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UNITED NATIONS INDUSTRIAL
DEVELOPMENT ORGANIZATION

JAMAICA

FINAL REPORT

CHEMICAL [illegible] 1/

by

H.A. El Sh[illegible]awy
UNIDO Expert

(OA 220 JAM-[illegible])

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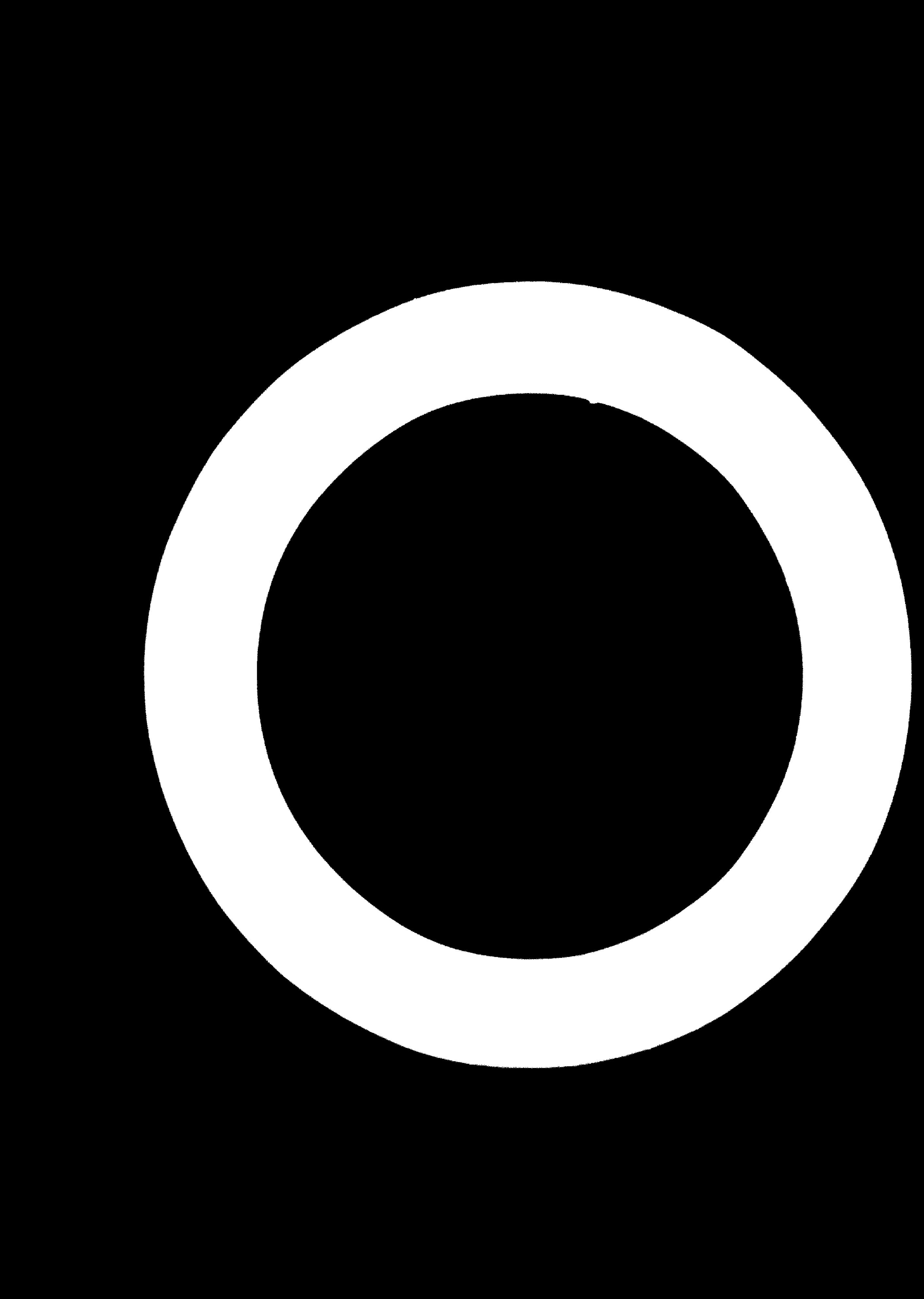

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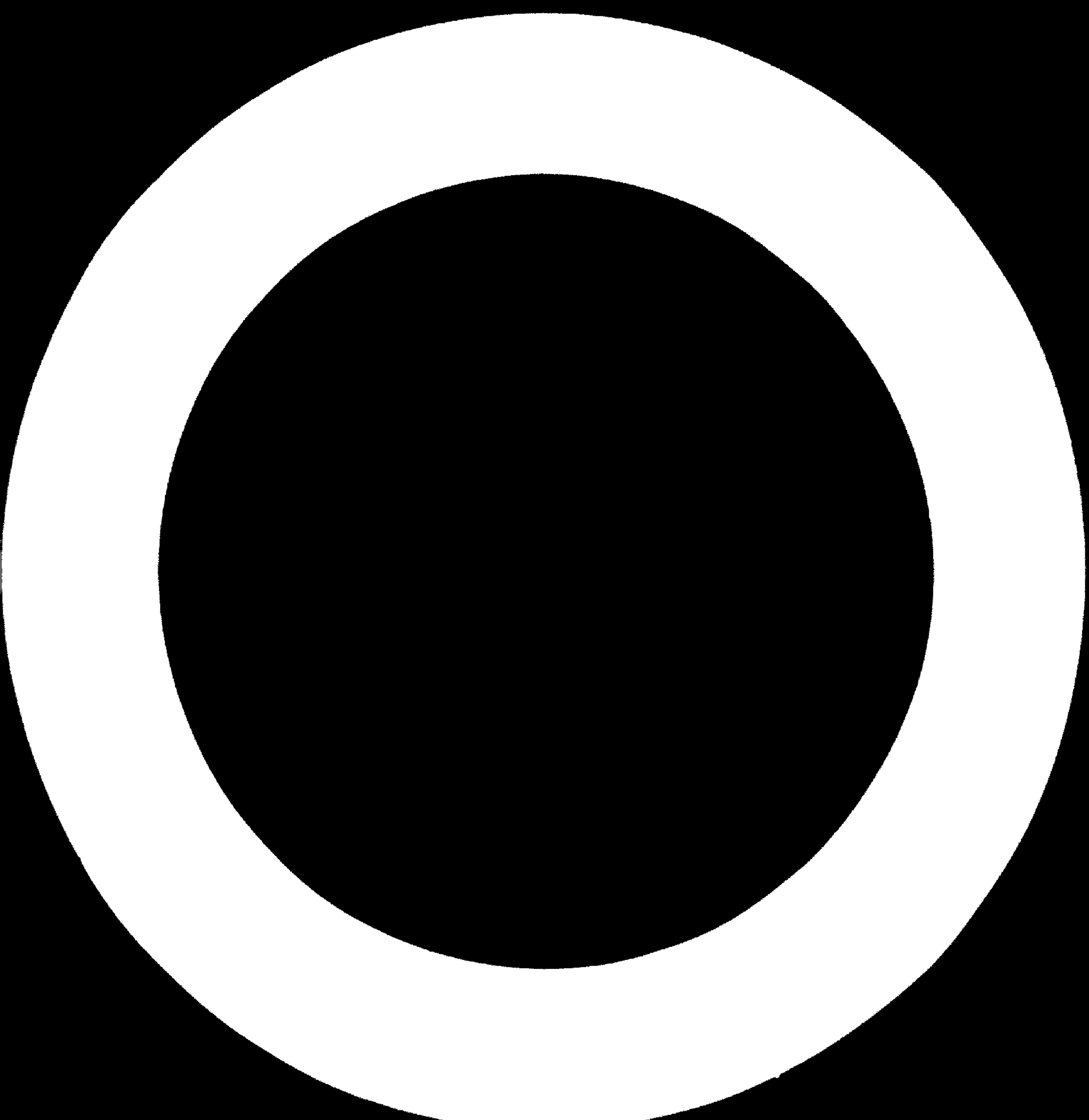

FINAL REPORT

RESTRICTED

COUNTRY: JAMAICA OFFICER: H.A. [illegible]

PROJECT NO.: JAM 011-B(SIS)

FIELD OF WORK: CHEMICAL INDUSTRIES [illegible]

INTRODUCTION

The main duties of this assignment [illegible] pertaining to investment promotion, i.e., formulation of proposals for expansion and for new investments on the basis of surveys. The duties also included the provision of engineering "know-how", identifying linkage industries as well as undertaking feasibility studies and other relevant tasks as required by the Jamaica Industrial Development Corporation (JIDC).

Accordingly, an overall survey of the situation of chemical industries in Jamaica was first made, and certain potential projects were identified in the following fields:-

- Production of solar salt from sea water.
- Electrolytic caustic soda and chlorine.
- Manufacture of chlorinated derivatives and petro-chemicals as part of a chlorine-caustic chemical complex.
- Manufacture of sulphuric acid and/or ammonium sulphate from gypsum and anhydrite.
- Manufacture of bagasse pulp and newsprint from bagasse.
- Manufacture of chemicals (citric and acetic acids) by fermentation of molasses.
- Recovery of chemicals and manufacture of by-products from effluents and unused remains of local leather tanning industry.

Surveys and feasibility studies for some of the above potential projects have been completed to a satisfactory effect, however, work on other projects is still proceeding.

NOTE: "This report has not been cleared with the United Nations Industrial Development Organization, which does not, therefore, necessarily share the views expressed."

At the request of JIDC, the expert undertook also the following tasks:-

- Reviewed and studied the question of the discharge or treatment of process waste of a contemplated yeast plant to be constructed near Spanish Town.

- Started an investigation and feasibility study for the manufacture of cassava products, especially starch (still not completed).

- Started investigations regarding two other projects, namely, the manufacture of Lubricating Greases and the manufacture of Thermoplastic Compounds with the purpose of giving recommendations to the Incentive Applications Committee of the JIDC for consideration under the Industrial Incentives Law (still not completed).

During the overall survey and the investigations carried out, several visits to institutions, chemical works and other plants, as well as to possible locations for salt works and sites for other projects were made.

During this term of duty numerous meetings and interviews with manufacturers and relevant Government authorities took place and four symposia on different subjects were attended.

It seems now that the mission would be leading to a specific project for the production of solar salt, initially at the level of 16,000-21,000 tons/year, and possibly later to another larger production project of about 148,000 tons/year (or 116,000 tons/year).

In the meantime it was possible to reach useful conclusions with regard to a chlorine-caustic complex based on salt. Units of this chemical complex with their opitmum capacities have been suggested as a project that could be implemented in Jamaica in one or more stages.

A study was also carried out on the possibility of manufacturing sulphuric acid from anhydrite or gypsum as raw material according to the new Kent-ISU process in which lime is produced as a by-product instead of clinker (cement). This study revealed the conditions under which this process would be more economic than the conventional sulphur burning process.

It was not possible to complete investigations of the other identified chemical possibilities in Jamaica during the period of the assignment due to either lack of time or unavailability of information.

Details of work done are outlined in the following sections of this report.

I. WORK DONE

1. Solar Salt Production

Solar salt is being produced in some countries in the Caribbean and Central American region in which weather conditions do not vary much from those in Jamaica. It is actually being produced in eastern and western coasts of Cuba*, western Haiti and in Anguilla. It has also been produced in southern Jamaican locations but abandoned due to the small size of the operations. One small facility was located on Pigeon Island** in Portland Bight during the forties and concrete pans are still in existence. According to sources of the Institute of Jamaica, the Yallahs Ponds near Kingston were the main location for solar salt production in Jamaica during the sixteenth and seventeenth centuries.

For the above reasons it is considered that weather conditions should be adequate for solar salt production in southern and may be western Jamaica especially on account of the relatively cheap cost of land as compared with the more expensive north. Accordingly, as mentioned in the previous Progress Reports, a physical survey of possible locations was undertaken. The following four locations were investigated:

a. The Great Morass

This is a large swampy area about 7½ square miles on the south west coast of Jamaica near Black River in St. Elizabeth. Details of this location were given in the Progress Report of August, 1970.

This location was excluded from further solar salt investigations at present owing to lack of evaporation data which would enable a meaningful evaluation.

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* Handbook of World Salt Resources.

** This Island has been visited and it is estimated that between 2,000-3,000 tons salt were produced annually.

b. The Great Salt Pond

This is the Great Salt Pond area in St. Catherine. It has the advantage of being near to the industrial centres of Kingston and Spanish Town, and could permit a production of 120, 000-150, 000 tons salt per year. Details of the area were given in the Progress Reports of August 1970 and January 1971.

However, this location was dropped from further investigations since it appeared from chemical analysis of the pond's brine, as well as from the physical survey, that fresh water from some springs have been mixing with the water of the pond to such an extent that it would be useless to use this site for a solar salt work, especially that soil conditions in this location seem to be unfavourable.

c. The West Harbour Ponds

This area has been described before in the Progress Reports of August 1970 and January 1971. The location is large enough thus having the advantage of enabling large scale production of salt. Other advantages were summarized before as follows:

- Weather conditions are relatively good.
- West Harbour itself could be used as a concentrating area and the smaller Bog and Boggy Ponds could be used as crystallizing ponds.

The main disadvantage of the location is that the cost of removal of mangroves covering the marsh land adjacent to the ponds would be too high to make the project economic and therefore investigations were previously stopped at this stage.

However, now that more monthly weather data for a period of 11 years and daily data for another period of 4 years are available for Monymusk, a new possibility has been considered for this location. This is based on utilizing West Harbour (with another extra area of the harbour outside the small islands near its opening to the sea), the two small ponds (Bog and Boggy Ponds), as well as a third small pond that can be created by connecting the Dolphin Island with the mainland. West Harbour would be separated by dikes into three concentrating ponds, whereas the other three small ponds would be used as crystallizers. West Harbour is actually at present connected with Boggy Pond by means of a creek (as mentioned in a previous Progress Report) not shown on the map.

Feasibility Study for the Production of 148,000 Tons Salt/Year at West Harbour Area

This solar salt facility would possibly have the lowest capital cost since West Harbour and the three other ponds are owned by Government, and on account of the fact that no land would be utilized thus avoiding any excessive costs for the removal of mangroves. A preliminary layout of such facility is shown in Figure 1 (page 6).

Basis of the Study

The study is based on the following assumptions -

- That the available rainfall and evaporation data for Monymusk would be adequately representing the area of West Harbour and the three ponds.

- That the total area of the facility is approximately 3,000 acres of which 2,600 acres are in the concentrating ponds and 420 acres in the crystallizing ponds.

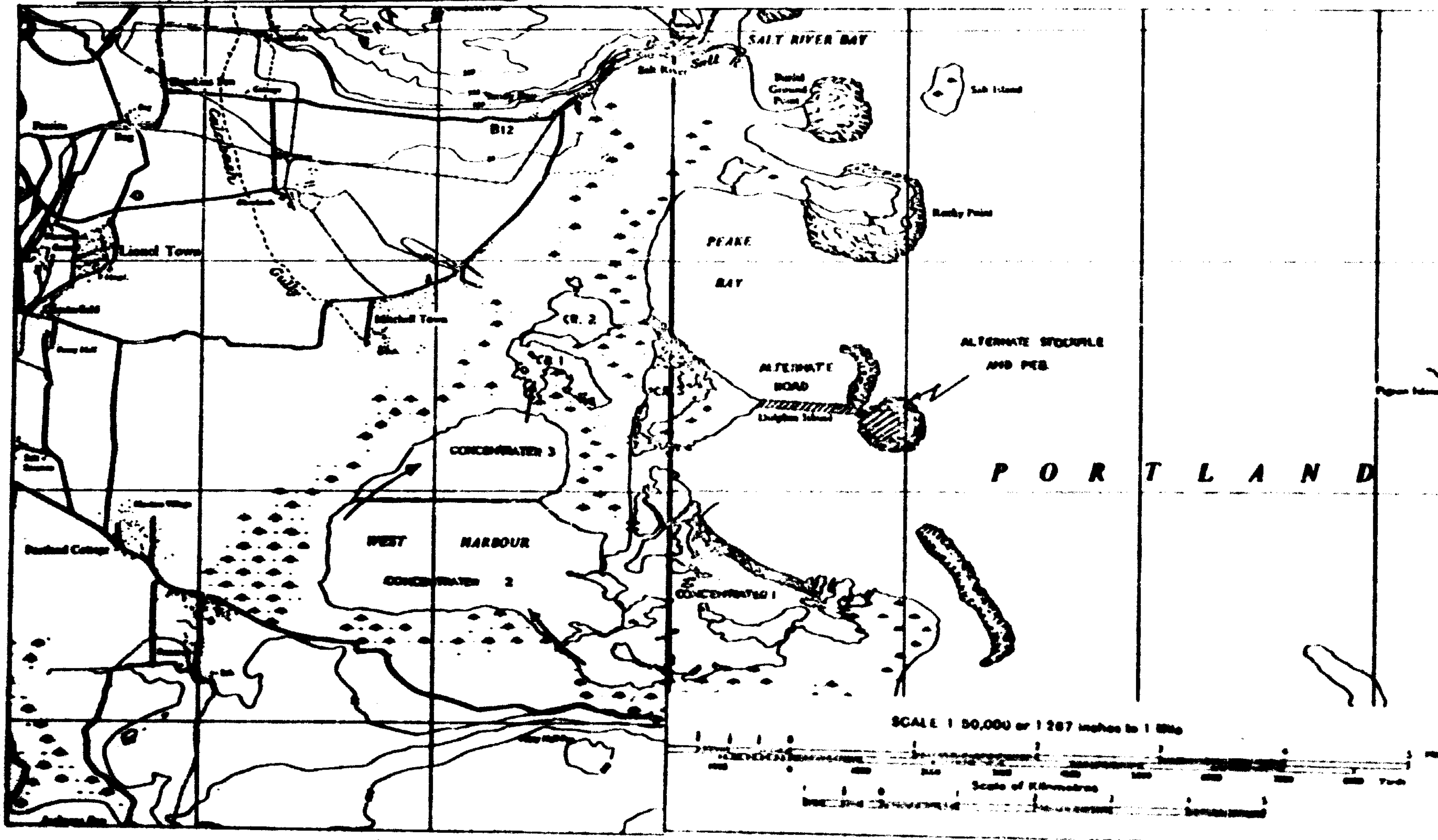
- That West Harbour has an average depth of six feet with the depth between the islands enclosing its mouth averaging two feet and a depth of approximately four feet where internal dikes will be built.

- That it is not practical to maintain a permanent salt floor, and that harvesting would be completed off a mud floor within a period of one month. This assumption must be verified as soon as possible since nothing is known of the bearing strength or the topography of crystallizing ponds.

- That deep sea shipping facilities would be possible either through rental of the nearby ALCOA bauxite pier at Rocky Point at US$0.50 per ton of salt, or through the construction of a new alternative pier on the coral reefs east of Dolphin Island. This location is near the crystallizing ponds and depths of 42 feet are available within about 100 yards according to Admiralty Charts. The first shipping alternative would imply lower capital cost but higher production cost, whereas the second alternative would have the opposite effect.

FIGURE 1

Preliminary Layout for the West Harbour Salt Facility



Analysis of the Available Monymusk Weather Data

Close examination of the available rainfall and evaporation data* pertaining to Monymusk indicates that year-round salt production is technically unfeasible. These data, if correct, suggest that it would be only possible to produce 16 tons per acre-year for a six-month evaporation season from November till the end of April. The production potential of the area may be higher, but since these are the only available data, a detailed analysis is warranted.

Table I (page 8) and Table II (page 9) show the monthly rainfall and evaporation at New Monymusk for 11 years respectively. It has been possible to obtain rainfall data pertaining to other nearby meteorological stations, however, the only available evaporation data for this area come from New Monymusk, and suggest with less confidence, that the gross evaporation from Class A meteorological pans is about 67 - 68 inches per year. This figure must be corrected to describe the evaporation of various brine densities from large solar ponds. The factors commonly accepted are 0.7 to convert fresh water evaporation from Class A pans to large reservoirs, and 0.9 and 0.8 to convert fresh water reservoir data to brine concentrations of 1.10 and 1.25 specific gravities respectively.

Using these above factors, the yearly evaporation rates were calculated as follows:

Type	Evaporation (Inches/Year)
Fresh water in Class A pans	68
Fresh water in large ponds	48
Brine in concentrating ponds (sp. gr. 1.10)	43
Brine in crystallizing ponds (sp. gr. 1.25)	38

Since the average annual rainfall is 37" - 38", it is obvious that year-round salt production would not be feasible under these conditions.

Table III (page 10) shows the analysis of the monthly rainfall and evaporation data for West Harbour site after conversion to brine concentrations of sp. gr. 1.10 and 1.25 (in concentrating ponds and crystallizing ponds respectively) and on a cumulative basis.

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* Sources: Meteorological Division, Ministry of Communication & Works, and Research Department, Sugar Manufacturers Association.

TABLE I

Eleven Years Monthly Rainfall in Inches at New Mooyamah (West Harbour Site)

Year	J	F	M	A	M	J	J	A	S	O	N	D	Total Annually
1950	0.00	0.77	0.00	2.25	2.87	0.21	0.88	13.15	7.90	19.64	2.13	0.09	50.69
1951	1.49	0.07	0.56	1.48	5.97	0.63	4.28	4.89	3.95	4.94	0.95	0.06	29.27
1952	0.87	2.94	0.42	3.41	0.78	1.63	2.76	0.48	5.99	8.59	0.63	7.90	36.40
1953	0.36	0.63	0.98	0.86	11.62	4.87	6.11	2.10	12.88	4.78	1.22	0.21	45.82
1954	0.26	2.07	1.68	0.12	5.86	3.25	0.48	3.05	6.95	4.81	2.73	2.26	33.12
1955	0.00	0.54	0.66	0.10	0.61	10.11	6.30	5.08	0.13	3.48	1.30	2.11	30.33
1956	0.52	2.02	3.42	0.53	0.20	0.43	3.31	0.22	1.30	5.52	1.57	0.17	19.29
1957	0.00	0.41	2.51	0.32	5.39	0.36	0.00	0.00	0.00	4.46	0.00	0.00	14.28
1958	3.99	1.40	0.61	0.00	15.08	12.97	0.67	12.97	5.10	14.32	1.89	1.60	70.12
1959	0.00	0.00	1.20	2.76	4.54	0.00	0.00	0.82	1.29	4.58	2.42	0.00	17.62
1960	1.90	0.73	0.00	1.61	1.49	28.10	0.00	1.85	5.97	12.72	0.93	1.40	52.66
Σ	9.95 •	11.61 •	12.80 •	12.62 •	58.97 •	59.64 •	25.39 •	44.17 •	50.22 •	87.86 •	15.86 •	15.88 •	408.97 •
n	11	11	11	11	11	11	11	11	11	11	11	11	11
$\bar{x}$	0.90	1.06	1.17	1.15	4.87	5.42	2.31	4.02	5.30	7.98	1.40	1.40	37.14

TABLE E

[illegible] Monthly Evaporation in Inches at [illegible] ([illegible] Site)

Year	J	F	M	A	M	J	J	A	S	O	N	D	Annual Total
1958	3.48	3.92	5.27	6.00	5.00	5.10	7.13	6.82	5.70	4.34	4.20	4.93	63.9[illegible]
1959	4.38	4.75	5.58	6.00	6.51	6.60	7.44	7.13	6.50	4.65	4.50	4.93	67.54
1960	3.72	4.35	5.27	4.80	4.96	5.70	6.20	6.51	4.50	4.65	3.90	3.72	58.[illegible]
1961	4.34	4.48	6.20	6.90	7.44	6.60	6.20	6.82	4.80	5.58	3.90	4.93	6[illegible]
1962	4.88	4.48	5.90	6.[illegible]	6.51	6.90	7.75	6.82	5.70	5.27	4.2[illegible]	4.93	[illegible]
1963	4.38	4.48	7.13	6.30	7.75	6.00	7.13	6.82	6.00	4.[illegible]	4.[illegible]	4.93	[illegible]44
1964	4.34	4.93	7.13	6.90	7.13	6.30	6.82	6.82	4.80	4.34	4.2[illegible]	4.[illegible]	[illegible]
1965	4.34	5.32	6.82	6.60	6.82	6.90	8.06	6.[illegible]	6.30	5.58	4.90	[illegible]	[illegible]
1966	4.66	5.32	5.09	6.90	6.5[illegible]	5.70	6.82	6.5[illegible]	6.30	5.27	[illegible]	[illegible]	[illegible]
1967	4.66	5.06	6.51	6.60	7.44	7.20	8.06	[illegible]	6.6[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1968	4.66	4.35	5.27	6.90	7.75	6.60	6.82	[illegible]	[illegible]	4.34	[illegible]	[illegible]	[illegible]
Σ	46.81	51.43	66.65	70.80	73.82	69.64	78.43	[illegible]	[illegible]	54.67	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
n	11	11	11	11	11	11							
Ȳ	4.26	4.68	6.06	6.44	[illegible]	[illegible]	[illegible]	[illegible]					

[illegible] -- [illegible]

TABLE [illegible]

[illegible]

Month	Rainfall (inches)	Fresh water class A pan (Gross)	EVAPORATION: Fresh water large reservoirs			Brine - Sp. gr. [illegible]			Brine - Sp. gr. [illegible]		
			gross	net	cumul.	gross	net	cumul.	gross	net	cumul.
Nov.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Dec.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Jan.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Feb.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mar.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Apr.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Jun.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Jul.	[illegible]	7.13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Aug.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sep.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oct.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total	[illegible]	[illegible]									

Examination of the monthly data [illegible] Table [illegible] III, however, reveals that evaporation conditions [illegible] the crystallisers [illegible] are positive during [illegible] six months of the year [illegible] results are [illegible] in graphical form in Figure 7, (page 1[illegible]).

Examination of the data [illegible] evaporation season starts in November and ends in April, [illegible] the entire salt production cycle from [illegible] to salt harvesting [illegible] be accomplished within the six months period [illegible] till end of April. The time schedule for [illegible] Figure 8 (page 1[illegible]). This tight schedule [illegible] must be added to the system each year, [illegible] available for obtaining saturated brine. [illegible] available for evaporation in the crystallising ponds. During [illegible] period the accumulated net evaporation of saturated brine [illegible] about 3.00" (from middle of February till end of March). [illegible] severe restrictions on any modern solar salt [illegible] evaporation data are correct, will render such an operation [illegible] unfeasible.

The following calculations show the quantity of salt [illegible] can be produced per acre of crystallising pond under the [illegible]

Total saturated brine evaporation = 3.00"/operating year [illegible])
Volume of brine evaporated per acre = $\frac{3.00}{12} \times 43{,}560$

= 10,890 ft^3/operating year

i.e., approximately 11,000 ft^3/operating year.

Quantity of salt crystallised at 26% concentration
= (% salt)(Density of Brine)(Vol. of Brine)
= $\frac{(0.26)(62.4)(1.[illegible])}{2,000}$ (11,000)

= 106.9 tons/acre - operating year

i.e., approximately 107 tons/acre - operating year.

Assuming crystallisers account for about 14% of total ponds area in this case,

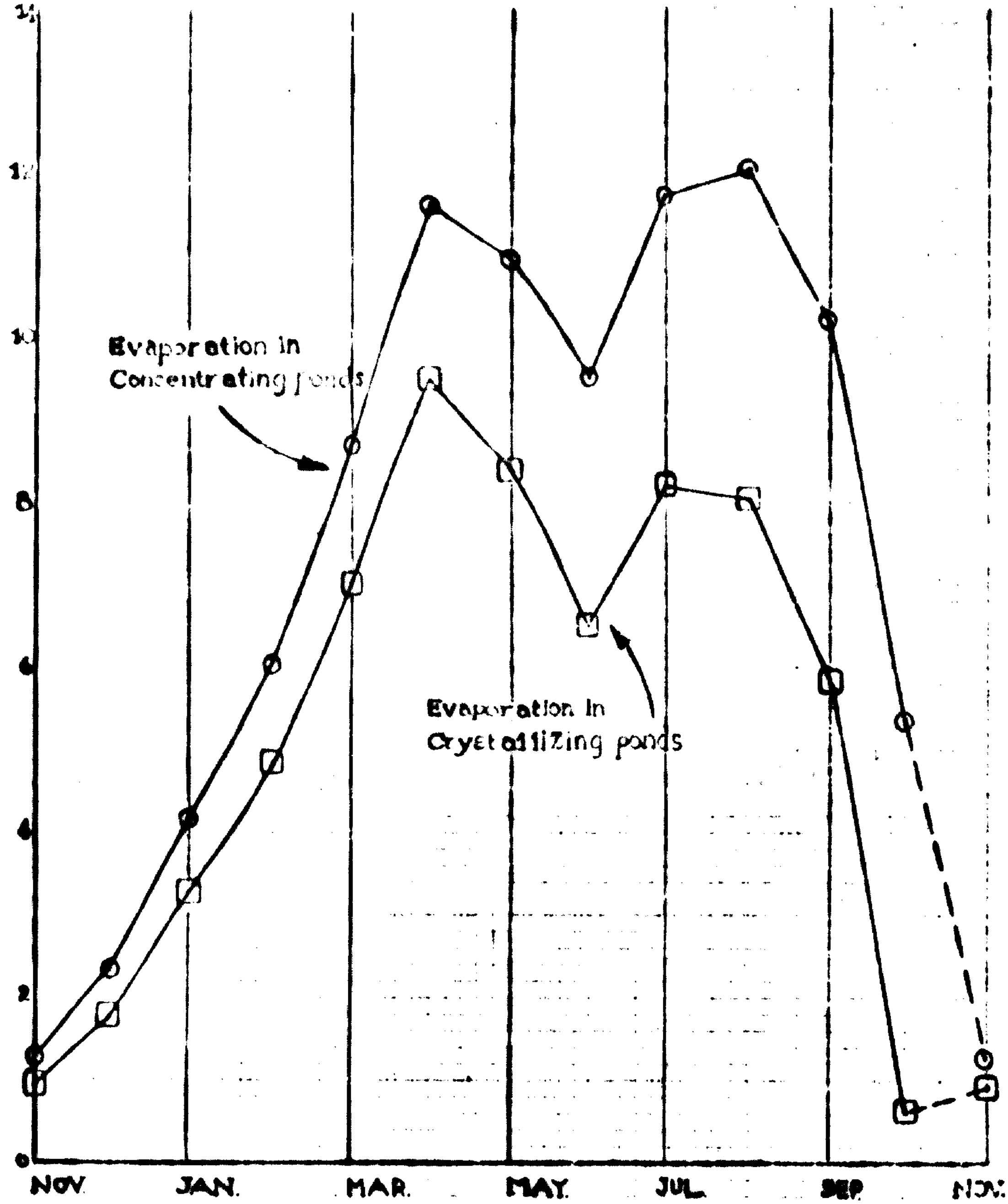
∴ Salt production rate would be $\frac{14}{100} \times 107$ = 15 tons/acre - year for the entire facility.

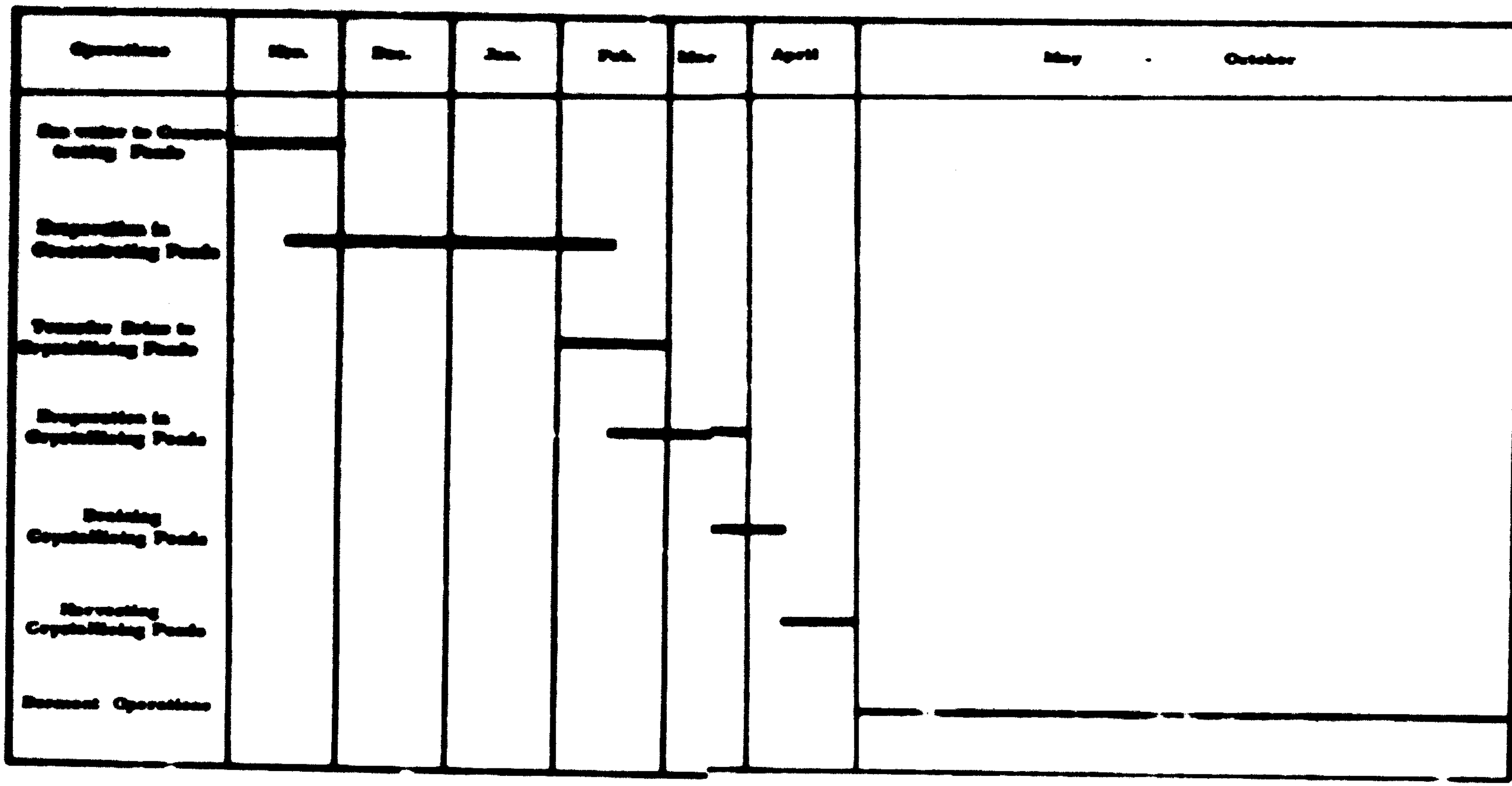
If the deposited salt density is 70 lbs./ft.^{3},

∴ The depth of the harvestable salt in the crystallisers would be

FIGURE 7

Cumulative Net Evaporation for West Harbour Site




Operations
Nov.
Dec.
Jan.
Feb.
Mar
April
May - October
Sea water to Concentrating Ponds
Evaporation in Concentrating Ponds
Transfer Brine to Crystallising Ponds
Evaporation in Crystallising Ponds
Draining Crystallising Ponds
Harvesting Crystallising Ponds
Dormant Operations

only be as follows:

$$\text{Volume of harvestable salt/acre} = \frac{107 \text{ tons} \times 2000}{70}$$

$$= 3,057 \text{ ft.}^3\text{/acre.}$$

Depth of harvestable salt in crystallizers

$$= \frac{3,057}{43,560} \times 12 = 0.84''.$$

Considering the above factors, it must be concluded that operation of this salt facility under these conditions will neither be economical nor technically feasible.

However, if the evaporation rates were more favourable, or if the rainfall during May until the end of July occurred primarily as a few major showers, it may be possible to decant nearly 60% of this rainfall before mixing and dilution takes place. If this were the case, the total accumulated net evaporation in the crystallizing ponds would be 15.76" between November and end of July instead of 9.51" between November and end of April. This would greatly enhance the economics of this salt facility since evaporation in the crystallizers would take place during 5.5 months from middle February until end of July instead of 1.5 months (in the case of 6-months operation) from the middle of February until the end of March, and the corresponding accumulated net evaporation of saturated brine would be 11.7" (during 5.5 months) instead of 3.0" (during 1.5 months).

Under these conditions, the quantity of salt that can be produced per acre of crystallizing area would be calculated as follows:

Total saturated brine evaporation = 11.7 inches/acre-operating year

$$\text{Volume of brine evaporated per acre} = \frac{11.7}{12} \times 43,560$$

$$= 42,470 \text{ ft.}^3\text{/operating year.}$$

Quantity of salt crystallised at 25% concentration

$$= 0.25 \frac{[(62.2?)(1.25)]}{2,000} (42,470)$$

$$= 413 \text{ tons/acre - operating year}$$

Assuming 20% for brine leakage occuring linearly in the crystallizers (i.e., 10% less production per acre),

∴ Quantity of salt crystallized at 25% after leakage

$$= 413 \times \frac{90}{100} = 371.7 \text{ tons/Crystallizing acre.}$$

Assuming crystallizers account for 14% of total ponds area in this case,

∴ Production rate of salt $= \frac{14}{100} \times 371.7 = 52$ tons/acre - operating year.

This is regarded as an economic rate.

Allowing 5% losses for salt harvesting, washing and loading

∴ Yield per crystallizing acre

$$= 371.7 \times \frac{95}{100} = 353 \text{ tons salt/operating year.}$$

Total annual production of the facility = 353 x 420 = 148,260

= approximately 148,000 tons/year.

If harvesting of salt crystals is carried out during the month of August, then the total operation period of this salt facility will last from November until about the end of August, i.e., approximately 10 months. The time schedule for this operation is shown in Figure 4 (page 16).

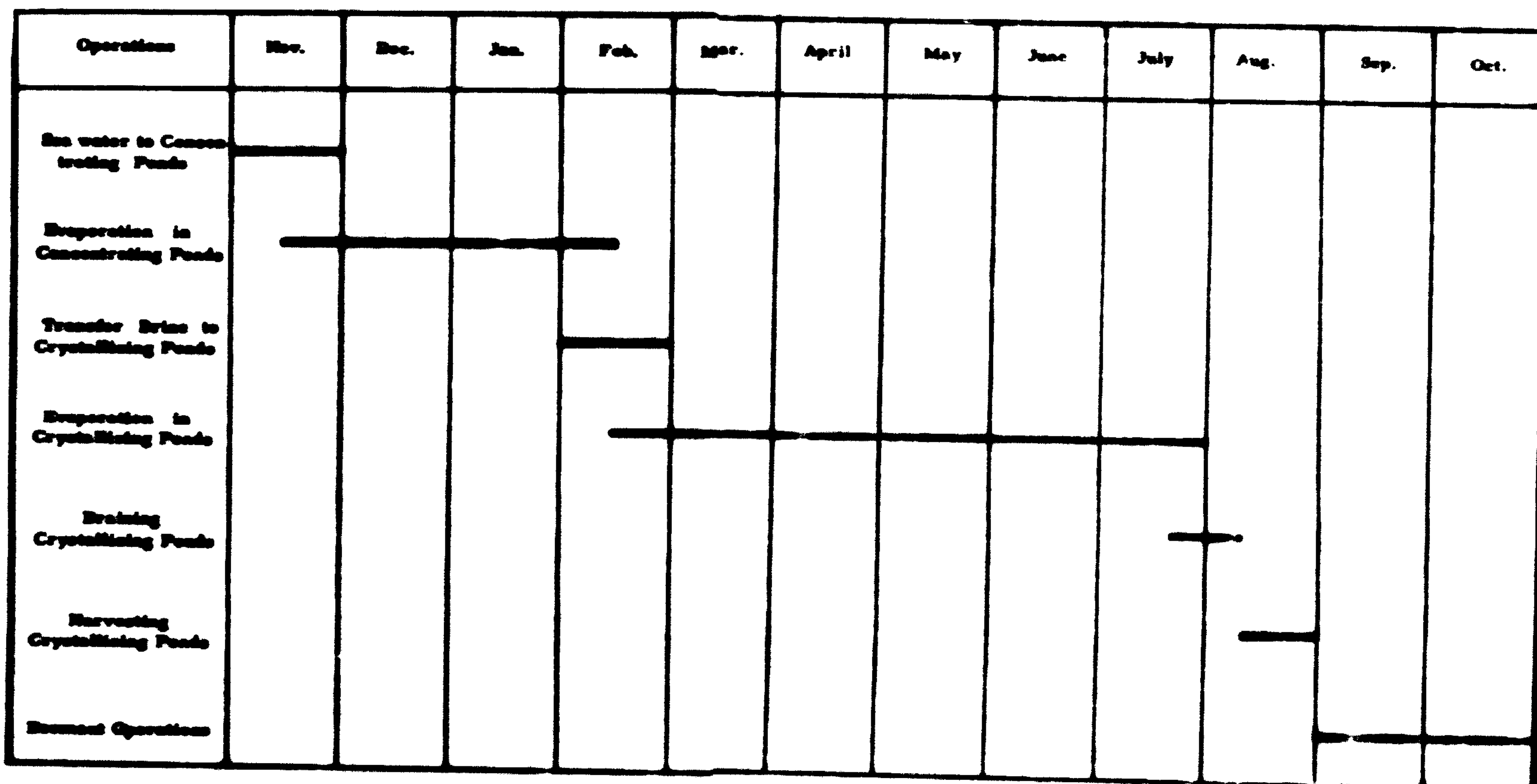
Daily Rainfall Data for 4 years (1966-1970) kindly provided by the West Indies Sugar Company (WISCO), supported the idea that rain falls primarily in a few heavy showers during the period from May until the end of July. Accordingly an economic study has been made for the West Harbour site for this assumed condition.

Final Report: Chemical Industries

5th July, 1971

FIGURE 4

Time Schedule for Ten Month Operation of Salt Facility at West Harbour Site



Economic Study for 148,000 Tons/Year Solar Salt Facility at West Harbour

Preliminary Capital Cost Estimates

Assuming that it will be possible to use the ALCOA Bauxite Pier for loading the salt, the following are the capital cost estimates:

ITEM	COST (US$)
1. Land -	Zero
2. Perimeter dikes -	64,000

Approximately one mile of perimeter dikes are required to enclose about 2,600 acres of concentrating ponds and about 420 acres of crystallizing ponds. These dikes are located in water 2 feet deep, and are 6 feet high and 12 feet wide at the top with a slope of 1 : 4. Material with sufficient impermeability is assumed to be locally available at a delivered cost of $1.53/yd.^3$ (i.e., $2.00/meter^3).

3. Perimeter dike protection -	58,000

Locally available limestone rip rap is used with about one foot thickness needed for adequate protection. The installed cost is estimated at $9.00/yd.^{3}.

4. Internal dikes -	128,000

Two internal dikes totalling 3,500 yards in length adequately divide the concentrating ponds to maintain a plug flow pattern. These dikes are 6 feet high, 12 feet wide at the top with a 1 : 4 slope. The implaced cost is estimated to be $1.53/yd.^{3} (i.e., $2.00/meter^3).

5. Internal dike protection -	72,000
6. Access Road -	20,000

An access road is only required if the bauxite pier is used for loading salt.

ITEM		COST US $
7.	Stockpile pad -	50,000
	A pad of approximately 15,000 yd.^{2} in area is required at the shipping location of ALCOA. Delivered fill is estimated at \$2.00/yd.^{3}.	
8.	Pumping Station -	60,000
	Minor pumping will be required to transfer the brine to and from the crystallizers. Extra pumping equipment will be required to decant part of rainfall occurring as heavy showers during May, June and July.	
9.	Washing Plant -	150,000
	This includes conveyors, screens, water sprays and pumps.	
10.	Harvesting Equipment -	72,000
	This includes one 500 ton/hour harvester estimated at \$60,000 and one automatic transmission tractor at \$12,000.	
11.	Four 50-ton trucks -	240,000
	Sub - total	914,000
12.	Contingencies (20%)	183,000
	Total capital cost estimates	1,097,000.

If, however an alternative pier has to be constructed, the following items will have to replace the corresponding ones in the previous estimates, or added :

1.	Access Road -	240,000
	A three mile road connecting the mainland, Dolphin Island and the coral reefs will be required.	

ITEM		COST (US$)
2.	Stockpile Pad -	120,000
	More filling will be required at the new pier and stockpile.	
3.	Loading and Pier Facilities -	400,000

Thus, the extra costs will be
760,000 - 70,000 = 690,000

and the Capital Cost will be as follows :

Preliminary Capital Cost Estimates Using Alternative Pier

Estimates using the Bauxite Pier	914,000
Extra Costs if Alternative Pier is used	690,000
Sub-total	1,604,000
Contingencies (20%)	321,000
Total capital cost estimates	1,925,000

Annual Production Costs Estimates

(a) Using Bauxite Pier

ITEM		COST (US$)
Depreciation	(15 years)	73,000
Interest	(8%)	88,000
Maintenance	(3%)	33,000
Insurance	(0.5%)	5,000
Labour	(60 workers)	60,000
Supervision		36,000
Fuel		15,000
Electricity		16,000
Loading Charges for Bauxite Pier		65,000
Total production costs estimates		391,000

ITEM	COST (US$)
Production cost per ton salt	2.64
Local Sales (18,000 tons at $6.00)	108,000
Exports (130,000 tons at $4.00)	520,000
Gross Annual Revenue	628,000
Pre-Tax Profit	237,000
Return on Investment (ROI) $= \frac{237,000}{1,097,000} =$	21.6%

(b) Using Alternative Pier

ITEM	COST (US$)
Total annual production costs (no loading charges)	477,000
Production cost per ton salt	3.22
Pre-Tax Profit	151,000
Return on Investment (ROI)	7.8%.

Since a considerable portion of the investment is tied up in the four 50-ton trucks to be used only one month per year, a leasing operation of the four trucks during the rest of the year would raise the profit and ROI. These trucks, however, have to be included in the investment since the harvesting period is seasonal and is greatly dependent on the use of them in this location.

Similarly the economics of the facility in the second case could be improved considerably if leasing of the pier is sought for other exports or imports.

The economics of the facility could be still enhanced by increasing the crystallizing area. This would be possible by utilizing an extra area, say 100 acres of the available low-cost marsh land between Bog and Boggy Ponds on the one hand and the coast opposite the newly created third pond on the other hand. Although the cost of removal of the mangroves in this area may be relatively high, yet its effect on the total capital cost of the facility would be small.

If in the future, the removal of mangroves could be carried out economically, then more land areas could be utilized to increase considerably the annual capacity of the facility.

However, before this project is implemented the production rate of salt must be verified by studying and having more detailed data regarding the following:

1. Weather conditions pertaining to the site should be determined at least for a short period, since those of Monymusk were taken as being representative. By having specific data for the site, the assumption that rainfall during May-July occurs as a few heavy showers would be ascertained. Three meteorological stations could be set up at the following points to serve the above purpose -

   (i) At the south coast of West Harbour;

   (ii) East to Mitchell Town, as near as possible from Bog and Boggy Ponds (possibly at Bog Beach);

   (iii) On Dolphin Island or on the coast of Peake Bay.

2. Leakage rates in the concentrating and crystallizing ponds, since only assumed rates were considered for the present study.

3. Topography and soil conditions of the bottoms of West Harbour and the three crystallizing ponds.

d. The Yallahs Salt Ponds Area

This area has been described before in the Progress Reports of August 1970 and January 1971. In the previous survey, the large pond (about 900 acres) and the flat land adjacent to it (about 200 acres) were suggested as a possible site.

Now that monthly rainfall and evaporation data for East Albion (near the Yallahs Ponds) have become available for approximately 5 years (1966-1971), the previous preliminary feasibility study for salt production at this site was reconsidered, especially with regard to the necessary correction for evaporation rates of brine in concentrating and crystallising ponds (with sp. gravity about 1.10 and 1.25 respectively).

Feasibility Study for the Production of 16,000-21,000 Tons Salt /Year at Yallahs Site

Two cases were studied for the Yallahs site based on similar lines to those considered for the West Harbour site and described before in this report. A preliminary layout for the proposed facility is shown in Figure 5 (page 23).

Basis of the Study

The study is based on the assumptions that -

(a) The available rainfall and evaporation data for "East Albion" would be adequately representing the Yallahs Ponds site.

(b) The total area of the facility would be either:

Case 1 (16,000 tons/year)

Approximately 354 acres of which 300 acres for concentrating and about 54 acres for crystallizing; or

Case 2 (21,000 tons/year)

Approximately 472 acres of which 400 acres for concentrating and 72 acres for crystallizing.

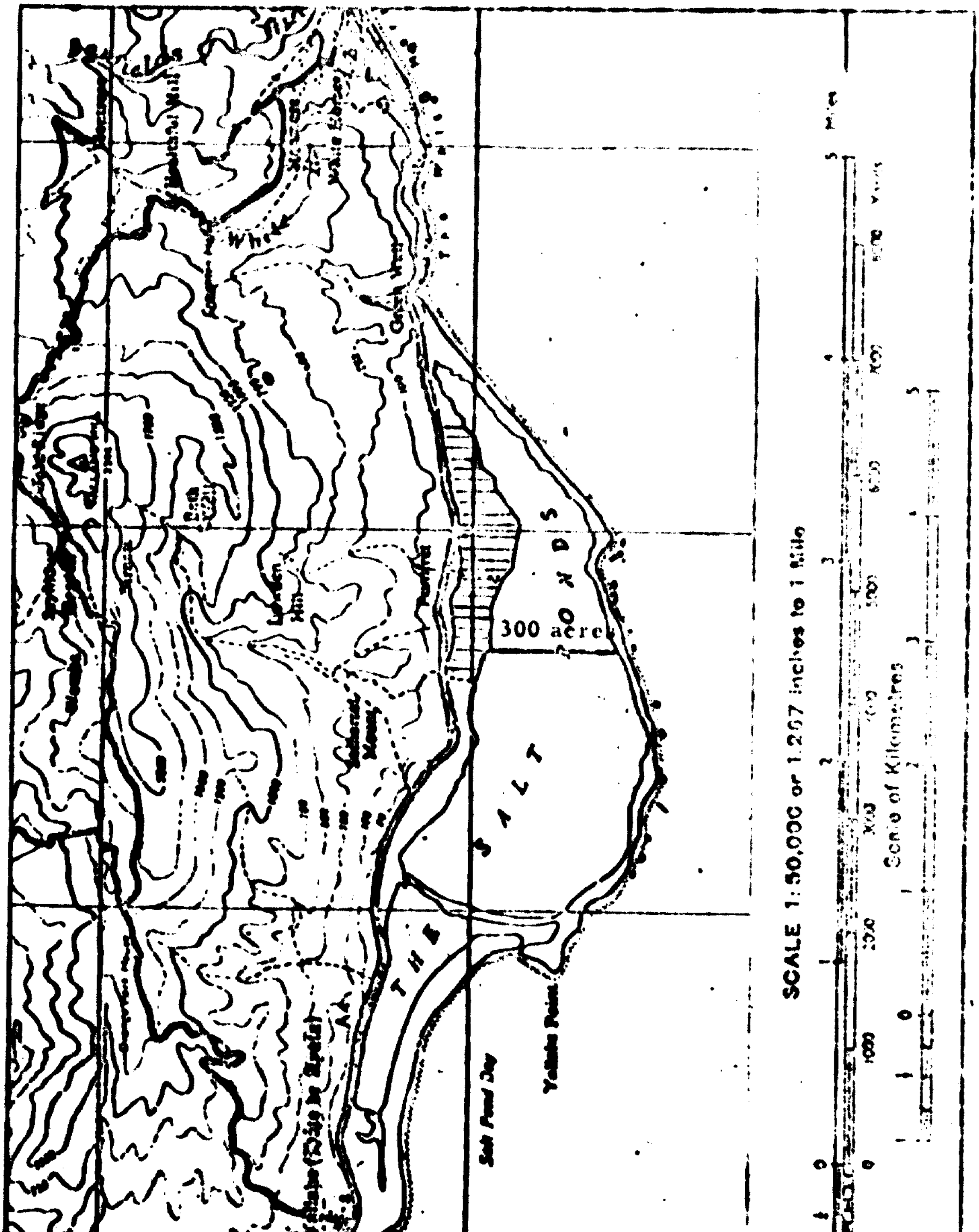
(c) The large Yallahs Pond would be divided by an internal dike into a large area to be utilized as a Pre-Concentrator (about 600 acres) and a smaller area to be utilized in both cases as a Concentrator (about 300 acres).

(d) If Case 2 is implemented, an area of about 100 acres of the flat land adjacent to the pond would be added to the facility to be used as a second Concentrator thus bringing the concentrating area to a total of 400 acres, whereas the crystallizing area would be increased by 18 acres of the same flat land thus bringing the total to 72 acres.

(e) The large Yallahs Pond has a depth of about 2 feet near the periphery, 11 feet in the centre, an average depth of about 6 feet and a depth of 4 feet only where the internal dike would be built.

FIGURE 5

Preliminary Layout for Yallahs Facility



(f) It will not be practical to maintain a permanent salt floor, and thus harvesting would be completed off a mud floor within a period of 2-3 weeks. Use of mechanical means for harvesting is not also practical, mainly due to the relatively small quantities of salt produced. It would therefore be preferable from both economic and social aspects to remove the salt from the beds by hand labour using picks and shovels on contractual basis, say about $1.50 per ton salt.

(g) Also, it will not be practical to complete the washing of salt at the site since this could be effected at the Spanish Town salt refinery, for an assumed extra cost of US$0.50/ton salt. It is also assumed that losses due to loading and washing of salt would be about 5%.

(h) All the salt produced would be consumed locally since Jamaica is importing at present about 16,000 tons/year at J$8.50/ton c.i.f.

About J$2.00/ton are added for unloading, therefore the landed price is J$10.50/ton (US$12.60/ton). It is therefore assumed that the local selling price, including the washing costs should be reasonably lower than this landed price.

Analysis of the Available East Albion Weather Data

Examination of the avialable rainfall and evaporation data pertaining to East Albion (near Yallahs Ponds), indicate that a year-round salt production is technically unfeasible. Table IV (page 25) and Table V (page 26) show the monthly rainfall and evaporation in inches at East Albion for approximately 5 years respectively.

The average annual rainfall is about 40.32", whereas average gross evaporation from Class A Meteorological pans is about 86.66" per year. This latter figure was corrected to obtain evaporation rates from fresh water reservoirs and brines having sp. gravity 1.10 (in concentrators) and 1.25 (in crystallisers). Calculations are as follows:

Type	Evaporation (Inches/Year)
Fresh Water Class A pans	86.66
Fresh Water large reservoirs	60.66
Brine in Concentrating Ponds (sp. gr. 1.10)	54.59
Brine in Crystallizing Ponds (sp. gr. 1.25)	40.52

* Source: Meteorological Division, Ministry of Communications & Works

TABLE IV

Five Years Monthly Rainfall in Inches at East Africa ([illegible] Site)

Rainfall	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total Annual
1966									3.71	0.50	0.39	[illegible]	-
1967	0.88	1.66	0.14	0.02	0.81	2.50	1.40	0.70	4.51	2.60	1.03	0.90	[illegible]7.03
1968	1.36	2.33	0.76	0.22	1.05	5.35	3.05	2.96	6.93	0.44	0.91	[illegible]	36.2[illegible]
1969	2.00	0.07	0.06	1.01	12.99	14.77	2.90	4.01	5.64	[illegible]	4.42	3.04	62.4[illegible]
1970	5.82	0.39	0.63	1.35	4.93	3.04	7.37	0.73	5.15	1.91	3.24	[illegible]	43.75
1971	2.15	1.39	0.90	0.40	[illegible].37	([illegible].99)*							
Σ	12.19	5.84	2.49	3.08	21.55	25.64	14.73	16.40	[illegible]	[illegible]	[illegible]	[illegible]	
n (months)	5	5	5	5	5	4	4	4	[illegible]	[illegible]			
X̄ (monthly average)	2.44	1.17	0.50	0.62	4.31	6.42	3.68	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]

(*) Figures in brackets were provided at a late date, and [illegible] are more favourable.

TABLE V

Five Years Evaporation in Inches at East Albion (Yallahs Ponds Site) (1966-1971)

Evaporation	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total Annual
1966									6.60	6.20	6.30	4.96	-
1967	6.20	5.04	8.37	8.40	8.68	7.20	9.61	9.30	8.10	8.06	6.00	6.20	91.16
1968	6.51	5.80	7.13	8.70	9.[illegible]2	7.80	8.99	8.68	6.60	6.20	5.70	6.82	88.85
1969	6.20	7.00	7.75	8.10	9.06	7.80	7.75	7.44	5.70	7.75	5.40	5.27	84.22
1970	5.56*	6.50	7.43	8.86	8.17*	8.55*	7.75	7.82*	5.52*	6.70*	5.16*	6.15	84.17*
1971	5.69*	6.88*	7.07*	8.68	7.93*	(9.40**)							
Σ ÷ n (months)	30.16* ÷ 5	31.22* ÷ 5	37.75* ÷ 5	42.74 ÷ 5	42.76* ÷ 5	31.35* ÷ 4	34.10 ÷ 4	33.24* ÷ 4	32.52* ÷ 5	34.91* ÷ 5	26.56* ÷ 5	29.40* ÷ 5	
$\bar{x}$ (monthly average)	6.03*	6.24*	7.55*	8.55	8.55*	7.84*	8.52	8.31*	6.50*	6.98*	5.71*	5.88*	(annual average) 86.66

(*) Corrected values of evaporation for complete month or year.
(**) Figures in brackets were provided at a late date, and thus were not considered in the calculations although they are more favourable.

Since the average annual rainfall is about 46.32" it is obvious that only about 8.2" of net evaporation per year would be available in the crystallizers which would render year-round salt production unfeasible.

Table VI (page 28) shows the analysis of the monthly rainfall and evaporation data for Yallahs Ponds Site after conversion to brine of sp. gr. 1.10 and 1.25, and on a cumulative basis. Close examination of the monthly data shown in this Table, however, reveal that evaporation conditions in the crystallizers are positive during 8 months of the year. Results are summarized in graphical form in Figure 6 (page 29).

Examination of the data in Figure 6 indicates that the evaporation season starts in December (or may be by the middle of November) and ends in May, i.e., the entire salt production cycle must be accomplished within a 6 - 6.5 month period. The time schedule for this operation is shown in Figure 7 (page 30).

Fresh brine must be added to the system each year. There are only 2.5 months for evaporation in the concentrator, then another 2.5 months for evaporation in the crystallizer. During the first period, the accumulated net evaporation in the concentrator (having already brine of 7 or more % w/w concentration) would be about 5" (after the necessary conversion to evaporation rates of brine of the corresponding specific gravity) from the beginning of December until the middle of February. During the second period, the accumulated net evaporation of saturated brine in the crystallizer would be about 9.1" from middle of February until end of April. Although this short period causes some restrictions for the operation, yet because this facility would be utilizing brine originally with much higher salt concentration than average sea-water, the project would still be feasible.

Calculation of the Production Rate and Yield of Salt

The following calculations show the quantity of salt that can be produced per acre of crystallizing pond in Case 1 under the above conditions -

Total saturated brine evaporation

= 9.1"/operating year (6-6.5 months)

Volume of brine evaporated per crystallizing acre

$$= \frac{9.1}{12} \times 43560 = 33{,}000 \text{ ft.}^3$$

TABLE VI

Analysis of Five Years Monthly Rainfall and Evaporation for East Albion (Yallahs Ponds Site)

Month	Rainfall (inches)	EVAPORATION: Fresh water Class A pans (Gross)	Fresh water large reservoirs			Brine - Sp. Gr. 1.10			Brine - Sp. Gr. 1.25		
			gross	net	cumul.	gross	net	cumul.	gross	net	cumul.
Dec.	1.75	5.88	4.11	2.36	2.36	3.70	+1.95	1.95	3.29	+1.54	1.54
Jan.	2.44	6.03	4.22	1.78	4.14	3.80	+1.36	3.31	3.37	+0.93	2.47
Feb.	1.17	6.24	4.37	3.20	7.34	3.93	+2.76	6.07	3.49	+2.32	4.79
Mar.	0.50	7.55	5.28	4.78	12.12	4.75	+4.25	10.32	4.22	+3.72	8.51
Apr.	0.62	8.55	5.98	5.36	17.48	5.38	+4.76	15.08	4.78	+4.16	12.67
May	4.31	8.55	5.98	1.67	19.15	5.38	+1.07	16.15	4.78	+0.47	13.14
Jun.	6.42	7.84	5.49	-0.93	18.22	4.94	-1.48	14.67	4.39	-2.03	11.11
Jul.	3.68	8.52	5.96	2.28	20.50	5.36	1.68	16.35	4.77	+1.09	12.20
Aug.	4.12	8.31	5.82	1.70	22.20	5.24	1.12	17.47	4.65	+0.53	12.73
Sep.	5.20	6.50	4.55	-0.65	21.55	4.09	-1.11	16.36	3.64	-1.56	11.17
Oct.	6.48	6.98	4.88	-1.60	19.95	4.39	-2.09	14.27	3.90	-2.58	8.59
Nov.	3.63	5.71	4.00	0.37	20.32	3.60	-0.03	14.24	3.20	-0.43	8.16
Total	40.32	86.66									

FIGURE 6

Cumulative Net Evaporation for Yallahs Site

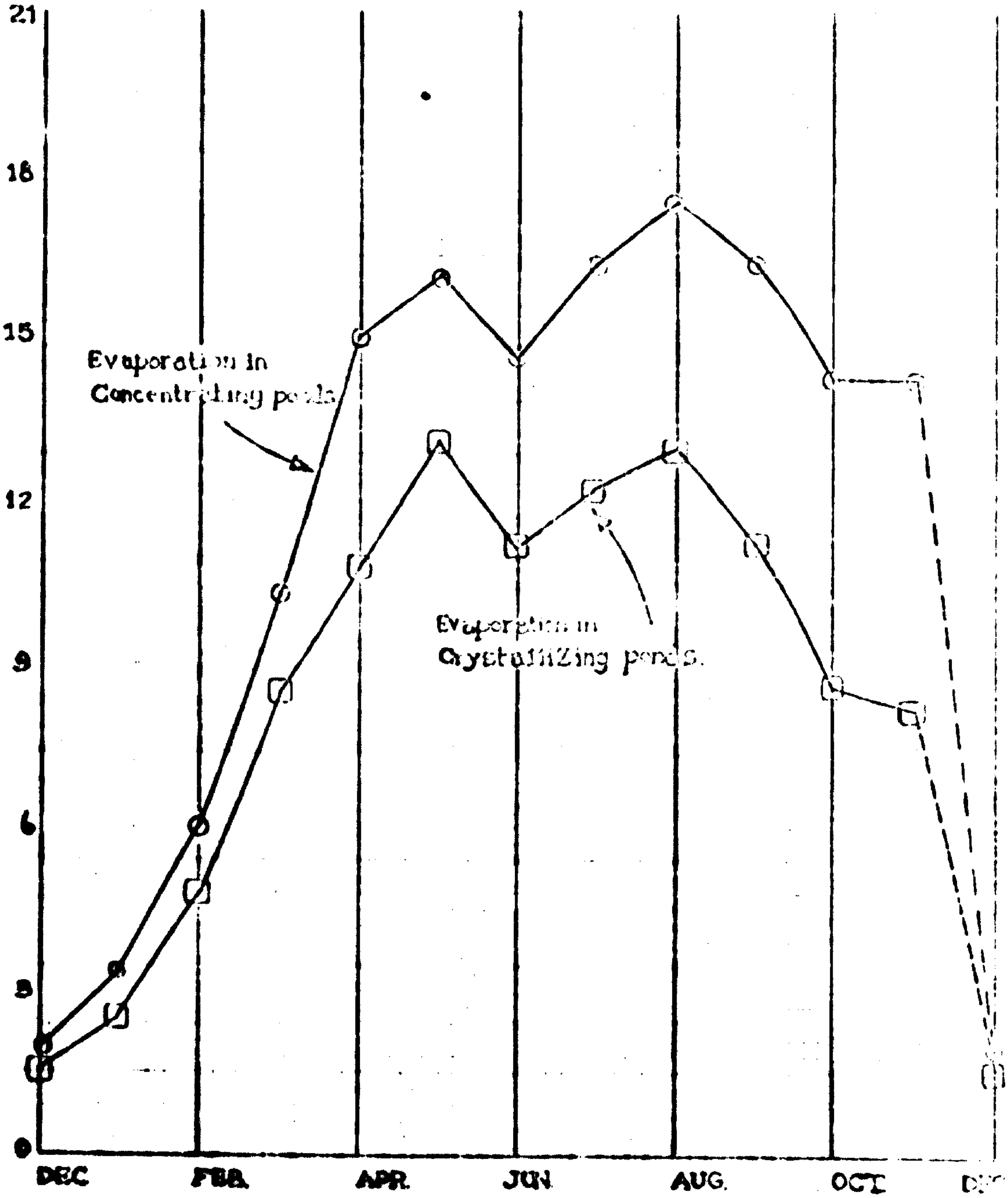


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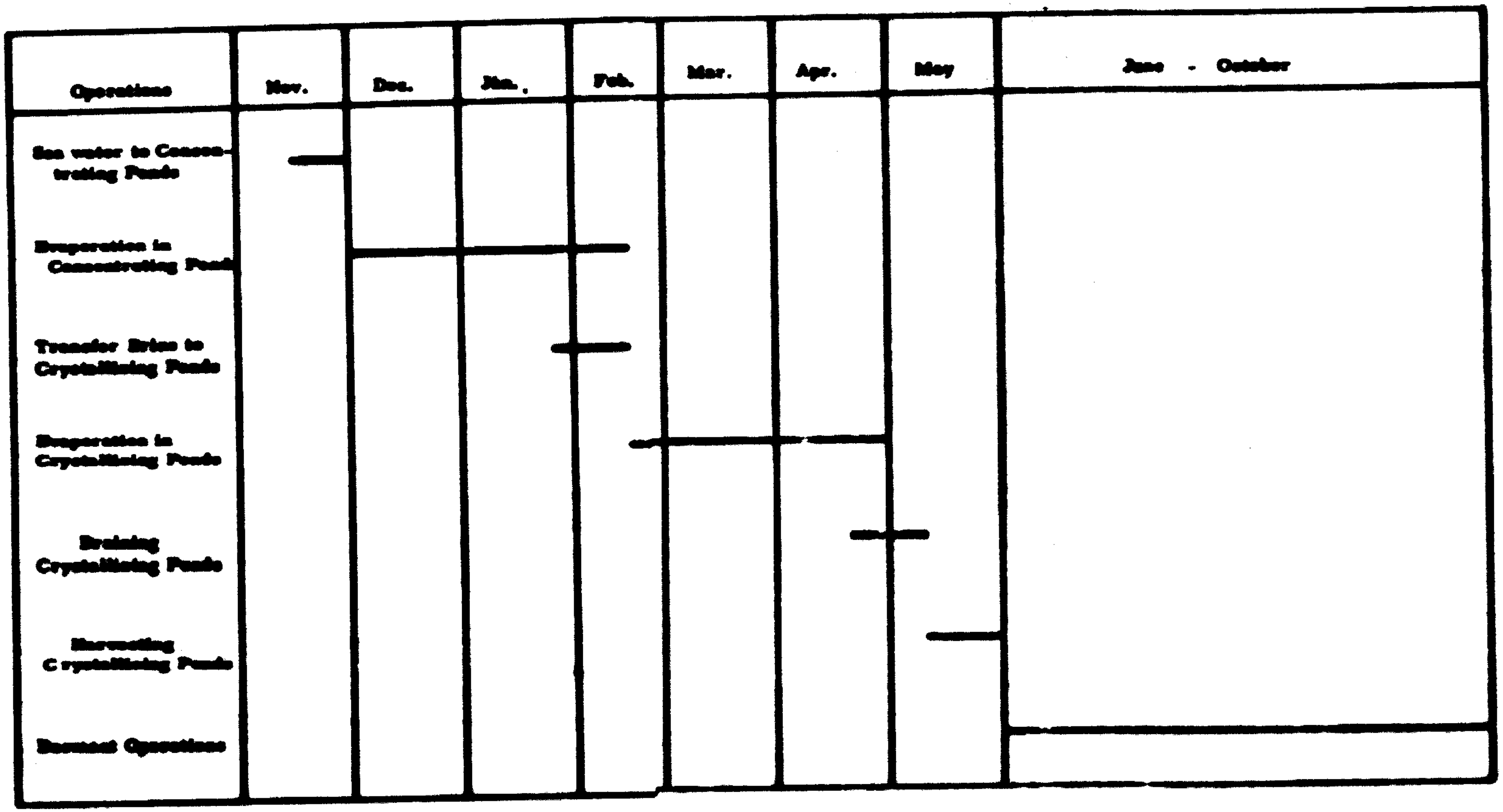
FIGURE 7

Time Schedule for Six and One-Half Month Operation of Salt Facility at Yallahs Site



Quantity of salt crystallized at 25%

$$= (\%\text{ of salt})(\text{Density of brine})(\text{Volume of brine})$$

$$= \frac{(0.25)[(62.24)(1.25)](33,000)}{(2000)}$$

= 321 tons/crystallizing acre-operating year.

Since the crystallizing pond is approximately

$\frac{54}{354} \times 100 = 15\%$ of the entire system,

∴ Production rate of salt = 321 x 15% = 48 tons/acre of the entire facility

(This is regarded as an economic rate).

∴ Quantity of salt crystallized in all the system

= 48 x 354 = 17,000 tons/year.

Allowing for 5% losses during harvesting, loading and washing of salt,

∴ Annual yield of the facility in Case 1

$= 17,000 \times \frac{95}{100} = 16,150$

= approximately 16,000 tons/year.

∴ Annual yield of the facility in Case 2

$= 16,000 \times \frac{4}{3} = 21,300$

= approximately 21,000 tons/year.

It is assumed that harvesting of salt would be carried out during 2 - 3 weeks in May, thus ending the operation before the heavier rainy season starts.

The volume of brine entering the concentrating pond would be about 244,000 m^3/year in Case 1 and about 325,000 m^3/year in Case 2. This volume would be withdrawn yearly from the concentrated brine available in the Pre-concentrator and which has a volume of about 4,000,000 m^3. It appears therefore that it will be possible to maintain the concentration of the brine in the Pre-concentrator at its high level during the years of operation.

No alternative study has been made based on partial decantation of rain during June and July, as in West Harbour, since the East Albion Meteorological Station was only set up in September 1966 and the available daily rainfall data (over a relatively short period) would not suggest with enough confidence any meaningful conclusion whether or not the rain during June and July falls as a few heavy showers.

If such is the case then the annual production of salt could be considerably increased and the economics of the facility would be greatly enhanced.

Preliminary Capital Cost Estimates for Yallahs Facility

Assuming that washing of salt will be carried out at Spanish Town salt refinery, and that harvesting will be by means of hand labour, the following are the capital cost estimates -

ITEM	COST (US$) Case 1	Case 2
1. Land - (at $360/acre) 54 acres of the flat land adjacent to the pond in Case 1 and 72 in Case 2.	20,000	62,000
2. Perimeter dikes - Approximately 200 yds of perimeter dikes are required to enclose about 900 acres in the large Yallahs Pond. These dikes are located in water 2 feet deep and are 6 feet high, 12 feet a the top with a slope 1:4. Material with sufficient impermeability is assumed to be locally available at a delivered cost of $1.53/yd.^{3} ($2.00/meter^3).	7,000	7,000
3. Perimeter dikes Protection - Locally available limestone rip rap would be used with about one foot thickness to give adequate protection. The installed cost is estimated at $9.00/yd.^{3}.	7,000	7,000

ITEM	COST (US$) Case 1	Case 2
4. **Internal dike** - One internal dike about 1200 yds. in length will divide the large Yallahs Pond into a Pre-concentrator (about 600 acres in area) and a concentrator (about 300 acres). The dike has an average height of 6 feet, 12 feet wide at the top with 1:4 slope. The implaced cost is estimated to be $1.53/yd.^{3}.	43,000	43,000
5. **Internal** dike protection -	40,000	40,000
6. **Second** Concentrating Pond - To construct, in case 2 only, a second concentrator with its perimeter edges at an average cost of approximately $300 per acre.	--	30,000
7. **Crystallizing Ponds** - To build perimeter edges and level floor of crystallizing pond (about 54 acres in Case 1 and 72 acres in Case 2) at an average cost of approximately $450 per acre.	24,000	32,000
8. **Pumping Station** -	30,000	40,000
Sub-Total	171,000	261,000
9. **Contingencies (20%)**	34,000	52,000
Total Capital Cost Estimates	205,000	313,000
This is equivalent to J$	171,000	261,000

Annual Production Costs Estimates

ITEM		COST (US$) Case 1	Case 2
Depreciation	(15 years)	14,000	21,000
Interest	(8%)	16,000	25,000
Maintenance	(3%)	6,000	9,000
Insurance	(0.5%)	1,000	2,000
Labour	(20 workers)	20,000	20,000
Supervision		10,000	10,000
Electricity		6,000	8,000
Water		1,000	1,000
Harvesting	(at 1.50/ton)	24,000	32,000
Washing charges	(at 0.5/ton)	8,000	11,000
Total Production Costs		106,000	139,000
Production Cost per Ton Salt (This is equivalent to J$5.53 and J$5.52 respectively).		6.63	6.62
Gross Annual Revenue (at $9.00/ton as compared with $12.60/ton for the present landed price)		144,000	189,000
Pre-Tax Profit		38,000	50,000
Return on Investment (ROI)		18.5%	16%

Although the production cost per ton is almost the same in both cases, yet the ROI in Case 2 is lower on account of the relatively high cost of the land that has to be added to the system in this case. However, the two Cases would be economically feasible under the above conditions.

Conclusions and Proposed Projects Regarding Solar Salt Production in Jamaica

As a result of the physical surveys and feasibility studies undertaken, the following conclusions were drawn regarding solar salt production in Jamaica, especially with respect to the West Harbour and the Yallahs Sites.

A - Conclusions Regarding the West Harbour Site

Two possible projects would be feasible under the conditions assumed before and on the basis of 60% decantation of rainfall during May-July being possible. These projects are

Project No. 1

Production of 148,000 tons salt/year using the ALCOA Bauxite Pier. Such a project would be considerably economic (ROI = 21-22%). If the four 50-ton trucks are leased as mentioned in the feasibility study, the economics would be enhanced and the ROI could be increased to about 25%.

Thus assuming that a lease of the 4 trucks would be possible for a 10-month period at $1,000/truck-month,

∴ Total lease = $40,000/4 trucks-operating year.

In this case,

		US $
Gross Annual Revenue	= 628,000 + 40,000	= 668,000
Pre-Tax Profit	= 668,000 - 391,000	= 277,000

$$\therefore \text{Return on Investment} = \frac{277,000 \times 100}{1,097,000} = 25\%.$$

Project No. 2

Production of the same quantity of salt as in the first project but using an alternative constructed pier. Such a project would be marginally economic if the 4 trucks and the Pier facilities were not leased (ROI = 7 - 8%).

However, if the 4 trucks, or the trucks and the pier were leased, the Gross Annual Revenue and the ROI could be increased to about 10% and 13% respectively.

Thus, assuming that the 4 trucks were leased at about \$40,000/10 months (operating year) and that the pier facilities were leased at about \$60,000 per 10 months (operating year),

∴ Gross Annual Revenue in case of leasing the 4 trucks only = 628,000 + 40,000 = 668,000

Pre-Tax Profit in this case = 668,000 - 477,000 = 191,000

∴ Return on Invêstment = $\frac{191,000 \times 100}{1,925,000}$ = 9.9%

= approximately 10%.

Gross Annual Revenue in case of leasing the 4 trucks and the Pier = 628,000 + 100,000 = 728,000

Pre-Tax Profit in this case = 728,000 - 477,000 = 251,000

∴ Return on Investment = $\frac{251,000 \times 100}{1,925,000}$ = 13%.

On the other hand if 60% decantation of the rainfall during May - July inclusive), would not be possible, but only about 40% possible, then one project only would be feasible in this case. The production capacity of the facility would thus be about 116,000 tons salt per year because the cumulative net evaporation would be smaller than the case of Projects 1 and 2. This 3rd Project is:

Project No. 3

Production of 116,000 tons salt/year using the ALCOA Bauxite Pier.

Calculation of the Annual Production would be as follows:

Cumulative net evaporation in the crystallizer between middle of February and end of July (40% decantation) = 9.2 inches,

∴ Quantity of salt crystallized at 25% concentration (after leakage) = 292 tons / crystallizing acre-operating year.

Production Rate of Salt (assuming crystallizers account for 14% of the entire facility)

$$= 292 \times \frac{14}{100} = 40.9 \text{ tons/acre-operating year.}$$

∴ **Total Annual Production** = 292 x 420 (crystallizing acres)
= 116, 340
= **approximately 116, 000 tons/acre-operating year.**

∴ **Return on Investment is calculated as follows (in case the 4 trucks are not leased):**

		US$
Annual Production Costs ($16, 000 less than Project No. 1		= 375, 000
Production Cost per ton Salt		= 3. 23
Local Sales	(18, 000 tons @ $6. 00/ton)	= 108, 000
Exports	(98, 000 tons @ $4. 00/ton)	= 392, 000
Gross Annual Revenue		= 500, 000
Pre-Tax Profit		= 125, 000
Return on Investment	$= \frac{125,000 \times 100}{1,097,000}$	= 11. 4%
	= approximately 11%.	

The project in this case would be economic.

If the four 50-ton trucks were leased as in the case of Project No. 1, then,

		US$
Gross Annual Revenue		= 540, 000
Pre-Tax Profit	= 540, 000 - 375, 000	= 165, 000
Return on Investment (in case of leasing the 4 trucks)	$= \frac{165,000 \times 100}{1,097,000}$	= 15. 04%
	= approximately 15%.	

(Which is considered economically good).

A fourth project for the production of 116, 000 tons salt/year would not be feasible if an alternative pier were used in case of 40% decantation of the rainfall between May and July (inclusive).

The Return on Investment in this case = 2%, which is **calculated as follows:**

		US $
Gross Annual Revenue (40% decantation)		= 500,000
Annual Production Costs (less than the case of 60% decantation by $16,000 since Export is 98,000 tons instead of 130,000 tons)		= 461,000
∴ Pre-Tax Profit		= 39,000
Return on Investment	$= \frac{39,000 \times 100}{1,925,000}$	= 2%.

(This is too small).

If it is assumed that leasing operations were possible for the 4 trucks at $40,000, and for the pier at $60,000 per operating year of 10 months, then,

		US$
Gross Annual Revenue (in case the trucks and pier are leased)		= 600,000
Pre-Tax Profit	= 600,000 - 461,000	= 139,000
Return on Investment	$= \frac{139,000}{1,925,000}$	= 7%

which would still be mraginal and risky considering the relatively large investment used in this case. Therefore such a project is not recommended unless a larger facility could be established in the future using the marsh land adjacent to the ponds.

B - Conclusions Regarding the Yallahs Site

Two possible projects would be feasible under the conditions assumed before. These projects are:

Project No. 1

Production of 16,000 tons salt/year using about 54 acres of the flat land adjacent to the ponds (to be used as a crystallizer) and about 300 acres of the large Yallahs Pond (to be used as a concentrator). The ROI of this project would be about 18%.

Project No. 2

Production of 21,000 tons salt/year using about 74 acres of the flat land adjacent to the ponds (to be used as a crystallizer, 100 acres of this flat land to be used as a second concentrator, and about 300 acres of the large Yallahs Pond (to be used as a first concentrator). The ROI in this case would be about 16%.

Either of the two projects is recommended, since the first has an advantage of having a higher ROI, whereas the second has the advantage of giving a higher production.

Recommendations for Implementing Solar Salt Projects in Jamaica

The following recommendations are proposed for finally implementing solar salt projects in Jamaica.

1. To expedite the steps to depute a UNIDO Solar Salt Production Expert (according to the terms of reference submitted already to the Government and accepted by UNIDO) since preliminary feasibility studies for Yallahs and West Harbour Sites have been completed, also, because the Ministry of Rural Land Development has no objections to the use of Yallahs Ponds for solar salt production.

2. At present, because conditions at Yallahs are more positive and mature, it is preferable to use this site primarily for salt production, especially because either of the two proposed projects would satisfy the needs of the local market.

   In the future, the West Harbour Site could be implemented as its operation would depend on ensured export markets or the manufacture of caustic soda in Jamaica.

3. To identify the topography of the large Yallahs Pond as well as leakage rates and soil conditions at the Pond and the adjacent land.

4. If the topography and soil conditions results are positive, a meteorological station should be set up at Yallahs site.

5. Project No. 1 could be implemented first, then it could possibly be expanded as Project No. 2.

6. In the meantime as the above steps are being taken, formal approval of the Ministry of Rural Land Development should be sought to use the West Harbour Site for salt production.

7. To identify the topography of West Harbour and the nearby Ponds, as well as leakage rates and soil conditions.

8. If results from 7 above were positive, three meteorological stations should be set up at the West Harbour Site to confirm the weather data as suggested in the feasibility study.

2. Chemical Complex Based On Salt

In the Progress Report of January 1971, it was possible to reach useful conclusions with regard to a Chemical Complex based on salt. The optimum capacities of the units of this complex were determined as a result of the preliminary economic study given in that Report. Accordingly, the Complex is suggested as a project that could be implemented in Jamaica in one or more stages in the future.

Units of the proposed Chemical Complex are:

a- A Chlorine-caustic Plant to produce 200, 000 tons caustic soda and 183, 000 tons chlorine per year.

b- An Ethylene Dichloride Plant having a capacity of 200, 000 tons per year.

c- An Ethylene Plant to product about 67, 000 tons/year ethylene from naphtha in a Stripped Down Plant (by the low-cost Dianor Process).

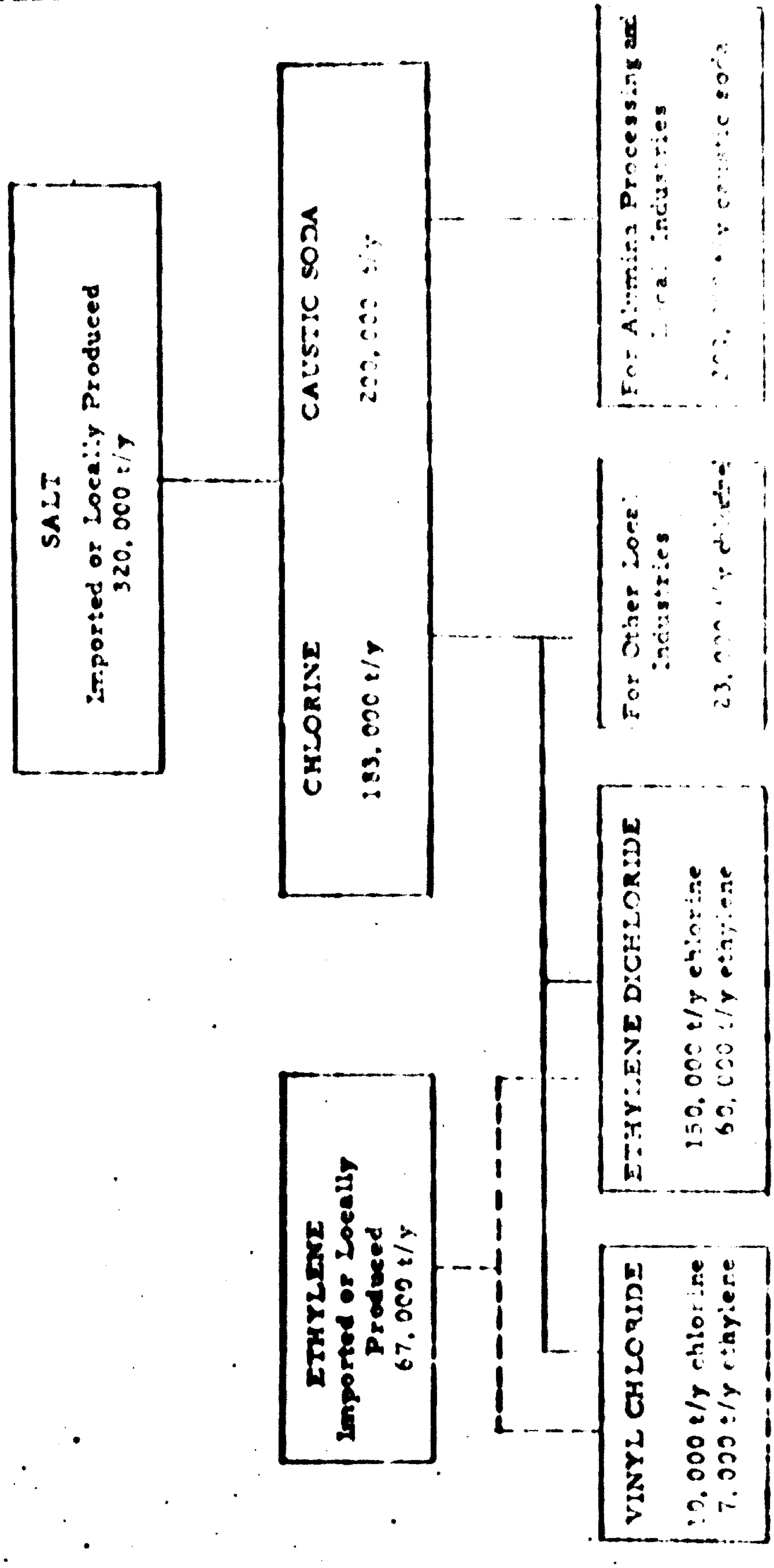
The production of Ethylene in Jamaica would only be an alternative in case the cost of imported ethylene becomes too high.

d- A Vinyl-Chloride Plant to produce 15, 000 tons per year vinyl monomer.

A diagram outlining these different units is shown in Figure 8 (page 41). However, on account of new information now available concerning the actual price of imported caustic soda, the economic study and conclusions regarding the suggested chlorine-caustic plant have been re-considered. In the meantime, the effect of plant capacity on the cost of production of caustic soda and chlorine in Jamaica has been reviewed based on factors different from those previously taken in the Progress Report of January 1971. Thus -

FIGURE 8

DIAGRAM OF CHEMICAL COMPLEX BASED ON SALT IN JAMAICA



Effect of Plant Capacity on Cost of Manufacture of Caustic Soda and Chlorine in Jamaica

Taking more realistic values for salt, power, fuel, labour and depreciation, estimates of costs of manufacture relevant to different plant capacities in Jamaica were determined and compared with those in the United States. Figure 9 (page 43) represents these relations graphically.

The new basis for this comparison is as follows:

ITEM	PRICE IN U.S.A. US$	PRICE IN JAMAICA US$
Salt	5.00 /ton	5.00/ton
Power	0.006 /Kwh	0.012 /Kwh
Fuel	0.20 /MMBTU	0.37 /MMBTU
Labour	4.00 /man hr.	3.20 /man hr.
Depreciation	15 years	15 years

It is obvious from the graph that the optimum capacity for the production of caustic soda and chlorine would be about 550 tons/day or more (i.e., about 200,000 tons/year or more). The corresponding cost of manufacture of electro-chemical unit (1.1 tons caustic soda 50% solution + 1 ton chlorine) is about $88.20 in Jamaica as compared with about $60.00 in U.S.A.

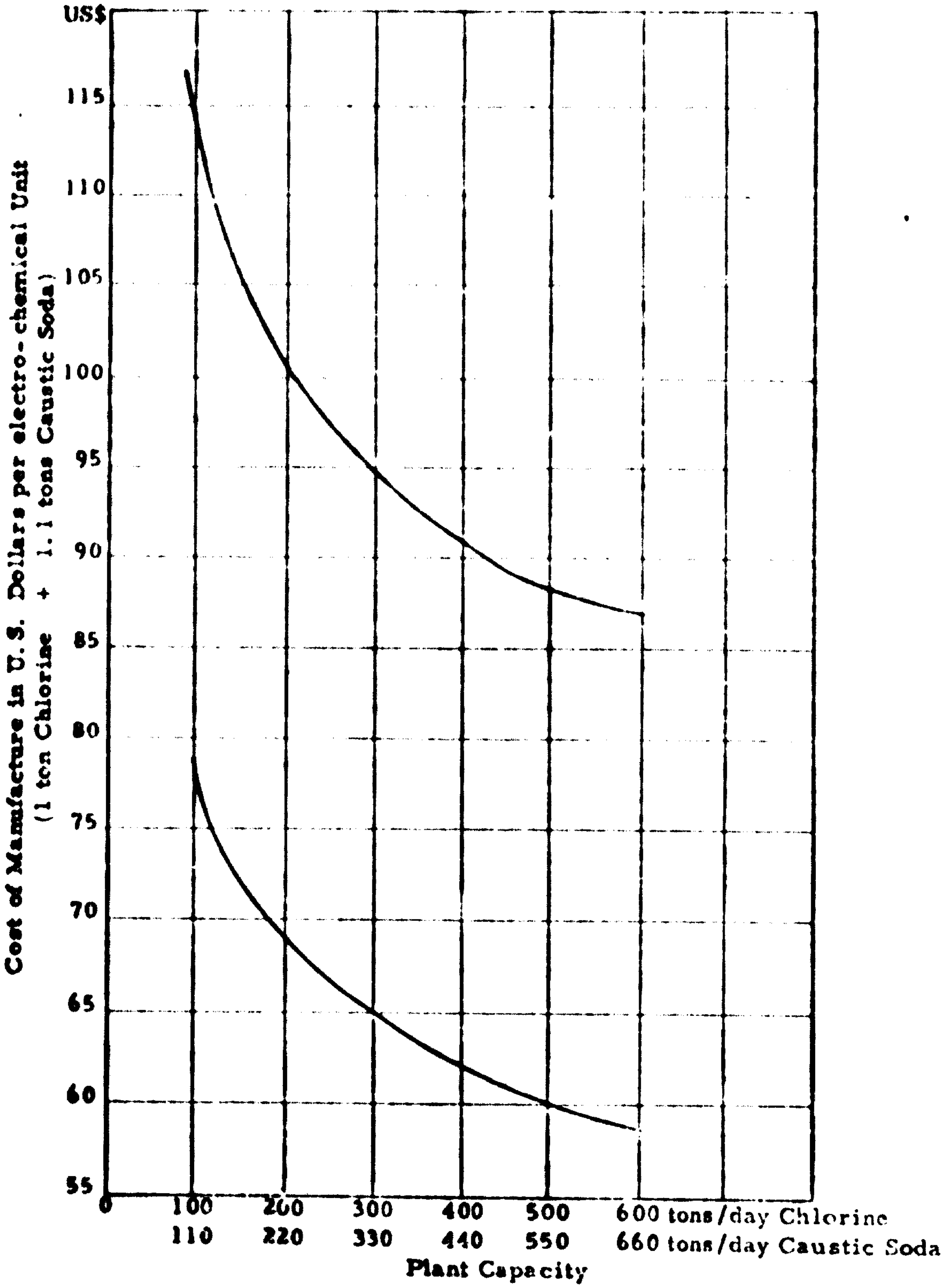
As mentioned in the Progress Report of January 1971, it would be interesting to draw a comparison between this estimated cost of manufacture of caustic soda (50% solution) and the actual price of caustic soda (50% solution) presently imported by the Alumina producers in Jamaica, since almost all of the locally produced caustic soda will eventually be utilized for alumina processing.

Preliminary Economic Study for the Chlorine-Caustic Plant

Price of Presently Imported Caustic Soda

	US$
F.o.b. price	33.00
Freight (by privately chartered vessels and on dry basis)	3.00
C & F price	36.00
Insurance (1.5% of C & F price)	0.54
C.i.f. price	36.54

FIGURE 9


US$
115
110
105
100
95
90
85
80
75
70
65
60
55
Cost of Manufacture in U.S. Dollars per electro-chemical Unit
(1 ton Chlorine + 1.1 tons Caustic Soda)
0
100
110
200
220
300
330
400
440
500
550
600 tons/day Chlorine
660 tons/day Caustic Soda
Plant Capacity

Price of Presently Imported Caustic Soda (cont'd) US$

		US$
	(B/f)	36. 54
Duties (15% of c. i. f. price)		5. 48
Surcharge (10% of duties)		0. 55
Landing or Wharfage Charges		2. 40
Tonnage Tax	(approx)	2. 00
Inland freight		3. 00
Total		49. 97

It could be assumed therefore that the price of caustic soda (50% solution) delivered at the ALCAN plant is approximately US$50. 00 (i. e., J$41. 66).

In other words, assuming that the caustic soda produced locally will be sold at US$50. 00 per ton as the imported, and assuming that the industrial incentive legislations will be applied, then -

The netback for 1. 1 tons caustic soda produced and sold locally	US$55. 00
If the netback for chlorine = (as compared with the current price of $46. 00/ton chlorine f. o. b. Gulf Coast)	40. 00
∴ Total netback for the electro-chemical unit =	95. 00
Since estimated cost of manufacture of electro-chemical unit =	88. 20
∴ Gross Profit	6. 80

Gross Return $= \frac{6.80}{88.20} \times 100 = 7.7\%$.

In this case the plant would be somewhat marginal but still recommended on account of the other aspects from which the national economy will benefit.

If, on the other hand, the netback for chlorine is $42. 00 or $44. 00,

∴ Gross Return = 10% and 12. 2% respectively.

In these cases the economics are improved.

Utilization of Co-Product Chlorine for the Production of Titanium Metal from Titania Slag

In the meantime, the regional UNIDO Senior Industrial Development Field Advisor suggested the possibility of using the co-product, chlorine, in industrial processes other than its familiar use for manufacturing ethylene dichloride and vinyl chloride which some other countries in the area are going to produce.

It was therefore suggested to investigate the possibility of using the co-product chlorine in the production of titanium metal from titania slag obtained in countries as Japan, U. S. S. R. and Canada from the smelting of ilmenite concentrates. Because the TiO_2 content in the Canadian slag is comparatively low (70-74%), the slag in this case is mainly used for the sulphate process of TiO_2 production. On the other hand, the high titania slag produced in Japan (90%) is utilised for the production of titanium metal by chlorination and subsequent reduction. The slag produced in the U. S. S. R. (also having a high TiO_2 content of 85-90%) is used as raw material for titanium metal and for the production of Pigment-Grade TiO_2 by a new chlorination-oxidation process.

Since Jamaica has no ilmenite, this investigation to utilise chlorine co-produced with caustic soda for the production of titanium metal or Pigment-Grade TiO_2 depends on the availability of investors who would be ready to import the titania slag or ilmenite concentrates to Jamaica for the chlorination process. Marketing of the Titanium metal produced (and the Pigment-Grade TiO_2) could be effected in nearby countries.

However, work on this investigation was not completed because it was not possible, until now, to obtain the necessary information regarding the material balances and particularly the quantities of chlorine required in these chlorination processes so that an alternative suggestion for the use of chlorine for manufacturing Ethylene Dichloride and Vinyl Chloride could have been worked out.

Therefore the completion of this investigation is suspended for the time being, and the only alternative for the use of the co-product Chlorine in the suggested Chemical complex Based on Salt remains unchanged as given before in the Progress Report of January, 1971, i. e., for the manufacture of Ethylene Dichloride and Vinyl Dichloride.

3. Sulphuric Acid and/or Ammonium Sulphate from Anhydrite or Gypsum

Because anhydrite and gypsum are available in abundance in Jamaica, it was planned according to Progress Report of August 1970, to study the feasibility of manufacturing ammonium sulphate and/or sulphuric acid from these raw materials. It was thought later, in the Progress Report of January 1971, to limit the study to the manufacture of ammonium sulphate only, due to certain reasons outlined in that Report.

However, on advice received from the Substantive Section in UNIDO, Vienna, the feasibility of manufacturing sulphuric acid from anhydrite by the new Kent-ISU Process was carried out.

A - Manufacture of Sulphuric Acid from Anhydrite or Gypsum

This process will be of particular interest in countries which have no indigenous elemental sulphur, but which have anhydrite or gypsum available locally. A feature of the process is that it produces lime as a by-product instead of the more familiar clinker (cement). Lime is considered to be easier than clinker to dispose of profitably.

The information published and received from UNIDO about this new process indicated that the process depends on using natural gas (pre-heated with air) to provide the reducing gas and the necessary heat for the reaction in the fluidizing bed reactor.

However, since Jamaica has no natural gas, it was decided to investigate the possibility of using fuel oil as a substitute for natural gas by analogy with another similar process (i.e., the manufacture of lime from limestone in fluidizing bed reactor), where it is possible to use either fuel oil or natural gas. The impact on the economics of the project, of such substitution in Jamaica, has to be determined in this case.

It was possible to contact the Licensors of the new Kent-ISU Process in the U.S.A. who confirmed that the fluid bed reactors in their process could be equipped to use either natural gas or fuel oil, with the oil being either injected directly into the bed, or alternatively to burn the oil in an external burner and feed the hot gas with the air for fluidization into the reactor.

The extra cost of the necessary facilities for fuel storage and fuel injection, that would be used in Jamaica, was estimated and its effect on the economics of the project was studied as shown later in this Report.

The published information received from UNIDO indicated the economics of manufacturing 1,000 tons/day sulphuric acid by the three known processes, viz.,

a - Kent-ISU process (using natural gas)

b - Sulphur-burning process

c - Cement/Sulphuric process.

The economics of the third process showed the highest capital and production costs and therefore was excluded from the present study.

However such economics of a large scale plant (1,000 tons/day) would not be meaningful if applied to Jamaica, since it is not likely that the country would be consuming or producing this amount.

Also, because Jamaica has a sulphuric acid plant in Spanish Town which has a capacity of about 100-120 tons/day from imported sulphur, it would be useful therefore to study the economics of a plant having similar capacity to that of Spanish Town or somewhat larger, say 300 tons/day, should the demand warrant this in the future.

To determine the best conditions under which sulphuric acid could be manufactured in Jamaica in the future, the economics of the Kent-ISU process (using fuel oil) and the Sulphur-burning process were compared. In the meantime the capital and production costs in Jamaica were compared with those in U.S.A. to establish the relationship in each case.

Economic Study for the Manufacture of Sulphuric Acid Either from Anhydrite or Sulphur

A. Capital Cost Estimates

A1 - Capital Cost Estimates for 300 Tons/Day Sulphuric Acid Plant from Anhydrite by Kent-ISU Using Fuel Oil in USA and Jamaica

	US $
Estimated 1968 cost of plant in USA* using natural gas (battery limit)	4,110,000
7% increase in machinery cost until end 1970**	290,000

* Kindly provided by Licensors
** From Marshal and Stevens Index.

	US $
Estimated Capital Cost (beginning 1971) in USA using natural gas	4,400,000
Fuel oil storage (2 weeks)	70,000
Fuel oil injection	30,000
Estimated Capital Cost (beginning 1971) in USA using fuel oil	4,500,000
Assuming 5% increase in case of Jamaica	225,000
Estimated Capital Cost in Jamaica (beginning 1971) using fuel oil	4,725,000

(It is interesting to note that Capital Cost estimates for 1,000 ton/day plant from anhydrite by Kent-ISU Process using natural gas in USA at beginning of 1971 are US$9,100,000).*

A2 - Capital Cost Estimates for 300 Ton/Day Sulphuric Acid Plant from Sulphur in USA and Jamaica

	US $
Estimated 1968 cost of plant in USA** from sulphur (battery limit)	1,870,000
11% increase in machinery cost until end 1970 ***	206,000
Estimated Capital Cost (beginning 1971) in USA	2,076,000
Assuming 5% increase in case of Jamaica	104,000
Estimated Capital Cost in Jamaica (beginning 1971)	2,180,000

(It is interesting to note that Capital Cost estimates for 1,000 ton/day plant from Sulphur in USA at beginning of 1971 are US $4,150,000)*.

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* From European Chemical News, January 1971
** Kindly provided through the Licensors.
*** From Marshal and Stevens Index.

A3 - Capital Cost Estimates for 120 Ton/Day Sulphuric Acid Plant from Anhydrite by Kent-ISU Process Using Fuel Oil in USA and Jamaica

Based on 1968 capital cost estimate for 300 tons/day plant in USA using natural gas = US $ 4,110,000, which was kindly provided by the Licensors, the following estimates were made -

	US $
Estimated Capital Cost (beginning 1971) in USA for 120 tons/day plant by Kent-ISU using natural gas	2,710,000
Fuel oil storage (2 weeks)	30,000
Fuel oil injection	13,000
Estimated Capital Cost (beginning 1971) in USA by Kent-ISU using fuel oil	2,753,000
Assuming 5% increase in case of Jamaica	137,000
Estimated Capital Cost (beginning 1971) in Jamaica	2,891,000
i.e., approximately	2,900,000

A4 - Capital Cost Estimates for 120 Ton/Day Sulphuric Acid Plant from Sulphur in USA and Jamaica

Based on 1968 capital cost estimates for 300 tons/day plant from sulphur in USA = US $ 1,870,000, which was kindly provided by the Licensors, the following estimates were made -

	US $
Estimated Capital Cost (beginning 1971) in USA for 120 tons/day plant from sulphur	1,420,000
Assuming 5% increase in case of Jamaica	71,000
Estimated Capital Cost (beginning 1971) in Jamaica	1,491,000

B. Production Costs Estimates

Since production costs of sulphuric acid in USA would be indicative to the international costs, and, to make this comparative study as complete as possible, the production costs of 300 tons/day sulphuric acid plant from anhydrite by Kent-ISU process using natural gas were estimated according to the present costs of input units in USA, thus -

B1 - Production Costs Estimates for 300 Ton/Day* Plant in USA by Kent-ISU Process Using Anhydrite and Natural Gas

Item	Amount/ton H_2SO_4	Cost/Unit of Input (US$)	Cost/Ton H_2SO_4 (US$)
1. Raw material - Anhydrite	1.5 ton	3.00 ton	4.50
2. Utilities -			
a. Electric power	80 Kwh	0.012/Kwh	0.96
b. Process water	50 gal.	0.40/1000 gal.	0.02
c. Cooling water	14,000 gal.	0.023/1000 gal.	0.32
d. Fuel (natural gas)	7.7×10^6 BTU	0.40/MM BTU	3.08
3. Labour -			
a. Operating (2 men/shift at average $4.00/man hr.			0.64
b. Supervision (40% of operating labour)			0.26
4. Maintenance - (5% of fixed capital)			2.20
Sub-Total			11.98
5. Indirect costs -			
a. Depreciation and interest (20% of fixed capital)			8.80
b. Overheads (100% of labour and maintenance)			3.10
Sub-Total			23.88
Less credit for lime (0.582 ton @ $9.00/ton)			-5.24
Production cost/ton H_2SO_4			18.64
Less depreciation and interest			-8.80
Production costs/ton after depreciation of plant cost			9.84

* Annual Capacity is approximately 100,000 tons based on 330 working days.

Then the following estimates of the production costs in both USA and Jamaica, using either anhydrite and fuel oil in the Kent-ISU process, or sulphur in the sulphur-burning process, were carried out.

B2 - Production Costs Estimates for 300 Ton/Day Plant in USA and Jamaica by Kent-ISU Process Using Anhydrite and Fuel Oil

Item	Amount/ton H_2SO_4	Cost/unit of Input		Cost/ton H_2SO_4	
		in USA US$	in Jamaica US$	in USA US$	in Jamaica US$
1. Raw Material - Anhydrite	1.5/ton	3.00/ton	3.00/ton	4.50	4.50
2. Utilities -					
a. Electric Power	80 Kwh	0.012/Kwh	0.015/Kwh	0.96	1.20
b. Process Water	50 gal.	0.40/1000 gal.	0.40/1000 gal.	0.02	0.04
c. Cooling Water	14,000 gal.	0.023/1000 "	0.03/1000 "	0.32	0.42
d. Fuel (fuel oil)	7.7×10^6 BTU	0.40/MMBTU	0.56/MMBTU	3.08	4.31
3. Labour -					
a. Operating (2 men/shift)		4.00/man hr.	2.50/man hr.	0.64	0.40
b. Supervision		40% (of operating labour)	100% (of operating labour)	0.26	0.40
4. Maintenance		5% (of Capital)	6% (of Capital)	2.25	2.83
Sub-Total				12.03	14.10
5. Indirect Costs -					
a. Depreciation & Interest (20% of fixed capital)				9.00	9.45
b. Overheads (100% of labour and maintenance)				3.15	3.63
Sub-Total				24.18	27.18
Less credit for lime (0.582 ton @ $9.00/ton)				-5.24	-5.24
∴ Production cost /ton H_2SO_4				18.94	21.94
Less Depreciation and Interest				-9.00	-9.45
Production costs/ton after depreciation of plant cost				9.94	12.49

B3 - Production Costs Estimates for 300 Ton /Day Plant in USA and Jamaica by the Sulphur-Burning Process

Item	Amount/ton H_2SO_4	Cost/unit of Input		Cost/ton H_2SO_4	
		In USA	In Jamaica	In USA	In Jamaica
		(US$)	(US$)	(US$)	(US$)
1. Raw material - Sulphur	0.3 ton	30.00/ton	32.00/ton	9.00	9.60
2. Utilities -					
a. Electric Power	8 Kwh	0.012/Kwh	0.015/Kwh	0.10	0.12
b. Process water	400 gal.	0.40/1000 gal.	0.80/1000 gal.	0.16	0.32
c. Cooling water	7,500 gal.	0.023/1000 "	0.03/1000 "	0.17	0.23
d. Boiler feed water	300 gal.	0.40/1000 "	0.80/1000 "	0.12	0.24
3. Labour -					
a. Operating (1 man/shift + 1 day man)		4.00/man hr.	2.50/man hr.	0.43	0.27
b. Supervision		40%	100%	0.17	0.27
4. Maintenance		5% (of capital)	6%	1.00	1.31
Sub-Total				11.15	12.36
5. Indirect costs -					
a. Depreciation & Interest (20% Of fixed capital)				4.15	4.36
b. Overheads (100% of labour and maintenance)				1.60	1.85
Sub-Total				16.90	18.57
Less credit for Steam				-1.20	-1.20
∴ Production Cost/Ton H_2SO_4				15.70	17.37
Less Depreciation and Interest				4.15	4.36
Production Costs/ton after depreciation of plant cost				11.55	13.01

B4 - Production Costs Estimates [illegible] Plant Either from Anhydrite (Using Fuel Oil) or Sulphur [illegible]

Item	Cost/Unit of Input (US $)	Cost/t H$_2$SO$_4$ [illegible] (US$)	[illegible] (US$)
1. Raw material -			
Anhydrite	3.00/ton	4.[illegible]	--
Sulphur	32.00/ton	--	9.60
2. Utilities -			
a. Electric Power	0.015/Kwh	1.20	0.12
b. Process water	0.80/1000 gal.	0.04	0.32
c. Cooling water	0.03/1000 gal.	0.42	0.2[illegible]
d. Boiler feed water	0.80/1000 gal.	--	0.24
e. Fuel (fuel oil)	0.56/MMBTU	4.31	--
3. Labour -			
a. Operating		1.00	0.67
b. Supervision		1.00	0.67
4. Maintenance		4.35	2.[illegible]
Sub-Total		16.82	14.09
5. Indirect Costs -			
a. Depreciation and Interest (20% of capital)		14.50	7.45
b. Overheads (100% labour & maintenance)		6.35	3.58
Sub-Total		37.67	25.12
Less credit for lime		-5.24	--
Less credit for steam (2,200 lb. @ $4.54/1000 lb.)		--	-1.20
∴ Production Costs/ton H_2SO_4		32.43	23.92
Less Depreciation and Interest		14.50	7.45
Production costs/ton H_2SO_4 after depreciation of plant cost		17.93	16.[illegible]

* Annual capacity is approximately 40,000 tons based on 330 working days.

It is interesting to note that the production costs of sulphuric acid in 1000 tons/day plant in USA are about \$12.40*/ton by the Kent-ISU process (using natural gas) and about \$12.10*/ton by the sulphur-burning process. These costs are as high as \$21.70*/ton if the third cement/sulphuric process is used.

From the above economic study, the following observations and conclusions were drawn -

Conclusions Regarding the Manufacture of Sulphuric Acid in Jamaica Either by the Kent-ISU Process of the Sulphur Burning Process

a. The effect of using fuel oil as a substitute for natural gas in the Kent-ISU process is not considerable. Only an increase of about US30¢ per ton would be involved in the case of a 300 tons/day plant in USA (costs of production being \$18.94 and \$18.64 respectively).

b. Sulphuric acid produced from anhydrite in a 300 tons/day plant in Jamaica by the Kent-ISU process (using fuel oil) would be higher than in USA by about \$3.00/ton.

c. The production costs of the acid are still higher by about \$3.4 - \$4.5 per ton in case of using the new Kent-ISU process in Jamaica as compared with the sulphur burning process. In the former case the costs are \$21.94/ton and in the latter they are \$18.5/ton (without credit for steam) or \$17.4/ton (with credit for steam).

However, after depreciation of the plant cost, the production costs of sulphuric acid by the Kent-ISU process in a 300 ton/day plant in Jamaica would be slightly lower than the sulphur burning process (\$13.0/ton as compared with \$12.5/ton respectively).

d. If the plant capacity is equal to or smaller than 120 tons/day, the Kent-ISU process becomes more expensive in both capital as well as production costs when compared with the sulphur burning process on the basis of the present prices of about \$30 or less per ton of sulphur. Even after depreciation of plant cost, the sulphur burning process would be still regarded the better of the two. This case is interesting because the Spanish Town plant in Jamaica has approximately an equal capacity and is applying the sulphur burning process.

In the future, should the need warrant an extension of the existing plant in Jamaica, or the construction of a new one, the sulphur burning process would be preferred under two conditions:

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* European Chemical News, January 1971.

(i) That the plant capacity does not exceed 300 tons/day (since for higher plant capacities the new Kent-ISU process would be economically better).

(ii) That the cost of sulphur does not rise up again to $40 or more per ton as it was a few years ago.

B - Manufacture of Ammonium Sulphate from Gypsum or Anhydrite

A feasibility study has been started as far as this project and discussed partly in the Progress Report of January 1971, especially with regard to -

- Plant capacity (50,000 tons/year)
- Plant location (two possible sites were investigated)
- Manufacturing process
- Material input.

Work on this project has been continued, but was delayed to some extent owing to practical difficulties in obtaining representative samples of available gypsum and anhydrite and also, to the long time consumed in carrying out the chemical analyses of these samples at the Scientific Research Council laboratories, and of water samples (from a source near one of the proposed sites) at the Water Commission laboratories.

The following are the results of analyses of gypsum and anhydrite representative samples collected from different locations, crushed and mixed well.

Chemical Analysis of Samples of Gypsum and Anhydrite

	Gypsum		Anhydrite	
	1	2	3	4
CaO	30.80	30.80	39.76	39.48
SO_3	42.48	42.98	52.89	53.2[illegible]
MgO	1.00	1.20	2.00	1.80
SiO_2 and Insoluble Residue	5.10	4.97	1.45	1.47
Fe_2O_3	0.25	0.21	0.07	0.07
Al_2O_3	0.67	0.86	0.43	0.28
Na_2O	0.18	0.13	0.16	0.16
K_2O	0.02	0.02	0.01	0.01
Cl	0.20	0.19	0.15	0.15
CO_3	0.79	0.60	1.57	1.64
H_2O	18.81	9.03	1.29	1.25
Total	100.30	100.99	99.78	99.60

The two proposed sites were further investigated especially with regard to soil bearing strength and the availability of nearby suitable utilities, especially process water, cooling water, electric power, etc.

The study was not completed due to lack of time and because priority was given to the study on manufacturing sulphuric acid from anhydrite.

4. Manufacture of Bagasse Pulp and Newsprint from Bagasse

This project has been discussed in the Progress Report of January 1971 especially with regard to -

- Feasibility of using bagasse pulp in the manufacture of newsprint, and the proposed proportion of chemical bagasse pulp in the fibre furnish.
- Availability of bagasse in Jamaica.
- Proposed plant location.

After resuming work on this project it had to be stopped and its priority was deferred, bacause the West Indies Sugar Company (WISCO), the largest potential supplier of bagasse, has decided for the time being not to use fuel oil as a substitute for bagasse in the boilers at their sugar mills. This is a new stand taken by the Company at their large mills at Monymusk in Clarendon and Frome in Westmoreland. This decision is contrary to the consent of the previous management of this Company to supply bagasse to the proposed bagasse pulp project since the boilers in the sugar mills are equipped to burn fuel oil as well as bagasse.

5. Manufacture of Chemicals by Fermentation of Molasses

This was identified as a potential project in the Progress Reports of August 1970 and January 1971. A techno-economic study of this project is pending the preparation of a market study (local and overseas) to be undertaken by the Jamaica National Export Corporation.

6. Recovery of Chemicals and/or Manufacture of by-Products from Effluents and Unused Remains by Local Leather Tanning Industry

The main sections of Tanners Limited plant were described in the Progress Report of January 1971 with the purpose of identifying chemicals which could be recovered from the effluents of the plant, and/or manufacturing by-products from unused remains, thus improving the economics of the plant.

However due to the relatively small size of the plant, the only promising section that has substantial quantities of remains for this purpose is the 'fleshing' and liming section. Composition of the flesh was given in the Progress Report of January 1971.

The Firm has been advised to determine the available quantities of fat and protein that could be obtained from flesh, and to find out whether glue, gelatine, soap or glycerol could be produced economically as by-products in the plant.

The first results of the work done at the Firm's laboratories were promising as far as production of glue.

Work on this project is still proceeding.

7. Other Tasks Undertaken at the Request of the JIDC

At the request of the JIDC the expert undertook the following tasks:

A - Disposal of Process Waste of the Contemplated Yeast Plant at Spanish Town

The West Indies Yeast Company Ltd. has been planning for a number of years to construct in Jamaica a plant to manufacture yeast from molasses. The proposed plant capacity was 75,000 lb./month (i.e., about 900,000 lb/year) but since 1969, CARIFTA Countries requirements were taken into consideration and the Company decided to increase the production of yeast to about 2,200,000 lb./year during the first year of starting production, then to 2,400,000 and 2,700,000 lb/year after 5 and 10 years respectively from the start of production.

A report dated December 1965 concerning the discharge of process waste was prepared for the owners by a certain water resources engineering firm in U.S.A. and submitted to the Ministry of Agriculture. The recommendations of the report, based on the initial proposed plant capacity, mentioned that laboratory tests using similar yeast wastes from another plant in U. S. A., samples of the Rio Cobre Canal water (in which the discharge would take place), have demonstrated that the discharge of untreated wastes into the canal system will not significantly affect the average PH, colour or B O D of the water. The report also mentioned that any short term or visual effects resulting from poor initial mixing of the waste with canal water, can be eliminated, if necessary, by the use of a simple holding tank to equalize waste discharge rates. Computations of re-aeriation characteristics demonstrate, as given in the report, that a depletion of dissolved oxygen will not occur from discharge into the canal. Also that nutrient value of the yeast effluent can be utilized on the canefields irrigated by the Rio Cobre Canal water. Therefore the Company found that waste treatment is not indicated prior to discharge to the canal.

However, after the decision to increase the plant capacity was taken, the Yeast Company reached an impasse with the Ministry of Health in Jamaica regarding the discharge of process waste. The Ministry of Health held the view that the proposed holding tank will become no more sufficient to equalize the new discharge rates, whereas the Company thought the tank would be adequate for the purpose.

The matter was referred to JIDC authorities and the expert was asked to take part in the talks between the representatives of the Ministry of Health, the Company and JIDC. The Ministry of Health had the view that B O D of water should not be higher than 100 p. p. m. whereas the plant, based on the new capacity, will produce 6, 350 p. p. m. and may possibly reach 14, 000 p. p. m.

The expert shared the view of the Ministry of Health which insisted on avoiding the canal water pollution. He was of the opinion that an anaerobic digestive water treatment system should be set up to bring the B O D to the required level, especially after being informed of the approximate oxygen deficits that were recalculated by the engineering firm in April 1971 on the basis of the new plant capacity.

The West Indies Yeast Company Ltd. has finally agreed to set up the anaerobic treatment system and steps to complete the erection of the plant are ahead.

B - Manufacture of Cassava Products (Especially Starch) from Locally Grown Cassava

C - Manufacture of Lubricating Greases

D - Manufacture of Thermo-Plastic Compounds

These projects were referred to the expert by JIDC to investigate with the purpose of carrying out a feasibility study for the cassava project and to give recommendations to the Incentive Applications Committee at the JIDC regarding the two other ones.

Work was still proceeding in these projects when this assignment came to an end.

II. VISITS TO SITES, WORKS AND MANUFACTURERS

Several visits to possible solar salt sites and locations, chemical works and other related industrial manufacturers were discussed in the previous Progress Reports.

More visits to other sites, locations and works were made. These are briefly mentioned below -

1. Pigeon Island

   (Used for solar salt production during the forties).

2. West Harbour Site

3. Yallabs Site

4. Ammonium Sulphate Potential Sites

5. West Indies Sugar Mill - Monymusk

6. Standard Building Products Ltd.

   (Bagasse Board Plant).

7. West Indies Pulp and Paper Company Ltd.

   This plant was under construction and is now completed. Details of the plant were described in previous Progress

Reports. Trial runs for the Paper and Tissue machines were attended.

8. Caribbean Steel Company Ltd.

9. Caribbean Galvanized Pipe Company Ltd.

10. British Insulated Callender's Cables (Caribbean) Ltd.

11. Jamaica Carpet Company Ltd.

III. SYMPOSIA, MEETINGS AND INTERVIEWS

A - Symposia

Four symposia were attended. These were on the following subjects:

1. The Bauxite and Alumina Industry in Jamaica
(University of the West Indies).

2. Middle Management Session
(JIDC)

3. The Application of Irradiations and Radio-isotopes in Agriculture, Food Storage and Industry
(Scientific Research Council)

4. Up-Dating Session for the Development and Promotions Department
(JIDC)

B - Meetings and Interviews

1. Meeting at the Ministry of Rural Land Development

(Presided by Mr. D. Dyer, Permanent Secretary, regarding permission to use the Yallahs Ponds for solar salt production)

2. Mr. K. Vyasulu, UNIDO Senior Industrial Development Field Adviser (Several meetings).

3. Mr. C. Langford, Commissioner of Government Lands

4. Mr. Michael Lewes, Managing Director, Jamaica Gypsum Ltd.
(Several meetings).

B - Meetings and Interviews (cont'd)

5. Mr. Ellsworth Gallimore - Lubricating Greases (2 meetings)

6. Mr. Barclay Ewart, Managing Director of
(a) Industrial Chemical Company Ltd. (Sulphuric Acid)
(b) Alkali Limited (Salt Refinery)
(c) Tanners Limited (By-Products of Tanning)
and
Mr. W. Saunders

7. Mr. Chester Dowdie, Director of Social Development Agency
(Cassava Products)

8. Mr. Derryck Stone, Soil and Crops Division, Ministry of
Agriculture and Fisheries
(Cassava)

9. Dr. Noel Lyon, Kaiser Development Corporation
(Cassava)

10. Mr. R. McClenaghan, Jr., Managing Director, West Indies
Yeast Company Ltd.
(Disposal of Yeast Waste)

11. Mr. Pitter, Ministry of Health
(Disposal of Yeast Waste).

12. Mr. Lloyd Langford, Director, Monymusk Sugar Estate.

Other meetings with the Executive Director and other Directors of JIDC took place to discuss various aspects of work.

H. A. El Sharawy
Chemical Industries Expert

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