sustained development.

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The restrictions on land use and the lack of a land use policy (Sections 2.4 & 5.5), together the incapacity of existing extension services to assist and supervise private agricultural development, renders consideration of these private lands unrealistic, in respect of controlling the expansion of the agricultural frontier. It is not suggested that private lands should not be developed, but control of the pace and scale of development of such lands (in the absence of a Land Use Policy) is lacking, and without such controls their inclusion in a development programme is impossible.

Therefore, it is recommended that only ungranted Crown Lands should form the project. It is accepted that the principles of irrigated practices can be used equally well on private land, and farmers on these lands may develop irrigation systems and make use of any credit or extension facilities offered by the project; but such services must be considered ancillary to the controlled horizontal expansion of agriculture.

4.2.1 Reduction in expansion of agricultural land

In considering the reduction of acreages it is noted that the details given by the Irrigation Engineer (reproduced as Tables 4 & 5) are not wholly consistent with the acreages shown on the accompanying maps. As the ecological/economic zonation maps (Section 4.9) have been produced from copies of the irrigation maps the values as shown on the irrigation maps will be used where relevant.

The following sub-sections discuss the reduction in area on an island-by-island basis.

4.2.1.1 Abaco

Abaco is an island where a number of conflicts in land use are demonstrated. The area possess much in the way of proposed Forest Reserves, contains a number of wellfields and major Water reserves, and holds the conservation area fro the Bahama Parrot (*Amazona leucocephala bahamensis*).

In common with other islands there are possibilities for phased agricultural development on Abaco, and the use of the abandoned sugar cane lands must form the first phase of any agricultural development that is environmental acceptable.

It is therefore recommended that the following areas be removed from the project:

AREA I. As this area represents prime Forest Reserve that is likely to be part of a combined forest production system in conjunction with the reserves on Little Abaco. Furthermore it is considered undesirable that this area should not be exposed to an

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increased level of agrochemical use, dominated as it is by the Bahama Star farm and lying adjacent to a Water Reserve.

AREA II. This area falls within private land, and as stated above should be removed from consideration by this.

AREA III. This area is also Forest Reserve, and may well be required for dendrothermal generation proposed at Marsh Harbour, as well as lying adjacent to the main wellfield for potable supply to the town.

AREA IX. This area is also in a Forest Reserve, and should not be given priority for development of agriculture.

In addition to the above it is proposed that reductions should be made (as shown on the Maps AB/E/3B & AB/E/3C) to two other proposed areas. These are:

AREA V. A reduction of some 660 acres of proposed agriculture that lies over the water supply wellfield.

AREA X. A reduction of some 1,880 acres to reduce the impact of agriculture on the proposed conservation area for the Bahama Parrot, as well as removing the agricultural land away from the main areas dominated by this bird.

The result of the above measures, together with the removal of leased Crown Lands, will be to reduce the total land for irrigated agricultural development on Abaco by some 6,523.4 acres, to a total of 11,221.7 acres.

4.2.1.2 Andros

The main conflict in Andros is one of development within Forest Reserves. Andros (like Abaco) is earmarked for forestry development, including a dendrothermal plant in the north at Morgan's Bluff. Further south there are large available areas for agriculture within Protected Forest Areas. A further conflict arises with the proximity of proposed development to both Blue Holes and the proposed Maidenhead conservation area.

The proposals for Andros can be considered as discrete plots, and it is considered that the form of the proposed development (unlike Abaco) does allow for reduction of these areas. Under these circumstances it is recommended that the following areas be removed from the project:

AREA I. This lies within a Forest Reserve. Its northern boundary lies on the line of a Water Reserve. Andros is increasing being used for additional potable supplies to Nassau, and so this area should not be further developed.

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AREAS: these two areas lie within a Forest reserve. They V & VI are placed on the perimeter of a large lens system, and are adjacent to one of the Andros Blue Holes. To ensure the future water quality of this aquifer, it is considered prudent to reduce the overall concentration of agriculture over this lens, and so it is recommended that these areas should be removed, leaving development to proceed only over the deeper portion of this particular lens.

AREA IX. This area is adjacent to the proposed Maidenhead conservation reserve, and it is considered that agricultural development will impact considerably on this area.

AREA XII. This area is proposed within a Forest Reserve, over a major stand of forest, and should not be developed.

The above deletions amount to some 14,227.8 acres, which together with the 1,578.6 acres of Area XI (private land) reduces the total available Crown Land for irrigated development on north and central Andros to 10,465 acres.

4.2.1.3 Grand Bahama

All the identified land for irrigated agriculture lies over private or leased land for timber. The areas lie within Forest Reserves. The irrigation design indicates that these lads are not available for immediate development, and (like New providence) it is recommended that Grand Bahama form no part of the project.

4.2.1.4 Eleuthera

Whilst it is accepted that the areas around the Bogue wellfields do not present a major threat to the water reserves, some areas are commonage land, and as such would be excluded from immediate consideration by the project. There is an area of some 230 acres shown as Area I on the map, which does not appear in Table 4. This area, together with the ungranted Crown lands, leaves a total of potential irrigated development of some 330 acres.

The potential risk to Tarpum Bay is partly negated by the fact that this land is private, and as such would recommended for removal from the project. In any event, if there was to be development of this area, it would be environmentally prudent to remove an area of 351 from the northern limits as drawn, leaving only a potential area (over the deeper part of the lens) of 372.3 acres.

There is no indication of the ownership of the area north of Waterford Settlement. If this is within the Crown Lands, then the total available land (within the project) on Eleuthera would be 545.4 acres.

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4.2.1.5 Cat Island

Of all the south-eastern islands Cat Island shows the greatest potential for irrigated agriculture, though the proposals consider only partial irrigation.

The greatest potential exists in the south of the island, where three areas are proposed between Devil's Point and McQueens, and north of Frankfort Creek. The last area should be reduced by some 300 acres (Map CT/E/3EF), to take development out of the Water Reserve. This brings the total acreage in this section to 2,952.8 acres. Whether this is available Crown Land is uncertain from the data provided, but much of the area is undeveloped and it will be assumed that this land is available to the project.

Further north is an area (413.9 acres) by Deanwood, on which ownership data has not been provided, but it was understood (on the site visit) that this is Crown Land.

No assessment could be made on the areas at Old Bight and Arthur's Town from the maps provided. However these lands are shown to be already under lease, and so exclude themselves from further consideration.

The lens at the Tea Bay site has been noted as being small, and given the need for multiple water use on so narrow a stretch of the island, it is recommended that this site be deleted from the project.

The area north-east of the Bight Settlement and adjacent to the airstrip (337 acres) is acceptable, as are the 155.2 acres north of Orange Creek. Again ownership is unclear, but it is assumed that this is available Crown Land.

With the deletions and reductions in acreage, the total available land for partial irrigation in Cat Island is 3,858.9 acres. It is noted that this is higher than the figures shown in Table 5, due to the discrepancies between the tables and maps noted earlier (Section 4.2.1).

4.2.1.6 Long Island

All the areas identified in this island pose problems for the water reserves if fully developed. The areas at Burnt Ground and Stella Maris are over wellfields, and the Roses and Cabbage Hill areas are on small lenses in an island with a scarcity of freshwater. It is recommended that the "1st. Phase" areas be considered as the total potential area for this island.

The acreages reproduced in Table 5 and those shown on the maps provided are at variance, though the locations agree. However it is noted that all these areas are stated (Table 5) to be on private

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land. As such Long Island should be excluded from the project as no Crown Land has been identified for development.

4.2.1.7 Crooked Island

The general comments on land ownership for Long Island (above) relate to this island as well. However it may be possible, in the long term, to allow full exploitation of this area for agricultural development.

4.2.1.8 Exuma Islands

The general comments on lens suitability and land ownership for Long Island (above) relate to this island as well. It is felt that the "1st. Phase" areas should be used for the total development area of some 700.3 acres., though the private ownership of the land excludes from direct development by the project.

4.2.1.9 Acklins Island

The areas shown for Acklins Island are acceptable and available. Therefore the total available area for this island is 1,460 acres.

4.2.1.10 Mayaguana

The areas shown for Mayaguana are acceptable and available. Therefore the total available area for this island is 330 acres.

4.2.2 Summary of land availability

The total Crown Land available to the project as shown by the sub-sections to 4.2.1 above, is 27,881 acres (Table 6). This is the total available Crown Land, and represents the acreage that the Ministry of Agriculture can consider for the long term expansion of the agricultural land under its control.

In addition to this land, are the private lands identified by the project,except those where an adverse environmental impact is possible. Whilst it is accepted that, in the absence of a land Policy, control on development in private lands (of whatever form) is limited, the enactment of suitable environmental controls to safeguard the public health and natural resources, allows an avenue of control even on these lands.

With the exception of Grand Bahama, which like New Providence, has unique reasons for being taken outside the project, the private lands available on the other islands is a further 3,637 acres.

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Therefore the total potential agricultural land can be considered to be 31,518 acres. This should be considered as a long-term target for complete development of the agricultural sector, allowing for environmental compatibility and the sustainable development of other natural resources.

4.2.3 Phased development

To place even 27,881 acres under some form of irrigated agriculture is not possible in the short term. However, accepting that the above section has defined the available land for development under the project, together with the total potential agricultural land, it is now important to phase the development, in order to obtain the most efficient use of natural resources and agricultural development, and to ensure that agricultural expansion does little significant harm to the environment.

To this end three phases of development are considered:

PHASE 1 : 0 - 5 years
PHASE 2 : upto 10 years
PHASE 3 : upto 20 years

In each phase there is an acceptable acreage that should be considered for irrigated development. It is considered that the partial-irrigation proposed for the south-eastern islands would be acceptable at any time, given that the major constraints in these islands will be land ownership, manpower and difficulties with infrastructure and marketing.

Consideration should also be restricted to that land which is to be made available to individual farmers, rather than developed by larger scale commercial investors. The latter are likely to undertake their own feasibility studies on land preparation, crop suitability, investment and marketing, and should they wish to proceed with development the Bahamian Government will be able to assess such studies in the light of the available land at that time. It is recommended that no commercial development be allowed in areas removed from the project under Sections 4.2.1 and 4.2.2.

The islands of Abaco, Andros, Eleuthera and Cat Island will be considered for the amount of land that could be made available in Phase 1.

4.2.3.1 Phase 1

In Abaco Areas V-VIII are the areas for initial exploitation. Given the relatively low farmer base in this island, and the demands that may be made from the commercial citrus farms for additional labour, it is considered that in the first phase some 1,700 acres could be successfully developed. This would allow existing farmers sufficient land (50 acres) for a wholly agricultural based income,

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and permit the smaller irrigation models proposed to be used. However, it is accepted that the entire area of abandoned sugar-cane lands could be developed if circumstances and resources allow.

In Andros Areas II-IV are suitable for agriculture, and could be considered as areas for development in this phase. If agriculture was to be developed in north-Central Andros, then Areas VII, VIII, X and XIII could be considered. Andros has a potentially higher labour force than Abaco, and it is thus possible to consider irrigated development up to 3,500 acres.

In Eleuthera the Bogue wellfield is the more favourable area for development, and the full acreage in this area of 330 acres (section 4.2.1.4) could be developed in Phase 1.

Cat Island will suffer (in common with other south-eastern island) from a shortage of manpower and infrastructure. The area to the south (Devil's Point-McQueens, Frankfort Creek) has considerable potential to attract commercial development. However, in considering the domestic potential, some 1,000 acres this area could be developed. The area around Deanwood was historically considered for sheep/goats, and may be better suited for husbandry in the future. North Cat Island requires agricultural support, and the areas north-east of the Bight Settlement and north of Orange Creek could be made available for agriculture in this phase. The total agricultural development in Phase 1 for Cat Island would thus be some 1,492 acres.

In summary Phase 1 should concentrate on irrigated agriculture up to a maximum of 7,022 acres.

4.2.3.2 Phase 2

In Phase 2 the it can be anticipated that a further 50% of all available land could be developed for irrigated or partially irrigated agriculture, representing an increase of a further 10,430 acres of Crown Lands. If a similar percentage of private land is developed (1818 acres) the total developed land (Phases 1 & 2) would be 19,271 acres.

4.2.3.3 Phase 3

In Phase 3 the remaining 10,429 acres of Crown Lands, and possible 1818 acres of private lands could be developed, giving a total new development of 12,247 acres for this phase.

4.2.4 Multiple land use

Whilst the reduction in irrigated land proposed in Section 4.2.1 may appear severe, it should be noted that forest land can still

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be considered for agricultural purposes in respect of livestock production.

The underbush of the pine forests are presently very poor, and prescribed burning is used to clear this under storey. However, if suitable grasses or other fodder crops could be sown (after firing) it might be possible to consider the use of sheep or cattle to both maintain the under bush, as well as providing an alternative agricultural development. The scale of the forest in Andros are particularly well suited to this concept, allowing for extensive grazing. In this respect a symbiotic relationship could be developed between the aims of Agriculture and Forestry; and this possibility should receive serious attention.

Such a concept could also be used during the land preparation stages in the coppice scrub of the south-eastern islands. During the period when land clearance and preparation was underway, adjacent scrub could be used for goats and sheep. Such a system would be possible in both Cat Island and Acklins Island where there are good lenses to provide watering sites for the animals.

The economics of the operation will need to balance the costs of security by fencing, etc. against loses from poaching and wild dogs. However, where there are large areas of such forest and scrub lands, losses may be scaled down in comparison to the scale of the husbandry operation, or offset against employment of rangers.

4.2.5 Land use - forestry

Much of the land removed from the project has taken account of the proposed Forest Reserves, and the exploitation of this natural resource. It is therefore recommended that the proposed Forest law be now enacted, and that the Forestry Management Plan be put into operation s soon as possible to ensure maximum benefit from this form of development.

4.3 Water Quality - Agrochemicals

The problems of agrochemical use cannot be fully quantified due to the lack of baseline data, as well as incomplete data in relation to the agricultural proposals.

The lack of data on water quality, and in particular on pesticide residues, has meant that no quantitative estimation of the effect of agricultural development can be made. However, as shown in Section 3.5 the matter is extremely complex, and it would be imprudent to rely on simple dilution as a solution to the potential problem.

The water quality standards presently in force for the Bahamas do not include standards for pesticides (Table 7). The data on fertilizer use is scant. The limestone soils of the Bahamas will

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rapidly fix phosphate, and so there is an increasing need for phosphate for soil nutrients. If such phosphate is made available by increasing the dosage of proprietary fertilizers, there will be a corresponding increase in nitrate, with a further risk to water supplies. This is borne out by the data in Table 2, which shows that nitrate levels can build up even in large aquifers on Andros.

It is understood that the agronomist will make recommedations on pesticides/herbicides. Such chemicals, if used, may reduce the problems of agrochemical contamination. However, details of possible fertilizer use will be needed to assess the potential contamination by nitrate; as well as an assessment of the suitablity of chemicals when set against tehir effect on humans and non-target organisms. It will still be necessary to maintain a regular and continuing check on the chemical residues, both in the water supplies and the soils.

Present agrochemical use (Table 1) suggests that the artisanal use of such chemicals is relatively light, especially in the Family Islands. This situation could change radically if extension services can provide farmers with a better understanding of improved yields by use of agrochemicals. Concern must be expressed over the use of chemicals, without adequate understanding of their dangers, in areas where the underlying aquifer is used for water supplies as well as for agriculture.

Many smallholders take their water, for potable and agricultural purposes, from the same aquifer, and often from the same pump. Many such farmers use little in the way of pesticides/herbicides, and should the use of these chemicals increase, these small farmers will need to be advised not only on the safe handling and dosages to be applied, but also on safe systems of storage and disposal of surplus stocks.

On a larger scale is a similar concern where communities rely on an aquifer for potable supplies as well as agriculture. It would seem that the most effective form of control will be by farmer education, sound extension and regular monitoring of the aquifer. These areas will be further at risk if any forms of irrigation are used. The amount of available water, at any one time, will be reduced by agricultural abstraction. There are a number of variables that define the rate of recharge; and it is impossible to set out guidelines for such multiple-use water resources with presently available data.

For control of pesticide and fertilizer use in large, commercial farms there will be a need to have a pesticides control law, as well as the ability for extension officers to inspect stocks and maintain records of use. These matters are addressed in more detail in Sections 5.6 and 6.1.

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4.4 Roads and land preparation

The present system of road construction (Section 2.5.3) is suitable for all secondary and tertiary roads. Primary roads should be surfaced. In all cases, it is important that suitable road curvature, and side drainage is maintained. It is important that compaction of the drainage areas should not occur, to allow for fast ground drainage.

The problem of borrow pits should be carefully considered. The practice of small pits located along a road system may be less desirable than a single quarry, that can subsequently be rehabilitated. This aspect of road construction will vary with location, island by island, but must be considered in all road planning.

The use of the existing forest road network in the northern islands will reduce the land clearance costs, and reduce the clearance of forest lands for approach roads into new agricultural areas.

4.5 Salinization

The problem of salinization through excessive pumping has been noted in Section 3.6. Comparison is made between the abstraction rates recommended by Little et al. and the project design in Section 3.9. In view of the need to preserve the water resources of the Bahamas, it is recommended that the lower abstraction rate be taken as a maximum rate for any island.

To ensure that excessive abstraction does not occur, or that saline water is not allowed to recharge the aquifer, large scale abstractions should require licenses and some form of regular water quality monitoring must take place. This should be combined with a monitoring system for overall water quality, and not (as in the past) concentrated on merely taking salinity or dissolved solids readings.

4.6 Coastal zones

It is considered that, with the reduction in area recommended above, there will be little impact on the coastal zone. Some localized impact will occur as new jetty, warehouses and packing house facilities are developed, especially where these are around harbours. However their impact, taken in the context of overall harbour impact is likely to be minimal.

4.7 Conservation areas

The reduction in agricultural area has removed the immediate threat to the major conservation areas in Andros and Abaco (Sections 4.2.1.1 & 4.2.1.2).

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It is strongly recommended that the Minister of Agriculture use his powers to define and enact the conservation areas proposed for Maidenhead Reserve, Staniard Creek, Andros and for Crossing Rocks, Abaco.

Conservation issues will also be strengthened by the appointment of the Conservation Officer (Section 5.2) and the conservation recommendations made for forestry and coastal areas (Section 7.5 & 7.6).

4.8 Solid waste and agricultural effluents

The problems of solid waste disposal are largely related to the abattoir and the Produce Exchange in Nassau. The former is under-utilized at the moment, and the main problem of solid waste is the open, and unsanitary container in wastes are kept prior to collection. This container needs a fitting cover, and arrangements should be made to ensure the collection of slaughter waste and carcasses would be undertaken on all killing days.

The produce Exchange is a greater problem. The present facility is inadequate, and poses a public health risk in the form of infestations. Because of the inability of the facility to separate the storage of waste and salable produce in discrete areas, pest containment is the best measure possible at the moment. Pest eradication is practically impossible.

If the facility of the produce Exchange is to continue, it needs to be radically improved or rebuilt/relocated. A major requirement is that the design must allow for easy separation of waste and salable produce; and that storage areas must be set well apart. Figure 3 sets out the diagrammatic flow pattern that an ideal facility might adopt to facilitate waste disposal and allow for infestation control.

Collection of produce exchange waste must also be considered. The design in Figure 3 shows separate containers on the external loading area. These must be (at least) lidded, containers designed to be accommodated by the collection facility. The practice of the Ministry of Agriculture removing the waste produce to the tip at GRAC should cease, and the public waste disposal system be utilized for waste removal.

The quantities of waste produce at the Produce Exchange could be reduced by better grading and storage facilities at the Packing Houses, and better storage during transport. This may increase the waste at the Packing Houses and some form of disposal must be considered here. The use of waste produce for animal feed or compost should be considered (see Section 7.4).

Any development of intensive ('broiler') husbandry will need careful attention to the disposal of agricultural effluent. The present systems of sewage disposal are potentially hazardous where

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adjacent aquifers are used for water supplies. It is recommended that no intensive livestock system be allowed to develop unless adequate provision is made for the treatment of the effluent produced. Such treatment systems should be of a digestor, filtration or activated sludge type, set above ground to permit cleaning, and repair; in which instance the use of underground septic tanks is not recommended. In no instance should slurries be held in unlined pits.

4.9 Economic/ecological maps

As part of this report a series of maps have been produced to define the proposed irrigated areas; the areas removed (under Section 4.2.1 above) from irrigation; conservation areas; forest roads; and water reserves. These maps serve to assist in the land use definitions that are necessary in considering a project of this scale and complexity.

Maps have been produced for Andros and Abaco, to the same scale and form as those provided by the Irrigation Engineer. Overlay maps (without forest roads) have been produced for northern Eleuthera and southern Cat Island.

The maps provided are as follows:

	Map Reference Number
North Andros	AN/E/3A
North/Central Andros	AN/E/3B
North Abaco/Little Abaco	AB/E/3A
Central Abaco	AB/E/3B
South Abaco	AB/E/3C
North Eleuthera (Bogue)	EL/E/3A
South Cat Island	CT/E/3EF

Figure 4 shows the key to the map symbols.

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5 INSTITUTIONAL STRENGTHENING

5.1 Introduction

The need to improve not merely the Ministry of Agriculture's role in the execution of its conservation duties, but also its contribution to the wider dialogue with other organizations is paramount. The Bahamas needs to conserve its natural heritage, both from the standpoint of its international obligations and reputation, and also for the safeguarding of its economic dependence on the general perception and influx of tourists, particularly from the North American continent.

This section considers simple, practical measures that can be implemented under the present legislation of the Bahamas, which would rapidly improve the situation of the Ministry's role in conservation; the general communication within the governmental and non-governmental bodies responsible for environment, natural resource management and conservation; a start to the delicate process of land use regulation; and consideration of agrochemical control.

It is considered that the conservation responsibilities of the Ministry of Agriculture fit it for a pivotal role in the development of broader national strategies in respect of the wise and safe use of the Nation's environment and resources.

5.2 Conservation Officer

The post of Conservation Officer in the Department of Agriculture has been ill defined, and is currently unfilled. The current perception is that the Conservation Officer is a lower-management post, largely related to keeping records of the wild birds, animals and plants, and maintaining an 'ad hoc' relationship with the Bahamas National Trust. There is apparently little awareness within the Department (particularly at middle-management levels) of the inter-relationship between conservation, environment, and natural resources, or of the role that could be fulfilled by the Conservation Officer to strengthen the environmental responsibilities of the Ministry and assist the sustainable development of agriculture in the Bahamas.

This section re-defines the post of Conservation Officer, and considers the wider role that this officer should play in executing the full range of responsibilities that rest within the conservation portfolio of the Ministry of Agriculture. It is recommended that this post (as re-defined here) be filled as soon as possible.

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5.2.1 Job Description General

The Conservation Officer will be the focus of the environmental, conservation and resource management activities of the Ministry of Agriculture. Additionally, the Conservation Officer shall represent the Ministry of Agriculture on the Environmental Affairs Committee, on the Council of the Bahamas National Trust, and any other bodies as shall be determined by the Minister.

Specific

The Conservation Officer shall execute, but not necessarily be limited by, the following specific duties:

(a) To carry out all necessary duties of the Ministry of Agriculture with respect to the obligations of the Department under all legislation pertinent to the protection of wild birds, animals and plants, and to the conservation of terrestrial and marine resources.

(b) To maintain a database of information relating to conservation and environmental matters in general, and specifically with aspects relating to agriculture, livestock, aquaculture and fisheries.

(c) To advise other members of the Ministry of Agriculture of any pertinent information or data relevant to the improvement of agriculture, livestock, aquaculture or fisheries in the Bahamas.

(d) To be the main governmental contact between Non-Governmental Organizations concerned with conservation, natural history and marine resources, specifically with the Bahamas National Trust, and to advise the Ministry of Agriculture on measures necessary for the conservation of the natural history and heritage of the Bahamas.

(e) To act as the Secretariat for the proposed Environmental Affairs Committee, and to maintain liaison between appropriate non-governmental organizations and the Committee.

(f) To advise the Ministry of Agriculture on the appropriate changes in legislation and regulation required to improve the environmental, conservation and natural resources of the Bahamas.

(g) To execute any necessary studies that may improve the database from which the Ministry of Agriculture can better execute its environmental and natural resource functions.

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5.2.2 Qualifications

The post holder must be a University graduate with at least a Bachelors Degree in one or more disciplines of Natural Sciences. Ideally the post holder will have further qualifications and/or experience in one or more of the following fields: chemistry, geography, geology, fisheries science, agricultural sciences, or veterinary science. An interest in ecology, together with an ability to undertake both desk and field studies as well as administrative duties is essential.

5.2.3 Level of appointment

It is recommended that the position be at the level of Senior Assistant Director, and that the Conservation Officer will work in the Office of the Director of Agriculture and report directly to the Director of Agriculture.

It is accepted that it may not be possible, at this time, to find a suitable local candidate for this post. Under these circumstance it is recommended that the post be filled by a international recruitment under contract. At the same time a suitable local candidate should be appointed as Deputy Conservation Officer (at Senior Agricultural Officer level), to be trained 'on-the-job', and to assume the Conservation Officer post on the expiration of that person's contract.

5.3 Inter-departmental liaison

There are a number of ministries, departments, public corporations and non-governmental organizations (NGOs) that are responsible for various aspects of environment and natural resource management in the Bahamas (summarized in Figure 1). This diversity of organizational responsibility is not, in itself, an undesirable situation. Many functions fit naturally into the collective brief of particular ministries (eg: pollution control fits in with the general public health responsibilities of the Ministry of Health). However, a system of formal, and continuous liaison between these groups is absent, as a result developments proceed without regard to the concerns of other groups, and control is piecemeal. In the absence of a single agency to monitor and control the natural resources and environment of the Bahamas, there is an urgent need to develop an inter-departmental network that will allow for forward planning, better communications and management. Discussions indicate that senior management is aware that the present situation is untenable, but due partly to a lack of a formal system of liaison and the over extension of middle and senior management, no real progress towards meaningful co-operation has been made.

All national institutions are headquartered in Nassau, New Providence with very few having adequate field stations in the Family Islands (all the other islands of the Bahamas). As a result

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there are considerable problems associated with poor communications, and transportation of personnel from Nassau into the field. Many of the Family Islands have thus received little, if any, attention with respect to monitoring or control measures.

Whilst some institutions have adequate equipment for monitoring purposes, a further constraint is found in the numbers of available, trained staff. This is, in part, a reflection of the small population of the country, but is also indicative of the restricted approach to job descriptions (which should reflect a broader appreciation of the issues of the country as a whole).

This situation could be remedied by the creation of a single natural resources and environment agency. This course of action, though highly commended could have the following adverse consequences or counter-productive effects in the short-term:

- the manpower requirements of such an agency would denude existing agencies of skilled managerial and technical staff, and leave them unable to execute other required functions; unless initiatives were taken to engage new staff or strengthen performing centres by way of technical assistance support.

- in the absence of established systems of monitoring and control, the new agency would be unable to properly execute its functions for a considerable period of time.

- integration of natural resources and environmental control into a single agency, without prior definition of functional areas, development policies and environmental regulations could lead to considerable conflicts of interest within the newly created agency.

It is recommended that some immediate action be taken, within the framework of the existing legislation and allotted responsibilities, to develop both the necessary inter-ministerial and governmental/non-governmental liaison, as well as addressing the main problems associated with ensuring sustainable development and effective environmental management throughout the country.

In this section recommendations are made for two governmental committees (the Environmental Affairs Committee, and the Land Use Regulatory Committee), to provide the appropriate lines of governmental/non-governmental liaison and address the technical problems in environmental and natural resource management; and the more important issue of land use administration which will be essential to the success of any further progress in these fields.

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5.4 Environmental Affairs Committee

5.4.1 Rationale

Environmental and natural resource responsibilities are spread between four Ministries (Health; Agriculture, Trade and Industry; Works; and Consumer Affairs); water resources are managed by the public Water and Sewerage Corporation; and conservation and National Parks by the Bahamas National Trust. All these bodies have their responsibilities and powers defined by Statute. In addition to these bodies, there are other non-governmental and international bodies that have an interest and involvement in aspects of Bahamian environment and natural resources.

These bodies , at a senior technical level, need to have a formal exchange of data and analysis in relation to individual policies and projects formulated either unilaterally or jointly. Presently such policies and projects are conceived and developed independently with little (if any) input from outside. Communications between bodies seem to be most effective on a personal and 'ad hoc' basis.

To improve this situation, and develop a more efficient, integrated approach to policy formulation and project development, it is strongly recommended that an Environmental Affairs Committee be set up. This organization will act as the technical forum for the pertinent ministries, as well as providing their respective organizations with a comprehensive overview of the concerns and recommendations in relation to conservation, environmental control, natural resource management and the heritage of the Bahamas.

5.4.2 Mandate

The Minister of Health carries the responsibility for "promoting the conservation and maintenance of the environment in the interest of health, for proper sanitation in matters of food and drinks and generally, for the provision and control of services, activities and other matters connected therewith or incidental thereto"; under the Environmental Health Services Act, 1987.

Under Part II, Section (6), of this Act, and the Schedule thereto, an Environmental Health Services Board shall be set up to advise the Minister as to any matters which the Minister refers to the Board relating to environmental health. It has been suggested that the proposed committee could function as part of the duties of the Environmental Health Board. However, the remit of the proposed Environmental Affairs Committee covers a wider scope than merely environmental health, and its purpose is to advise various Ministries of developments over a wide field, and should not be restricted to the primary concerns of any single ministry, or issues.

It is considered that grounding for the Environmental Affairs Committee is best provided by Part II, Section 5(1)(d), of the

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Environmental Health Services Act, 1987, which places on the Department of Environmental Health Services the duty to "promote the planning, approval, funding and implementation of measures designed to ensure the wise and safe use of the environment".

Such a duty would permit the Director of the Department of Environmental Health Services to convene meetings of the Environmental Affairs Committee, to which representation from the appropriate ministries would be invited. The Department of Agriculture could be requested to provide the office of the Conservation Officer as Secretariat for this Committee. This achieves the objectives of immediately developing a formula for liaison at a senior level between the Department of Agriculture and Department of Environmental Health Services (and indirectly with the other departments and organizations with which both bodies liaise independently; while allowing the efficient use of manpower, by placing the Secretariat in a newly strengthened office, rather than further overloading the already burdened Department of Environmental Health Services.

Such an arrangement would also encourage active participation by the other Ministries. In this regard the Ministry of Works and the Ministry of Consumer Affairs are the two most involved.

5.4.3 Terms of Reference

The purpose of the Environmental Affairs Committee is to provide a forum between governmental organizations concerned with conservation, environmental control, the natural resources and heritage of the Bahamas; and through this liaison provide their organizations with a comprehensive overview of the concerns and recommendation (collectively arrived at) necessary for the sustainable development of the Bahamas.

The Committee will consider the potential environmental impact of specific policies and projects sent to it for consideration, and prepare guidelines and recommendations to mitigate and reduce any negative environmental impacts.

The Members of the Committee will thus assist their various government departments in the preparation of policies and projects, in the light of all identified environmental and conservation requirements, as well as the personnel, mechanisms and services necessary to meet these requirements.

The Committee will advise the governmental organizations responsible for national planning and development of the wider concerns and conclusions with respect to the wise and safe use of the environment.

The Committee will liaise with any other governmental or non-governmental bodies as it see fit, in order to obtain the widest possible database, which it may then analyse and make recommendations.

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5.4.4 Composition of the Committee

The Environmental Affairs Committee will be an advisory body to various government departments and so should reflect its public duties. The Committee should be small, with the ability to invite representatives from other organizations to participate on specific matters. The inputs from non-governmental or international organizations, as well as the private sector, could thus be included; either directly by invitation or through existing liaison channels with standing committee members.

It is therefore recommended that the Committee comprise of the following representatives or their nominates:

Chairman Ministry of Health Director, Department of Environmental Health Services Secretary Ministry of Agriculture Conservation Officer and Industry

Members Ministry of Works Director, Department of Lands & Surveys

Ministry of Consumer Director for liaison Affairs with Water & Sewerage Corporation

5.4.5 Meetings

The Committee should meet every two months, against a set agenda. The agenda should be available to all members at least two weeks before a meeting, and minutes should be available to any member within two weeks of a meeting. Alternates should be provided in the event that any delegate be unable to attend a meeting.

5.5 Land Use Regulatory Committee

5.5.1 Rationale

The forms of land ownership (Section 2.4), and the restrictions that they apply to regulated land use, are the major constraint on an effective policy of environmental and natural resource management. The problem of developing regulations to enforce and encourage the use of land within a policy of resource allocation is extremely complex, and the solutions must reflex the cultural and political aspirations of the Bahamian people.

Nevertheless there is a need for the process to begin, and in this regard, a definition of the potential uses, timescale and systems for resource management and integrated development should be elaborated.

It is therefore recommended that a Land Use Regulatory Committee be set up, with a duty (as the first phase in an ongoing process) of defining the resource zonation of the country, both in a spatial and temporal framework.

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5.5.2 Mandate

Given the importance of the task assigned to the proposed Committee, it is recommended that the committee be mandated by the Cabinet, through the Ministers concerned. The Ministers will necessarily be able then to delegate the technical work of the committee to the appropriate level of officer within their ministries.

5.5.3 Terms of Reference

The Land Use Regulatory Committee will consider the systems available to regulate the use of the natural resources of the Bahamas, including the zoning and regulation of all forms of development and resource exploitation.

As a first phase in the process of regulation, the Committee shall be responsible for the development of a Master Plan for the country, by means of an exercise to zone all parts of the Bahamas with respect to the natural resources and development options in all areas.

The Committee shall take account of the criteria used by the various statutory departments responsible for individual forms of control and development, but shall consider the possible options best suited for the sustainable development of the country. To this end the zonation defined by the Committee shall be in the form of a Master Plan for the Bahamas, specifying areas not merely spatially, but also indicating the potential for multiple use of resources, together with a timescale for exploitation and development.

The Committee shall periodically review and update the Master Plan, in the light of changes in the social and economic climate of the country.

The Committee, as a second phase, shall formulate regulations to be enacted to ensure that the resource use, as defined by the Master Plan, can be controlled both in the public, common and private sectors of land tenure, in order to protect the environment of the Bahamas whilst maintaining progress in economic and social development.

5.5.4 Composition of the Committee

It is recommended that the Land Use Regulatory Committee shall be composed of:

The Minister of Finance
The Minister of Works
The Minister of Consumer Affairs

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The Minister of Tourism and Public Personnel
The Minister of Agriculture, Trade and Industry
The Minister of Housing and National Insurance

The Committee members shall decide on and appoint their Chairman and the form of their Secretariat. All members of the Committee may delegate technical matters to any persons in their ministries as they see fit. The Committee may require such individual, or other persons and representatives of governmental and non-governmental organizations, to assist in the work of the Committee on specific matters.

5.5.5 Meetings

Meetings of the Land Use Regulatory Committee should be held every four months, to review the work of technical sub-group, and define future tasks, including regulations to be enacted.

5.6 Agrochemical regulations

5.6.1 Rationale

Given the limited freshwater resources of the Bahamas, the dangers in the handling of certain chemicals, and the persistence or bioaccumulation of pesticides in the environment, the control of agrochemicals is an essential requirement if the quality of the Bahamian environment is to be maintained.

5.6.2 Mandate

The Environmental Health Services Act, 1987, gives the Minister (Health) the responsibility to ".. regulate, monitor and control the actual and likely, contamination or pollution of the environment from any source, ensure compliance in all matters and activities relating thereto and establish minimum standards required for a clean, healthy and aesthetically pleasing environment" (Part II, 3(2)).

Furthermore, under Part IV of the same Act, the Minister may make regulations for:

> "pest and vector control including rodent proofing of buildings, preventive measures and use of pesticides" (Part IV, 17(c))

> "the prevention and control of pollution of any waters, measures for monitoring and ensuring the safety of water supplies and prevention of the supply and use of unsafe water for human consumption" (Part IV, 17 (e))

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and procedures relating to the inspection of stores, ›ssing and distribution of agrochemicals, storage in ite, and use of such chemicals, as well as rights any he seizure, impoundment and destruction of chemicals d in breach of the regulations.

s for the breach of any regulations.

ommendations for development of regulations

›d for both technical and legal inputs in the and enactment of these regulations. Both the : Environmental Health Services and Agriculture should ı the technical process. At present, both Departments :his area, and could not provide the full range of l to the legal experts in drawing up suitable ›r enactment.

ore strongly recommended that the Department of Health Services (as the primarily responsible body) ıical Assistance in the form of a suitable technical ›pecialist to assist local legal specialists in the these regulations. Further, the recommendation is ıvolve the Department of Agriculture who will be the ı of monitoring of agrochemicals, and whose concerns nust be taken into account in the development of this

rms of Reference of the technical specialist, the cts should be included:

ın of the technical standards for the regulation of stribution and sale of agrochemicals.

rate with counterparts in the Departments of Health Services and Agriculture, and the legal lefine the methods for monitoring and enforcing ›gulations; and to provide appropriate guidelines for : such regulations to cover the methods of monitoring use.

requirements for the packaging, storage, transport, ıfe handling of agrochemicals.

ı Bahamian authorities on the sources and methods to p-grade and up-date their information on specific including the obtaining of international standards, ysis, and national prohibitions that may affect the ıian produce.

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D TRAINING

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ıental aspect the value of the Extension Service ıdvice to farmers on agrochemical use, and the ıe safe application of such use. It is also the Extension Service must be able to sample and r and soils in and around the farming areas, as al level of use of agrochemicals in their areas. ould be covered in the general training of the ·, particularly where extension officers are at ciate graduate level. This section considers the general training to better equip the Extension task of agrochemical monitoring.

ıl monitoring

ll informed extension service, with a presence on is paramount if agricultural development is to be regard to environmental monitoring and control the will have to play a major role.

tment of Environmental Health Services has the or environmental monitoring and pollution control hemicals), the Department would not have enough a monitoring function in all the Family Islands, h regard to groundwater quality and agrochemical t is not considered desirable to transfer the or these tasks to the Department of Agriculture, ag period that laboratory development and staff ake, and the duplication in facilities with the whose laboratories will remain for other public

sary to consider a close cooperation between the and in this regard the role of the Conservation forum of the Environmental Affairs Committee will veloping a working relationship. In practical terms ficers, being on site and knowing of the usage of agrochemicals, are the best cadre of persons to tions of sampling and monitoring, with the Public g the analytical backup.

recommended that the Extension Officers be trained evel of Public Health Inspectors, thus certifying ıples (water, produce, chemicals, etc.) and giving ıspect premises and stocks. The course for training service course, leading to the Diploma of Trained r. The course would take an University graduate or an Associate of the Graduate College about 9

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›aseline for agrochemical contamination of tem of water quality monitoring; re-use of solid n of conservation and nature reserve management, hat specific research studies, and technical :orporated into the design of the project, and e first phase of project implementation.

monitoring

ırcise of water quality monitoring will require ›rior to implementation. Part of this planning a preliminary exercise to provide information on costs of a monitoring programme.

exercise, there will need to be a collaborative ›partments of Environmental Health Services and cially between the Public Analyst and the sion Service. It is considered that the exercise :iod a period of not less than four months, to :y seasons (August to December). Some upgrading services, purchase of sampling equipment and ecessary before this exercise can commence.

:omprise of a series of individual exercises, j logistical data and costs on the following

sites for each island
y of sampling at each site
ıumber of samples to be taken
y of sampling
›f storage and transportation
:y of using field kits for measurement
:s to be measured routinely

study

ıd Bahama Star citrus farms in Abaco are the . agricultural enterprises in the country. :ing of their irrigation and agrochemical with water quality monitoring of the surrounding ld valuable data on groundwater contamination, ›lanning.

hat both farms be approached to allow access to nd provide data on types, quantities and times ›lication. If co-operation is not forthcoming, ıt be given to using powers under the :h Services Act to permit monitoring of the

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operations to take place. In any case the surrounding aquifer should be continuously monitored using a radial network of wellheads, spreading outwards from the boundaries of the farms.

This exercise will take up considerable amounts of manpower, both in the field and in the laboratory. It is accepted that personnel may not be available, and that the study may best be carried out as a short-term Technical Assistance project, with a component for analytical services.

It is strongly recommended that such a study be done, as the baseline for agrochemicals is non-existent; and agricultural development within the Bahamas should be allowed to proceed as far as the potential for groundwater contamination will allow. In the absence of a baseline, restrictions on agricultural expansion will (of necessity) be arbitrary, in order to safeguard the general public health and the Nation's water reserves.

7.4 Solid waste managment and re-use

The problem of the waste produce at the Packing Houses and the Produce Exchange must be dealt with. Even allowing for a significant improvement in operations there would still be a large quantity of waste to be disposed of. In the case of the Produce Exchange, if waste could be kept down to around 15% of incoming produce, a minimum of 600 tons a year would still be generated. A 50% improvement in the Packing House and transport system would result in an estimated 1000 tons of produce might still need to be rejected.

The present system of using this waste for landfill, both at the Packing Houses and in New Providence, should be discontinued. The need to develop organic soils in the Bahamas is paramount, and it is recommended that this material be recycled as compost.

Re-use of the waste material as compost may not be as economic as landfill in terms of capital investment. The true vale of the system must be seen in the improvement of local soils, with the concomitant reduction in the need for fertilizers, and the improvement in the potential for agrochemical contamination of groundwater.

Compost can be considered to be of a greater long-term benefit than the re-use of the waste produce as animal feed, especially for pig rearing. It is accepted that feed production might be both cheaper in terms of capital investment, and more capable of providing quatifiable returns on investment.

At the Packing Houses, and on the farms themselves, small scale composting should be encouraged. This will provide a continuing source of soil dressing to the small farmers that will assist in offsetting the costs of increased production using agrochemicals.

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For the concept of waste re-use to become a reality, it is recommended that a short-term Technical Assistance project be reformulated, to engage a suitable expert to advise on the possible technology, and costs. The Terms of Reference for this Solid Waste Specialist should include:

(a) Estimation of the amounts and seasonality of waste produced at the Packing Houses and the Produce Exchange, taking into account the existing situation as well as plans for future improvement in the system.

(b) Identification of the possible systems of waste re-use, together with detailed specifications as to equipment, infrastructure, energy requirements, storage, etc.

(c) Estimation of the costs of the recommended options, together with a comparison of costs for municipal or commercial collection and disposal. Costs should also reflect the benefits to be gained by the re-use of the waste material.

7.5 <u>Forest conservation areas</u>

Within the pine forests a number of areas have been proposed as conservation reserves. There is now a need to more precisely define the individual areas, with a detailed justification of the need for such reserves, together with a practical system of protection and wardening. It is accepted that the Department of Forestry is equipped (at present) to undertake the day-to-day wardening of these forest areas, and systems should be set up to allow their practical involvement to be coordinated with the conservation responsibilities of the Department of Agriculture.

It is therefore recommended that the Environmental Specialist to be engaged under a Technical Assistance Agreement between the Department of Forestry and the Inter-American Development Bank, should have his/her terms of reference modified to include:

(a) Assess the present nature reserve areas in the islands of Andros, Grand Bahama, New Providence and Abaco, and advise on the need for the establishment of any new reserve areas, and the agreement to reserve creation from existing proposals.

(b) Assess the capability of the national institutions to execute, at a technical level, their responsibilities for conservation, natural resource and environmental management.

(c) Draw up a plan of action to define, with timescales and costs, the necessary personnel, equipment, services, institutions and inter-institutional co-operation that will improve the technical monitoring, management and conservation of the natural environment of the Bahamas.

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In addition to the above specialist it is further recommended that a request be made by The Department of Forestry for a Hydrological Specialist to be engaged on a short-term Technical assistance contract, to undertake an estimation of the effect of the pine forests on the groundwater table and the capacity of the underlying aquifer.

7.6 Coastal protection studies

It is accepted that the project will have little impact on the coastal environment, but it is also noted that this area has considerable importance not merely in respect of tourism potential but also in the potential productivity of the mangrove areas and the saline swamps.

It is therefore recommended that, as a component of the conservation responsibilities of the Department of Agriculture, a short-term Technical Assistance project be requested by the Department, to permit the drawing up of terms of reference for a complete study of the coastal and marine conservation needs of the country. It is expected that this will require close collaboration with the Department of Fisheries, but it is noted that the responsibility for these areas presently falls within the overall conservation and natural resources portfolio of the Ministry of Agriculture.

7.7 Estimation of Guano Reserves

The use of bat guano by the small farmers of the Southeast islands could considerably assist them in improvement of soils, as well as cutting back on fertilizer use. To this end a study of the reserves in the Southeast islands should be carried out, together with an estimation of their sustainability and exploitation rate.

It is therefore recommended that two specialist be sought to undertake a Technical Assistance project to determine the extent and sustainability of these reserves. The specialists would be: (a) a natural resources expert, with experience in estimation of guano reserves and the methods for their extraction; and (b) a mammalian zoologist with experience in bat populations. It is possible that one expert could undertake both aspects of the study.

The Terms of Reference for this study should include:

(a) The determination of the locations of the major bat caves, means of access, and methods (and costs) to improve access.

(b) An estimation of the quantity and quality (as fertilizer) of the guano and bat earth reserves in each location.

(c) An estimation of the replenishment of the reserves by any resident bat populations.

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(d) An estimation of the exploitation rate for guano at each location, together with a cost plan of extraction and use within the local farming community.

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8 ACTION PLAN

8.1 Introduction

This section will consider the proposed phased development of the project, and the various environmental programmes and actions that should be undertaken in each phase. Wherever possible an indication of the budgeted cost of programmes have been given.

8.2 Phase 1

8.2.1 General objectives

The agricultural development programme will be started during this phase, and it is expected that the programme will broadly be in line with the recommendations (in respect of irrigated land) made in Section 4.2.1.

During this phase the foundations for future environmental management must be laid. Certain programmes will relate to strengthening of the database and institutions, whilst other will be concerned with specific problems areas. With both technical assistance projects and training there must be some delay, whilst staff are recruited and equipment purchased. Such programmes may therefore over-run into the proposed timetable for Phase 2.

8.2.2 Institutional strengthening

Strengthening of the institutional and administrative framework for environmental and natural resource management is a high priority if these sectors are to be management efficiently. To this end the recommendations in Section 6 should be put into effect.

The appointment of the Conservation Officer and the setting up of a system of inter-departmental liaison, together with the formation of the Environmental Affair Committee, are the immediate tasks for this programme.

As land use regulations are the key to the future successful and controlled development (in any sector) within the country, the formation of the Land Use Regulatory Committee is also urgent. This body should ensure that the first task: the development of the Master Plan, is started within this phase.

It is accepted that the cost of Mater Plan development will be high, and that this may require external funding and technical assistance. The inputs required will be dependent existing economic and technical resources. The Committee must therefore develop a costed programme of operations as a first stage in Master Plan production.

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8.2.3 Water quality studies

The development of a permanent system for water quality monitoring is essential, given the localised nature of this resource and its vulnerability to contamination.

The recommendations in Sections 6.1 and 7.2 should therefore be put into effect. As noted, this will require an increase in staff in the Public Analyst's laboratory, as well as further gas-chromatography equipment . The latter should be budgeted at about $ 130,000.

The specific study on agrochemical residues in Abaco (Section 7.3) should be put into effect.

Consideration of these separate, but related programmes, indicates that there will be a need to find further funds for equipment and increased labour/traveling costs, as well as training component for staff. There may also be a need for technical assistance in programme design. The logistics of sampling, storage and transport will have a considerable bearing on the methodologies chosen for monitoring. It is therefore recommended that all three programmes discussed in the above three paragraphs be brought together under a single sub-project, and a request for Technical assistance for the extra funding and technical inputs made. The three programmes could be executed within a sub-project budget of between $ 300,000 - $ 400,000.

The effect of executing these programmes will be to provide the means of developing a water quality monitoring programme, and baseline data for agrochemical contamination of water supplies. This information is crucial for future management of water resources.

8.2.4 Agrochemical control measures

The training of extension workers as Public Health Inspectors is very important, both to permit a greater inter-action between the Ministries of Agriculture and Health, and also to ensure early control and management of agrochemical use (particularly in commercial farms). The recommendation of an initial 4 extensions workers to be so trained should be followed, the cost of this being some $ 12,000.

Section 5.6 details the requirements for the development of pesticide regulations. As regulations will take some time to become law, this task should be given high priority, using the small technical assistance consultancy as recommended (budgeted within $ 50,000).

Once agrochemical regulations and controls are in place, and in view of the comments in Section 5.6.4, consideration should be given to initiating a public awareness campaign, to inform the public on the hazards and safe handling of agrochemicals. This

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campaign should be seen as a long-term event, and the designed accordingly. An initial budget of $ 50,000 should be set aside for the initial campaign which must also define the intervals and amounts for subsequent inputs.

8.2.5 Natural resource development : Forestry

There is a need to enact the proposed Forestry Law (Section 2.5.4) to allow the Forest management Plan to be fully effective. This is a first step to the successful exploitation of this natural resource.

The pine forests of the Bahamas represent an available resource, ready (in some areas) for exploitation. The Forestry management Plan should now be put into effect, and forest production started. This will both assist the economic base of the country, as well as defining productive timber areas to be keep free of other destructive development.

It should also be possible to consider the practicalities of a multiple use system of livestock/forestry, as proposed in Section 4.2.4.

The conservation areas proposed for the Maidenhead Reserve, Staniard Creek, Andros and for the Crossing Rocks/Hole in the wall reserve, Abaco should be put into place, in accordance with the recommendations (including wardening) in Section 2.5.4.

8.2.6 Technical assistance projects

Section 7 defines a number of projects that should be undertaken, most requiring external technical assistance. These projects have a direct bearing on the improvement of future environmental management and agricultural development.

The solid waste and re-use project will be of importance in respect of the disposal of solid wastes and more directly their potential for re-use. The development of a local soil-dressing, to improve the soils of the island, and available to the artisanal farmers will be of considerable benefit to these people.

The proposed Technical Assistance consultancy for solid waste disposal and re-use should fall within a budget of $ 50,000.

The other source of both soil dressing and fertilizer is bat guano. The technical assistance proposed for this will need (probably) a two expert team, and considerable inter-island travel. This project should be budgeted within $ 100,000.

The additional proposals for inputs in Forestry and Coastal Conservation will rely on the timing of those programmes, and no further economic inputs are envisaged at this time.

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8.3 Phases 2 & 3

The detailed content of these phases will be determined by the progress and results of the work undertaken in Phase 1. It is accepted that there may be an over-run of certain programmes into Phase 2, and that individual projects may not be fully defined until this phase. However it is important that the Environmental Affairs Committee, as the primary group responsible for inter-departmental liaison, identify suitable programmes, extensions to existing programmes, and courses of action to permit a smooth continuity in environmental management.

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BAHAMAS : AGRICULTURAL SERVICES DEVELOPMENT FEASIBILITY STUDY
TABLE 1
FISH & FARM STORE AGROCHEMICAL DISTRIBUTION : 1988

CHEMICAL	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.	DEC.	ANN.AMOUNT (9 mths) (Kg/L)
ABACO													
BAHAMA TOM&VEG DUST	5	23		7									34.1
FERTILIZER 12-8-30						91		1363	3181				4635.9
FERTILIZER 4-9-6	273	1136	727	454	364	636	91						3681.4
FERTILIZER 8-18-8						1591	1318						2908.8
ACKLINS ISLAND													
FERTILIZER 4-9-6	91		182	227	591	91							1181.7
ANDROS													
BAHAMA TOM&VEG DUST		23											22.7
DIATHANE		5											5.5
DIAZINON									6				5.8
FERTILIZER 12-8-30					318		91		818				1227.1
FERTILIZER 4-9-6	909	45	1227	409	1636	1091	136	91	227				5772.1
FERTILIZER 7-14-7	182						227	2272	45				2727.0
FERTILIZER 8-18-8			1363	10544	4727	273	45	5045	10681				32678.5
GRAMOXONE						4	4						7.7
REGLONE								15	8				23.1
CAT ISLAND													
BAHAMA TOM&VEG DUST			163		23								186.1
FERTILIZER 12-8-30	45	45		45					91				227.2
FERTILIZER 4-9-6	7772	2091	3272	10317	7590	8817	1182		4409				45450.0
FERTILIZER 7-14-7	1863						273		8181				10317.1
FERTILIZER 8-18-8				45	273		1636		591				2545.2
SEVIN DUST 10%	2												2.2
CROOKED ISLAND													
FERTILIZER 4-9-6	1045		227	454	182								1908.9

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TABLE 1 (CONTD.)
FISH & FARM STORE AGROCHEMICAL DISTRIBUTION : 1988

ELEUTHERA

ATRAZINE					4	4		69		76.9
BAHAMA TOM&VEG DUST					9	14				22.7
BLACK LEAF 40								4		3.8
DIAZINON								8		7.7
DIPTEREX						1				1.0
FERTILIZER 12-0-30	45							4545		4590.4
FERTILIZER 4-9-6	591	1500	45	409	2000	2863	45		19362	26815.5
FERTILIZER 7-14-7						91	500	909	818	2317.9
FERTILIZER 8-18-8			364	8181		727	91	1227		10589.8
GRAMMOXONE	15	19	12		42	38				126.9
LIQUID SEVIN	6									5.8
MALATHION							4	4	4	11.5
MALATHION PG	4						4	4	4	15.4
OIL EMULSION						31			4	34.6
PRINCEP(SIMAZINE)						5				4.5
REGLONE		4	4		8	42	8	15	15	96.2
SEQUESTRENE 138Fe	7							5		11.4
SEQUESTRENE 138Fe								5		4.5
SEVIN DUST 10%	0									0.2

EXUMA

BAHAMA TOM&VEG DUST					91					90.9
FERTILIZER 12-0-30	45							45		90.9
FERTILIZER 4-9-6	2818	5181	1863	1636	5045	2682	1318		954	21497.8
FERTILIZER 7-14-7	45						136	909	1091	2181.6
FERTILIZER 8-18-8						91	1227	1318		2636.1
GRAMOXONE	12	8	8		27	31	8			92.3
MALATHION PG	4		4		4				395	406.5
REGLONE							58	108	38	203.8
SEVIN DUST 10%	2	2								4.4

GRAND BAHAMA

FERTILIZER 12-0-30	45	91								136.3
FERTILIZER 4-9-6		454		91	545				454	1545.3
FERTILIZER 7-14-7							182			181.8
FERTILIZER 8-18-8				45	91			636		772.6
FURADAN								1		0.9
GRAMOXONE					4					3.8
SEVIN DUST					2					2.4

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TABLE 1 (CONTD.)
FISH & FARM STORE AGROCHEMICAL DISTRIBUTION : 1988

LONG ISLAND

ATRAZINE	5						14		5				23.2
BAHAMA TOM&VEG DUST	5	9											13.6
CUPRAVIT BLUE			2										2.0
DIPTEREX			2										2.0
FERTILIZER 12-8-30	91	45	227				227	182	1363				2136.1
FERTILIZER 4-9-6	1454	5227	5908				909		8590				22088.7
FERTILIZER 7-14-7	682						318	1045	1682				3726.9
FERTILIZER 8-10-8			91				2772	2500	182				5544.9
GRAMOXONE	19	15											34.6
MALATHION PG			1					1					1.9
PRINCEP(SIMAZINE)							9						9.1
REGLONE							46	15	4				65.4
SEVIN DUST	2												1.6
TRAMISOL 24 oblt			0										0.0

TABLE 2
CHEMICAL ANALYSIS OF SELECTED DEPTH SAMPLES : ANDROS 1972
(FROM: LITTLE ET AL. 1976)

	SAMPLE SITE & DEPTH (results in mg/l)									
	B33 10M	B1 10M	B67 10M	B23 10M	B41 35M	B80 40M	B35 30M	B52 10M	B84 45M	B19
Calcium (Ca)	61	51	64	43	85	50	64	34	70	38
Magnesium (Mg)	23	9	48	18	75	40	41	3	19	5
Sodium (Na)	226	96	346	84	624	320	290	31	226	44
Potassium (K)	8.6	14.5	18	3.4	28	14	12	1.5	9.7	1.3
Strontium (Sr)	1.77	1.37	1.73	0.91	1.16	1.4	1.14	0.82	1.64	
Alkalinity (CaCO3)	110	80	130	120	140	130	160	90	110	80
Chloride (Cl)	406	188	690	144	1190	558	534	54	420	52
Sulphate (SO4)	87	58	146	52	213	116	126	48	120	44
Nitrate (N)	4.4	5	4.5	2.3	5.3	3.2	2.7	<0.1	2.7	<0.1
Floride (F)	0.2	0.12	0.17	<0.1	<0.1	<0.1	<0.1	<0.1	0.17	<0.1

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TABLE 3
INCREASE IN IRRIGATED LAND (WITH PROJECT)
(FULL IRRIGATION)

ISLAND	PRESENT IRRIGATED LAND (ACRES)	PROPOSED IRRIGATED LAND (ACRES)	PERCENTAGE INCREASE TOTAL LAND (%)
ELEUTHERA	440	1241	282
ABACO	4200	18014	429
ANDROS	2000	26270	1313
NEW PROVIDENCE	50	0	0
GRAND BAHAMA	660	5435	823

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TABLE 4. CHARACTERISTICS OF MINIMUM POTENTIAL AGRICULTURAL LAND AND THEIR FRESHWATER LENSES AS WELL AS RECOMMENDED DEPTHS OF WELLS IN NORTHWESTERN ISLANDS

ISLAND	TOTAL ISLAND AREA, ACRES	CHARACTERISTICS OF FRESHWATER LENSES OF MORE THAN 40 FEET THICKNESS				FEATURES OF MINIMUM POTENTIAL AGRICULTURAL LAND			
		NAME OF LENS	AREA OF LENS, IN ACRES	MAXIMUM LENS THICKNESS IN FEET	AVERAGE DEPTH OF INTERFACE, IN FEET	TOTAL AREAS IN ACRES	TYPES OF LAND TENURE OR USE	AREAS THAT CAN BE CONSIDERED FOR IRRIGATION IN THE 1st PHASE	RECOMMENDED DEPTH OF WELLS FEET
ABACO IS.	415360								
		BLACKWOOD VILLAGE (AREA I)	11276	50	50	564	LEASED C.L	-	20
		PUMKIN BAY (AREA II)	327	42	45	376	PRIVATE		
		LAKE CITY TO MARSH HARBOR:	33942.7	65	60				20
		AREA IV				1341	LEASED C.L	-	
		AREA V				6296.3	UNGRANTED C.L	6296.3	
		AREA VI				615	LEASED C.L	-	
		AREA VII				343.4	LEASED C.L	-	
		AREA VIII				2960	UNGRANTED C.L	2960	
		EIGHT MILE BAY (AREA IX)	1823.5	42	45	744	UNGRANTED C.L	744	20
		CROSSING ROCK TO HILL IN THE WALL (AREA X)	26706.1	64	45	4775	UNGRANTED C.L	4775	20
		SUBTOTALS	74075.3			10014.7		14775.3	
ELEUTHERA IS.	120000	*							
		NORTH ELEUTHERA:	6698.2	70	80				20
		AREA I				43	UNGRANTED C.L	43	
		AREA II				57	UNGRANTED C.L	57	
		AREA III				204	COMMONAGE	204	
		AREA IV				53	COMMONAGE	53	
		AREA V				164	COMMONAGE	104	
		TARPUM BAY TO ROCK SOUND (AREA VI)	1777.4	40	50	703.3	PRIVATE		15-20
			8475.6			1241.8		538.5	
ANDROS IS. * NORTH & CENTRAL	921600								
		MORGAN'S BLUFF TO STANIARD CREEK:	52720	60	55				20
		AREA I				3900	UNGRANTED C.L	3900	
		AREA II				2862	UNGRANTED C.L	2862	
		AREA III				2526	UNGRANTED C.L	2526	
		AREA IV				1962	UNGRANTED C.L	1962	
		STANIARD CREEK TO FRESH CREEK:	10090.8	110	55				20
		AREA V				2935	UNGRANTED C.L	2935	
		AREA VI				790	UNGRANTED C.L	790	
		AREA VII				555	UNGRANTED C.L	555	
		AREA VIII				564	UNGRANTED C.L	564	
		AREA IX				1102.0	UNGRANTED C.L	1102	
		AREA X				108	UNGRANTED C.L	108	
		AREA XI				1570.6	PRIVATE		
		AREA XII				5500	UNGRANTED C.L	5500	
		AREA XIII				1008	UNGRANTED C.L	1008	
		SUBTOTALS	62810.8			26270.6		24692	
GRAND BAHAMA	339200								
		FREE TOWN TO HIGH ROCK:	** 50007	40	55				20
		AREA Ao				2550	FORMER AIRFORC BASE	-	
		AREA A1				1390	TIMBER CONCESSION	-	
		MOUNT PLEASANT TO HIGH ROCK (AREA II)	7281.4	45	60	572	TIMBER CONCESSION	-	20
		PELICAN POINT (AREA III)	1424.9	45	60	270	TIMBER CONCESSION	-	20
		TAN PATCH:	1311.9	47	50				
		AREA IV				276.1	TIMBER CONCESSION	-	
		AREA V				367	TIMBER CONCESSION	-	
		SUBTOTALS	60025.2			5435.1			
TOTALS			205394.9			50962.2		40005.8	

* FRESHWATER LENSES EXIST IN SOUTH ANDROS & SOUTH ELEUTHERA BUT THEY HAVE NOT BEEN EXPLORED.
** MOST AREAS HAVE BEEN LEASED TO PORT AUTHORITY CO.

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TABLE 5 CHARACTERISTICS OF MINIMUM POTENTIAL AGRICULTURAL LAND AND THEIR FRESHWATER LENSES AS WELL AS RECOMMENDED DEPTHS OF ABSTRACTION PITS IN SOUTHEASTERN ISLANDS

ISLAND	TOTAL ISLAND AREA, ACRES	CHARACTERISTICS OF FRESHWATER LENSES OF MORE THAN 20 FEET THICKNESS				FEATURES OF MINIMUM POTENTIAL AGRICULTURAL LAND			
		NAME OF LENS	AREA OF LENS, IN ACRES	MAXIMUM LENS THICKNESS IN FEET	AVERAGE DEPTH OF INTERFACE, IN FEET	TOTAL AREAS IN ACRES	TYPES OF LAND TENURE OR USE	AREAS THAT CAN BE CONSIDERED FOR IRRIGATION IN THE 1st PHASE	RECOMMENDED DEPTH OF ABSTRACTION PITS, FEET
LONG ISLAND	206.72								
		DEADMANS CAY *							
		BURNT GROUND	40.9	25	20	40.1	PRIVATE	21	] 2-3
		STELLA MARIS	374.6	40	20	374.6	PRIVATE	107	] FEET
		ROSES	49.1	20	20	49.1	PRIVATE	25	] BELOW
		CABBAGE HILL	49	20	20	49	PRIVATE	25	] WATERTABLE
		SUBTOTALS	554.3			512.8		258	
CAT ISLAND	96000								
		OLD BIGHT	413.9	20	30	270	LEASED C.L.	130	8-10
		ARTHUR'S TOWN	770	50	35	500	LEASED C.L.		8-10
		DEVIL'S POINT TO McQUEENS:	9457.6	50	50				
						832	MOSTLY GRANTED	832	[1 8-10
						1400	MOSTLY GRANTED	710	8-10
		TEA BAY	50	30	25	14.5	PRIVATE	7	8-10
		SMITH BAY & BIGHT *	1797.7	30	25	337.3	CROWN LAND	2179	8-10
		SUBTOTALS	12489.2			3351		2179	
EXUMA ISLAND	71000								2-3
		FOREST	4914.4	47	45	1040	PRIVATE	350	] FEET
		GEORGE TOWN	3741.5	45	30	855	PRIVATE	351	] BELOW
									] WATERTABLE
		SUBTOTALS	8655.4			1895		701	
CROOKED ISLAND	50000	COLONEL HILL	1014	37	40	260	PRIVATE	260	8-10
ACKLINS ISLAND	94000								
		SPRING POINT TO DELECTABLE BAY	770.2	20	40	300	UNGRANTED & CROWN LAND	300	
		POW PEG BAY	2840.1	27	45	1160	UNGRANTED & CROWN LAND	430	2-3 FEET BELOW WATER TABLE
		SUBTOTALS	3610.3			1461		730	
MAYAGUANA ISLAND	70400	AIR FIELD TO CENTER	659.6	30	30	330	UNGRANTED CROWN LAND	151	2-3 FEET BELOW WATER TABLE
TOTALS	677000		25968.0			7009.0	3061 CROWN LAND + 1219 PRIVATE LAND		

* FRESHWATER LENSES EXIST BUT FURTHER STUDIES ARE NEEDED
1) AREA CONSIDERED FOR SUPPLEMENTARY UNLIMITED IRRIGATION. OTHER AREAS ARE CONSIDERED FOR SUPPLEMENTARY LIMITED IRRIGATION

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TABLE 6
REDUCTION IN PROPOSED IRRIGATED LAND

ISLAND	PROPOSED IRRIGATED LAND (ACRES)	REDUCED TOTAL (ACRES)
ELEUTHERA	1241	545
ABACO	18014	11221
ANDROS	26270	10465
NEW PROVIDENCE	0	0
GRAND BAHAMA	5435	0
CAT ISLAND	3351	2952
LONG ISLAND	512	0
CROOKED ISLAND	260	0
EXUMA ISLANDS	1895	0
ACKLINS	1460	1460
MAYAGUANA	330	330

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TABLE 7

STANDARDS FOR DRINKING WATER

PARAMETER	STANDARD BAHAMAS	STANDARD INTERNATIONAL
Coliforms	0	
E. coli	0	
Chloride (Cl)	600 mg/l	250 mg/l
Total Hardness (CaCO3)	500 mg/l	----
Sulphate (SO4)	500 mg/l	400 mg/l
Phosphate (P)	2 mg/l	----
Nitrate (N)	10 mg/l	10 mg/l
Iron (Fe)	0.5 mg/l	0.3 mg/l
Flouride (F)	1.5 mg/l	1.5 mg/l
pH	6 - 8.5	6.5 - 8.5
Turbidity (NTU)	5	5
Biochemical Oxygen Demand	20 mg/l	----
Total Dissolved Solids	1000 mg/l	1000 mg/l
Residual Chlorine (Cl2)	3 mg/l	----
Copper (Cu)		1 mg/l
Cobolt (Co)		----
Boron (B)		----
Magnesium (Mg)		----
Manganese (Mn)		0.1 mg/l
Molybdenum (Mo)		----
Selenium (Se)		0.01 mg/l
Sodium (Na)		----
Zinc (Zn)		5 mg/l

NOTES:

Bahamas figures provided by Public Analyst for routine water quality monitoring. International standards from WHO 'Guidelines for Drinking Water Quality'

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MINISTRY OF AGRICULTURE, TRADE & INDUSTRY	
DEPARTMENT OF AGRICULTURE	Natural history specimens Liaison with National Trust* Andros Blue Holes Wild Animals & Birds Protection Plant protection Veterinary services Public Markets & Abattoirs
DEPARTMENT OF FISHERIES	Fisheries
MINISTRY OF CONSUMER AFFAIRS	Liaison with Water/Sewerage Corp.**
MINISTRY OF HEALTH	
DEPARTMENT OF ENVIRONMENTAL HEALTH SERVICES	Public health Solid waste disposal Public Analyst Pest control
MINISTRY OF WORKS	
DEPARTMENT OF PUBLIC WORKS	Hydrology Beaches & Roads
DEPARTMENT OF PHYSICAL PLANNING	Urban & Island Planning Land use
DEPARTMENT OF LANDS & SURVEYS	Land surveys Crown land allocation Aquisition of lands Mining,petroleum geology surveys Forestry
BAHAMAS NATIONAL TRUST *	Conservation of National Parks
WATER AND SEWAGE CORPORATION **	Water supplies Sewerage Sewage treatment

FIGURE 1
ENVIRONMENTAL & NATURAL RESOURCE RESPONSIBILITIES

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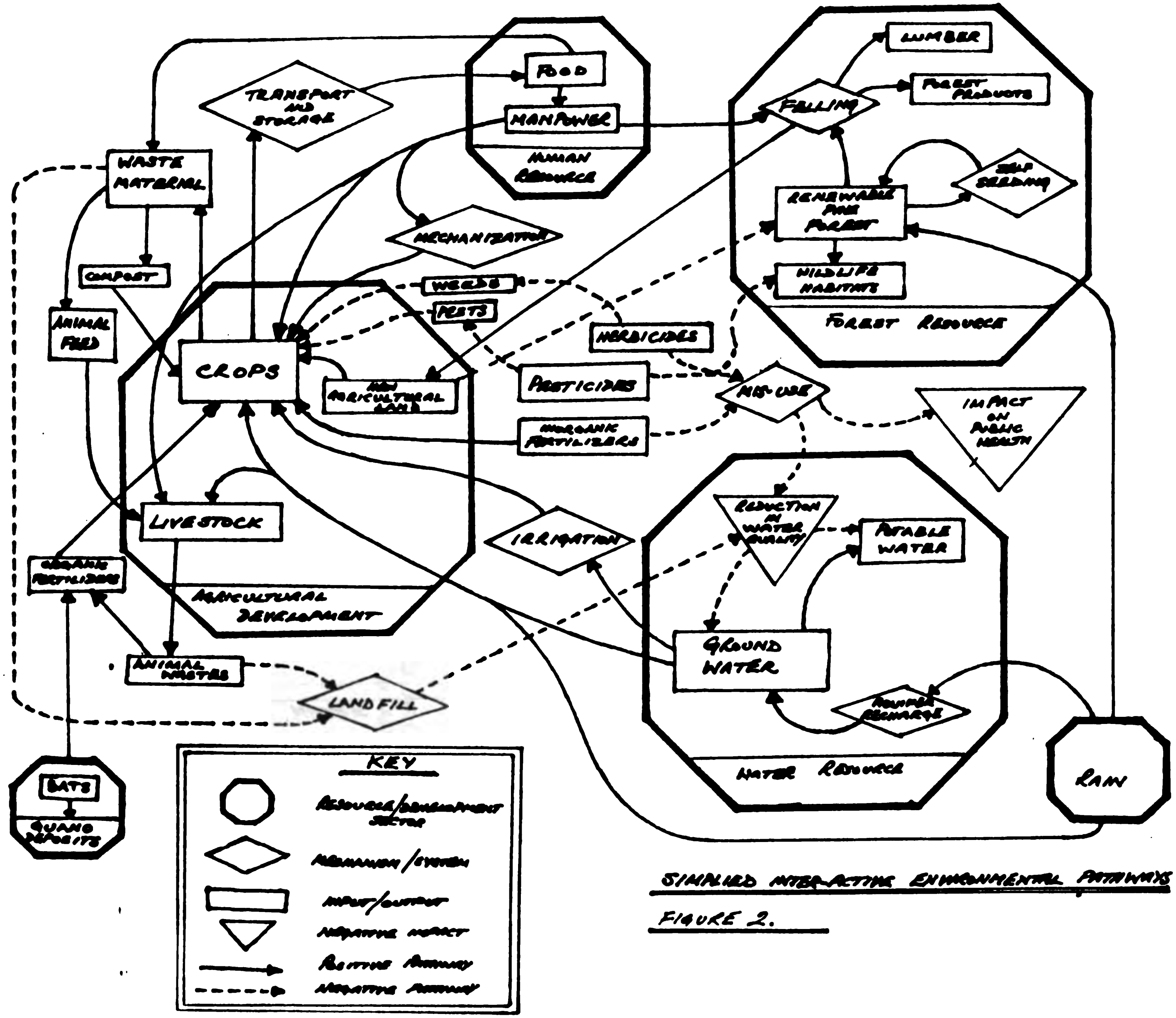

SIMPLIFIED INTER-ACTIVE ENVIRONMENTAL PATHWAYS

FIGURE 2.

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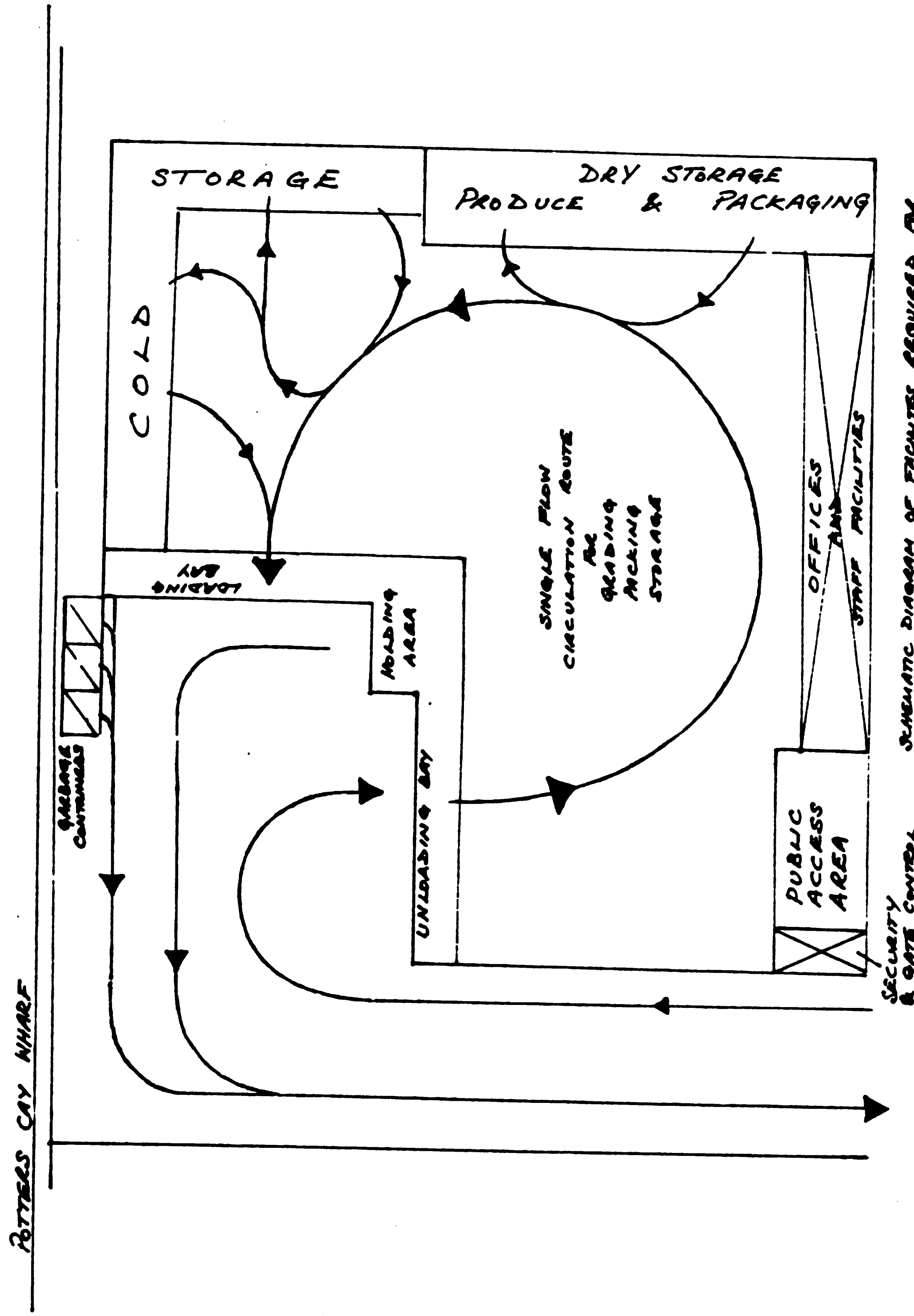
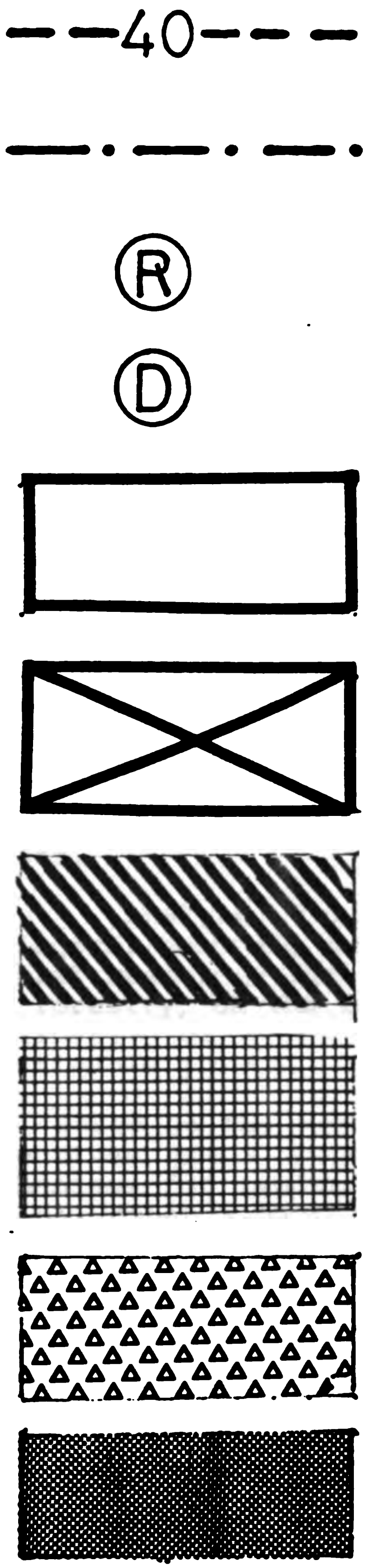


SCHEMATIC DIAGRAM OF FACILITIES REQUIRED FOR NEW PRODUCE EXCHANGE

FIGURE 3

FIGURE 4 KEY TO ENVIRONMENTAL/ECONOMIC MAPS



- BOUNDARY OF FRESHWATER LENS (DEPTH IN FEET)
- BOUNDARY OF FOREST RESERVE (AROOW INDICATES RESERVE)
- AREA REDUCED FROM PROPOSALS
- AREA DELETED FROM PROPOSALS
- WATER RESERVE
- WATER SUPPLY WELLFIELD
- PROPOSED AREA FOR IRRIGATED ARGRICULTURE
- AREA TO BE REMOVED FROM ARICULTURAL PROPOSALS
- CONSERVATION RESERVE
- FOREST RESERVE (MAIN AREA)

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APPENDIX I

TERMS OF REFERENCE FOR ENVIRONMENTAL EXPERT

1. OBJECTIVES

1.1 General

Based on an environmental impact study, prepare an environmental action plan to prevent, control and/or lessen any negative environmental effects which are the direct result of activities associated with the implementation and operation of this project. The study shall contribute part of the required feasibility studies.

1.2 Specific

a) Determine which ecological changes and negative effects would affect public health, renewable natural resources and habitat, and make recommendations as to specific measures, actions and activities to prevent, control and/or lessen these changes and effects. Special attention should be given to the negative effects caused by: i) road construction and/or improvement; ii) expansion of the agricultural frontier; ii) use of agrochemicals and water pollution, especially of underground water; iv) land preparation, including deforestation and erosion/sedimentation; and v) salinification as a result of encroachment of water water, or from other causes.

b) Analyze land use and divide the same into ecological/economic zones based on the potential of renewable natural resources for use in agriculture, livestock raising and forestry, on the fragility of the ecosystems, and on the application of appropriate technology, in order to achieve sustainable growth.

c) Based on the proceeding, prepare a plan of action with objectives, goals, schedule of activities, costs per activity, mechanisms for implementation, evaluation and surveillance, and all other aspects that will enable national authorities to prevent, control and/or lessen ecological changes and negative environmental effects.

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APPENDIX II

LIST OF PERSONS ASSISTING IN PROJECT & PLACES VISITED

The following list is of the principal individuals who assisted the progress of the Environmental Aspects by their contribution in information and services, and acknowledgment is paid to their contribution to the Project.

DEPARTMENT OF AGRICULTURE

Dr. Earl Deveaux, Advisor to the Minister
Dr. Prince Bonamy, Director, Dept. Of Agriculture
Mr. Arnold Dorsett, Assistant Director, Agriculture
Mr. Audley Greaves, Senior Agricultural Officer
Mr. Simeon Pinder, Senior Agricultural Officer,
Dr. Keith Campbell, Senior Vetinerary Officer
Dr. Maurice Issacs, Environmental Counterpart
Mr. Egbert Wallace, Environmental Counterpart
Mr. Elvis Rolle, Marketing Counterpart
Mr. North, Produce Exchange

DEPARTMENT OF FISHERIES

Mr. R.W. Thompson, Director, Department of Fisheries

DEPARTMENT OF LANDS & SURVEYS

Mr. Francis Garraway, Director, Dept. of Lands & Surveys

DEPARTMENT OF FORESTRY

Mr. John Hook,Head Forester
Miss. Shireen Chambers, Forester, Abaco

WATER & SEWERAGE CORPORATION

Mr. Philip Weach
Mr. Lawrence Owen

MINISTRY OF WORKS

Mr. Richard Cant

DEPARTMENT OF ENVIRONMENTAL HEALTH SERVICES

Mr. Glen Archer, Director, Dept. of Env. Health Services
Dr. Donald Cooper, Public Analyst
Mr. Peter Brown, Senior Health Inspector
Mr. Andrew Thompson

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DEPARTMENT OF PHYSICAL PLANNING

Mr. Davis, Director, Dept. of Physical Planning

BAIC

Mr. Woodside

BAHAMAS NATIONAL TRUST

Mr. Gary Larson, Executive Director

INTER-AMERICAN DEVELOPMENT BANK, BAHAMAS FIELD OFFICE

Mr. Johann Schmalzle, Representative, IDB
Mr. Fred. B. Gimenez, Sectoral Specialist

INDIVIDUALS

Mr. 'Pat' Smith, Manager, B.G. Harmon Farms, Abaco
Miss R. Gnam, Researcher, Amer. Museum Nat. Hist., NY
Captain Brown, Farmer/Fisherman, Mayaguana
Mr. Vincent Mitchell, Farmer, Mayaguana
Mr. Kermit Rolle, Agricultural Superintendent, Exuma
Mr. E.J. Rolle, Agricultural Superintendent, Exuma
Mr. Musgrove, Farmer, Exuma
Mr. Curry, Farmer, Exuma
Rev. Nixon, Farmer/Preacher, Eleuthera
Mr. Sam Stubbs, Farmer, Cat Island
Rev. Wilson, Farmer (livestock), Cat Island
Mr. MacKenzie, Farmer (livestock), Cat Island
Mr. Thompson, Farmer, Crooked Island
Mr. Scaralla, Farmer, Crooked Island
Mr. Johmson, Farmer (livestock), Acklins Island
Mr. Roker, Cascarilla buyer, Acklins Island
Mrs. Knowles, Pineapple farmer, Long Island

PLACES VISITED (Other than Family Island small farmers)

Produce Exchange, Nassau
Fish & Farm Store, Nassau
Abattoir, Nassau
Municipal Refuse Tip, Nassau
Potters Cay (mailboats), Nassau
Clifton Pier, Deep Water Terminal, New Providence
Gladstone Road Agricultural Centre, New Providence
Bahama Star Farms, Abaco
B.G. Harmon Farms, Abaco
Packing House, Exuma
Packing House, North Eleuthera
Bat caves in Mayaguana and North Cat Island

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APPENDIX III

CRITERIA FOR PROJECT IMPACT ASSESSMENT

These criteria should be considered as being specific to the project, and represent the basis for the assessment of the impact of the proposed project design. In some cases criteria cannot be used through lack of data (eg: water quality). Such criteria are included to permit later review and updating of the EIA as the database improves.

1. WATER RESOURCES

1.1 General

The freshwater resources must be considered as the most valuable resource in the Bahamas, and all domestic, urban and industrial supplies (present and proposed) must be protected on a sustainable basis. Water resources will be given first priority in impact assessment.

Criteria

1.2 The minimum acceptable chemical water quality for any aquifer used for present supply or proposed for future supply or as a water reserve should be within the standards laid down by the Public Analyst, or (if no standard is set) at the WHO recommended value (Table xx).

1.3 The proposed future Family Island water reserve areas (Cant, 1981) are accepted. To protect all water supplies, both present and proposed, no form of development (agriculture, industry, or urban expansion) should be permitted within the area boundary of a wellfield or reserve.

2 LAND

2.1 General

The land resources of the Bahamas are limited, and the ecosystems of the island very fragile. Thus zonation and land use regulation are essential phases for sustainable development.

Criteria

2.2 As land use regulation (at present) can only be enforced over Crown or Government land, first priority for agricultural development will be given to these lands, and specifically (in the first instance) to any such land that has been previously cleared, or prepared, and is now not under production.

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2.3 No designated conservation reserve or National Park shall have any form of development (agriculture, industry or urban expansion) allowed within its boundaries. For the purpose of the EIA any such proposed reserve will be treated as if designation has been approved.

2.4 All conservation areas (existing and proposed) will be given priority over agriculture, although compatible systems of multiple use will be given consideration.

2.5 No road systems, other than access roads, shall pass through any conservation reserve or National Park.

2.6 All land use zonation will be carried out be regard to the following concepts:

2.6.1 Wherever possible multiple use of land should be positively encouraged.

2.6.2 Zonation plans should be considered over a timescale that allows for changes to be made as conditions alter. Rigid allocation of areas to various sectors should not occur.

3. FORESTRY

3.1 General

The pine forests (*Pinus carabaea*) of the northern islands are a valuable natural, self-generating, commercial resource. The Bahamas should seek to exploit this resource on a sustainable basis.

Criteria

3.2 The proposed forestry reserves (McHenry, 1987) are accepted, and will be used in this assessment.

3.3 The pine forests of the north, and the coppice lands of the south-east will be used to provide ground cover for the water reserve areas.

3.4 Forest reserves will be given priority over destructive development (eg: crops, industry, urban expansion), but multiple use with other forms of development (eg: some livestock, nature tourism) will be encouraged.

3.5 All forms of development will be given priority in areas of protected forest which do not lie over water reserves.

3.6 Conservation forests will be considered according to the criteria in 2.3, 2.4 and 2.5.

3.7 The above criteria can serve as guidelines for hardwood forestry improvement in the south-east islands.

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4. MINERALS

4.1 General

Minerals, including guano deposits, should be considered as finite reserves and their exploitation controlled. As such reserves are limited exploitation should be undertaken on a long-term (20+ years) basis. Deposits of guano may be limited, but exhaustion of these reserves may be considered if these deposits are directly used in local agriculture.

5. HUMAN RESOURCES

5.1 General

The indigenous population of the Bahamas is small, culturally independent and proud of their island of birth or home. There is increasing political and cultural concern about the high level of immigration from neighbouring islands; and positive consideration should be given to forms of development that will not exacebate this concern.

Criteria

5.2 The following cultural and social aspects will be considered when assessing development in the South-East islands:

5.2.1 Farming is well represented in these islands, where farming is partly a form of subsistence living, with most people farming on a part-time basis.

5.2.2 Farming must compete with other, more lucrative (or better organized) occupations; together with an extended family situation that goes beyond the island but helps to provide an income (or benefits) to the islanders.

5.2.3 There is a steady drift away from the islands, partly a reflection of the lack of amenities and services, including education and health services.

5.2.4 Quality of life expectations are high, and achievable, making the hard work associated with present-day small scale agriculture unattractive compared with other forms of employment or migration from the islands.

6. COASTAL AND MARINE RESOURCES

6.1 General

The marine resources are a vital element of the Bahamian economy, both for food and exports. The project has concentrated on terrestial agriculture, and so forms of aquaculture (including mariculture) that might have a direct impact on coastal regions

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mariculture) that might have a direct impact on coastal regions have not been considered.

Criteria

6.2 Most intensive, irrigated agriculture situated within a 40' deep lens would be sufficiently far from the coasts not to have a direct impact on the coastal zone; but consideration will be given to some 20' deep lens that a found close to coastlines.

6.3 Construction of harbours, jetties and packing houses will have some direct local impact.

7. AGRICULTURAL DEVELOPMENT

7.1 General

It is accepted that agriculture has an important role in the sustainable development of the Bahamas. Such development should be planned over a phased timescale, and wherever possible (given the limitations of land and resources) multiple-use scenarios should be encouraged.

Criteria

7.2 To encourage a multiple-use situation, no distinction will be made between the value of crop production (irrigated or rainfed) and livestock rearing in considering any area.

7.3 Consideration will be given to the viability of phased development plans, and to the timescale needed to develop the potential agricultural land within the framework of these criteria.

7.4 To mitigate the impact of road construction agricultural development that can use the existing forest road network will be encouraged.

7.5 Proposals for irrigation abstraction, together with their supporting arguments, will be considered against the recommendations made in the extensive study by Little et al (1976) in the absence of more recent data, particularly in regard to salinization.

7.6 The criteria assume that proposed agricultural development can be supported by acceptable evidence of available inputs (including human resources), irrigation systems that will not damage (in the short or long term) the Nation's water resources, and available markets. Where this evidence is not available, or subject to reasonable doubt, then the proposed development will be modified.

7.7 Where a proposed agricultural development may cause a negative environmental impact that cannot be mitigated, then that proposed agricultural development should be rejected.

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