2.3 FORESTRY

In 1975, the production of forestry industry in real terms reached US$4.1 million, equal to 2% of the total GDP. Though small in scale, it can be said that this sector is comparatively promosing, considering the rapid growth of national log production with the increase from 220,500 m^3 in 1970 to 532,500 m^3 in 1974. Geographically, forestry in the country destributes in south-east territory which consists of Grand Capa Mount and Lofa counties, while the north-west territory which consists of Grand Capa Mount and Lofa counties. The forest area in the north-west territory is about 800,000 ha. 700,000 ha (88%) is unexploitable due to hard accessibility at present. The remaining 10,000 ha (12%) of forest is ready for exploitation. On the other hand, in the south-east territory, exploited log and lumber are being transported either to Harper port or Greenville port through the feeder road network. (Refer to Fig. 2.2)

If inland access in the north-west territory is established, lumber exploitation in this area will be promoted, contributing to the regional development especially in Lofa and Grand Cape Mount counties.

2.4 RUBBER

In real terms, the annual production of rubber was US$23 million in 1970 and US$24.2 million in 1975. Though slightly staggering in these years, rubber production accounts for 6.3% of total GDP, next to iron ore exploitation. Geographically speaking, rubber plantations are mainly distributed in Bong and Monserado counties where the forest density is scarce as shown in Fig. 2.3. Besides the above two counties, one more plantation zone is extending along the coastal area of Liberia.

Fig. 2.1 MINERAL RESOURCES

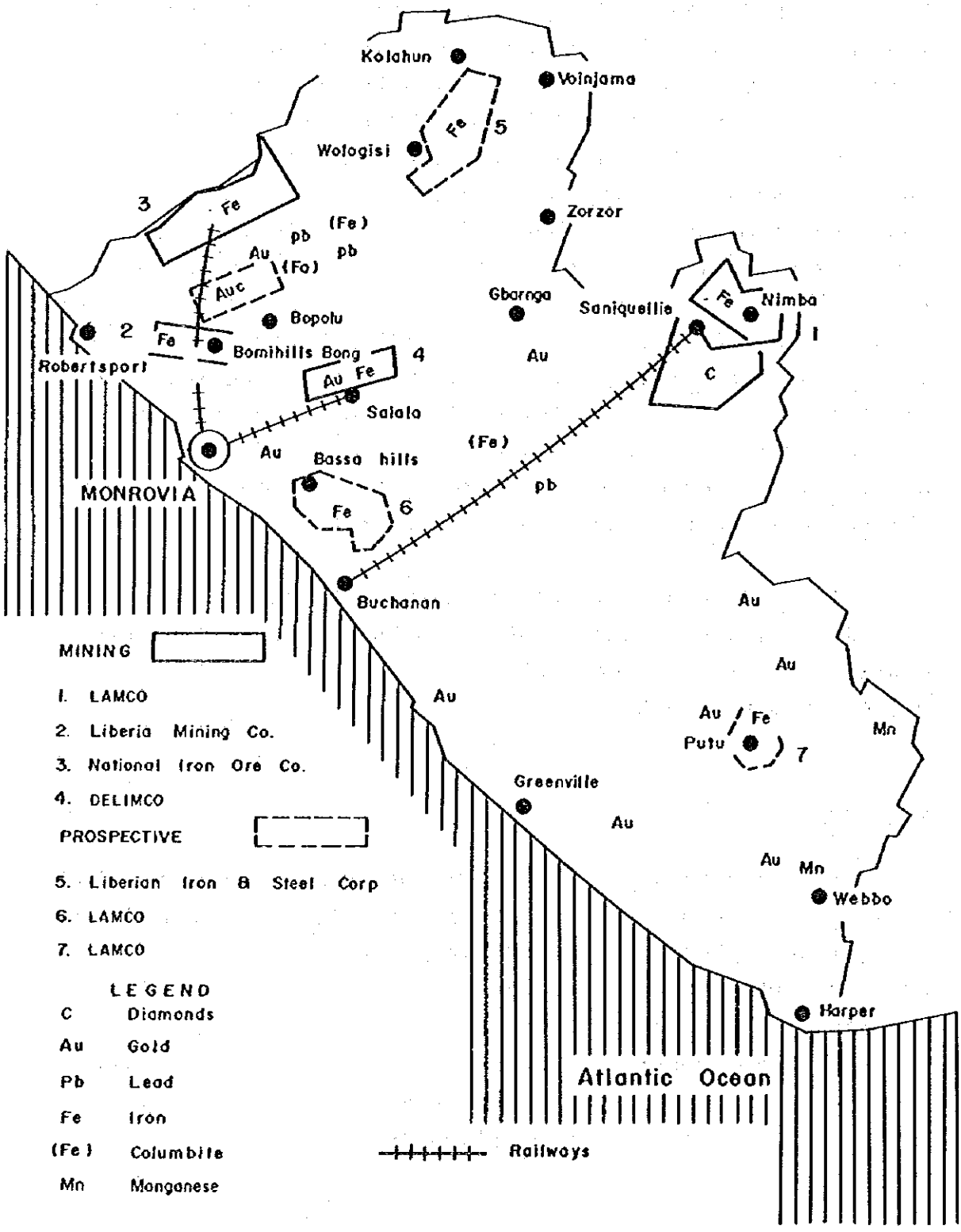


Fig. 2.2 FOREST ESTATE

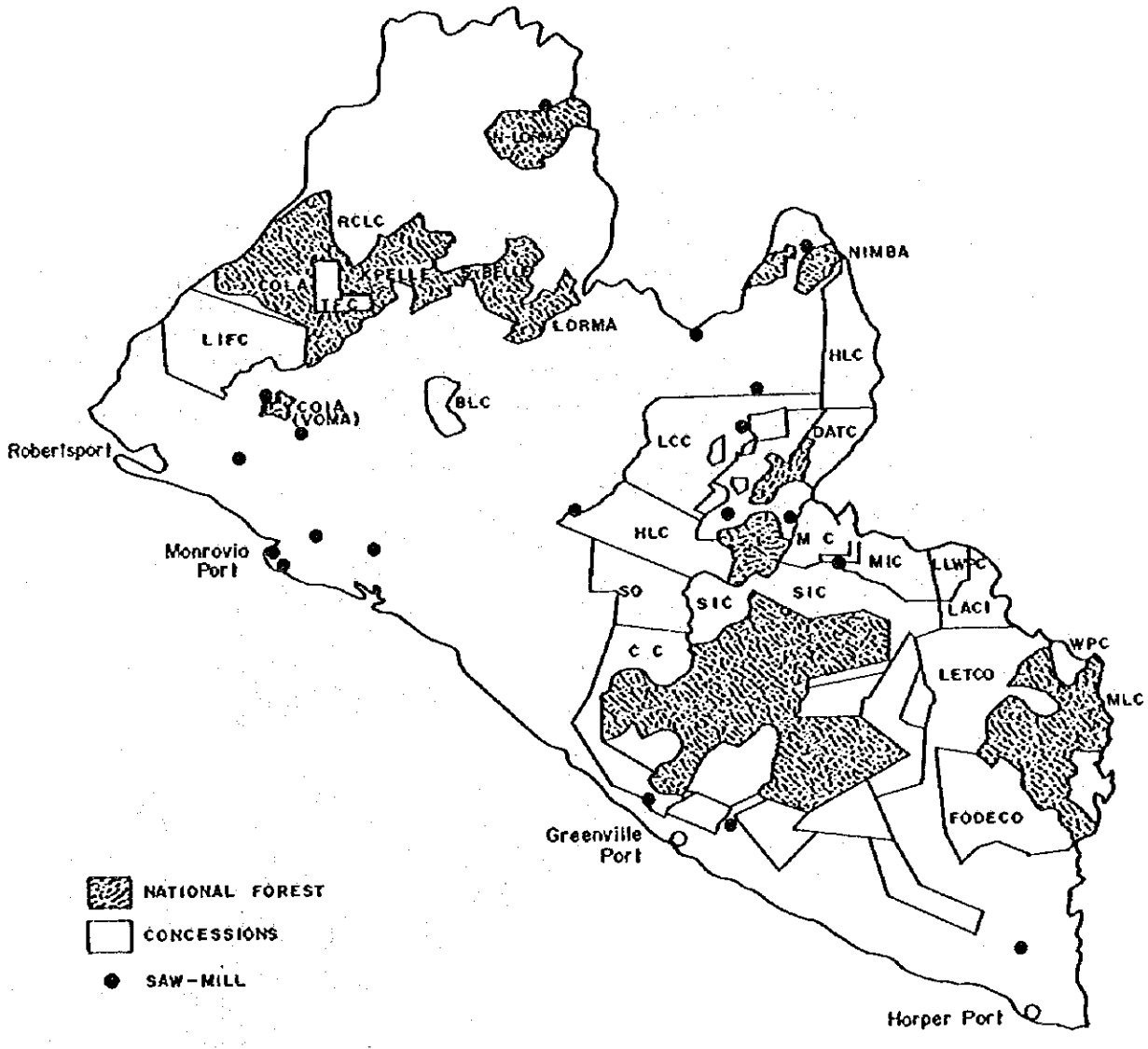
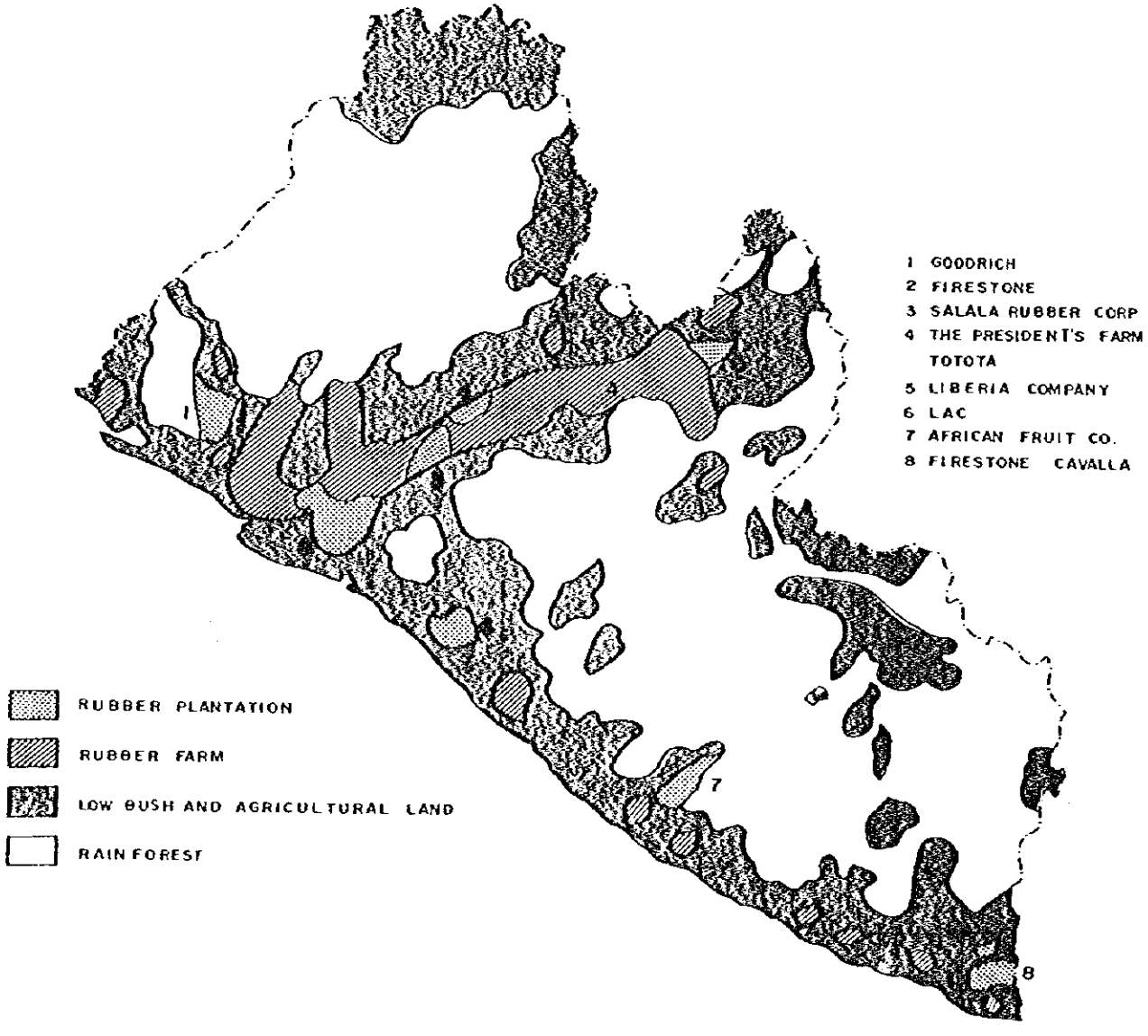


Fig. 2.3 RUBBER



CHAPTER III

CONDITION OF EXISTING PORTS

CHAPTER III

CONDITION OF EXISTING PORTS

3.1 NATURAL FEATURES SURROUNDING THE EXISTING PORTS

The coast of Liberia is about 520 km long and oriented in almost NW-SE direction. It is roughly situated between Lat. 4° and 7° North, and long. 7° and 12° West of Greenwich. Far out at sea the Guinea currents flow in an easterly direction, with an average speed of 1 knot. On the other hand, predominant longshore currents are moving in the opposite direction, e.g. from southeast to northwest. This process can be explained by studying the direction of the ocean waves to the Liberia coast; waves from SE to NW generate a currents along the shore running toward NW. These predominant longshore currents produce a littoral drift in a northwestery direction.

The coastal plane of Liberia is generally low and flat. Narrow sandy beaches are separated from each other by many rocky points or capes. This beach line curves deeply behind the capes in such a manner that formes small bay which lie protected from the strongest and most frequent waves from southerly directions.

The following major rocky points and adjacent bays are located along the coastal line of Liberia:

i) Cape Mount and Cape Mount Bay (Robertsport)

ii) Grand Bassa Point with Waterhouse Bay (Port of Buchanan)

iii) Cape Mesurado/Mamba Point of Monrovia

iv) Cestos Point and Cestos Point Bay

v) Baffu Point and Baffu Point Bay

vi) Blubbarra Point with Sinu Bay (Port of Greenville)

vii) Fish Town Point

viii) Cape Palmas/Russwurm Island (Port of Harper)

An additional feature of the coast line is that surface waters on land (rain water) cannot easily drain to the sea. The beaches of coarse sand have rather steep gradients and the beach ridges are higher than the land behind the ridges. Any cut through the beach made by a water course is quickly closed again with sand, due to vigorous wave action. Surface waters remain stagnant behind the beach ridges and form often large swamps.

Behind or northward of the rocky points or capes, wave action is much weaker, and this favourable condition allows small rivers, lagoons and swamps to keep permanent outlets to the sea in the adjacent bays. On the unprotected beaches, only the much larger rivers, with large discharge flows, are strong enough to resist the sand banks to be formed by the wave action.

It can be said that several fundamental factors, which have influenced the past development of Liberian ports, are deeply concerned with the natural features as explained in the above. They are summalized as follows:

i) natural protection afforded by rocky promentories

ii) longshore transport of sand

iii) outlets of lagoon, swamps and small rivers

iv) occurence of rock outcrops in sheltered bay

Most of the ports in Liberia were constructed in the bay sheltered by natural rocky capes or points. The capes and points projecting out to the sea in the westerly directions provide the comparatively calm basin against the prevailing waves and swells from southerly directions. However, for the navigation of larger vessels, it is required to provide with breakwaters to gain sufficient calmness for ships to berth, moor and deberth safely.

These breakwaters, though helpful for navigation, cause another major problem of siltation in or near the port area. The existence of breakwater breaks the balance of littoral drift movement along the coast near the harbour, resulting in accretion in the east side of the harbour and erosion in the west side of the harbour. In addition, sand deposited in the east side of the breakwater is dragged out by a strong longshore current running westward and flown into the approach channel, and thus imposes a serious navigational problem on the existing ports.

The combination of tidal esturies, longshore sand transport and physical coastal development has resulted in the formation of shifting sand banks in the bay into which the smaller rivers and lagoons discharge. Such a bay is obviously an suitable site for a deep sea port.

Many rocks and reefs are often found in and near the sheltered bays provide physical constraints for the location of harbours.

Schematic presentation of the Liberian coast and the location of ports (Monrovia, Buchanan, Greenville and Harper) are shown in Fig. 3.2-3.5.

3.2 GENERAL FEATURES OF THE EXISTING PORTS

3.2.1 General

In Liberia there are four ports, namely Monrovia Port, Buchanan Port, Greenville Port and Harper Port. These ports have been developed only to meet the regional requirement such as the export iron ore or timber. And the hinterland of each port is not linked with each other by means of rails or roads.

The government of Liberia established National Port Authority in 1967 to promote the port development in Liberia. Until then, most of the ports except for Greenville Port, which was administered by Germany, had been operated by the private firms. National Port Authority (N.P.A.) took over the administration of Monrovia Port in 1972 and Greenville Port in 1970, respectively. Buchanan Port is being operated by LAMCO, the biggest iron ore mining company in Liberia, and administered by N.P.A. For reference, the port statistics of each port are given in Table 3.1. As shown in the table, most of exports and imports of Liberia are handled by Monrovia Port and Buchanan Port.

Table 3.1 SHIPS CALLING & CARGO HANDLING IN LIBERIAN PORTS (1973 - 1975)

(Unit: LT)

Port	1973		1974		1975	
	Ship	Cargo	Ship	Cargo	Ship	Cargo
Monrovia	1,729	13,744,369	1,202	13,311,626	1,019	11,018,684
Buchanan	240	12,956,429	405	13,103,856	356	8,956,845
Greenville	193	204,033	121	123,094	169	152,854
Harper	67	53,850	73	37,087	-	35,208
Total	2,229	26,958,681	1,803	26,575,665	1,544	20,163,591

3.2.2 The Port of Monrovia

The artificial harbour is protected by two breakwaters extending 2,250 m out into the open sea, encompassing some 300 ha of protected waters. The width of the entrance between two breakwaters is 290 m. In the center opening, a 150 m wide channel marked by buoys has been dredged to 14.7 m M.L.W. This channel is 2,400 m long with one 30° turn halfway and marked by means of four lighted channel buoys. The North and South mole ends of the breakwater are marked by red and green light, respectively. The channel inside the breakwaters gradually widens into a turning basin whose depth towards the Iron Ore piers is dredged to 14.1 m M.L.W. and 9.0 m off the general cargo pier.

The central part of the port area is occupied by three iron ore companies, who operate their own facilities. A crude oil discharging berth is located between the iron ore facilities. The general cargo berths, operated by NPA, are located south of the central area, and consist principally of an open piled, 595 m long and 11 m wide marginal wharf, with a concrete deck; the main wharf serves coastal and main line vessels.

On the southern breakwater, an oil jetty for refined products is connected to the storage tank yard in the port area, while on the northern breakwater a fishing pier and repair facilities are located. The area north of the central section of the port is, at present, being used by NPA as a housing area.

The port facilities, mainly constructed in 1948, are generally well maintained, although the size of the general cargo berth aprons prevent efficient cargo handling operations. Sufficient facilities for storage are available within the port area. In addition to the NPA facilities, a number of facilities are owned by private companies. The layout of Monrovia Port is shown Fig. 3.6

Iron ore is the most predominant item, accounting nearly 90%, of annual cargo handled in Monrovia port.

Statistics of annual port cargo in Monrovia are given in the following table.

Table 3.2 CARGO INVENTORY THRU MONROVIA PORT (1970 - 1975)

(Unit: LT)

Cargo	1970	1971	1972	1973	1974	1975
Iron ore	12,092,435	10,866,742	11,145,165	12,515,541	11,914,120	9,568,370
Oil products	436,697	510,697	599,943	488,159	562,310	595,431
General cargo	421,276	722,736	184,818	404,490	422,377	426,367
	85,468	99,655	71,734	109,163	167,554	94,310
Coffee	*	*	*	*	4,067	5,432
Latex	51,828	50,926	54,549	19,248	42,775	63,008
Rubber	21,137	41,488	34,364	63,171	45,836	23,999
Cocoa	*	*	*	*	3,248	2,113
Palm oil	-	-	3,915	6,537	6,774	6,080
Log, timber	*	*	*	*	12,203	3,126
Transship	61,245	105,619	29,320	106,729	51,336	115,404
Coastal trade	23,060	12,954	410,077	*	*	149,745
Parm Kernel	*	*	*	*	*	6,849
Coal	*	*	*	*	*	20,050
Total	13,194,046	12,410,617	12,369,723	13,744,369	13,311,626	11,081,684

* Included in General Cargo

SOURCE: Middle-Eastern and African Bureau, Japan; Outlook of the Republic of Liberia-Historical Background and the Present Social and Economic Condition

3.2.3 The Port of Buchanan

Buchanan Port is located 100 km east of Monrovia and was constructed for exporting iron ore of Nimba mine operated by LAMCO, Joint Venture Co. Like Monrovia, this port is an artificial port with two breakwaters which project obliquely to the coastline with right angled return terminating centrally 210 m apart. The eastern breakwater or main breakwater, is 1,890 m long and the western breakwater, secondary breakwater, is of 590 m. An ore loading quay is situated in the center of port with a water depth of 12.95 m. At the rear of the western breakwater is located a commercial quay, 334 m long, with an ailable water depth in front of 10.15 m below chart datum. At this quay no covered shed space is available. This commercial quay has been brought within the jurisdiction of U.P.A. According to the port statistics of Buchanan Port, export of iron ore accounts for more than 96% of total port handling amount. The layout of Buchanan Port is shown in Fig. 3.7

Table 3.3 CARGO INVENTORY THRU BUCHANAN PORT (1970 ~1975)

(Unit: LT)

Cargo	1970	1971	1972	1973	1974	1975
Iron ore	11,020,297	10,032,400	11,325,810	12,580,475	12,774,639	8,616,413
Oil products	131,058	157,124	148,147	164,523	104,084	147,417
General cargo	40,167	41,603	47,569	42,054	110,758	59,552
Lime stone	47,012	66,051	75,429	39,958	39,734	31,682
Log	24,532	21,774	65,415	21,825	58,397	84,970
Coastal trade	2,359	2,359	728	1,328	1,396	658
Rubber	*	*	*	3,265	10,705	13,987
Palm oil	*	*	*	3,265	4,703	22,167
Total	11,277,630	10,339,953	11,608,333	12,956,475	13,103,856	8,956,345

* Included in General Cargo

SOURCE: Middle-EAstern and African Bureau, Japan; Outlook of the Republic of Liberia-Historical Background and the Present Social and Economic Condition

3.2.4 The Port of Greenville

The port of Greenville was originally constructed mainly for shipping banana and general cargo. Now the major export is replaced by logs and timber followed by rubber. Import is gasoline and town commodities. Total annual throughput is 150,000 tons in 1975 and 250,000 tons in 1977, respectively.

In the hinterland of Greenville Port, lies a lot of forest land capable of exporting good timber and logs. Most of the promising concession area for timbering is situated in Sinoe County and Grand Gedeh County. Greenville Port, dealed with forest products mainly from the Grand Gedeh County, and Horper Port mainly from the Sinoe County. However, aiming at more efficient handling of Greenville Port, the share of Harper has been replaced by Greenville.

The harbour basin is protected by a 400 m long breakwater off Blubarra Point. On its inner side two quays, situated at an angle to each other, provide two bearing facilities, 70 m and 180 m long respectively, with an existing water depth of 6 m below chart datum. The existing berth layout brings about tight and difficult ship maneouvering both in berthing and deberthing. Arriving ships traveling along the approach channel are forced to make sharp turns before berthing.

The water depth at the entrance of channel is shallowed by sand deoisut brought by littoral drift. When mooring, ships are considerably affected by prevailing winds and currents, resulting in severe damages to breasting facilities of the wharf. The coping concrete blocks of the breakwater are in part washed away or slided shoreward by breaking waves.

Rehabilitation program for Greenville Port is just under way, including the following works;

i) Dredging basin and entrance channel to depth of 8.10 m below chart datum.

ii) Extension of the existing breakwater to cater for larger vessels.

iii) Fendering of the quay and log storage areas.

iv) Construction of access and harbour roads.

v) Construction of electricity, water and sewage facilities.

vi) Repair of existing mole and quay.

For reference, annual cargo handled in Greenville Port is tabulated on Table 3.4. The layout of Greenville Port is shown in Fig. 3.8

Table 3.4 CARGO INVENTORY THRU GREENVILLE PORT (1970 - 1975)

(Unit: LT)

Cargo	1970	1971	1972	1973	1974	1975
Log	97,009	125,749	155,621	189,764	112,015	131,346
Timber	*	*	*	*	*	8,696
General cargo	43,929	37,100	2,962	7,884	5,045	6,830
Oil product	3,047	3,352	3,383	4,399	4,670	4,558
Rubber	*	*	*	1,983	1,364	1,424
Total	124,045	166,201	160,227	204,033	123,094	152,954

* Included in General Cargo

SOURCE: Middle-Eastern and African Bureau, Japan; Out look of the Republic of Liberia-Historical Background and the Present Social and Economic Condition

3.2.5 The Port of Harper

The port of Harper (Cape Palms) is situated in the Sinoe County, near the border to the Ivory Coast. The port was constructed on the western tip of Russwurm Island, connecting to the main land by 200 m long causeway. Russwurm Island is leveled off for serving as stockyard of lumber, and the southern part of island facing the open sea is protected by island and Cape Palms, is 55 m long pier for feeder craft with a water depth of 5.50 m on both sides. Arriving ships sail through the channel between Cape Palms and the Cape Rocks, accelerated by littoral drift moving east to west. The port and breakwater were rehabilitated in 1970, so that at present all facilities are in good condition.

Major export products are logs, timber, rubber, latex, sugar and general cargo, while small amount of petroleum and town commodities are imported. The layout of Harper Port is shown in Fig. 3.9

Table 3.5 CARGO INVENTORY THRU HARPER PORT (1970 - 1975)

(Unit: LT)

Cargo	1970	1971	1972	1973	1974	1975
Log	25,467	25,693	22,651	24,174	22,306	9,546
Timber	*	*	242	229	680	6,315
General cargo	24,633	18,960	8,131	8,880	4,668	8,663
Oil	3,884	3,996	2,898	5,654	3,193	3,665
Rubber	*	*	341	4,249	2,642	2,278
Latex	5,631	5,628	3,347	10,664	3,598	4,741
Total	59,615	54,247	37,610	53,850	37,087	35,208

SOURCE: Middle-Eastern and African Bureau, Japan; Outlook of the Republic of Liberia-Historical Background and the Present Social and Economic Condition

3.3 PRINCIPAL PORT OF MONROVIA

3.3.1 Port Administration and Operation

1) Organization of National Port Authority 1/

All powers of the National Port Authority (N.P.A.) are vested in a Board of Directors which is appointed by the Government of Liberia. The Board has general powers to manage the affairs of the National Port Authority. At the head of the organizational hierachy is the Office of the Managing Director who is Chief Executive Officer. As such, he has the responsibility for the conduct of the management and operations of the National Port Authority as provided for by the Act. Generally, he is accountable for all of the duties appertaining to this office and such other duties as the Board of Director shall specify from time to time.

This principle arms of management presently consists of four divisions, namely:

The port Division - This Division is headed by the Deputy Managing Director who reports directly to the Managing Director. He is responsible for the activities of Port Manager and the Harbour Master who report directly to him.

The Administrative Division - This Division is headed by an Administrative Director who is responsible for handling administrative matters and providing additional logistics for the Authority through the various departments reporting to him. He reports directly to the Managing Director.

The Engineering Division - This Division is headed by the Chief Engineer and is responsible for all aspects

1/ Refer to Fig. 3.10

of engineering and maintenance works within the NPA. This Division is composed of Civil, Mechanical and Electrical Departments.

The Finance Division - This Division is headed by the Comptroller and is responsible for all aspects of financial administration and control within the NPA. It supervises and prepares accounting records and statement on financial affairs of the NPA.

2) Port Operation

The interpretation through the recent edition of annual report covering the general activities and accomplishments of NPA/FREEPORT OF MONROVIA reveals the following major characteristics of port operation. The turn around time (from berthing the deberthing) of vessels average around 2-1/2 days. As to general cargo in 1977, tonnage handled through the port is about 780 tons/year, 1300 ton/wharf length (m)/year and 260,000 ton/berth/year (1 berth = 200 m). Actual average number of days for cargo to remain in port is ranging 21 days (imports) to 7 days (exports). Berth occupancy is nearly 100%, resulting in average queuing time of 3 days/vessel. The figure on utilization of mechanical equipment is around 60%, and occupancy of transit shed and open storage around 80%. Judging from the above situation, it is concluded that the general cargo flows within the port is extremely congested, reaching the critical point of cargo handling capacity.

3) Cargo Movement

In the section 2.2.2 is shown the cargo movement between 1970 and 1975. The latest statistics of cargo movement is shown on table in this section.

The statistic data shows the drastic fall in annual export from 1976 to 1977, annual decrease rate of 25%. This decline is mainly based on the export of iron ore; 7,667,933 tons in 1977 and 10,248,569 tons in 1976. The Monrovia Port has been taking care of shiping iron ore from L.M.C. N.I.O.C. and B.M.C., among which L.M.C. has already completed mining and the deposit of the remaining two mines comes scarce. The share of commodity, other than iron ore, which consists of general cargo, rubber and latex, etc., is less than 2% in volume of export. Over the past 5 years, the export of rubber was in the order of 20,000 - 60,000 tons/year, the export of latex between 30,000 - 50,000 tons/year. Coffee, cocoa and palm kernel are less than 10,000 tons/year respectively. Wood exports, which are included in general cargo export, are expected in the order of 5,000 - 15,000. The total amount of import in 1977 decreases 2.6% compared with the figures in 1976, but up to 1976 the annual tonnages handled had been increasing with the annual growth of 3 to 5%. The major commodity groups are general cargo and petroleum products, accounting for more than 80% of total import, followed by clinker and rice. Oil products such as crude oil are refined in the Liberian Refining Company and subsequently distributed over the country. The quantities used by iron ore companies amounts to nearly 50%, whereas the rubber and wood industry as a whole accounts for about 15%. The consumption of clinker is deeply linked to the consumption of cement in Liberia. Accompanied by the poor consumption of cement, the import of clinker tends to reach the sufficient level. The import of general cargo has been staggering due to port constraint, but by application of container system, which is just under consideration, the future

import of general cargo is likely to expand to meet the town requirement.

3.3.2 Port Facilities of Monrovia Port

As outlined in section 3.2.2, Monrovia port is provided with the general cargo berths of marginal type, a bunker berth, an oil berth and three iron ore berths. The major dimensions of these berths and attendant facilities are summarized hereunder.

1) General Cargo Berths

The marginal cargo wharf is 600 m long 11 wide with 3 transit warehouses. The wharf has a concrete deck and has a depth alongside of 9 m at M.L.W. All cargo is discharged and loaded by ships gear. Sufficient amount of cargo-handling equipment is available such as forklift trucks ranging from 3-tons to 25-tons capacity. The details of up-to-date inventories of mechanical equipment is given in Table 3.7.

Table 3.7 INVENTORY OF MECHANICAL EQUIPMENT

Mechanical Equipment	Capacity (tons)	Q'ty	Manufacturer
Heavy crane	50	1	American Hoist
Forklift	2 - 3-1/2	3	Hyster, Catepiller
Mobile crane	10 - 25	6	Tones, Bucyrus, Krupp
Tractor	DBP-600 - 6000LBS	22	Monlgomerice Reid, Weosex
Trailer	12 - 50	44	-
Container LFT	31	3	Hyster

2) Banker Pier

This is a "T" jetty on the South edge of the dredged basin with a depth of 10 m M.L.W. No fresh water is available at this pier.

3) L.R.C. Crude Oil Berth

This is situated between the B.M.C. and N.I.O.C. piers and consists of one breasting dolphin and an after-mooring dolphin. Crude discharging tankers are moored by means of two anchors and starboard side to the breasting dolphin with the stern made fast to the mooring dophin. Discharge is by means of submarine and floating pipelines connected on the starboard side midships. Tankers are limited to a length of 210 m and draft of 12 m. Fresh water is available at this pier.

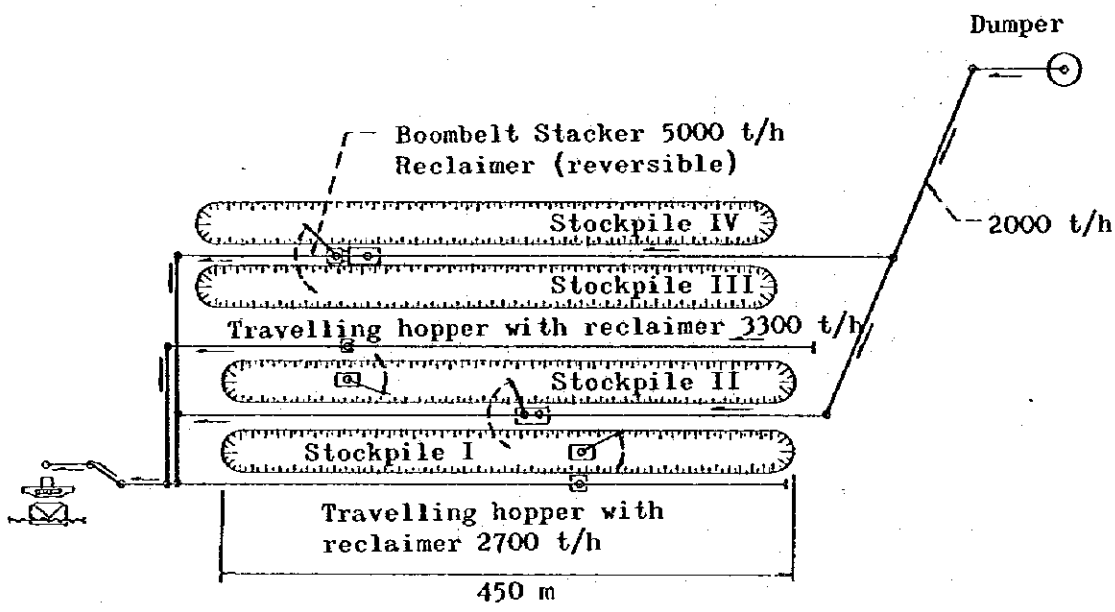
4) Fish Pier

A pier with its own dredged channel and turning basin is used by fishing vessels to discharge cargo into cold storage. This pier is situated on the Northern breakwater with the cold storage facility located on the inshore and of the breakwater. Fresh water is available at this pier. The channel to the fish pier is 27 m wide and dredged to 6 m M.L.W. Size of vessels using this pier is limited to 72 m length and 5.7 m draft.

5) B.M.C. Pier

The loading system of this pier has a maximum theoretical capacity of 11 million tons/year and is backed by stockpiles areas with a capacity of over one million tons.

Fig. 3.11 Flow Sheet of B.M.C. Terminal



The major dimensions of the pier is summarized as follows:

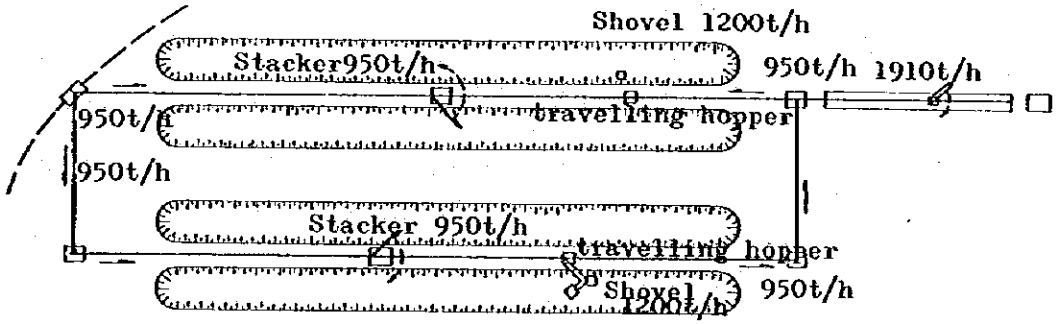
Approach Max. Draft on M.L.W.	13.5	m
Alongside Max. L.O.A. of vessel	270	m
Max. Beam of vessel	37.5	m
Max. Draft on H.W.	13.5	m
Alongside Pier Length	266	m
Loading Boom outreach from fenderline	17.1	m
Loading Boom height above HWOST	135	m
Pier Length covered by Loading Boom	21.9	m
Loading Rate	500 - 2500	ton/year

Fresh water is available at this pier.

6) N.I.O.C. Pier

The loading system of this pier has a maximum theoretical throughput of about 4.5 million tons/year. The facility is backed by stockpiled areas with capacity of some 600,000 to 700,000 tons.

Fig. 3.12 Flow Sheet of N.I.O.C. Terminal



The major dimensions of the pier is summarized as follows:

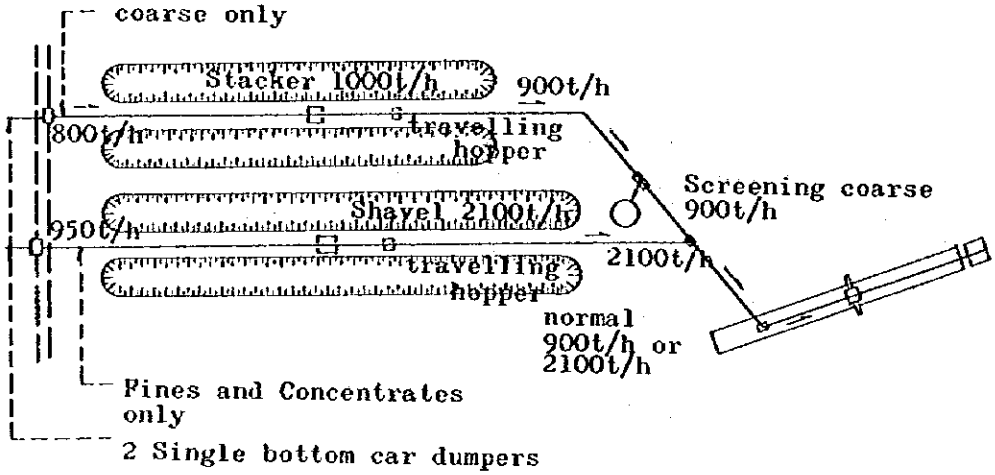
Approach Max. Draft on M.L.W.	13.5 m
Alongside Max. L.O.A. of vessel	300 m
Max. Beam	34.2 m
Max. Draft on H.W. ..	13.5 m N side, 12.6 m S side
Alongside Pier Length	270 m
Loading Boom outreach from fenderline	18 m
Loading Boom HT above HWOST	12.9 m
Pier Length covered by Loading Boom	192 m
Loading Rate	2000 ton/hr

Fresh water is available at this pier.

7) L.M.C. Pier

The loading system of this pier has a maximum theoretical capacity of 3.5 million tons per year. The loading facility is backed by storage stockpiles of 400,000 to 500,000 tons capacity.

Fig. 3.13 Flow Sheet of L.M.C. Terminal



The major dimensions of the pier is summarized as follows:

Approach Max. Draft on M.L.W.	13.5 m
Alongisde Max. L.O.A. of vessel	249 m
Max. Beam	39 m
Max. Draft on H.W. .. 13.5 m N side, 11.4 m S side	
Alongside Pier Length	247.5 m
Loading Boom outreach from fenderline ...	18.3 m
Loading Boom H.T. above HWOST	13.8 m
Pier Length covered by Loading Boom	168 m
Loading rate	2000 ton/hr

Fresh water is available at this pier.

8) Navigation and Service Facilities

Pilotage is compulsory. Pilots are to ward incoming vessels at the roadstead off the fairway buoy. The Pilot launch displays the international code flag "H" by day and "WHITE over RED" lights by night. Pilotage is day and night except for vessels berthing at the oil jetties.

There are three tugs available of 1700 H.P, and two pilot boats and two mooring boats.

No NPA lighters available

Recommended anchorage in roadstead is south of the buoyed channel which provides good holding ground on a sand and mud bottom.

The inner harbour bottom is sand and mud with good holding ground. Vessels are not anchored within the inner harbour except for very short period of time.

3.3.3 Future Port Development Program

1) General

The Comprehensive Port Development Study conducted by the Dutch consultants "NEDECO", says that the general cargo movement is staggering due to the limitation of the existing quay capacity. The main wharf through-put in 1977 was estimated at 740,000 tons, while the improved capacity of existing facilities in future is figured out around 850,000 tons/year even in case that berth occupancy is 100%. This fact shows that at present, Monrovia Port is operated at the upper limit of port capacity. Under these circumstances, two different stage measures are being considered; short-term measures and long-term measures.

Short-term measures are immediate repairing to the damages of the general cargo wharf so as to cope with recent severe and heavy traffic like containers. Long-term measures require for the extension and modernization of the entire port facilities for another 10 - 20 years of port operation. This will consist of the construction of multipurpose berths to accommodate three additional general cargo vessels or two container vessels. In the course of completion, a new container terminal might have to be considered together with additional warehouse. This chapter briefly mentions the long-term port expansion plan of "NEDECO", which is also the basic port prospect envisaged by N.P.A.

2) South of the General Cargo Quay

Between the oil products tankpark and the general cargo berths is an area of 320 m long and 100 m wide. The waterfront is about 320 m long. The water depth is probably 4.5 m below MLW. The area is separated from the general cargo quay by the ship repair facilities of Farrel Lines and the rubber and latex storage installations of N.P.A. Firestone. These structures block the extension of the general cargo berths; to extend the general cargo berths, these installations would have to be removed to make place for the new transit sheds of the new berths.

3) North of the N.I.O.C. Stockpile

Between the northern N.I.O.C. stockpile and the fence of the LRC crude oil tankpark is an unused strip of land with about 120 m of waterfront and 500 or 600 m wide, which belongs to the area leased by N.I.O.C. The water depth of the adjacent shipping basin is 13.5 m. This basin is used for navigation and

manoeuvring by large ore carriers up to 110,000 DWT with maximum drafts of 13.5 m. It is obvious that the basin is a very valuable asset of the port.

If the crude storage tanks are relocated somewhere on the other side of United Nations Drive about 9 ha of port area along deep water is available. In this way, together with the unused strip of land of N.I.O.C., the total land area for a new terminal would become some 15 ha.

4) North of the B.M.L. Pier

Between the shore facilities of Bong Mining Company and the northern breakwater, a water front of some 400 m to 450 m is used. Water depths are shallow, probably 3 to 4.5 m. The width of the area measured from the beach to the N.P.A. housing area is some 200 m. This site lies in a corner of the harbour, which is not really accessible from the sea due to its shallow depth. A relative large quantity of dredging work would be required to remedy this situation. On land the direct connection with the port is blocked by the ore storage yards. For these reasons, the site is not attractive for possible new general cargo berths. Its only proper user could be by a special terminal for a special type of cargo and ships such as logs and log carrier, for instance.

5) Unused Land without Water Frontage

There are also some smaller parcels of unused land available for construction; because they are not near water, they are unsuitable for the construction of terminals for ships, but should rather fit in with a modernization plan. The ore stockpile yard of

L.M.C. falls within this category of landlocked sites for development. Though the problem of taking over the L.M.C. facilities is pending, its large yard of 480 x 380 m will become available for other purposes. This area does not possess sufficient length of water-front for the construction of new marginal quays, except its ore jetty and hence use must be made of this jetty for shipping purposes.

6) The Northern Area Extension

Aside form the rehabilitation program to the existing facilities inside the port, the only realistic way to obtain land for the construction of new berths is reclaming new land by filling sand in a shallow-place of the harbour basin, adjacent to the southern break-water. As shown in Fig. 6.1, the side of the new land, facing the harbour basin, has a length of about 1,000 m forming almost a right angle with the quay of the existing general cargo berths; a thousand meters of new quay equivalent to 5 or 6 new berths could be constructed. The new area has a total size of some 70 ha.

7) Northern Area Extension

The only remaining space of comparable size between the breakwaters is at the corner in front of the North Beach compound. Further expansion beyound the break-waters would no longer be the possible without removing by dredging, part of the new land created earlier.

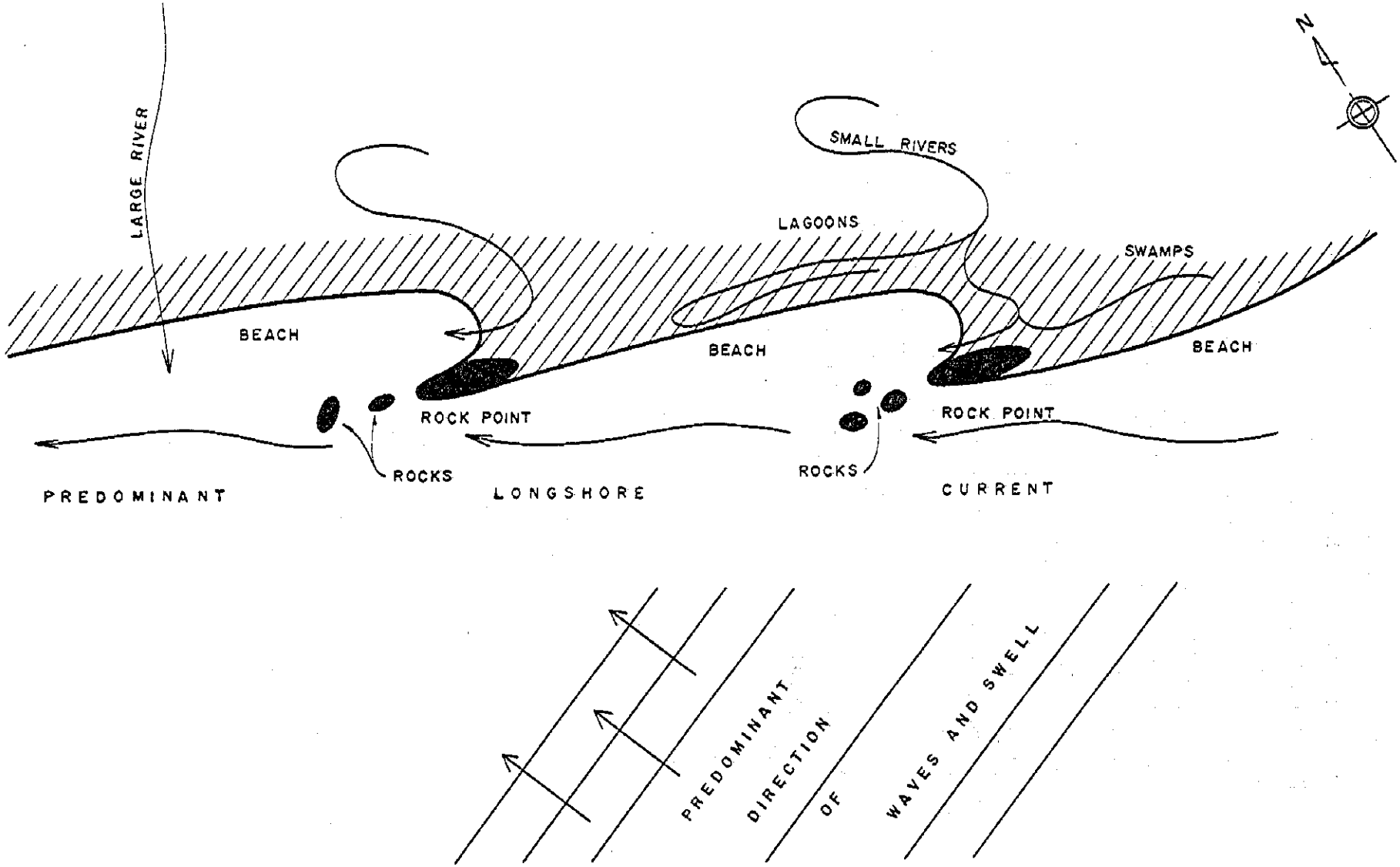
8) Allocation of Wologisi Berths

Considering the future trend of cargo movement, it can be said 3 or 4 additional general cargo berths will

meet the cargo handling requirement in Monrovia Port. Total berth length required is 800 m in case of 20,000 DWT class vessel. The space for allocating these general cargo berths can be easily found, if N.P.A. makes decision in consultation with the related firms inside the port area. The definitive details of how to promote this plan is under study by German Consultant.

The berth requirement for Wologisi Project is one general cargo berth, one oil berth and one ore berth. Assuming that general cargo is handled by N.P.A. owned cargo berths and oil/fuel by the existing oil berth, the Wologisi related berth is only one ore berth, so that the study of Wologisi Port Development at Monrovia port is limited to the planning of this iron ore berth.

Fig.3.1 SCHEMATIC PRESENTATION OF LIBELIAN COAST



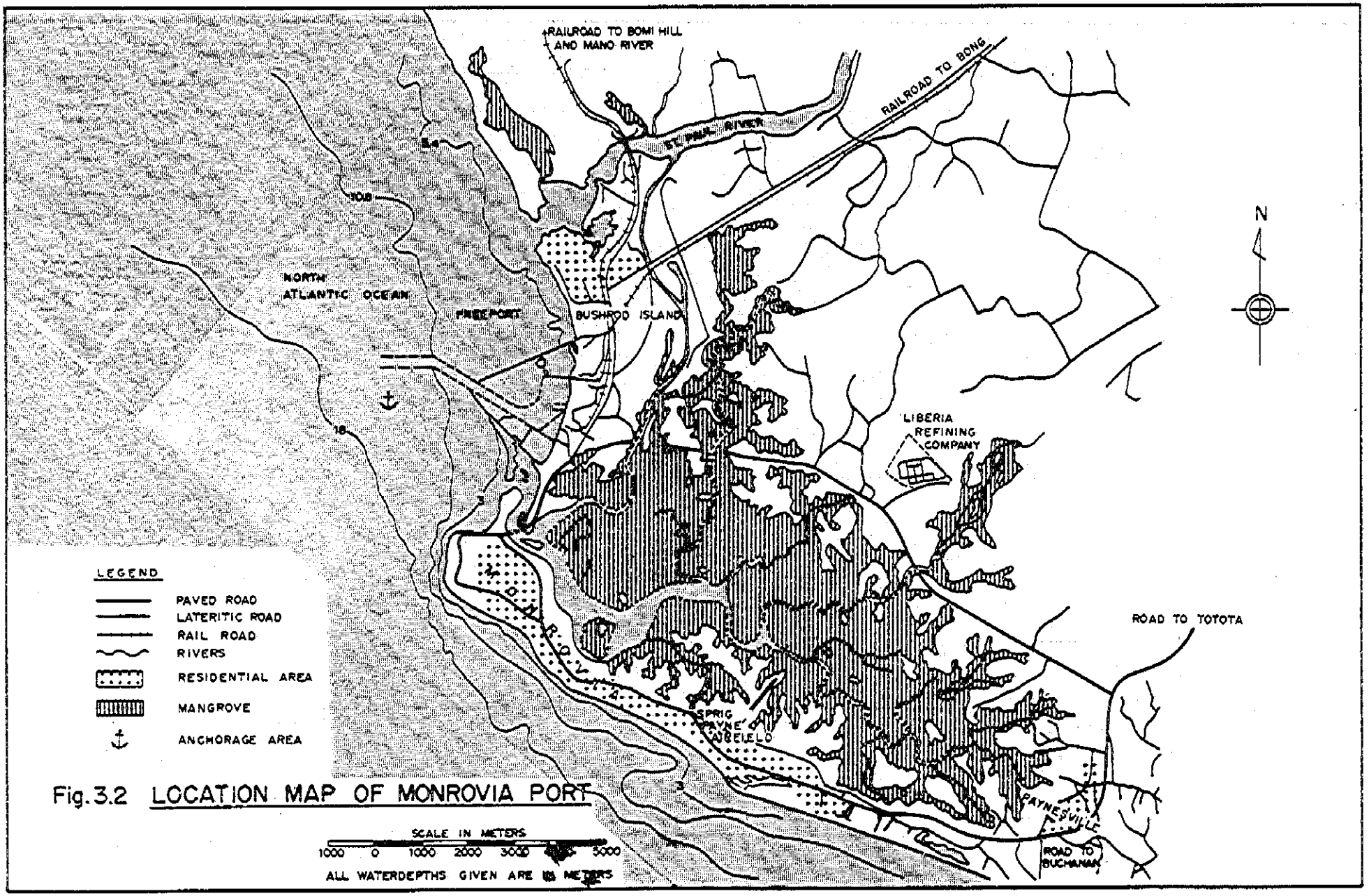


Fig. 3.2 LOCATION MAP OF MONROVIA PORT

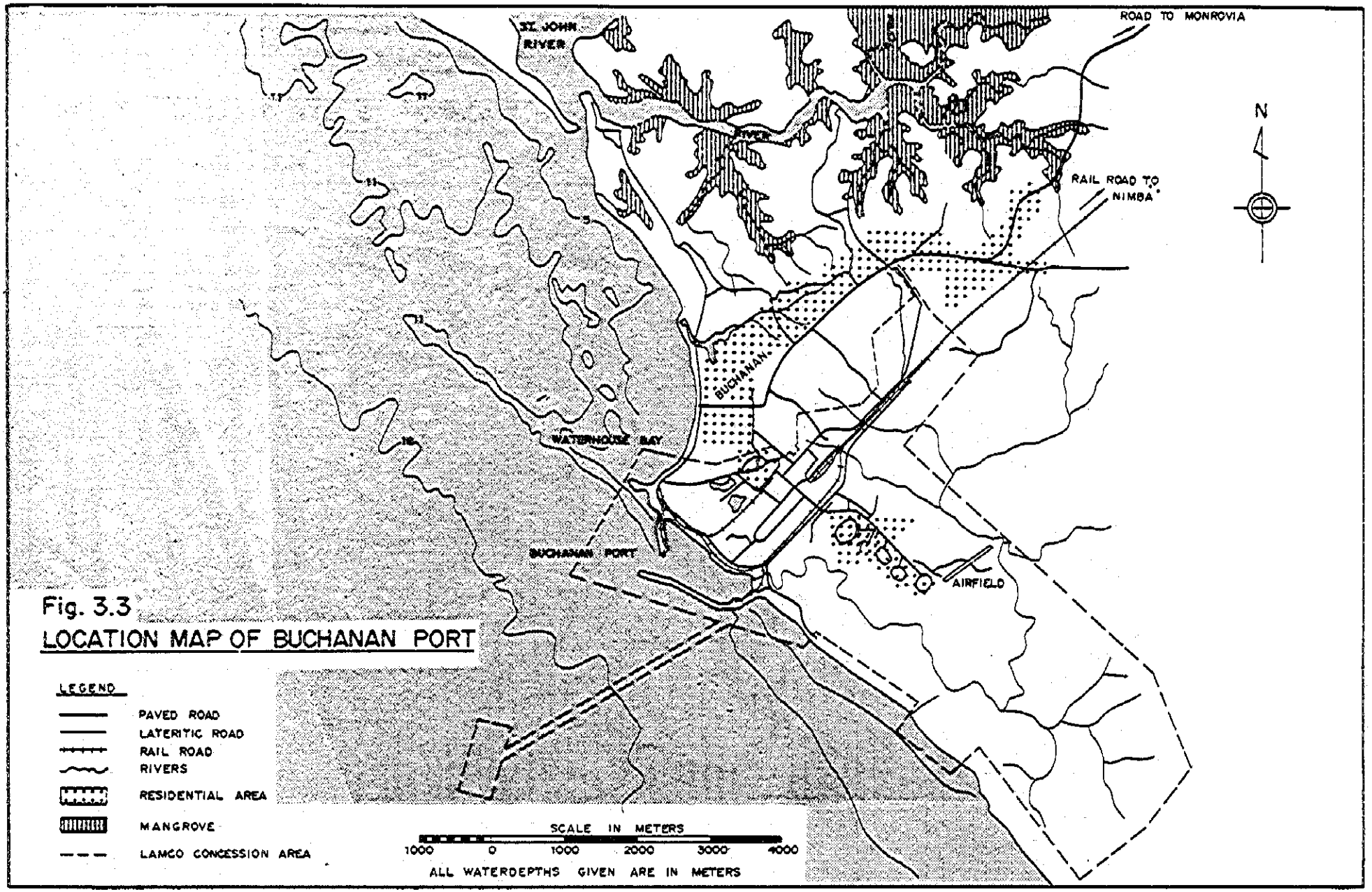


Fig. 3.3
LOCATION MAP OF BUCHANAN PORT

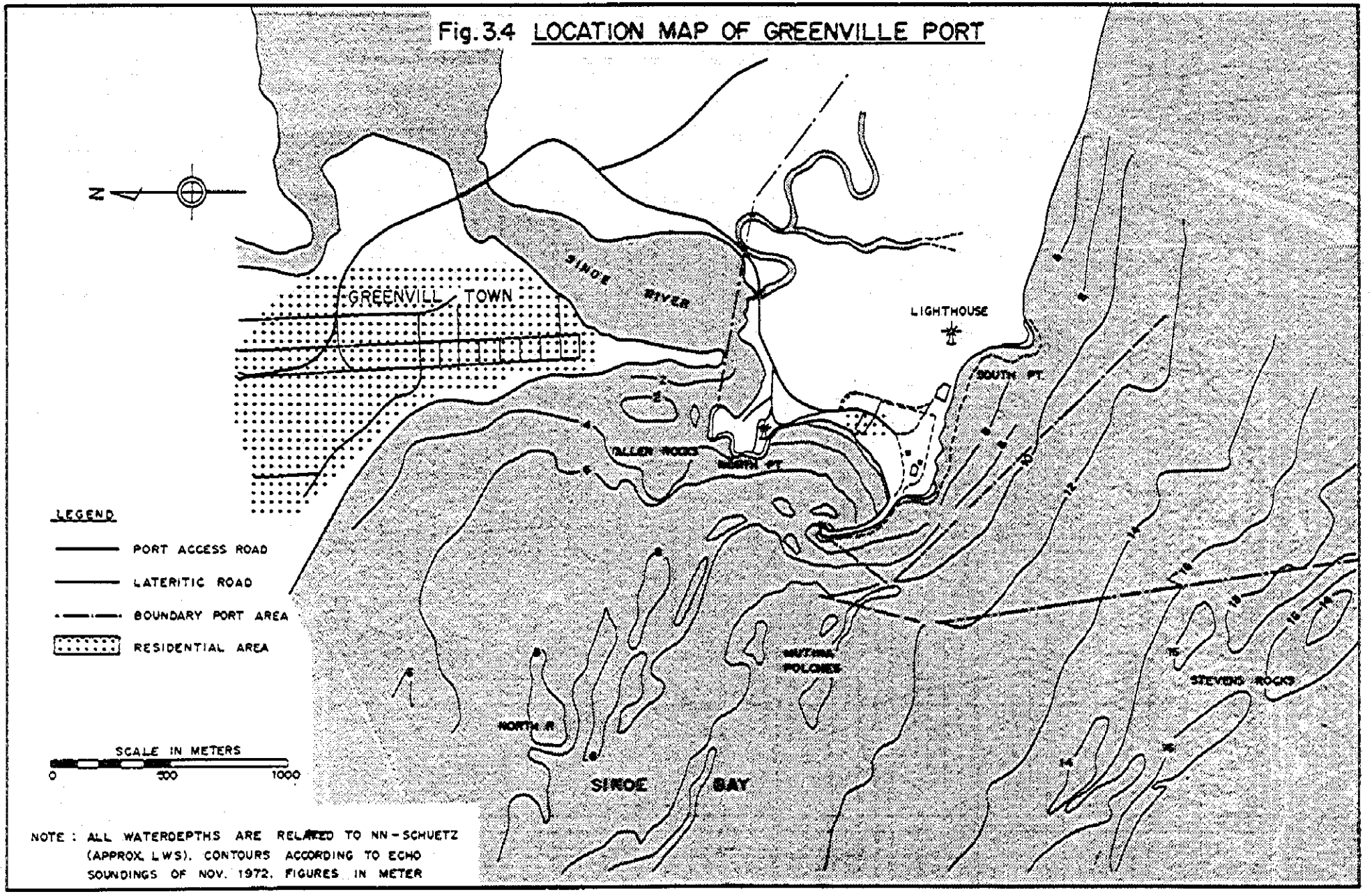


Fig. 3.4 LOCATION MAP OF GREENVILLE PORT
N
GREENVILL TOWN
SINOE RIVER
LIGHTHOUSE
SOUTH PT.
ALLEN WOODS
NORTH PT.
LEGEND
PORT ACCESS ROAD
LATERITIC ROAD
BOUNDARY PORT AREA
RESIDENTIAL AREA
SCALE IN METERS
0
500
1000
NORTH R.
SINOE BAY
STEVENS ROCKS
NOTE : ALL WATERDEPTHS ARE RELATED TO NN-SCHUETZ (APPROX. LWS). CONTOURS ACCORDING TO ECHO SOUNDINGS OF NOV. 1972. FIGURES IN METER

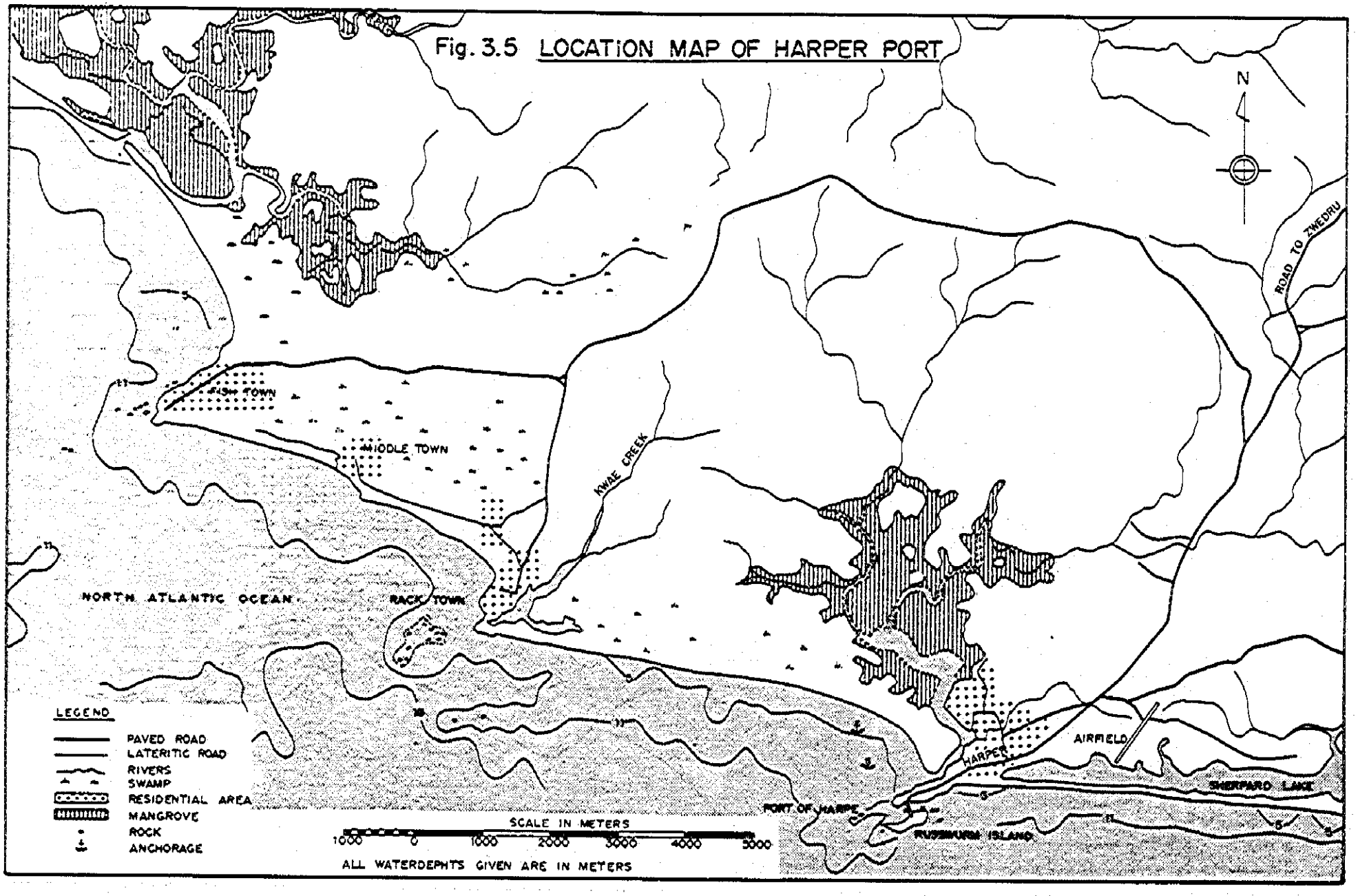
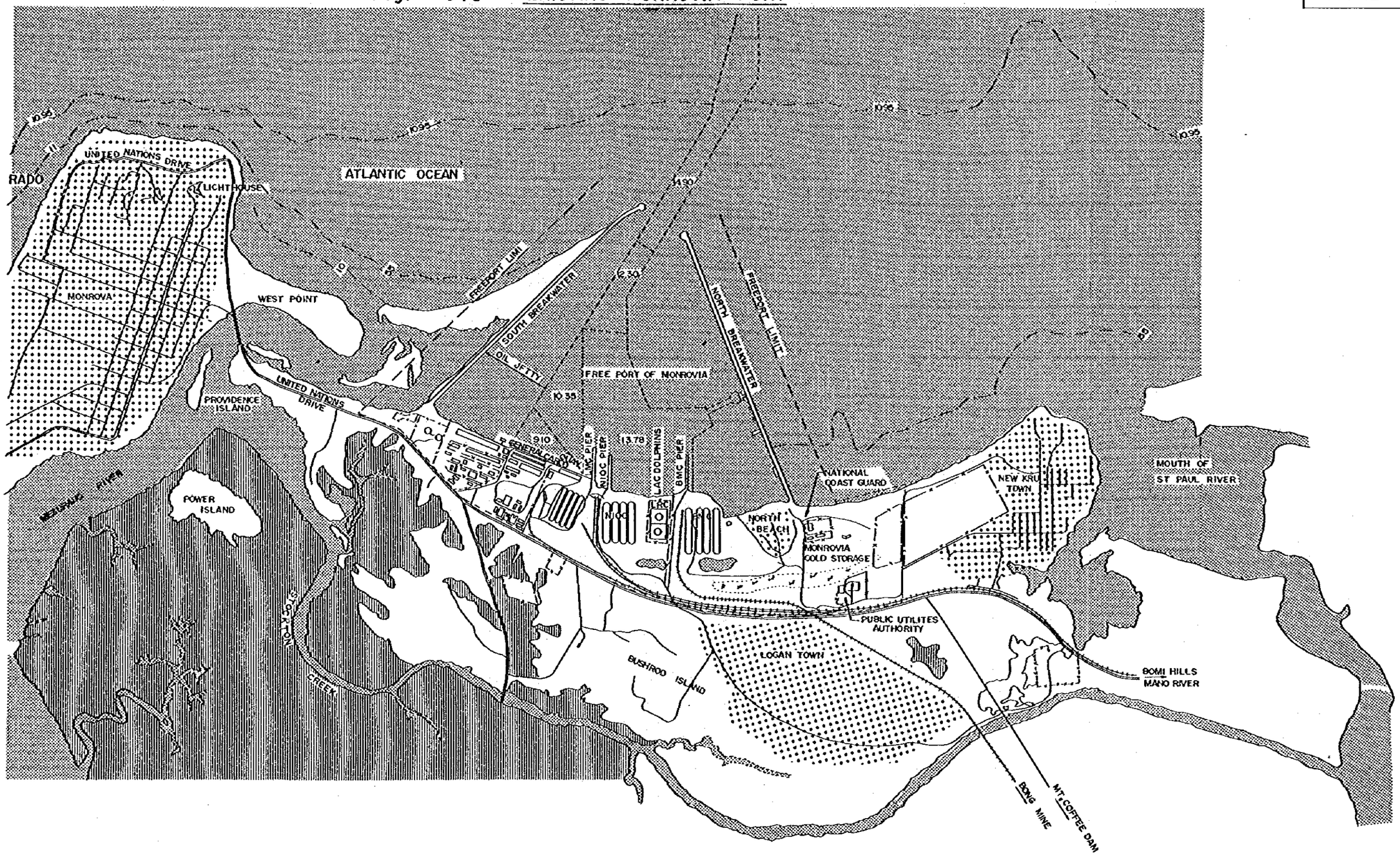


Fig. 3.5 LOCATION MAP OF HARPER PORT
N
ROAD TO ZWEDRU
FISH TOWN
MIDDLE TOWN
AWAE CREEK
NORTH ATLANTIC OCEAN
RACK TOWN
AIRFIELD
HARPER
SHERPARO LAKE
PORT OF HARPE
RUSSEKURU ISLAND
LEGEND
PAVED ROAD
LATERITIC ROAD
RIVERS
SWAMP
RESIDENTIAL AREA
MANGROVE
ROCK
ANCHORAGE
SCALE IN METERS
1000 0 1000 2000 3000 4000 5000
ALL WATERDEPHTS GIVEN ARE IN METERS

Fig. 3.6 EXISTING MONROVIA PORT

FIGURE 3.6



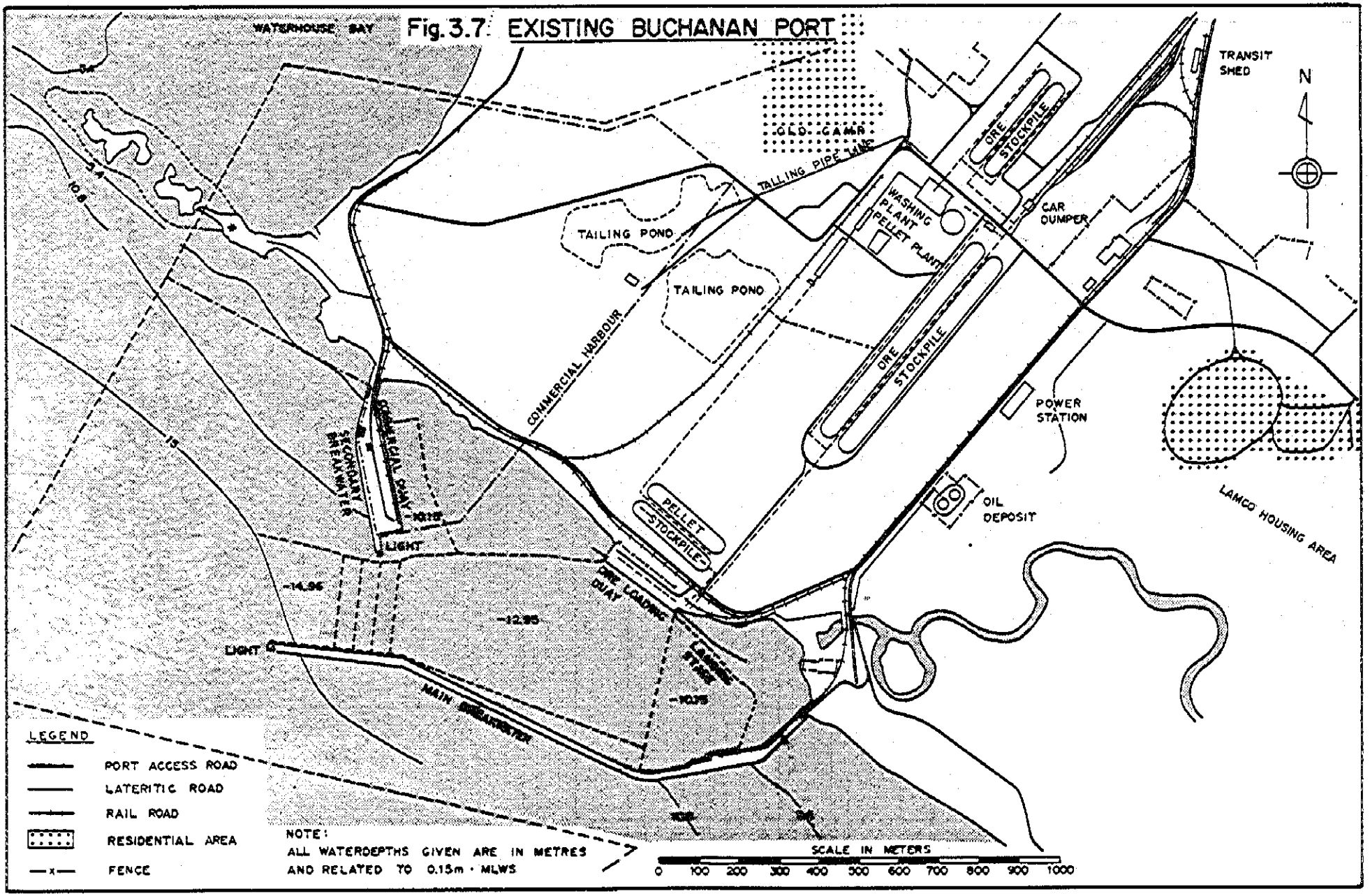


Fig. 3.7: EXISTING BUCHANAN PORT

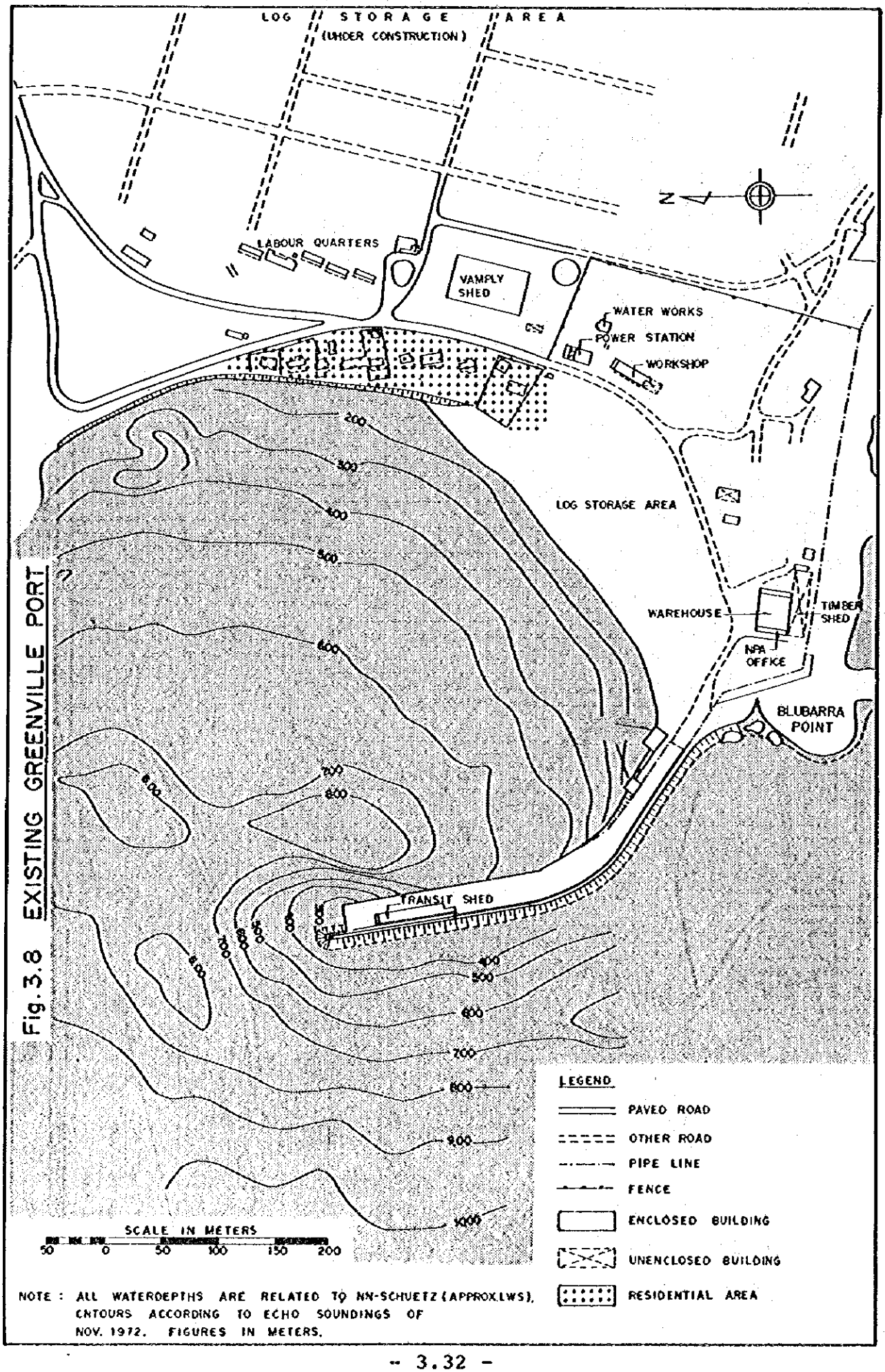


Fig. 3.8 EXISTING GREENVILLE PORT

NOTE : ALL WATERDEPTHS ARE RELATED TO NN-SCHUETZ (APPROX.LWS). CNTOURS ACCORDING TO ECHO SOUNDINGS OF NOV. 1972. FIGURES IN METERS.

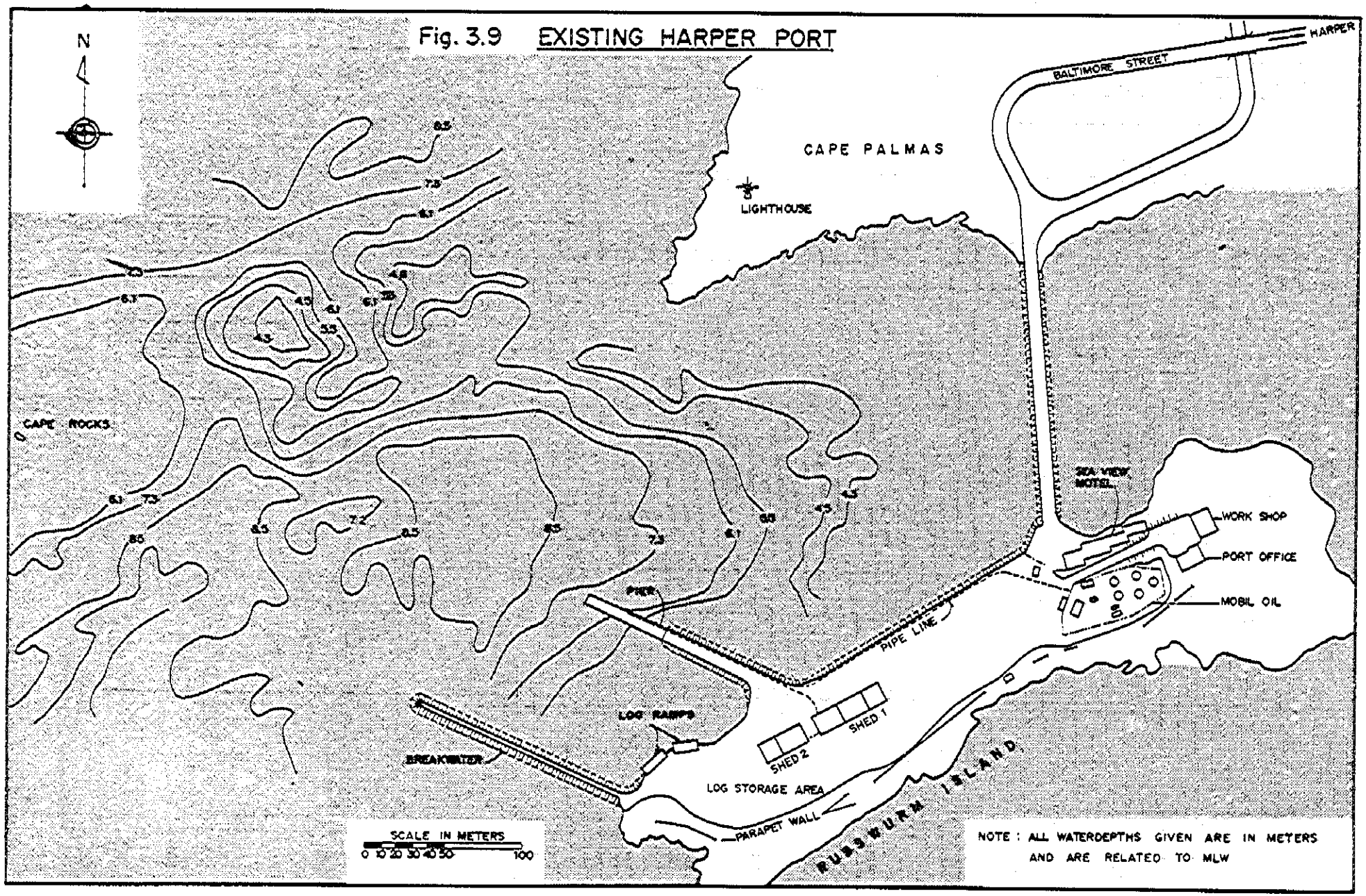


Fig. 3.9 EXISTING HARPER PORT
N
HARPER
BALTIMORE STREET
CAPE PALMAS
LIGHTHOUSE
CAPE ROCKS
SEA VIEW MOTEL
WORK SHOP
PORT OFFICE
MOBIL OIL
PIER
PIPE LINE
LOG RAMPS
SHED 1
SHED 2
BREAKWATER
LOG STORAGE AREA
PARAPET WALL
RUSSWURM ISLAND
SCALE IN METERS
0 10 20 30 40 50 100
NOTE : ALL WATERDEPTHS GIVEN ARE IN METERS AND ARE RELATED TO MLW

Fig. 3.10 ORGANIZATION CHART OF N.P.A.

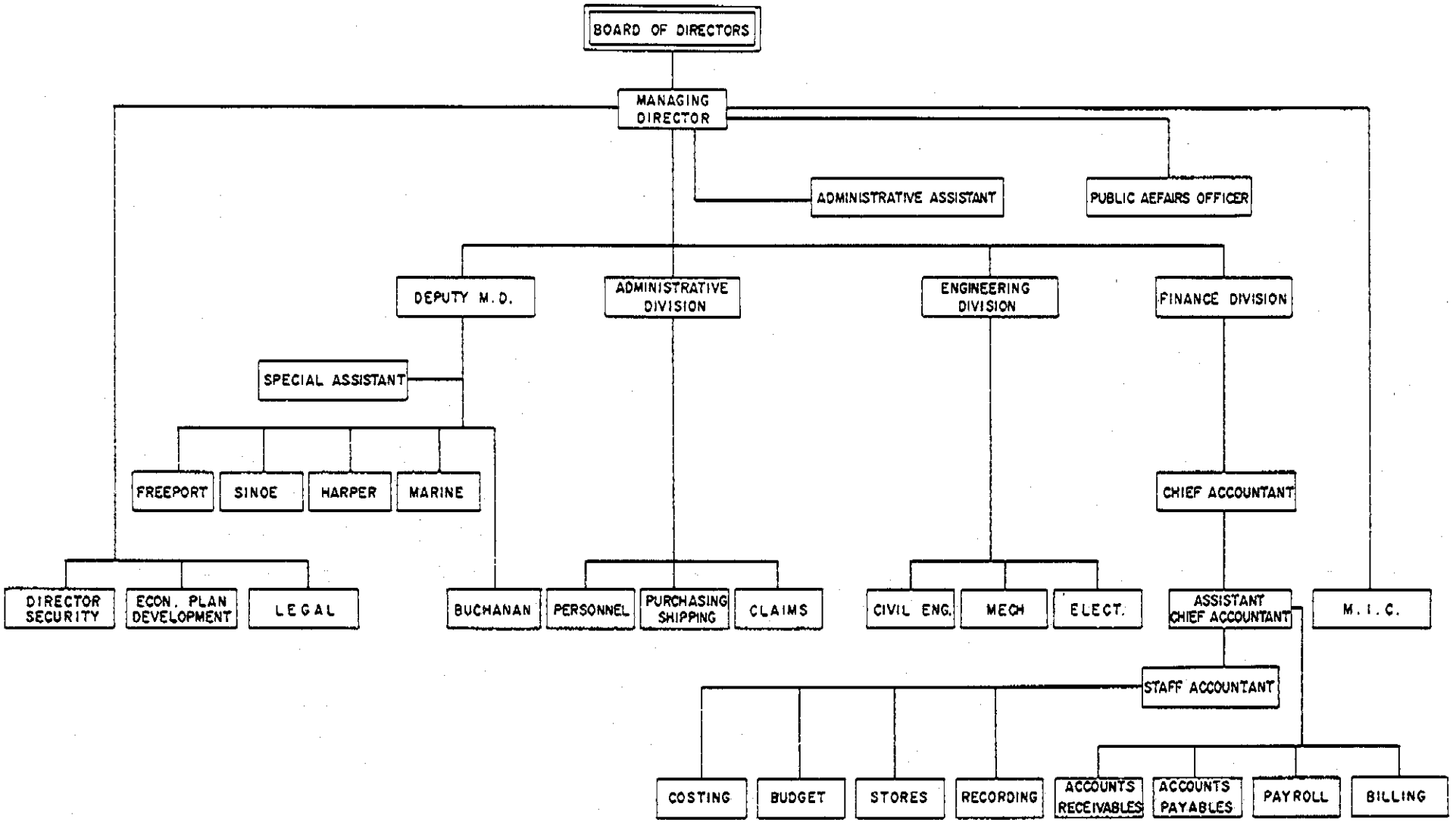


Table 3.6(1) CARGO MOVEMENT/MONROVIA PORT - 1976/EXPORT

Unit: tons

Month	General	Rubber Latex	Iron Ore	Scrap Iron	Coffee	Cocoa	Palm Kernel Oil	Con-Tainers	Cargo Van	Petroleum Product	Total
Jan.	9,965	4,420	787.832								802,217
Feb.	12,900	2,926	1,015,064								1,030,884
Mar.	10,086	4,209	715,132								729,427
Apr.	9,209	8,500	759,648								777,357
May	8,584	908	1,327,547								1,337,039
June	14,070	4,209	653,474								671,753
July	13,314	475	1,238,254								1,252,043
Aug.	11,023	3,533	1,021,202								1,035,758
Sept.	7,082	2,542	817,616								827,240
Oct.	9,649	3,088	783,598								796,335
Nov.	8,852	4,819	458,534								472,205
Dec.	36,711	3,082	670,677								700,470
Total	151,445	42,705	10,248,569								10,432,728

Table 3.6(2) CARGO MOVEMENT/MONROVIA PORT - 1976/IMPORT

Unit: tons

Month	General	P/Product	Clinker	Rice	Vehicles	Containers	Cargo Van	Cement	Fish	Trans-Shipment	Total
Jan.	37,312	35,475	-								72,787
Feb.	32,995	68,324	-								101,319
Mar.	30,312	32,985	19,109								82,406
Apr.	33,658	77,459	15,934								127,051
May	36,408	31,322	19,532								87,262
June	38,964	1,512	-								40,475
July	50,547	50,000	-								100,547
Aug.	40,219	-	-								40,219
Sept.	35,082	29,520	19,500								84,375
Oct.	42,392	79,520	-								121,912
Nov.	41,301	40,522	19,500								101,323
Dec.	37,513	50,197	39,303								127,013
Total	456,703	496,836	133,152								1,086,690

Table 3.6(3) CARGO MOVEMENT/MONROVIA PORT - 1977/EXPORT

Unit: tons

Month	General	Rubber	Latex	Iron Ore	Scrap Iron	Coffee	Cocoa	Palm Kernel Oil	Containers	Cargo Van	Petroleum Product	Total
Jan.	1,590	4,316	6,649	1,013,805	1,366	240	850	-				1,028,816
Feb.	5,624	4,020	3,044	713,530	-	315	275	-				726,808
Mar.	3,060	2,751	1,350	887,321	1,605	1,403	400	497				898,387
Apr.	1,660	3,441	2,871	787,589	-	537	165	503				796,766
May	1,433											1,443
June	1,041	4,119	-	134,959	-	1,249	-	500				141,868
July	4,803	265	2,230	641,919	1,839	1,200	49	302				652,607
Aug.	2,248	3,101	3,100	775,790	-	448	-	506				785,193
Sept.	2,432	4,712	3,475	733,300	-	761	-	500				745,180
Oct.	9,131	3,659	6,580	669,475	-	-	-	246				689,091
Nov.	9,324	3,516	3,691	671,626	-	1,065	150	507				691,317
Dec.	10,559	1,894	500	638,619	-	463	450	-				652,485
Total	51,249	35,794	33,490	7,667,933	6,248	7,681	2,339	3,561				7,809,951

Table 3.6(4) CARGO MOVEMENT/MONROVIA PORT - 1977/IMPORT

Unit: tons

Month	General	P/Product	Clinker	Rice	Vehicles	Containers	Cargo Van	Cement	Fish	Trans-Shipment	Total
Jan.	41,767	54,619	19,500	1,728	899	600	34				119,147
Feb.	27,977	45,731	-	4,202	561	950	24				79,445
Mar.	35,409	24,170	-	-	630	1,601	43				61,853
Apr.	38,342	61,102	19,433	2,306	3,207	3,011	362				127,763
May	40,734	23,646	-	-	5,772	1,164	11				71,297
June	31,323	3,209	29,133	12	3,289	1,732	12				79,010
July	29,506	35,693	19,546	23,133	2,226	875	43				111,022
Aug.	45,446	21,555	-	31,058	4,665	1,798	98				104,618
Sept.	29,100	79,001	-	311	4,306	1,863	33				118,614
Oct.	36,197	20,437	-	7,251	4,436	3,356	60				71,437
Nov.	39,983	39,463	-	2,226	3,714	1,716	36				87,138
Dec.	40,583	21,653	19,847	-	1,376	4,990	18				88,467
Total	436,357	430,275	117,759	76,227	34,781	18,656	774				1,058,811

CHAPTER IV

PORT FACILITIES REQUIRED FOR WOLOGISI PROJECT

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PORT FACILITIES REQUIRED FOR WOLOGISI PROJECT

4.1 GENERAL

The Wologisi Iron Ore Terminal is designed to handle the annual throughput tonnages of 4.0 million in the first stage (1983 - 1987) and 7.0 million in the second stage (1988 - 2013). The terminal consists of such major facilities as slurry pond, dehydration plant and stockyard plus conveying system like conveyors and stacker reclaimers together with shiploading system.

Iron ore exploited in the Wologisi Mine is pumped in the form of slurry to the Wologisi Iron Ore Terminal. This slurried iron ore is stocked in the slurry pond in the first place, then dredged and pumped to the dehydration plant where slurry is dried up, turned into fine material. This dried iron ore is conveyed to the stockyard and stacked waiting for shiploading. This stocked iron ore is reclaimed and fed by approach conveyor to the shiploader on the pier.

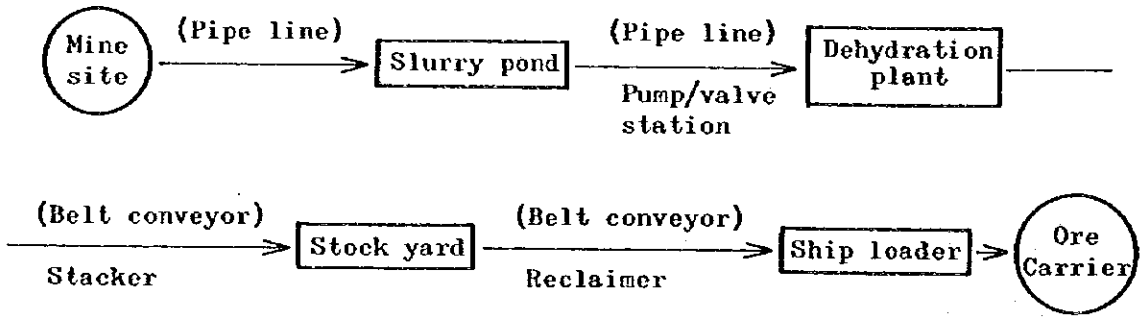
The stock capacity of slurry pond and stockyard is 75,000 m^2 and 350,000 tons, respectively. The capacity of dehydration plant is 1,300 m^2.[1/] The capacities of approach conveyor and shiploader are both rated at 6,000 tons/hour.

To accommodate the above major facilities, a minimum of 20 ha is required with firm and stable foundation.

1/: filtration areas basis

The schematic iron ore material flow is shown in Fig. 4.1

Fig. 4.1 IRON ORE FLOW DIAGRAM



In order to operate onland facility in the terminal, the iron ore berth shall take care of shiploading iron ore, while the cargo berth shall handle unloading and loading the Wologisi related materials and commodities. The onshore material handling facilities and the feed to the ore conveyor are excluded from the scope of this report, which is exclusively dealed with planning port facilities connected with the iron ore terminal.

4.2 EXPORTS AND IMPORTS

The Wologisi port shall be provided with two berths, one for handling iron ore export and other for general cargo. Annual export of iron ore is 4.0 million tons/year for the 1st stage and 7.0 million tons/year for the 2nd stage. The major item of import is fuel oil for generating power and operating plants and vehicles.

The estimated amount of fuel oil is 60,000 kℓ/year for the 2nd stage. Other main materials are lime stone in the order of 4,000 tons/year and spare parts for machines and plants. Total amount of cargos to be handled through a general cargo berth is expected less than 100,000 tons/year.

4.3 PORT FACILITIES REQUIREMENT

4.3.1 Vessel Characteristics

Generally, in the viewpoint of ocean freight, it can be said that the larger the DWT of ore carriers get, the less costly the ocean freight becomes. On the contrary, the larger ships require the deeper water depth and the higher design criteria, leading to higher cost for port facilities.

In there grounds, the size of ore carrier for the port is determined 120,000 DWT for overall economization of iron ore export. For general cargo handling, 20,000 DWT class which predominates all over the world at present is adopted.

The major dimensions of these vessels are shown in Table 4.1.

Table 4.1 MAJOR DIMENSIONS OF VESSELS

(Unit: m)

	120,000 DWT Ore Carrier	20,000 DWT General Cargo Ship
Vessel length	230	170
Beam	45	21
Draft (full)	17	10

4.3.2 Number of Berths

A general cargo berth of 20,000 DWT class is generally capable of handling cargos in the order of 200,000 tons/year to 400,000 tons/year, so that one berth is enough to deal with 100,000 tons of cargos for Wologisi Project.

The number of ore carrier berths shall be determined more carefully, taking into account the following parameters:

- the annual quantity of iron ore handled at the berths
- the average quantity of iron ore handled per ship
- the average ship service time
- the acceptable average ship queueing time

It can generally be said that if the berth occupancy is less than 40 to 50% in case of using one berth, no significant waiting is yielded. Assuming that the class of ore carrier is ranging from 70,000 DWT to 120,000 DWT, the berth occupancy is calculated at 17% for the 1st stage (4 million tons/year), and 30% for the 2nd stage (7 million tons/year).
(Refer to Appendix A)

Accordingly, one ore berth is sufficient to export the Wologisi iron ore.

4.3.3 Water Depth

The water depth required for ships to maneuver in approach channel and turning basin shall be determined by adding some allowances to the maximum draft of the ships calling at the port. The Design Manual of Ministry of Transport in Japan prescribes that the outer channel requires at less 15% allowance, and inner channel and berthing area require 10% allowance. On the basis of this design criteria the water depth of each section in the port is determined as follows:

Table 4.2 WATER-DEPTH REQUIREMENTS

	120,000 DWT Ore Carrier	20,000 DWT General Cargo Ship
Outer channel	- 19.5M	- 11.5M
Inner channel	- 18.5	- 11.0
Berthing area	- 18.5	- 11.0
Turning basin	- 18.5	- 11.0

4.3.4 Turning Basin and Channel

The vessels of 20,000 DWT class or more will navigate inside the port with tug assistance. In this case, a minimum diameter of the turning basin is twice as long as the maximum ship length; 2.0 x 280 = 560 m.

The width of channel is designed for one way traffic. To allow 120,000 DWT class ships to pass through the channel safely, 180 m is so adopted that is 3.8 times as wide as the beam of 120,000 DWT ore carrier.

CHAPTER V

SELECTION OF PORT SITES

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SELECTION OF PORT SITES

5.1 SELECTION OF PORT SITES

Along the coast of Liberia, there are four major ports; Monrovia, Buchanan, Greenville and Harper. Monrovia port, as a principal port, deals with importing most of general cargo consumed in Liberia together with exporting iron ore from three major mines. Buchanan port, which is being operated by LAMCO, handles mainly iron ore railed from Nimba Mine. Greenville and Harper ports serve exporting timbers and logs. Taking the least distance from Wologisi Mine to open sea into account, Monrovia port is superior to other three ports. Besides the existing ports, Robertsport, near the national border to Sierra Leone, which has prospective conditions for future port development, is also located within a reasonable distance from the Worogisi Mine.

Robertsport, without cargo port facilities at present, has only small jetty for fishing boat near the outlet of Lake Piso. The Cape Mount is projecting to the open sea, providing some sheltered waterground in front of Robertsport town. The land facing the outlet of Lake Piso west of Cape Mount is comparatively inhabited, but other area remains deserted. The coastal area between Lake Piso and the open sea, though poor in drainage, has good potential for industrial development.

In view of the above, Monrovia site and Robertsport site were selected for further investigation and planning.

5.2 PRINCIPAL FEATURES OF THE SELECTED SITES

5.2.1 Distance from Wologisi Mine

Monrovia and Robertsport is located at the nearly same distance about 180 km from Wologisi mine site if measured in a straight line. In practice, though, iron ore is transported by slurry pipe system from the mine site to a proposed port, and the actual distance shall be measured along the proposed pipe line route for each alternative port. Irrespective of the port sites, the pipe line traces the same route from Wologisi to Bopolu (Refer to Fig. 01), so that the difference in inland transportation mileage between two alternatives results from the difference in the pipe line length between Bopolu to Monrovia or Robertsport. The planned pipe line length up to Monrovia is 105 km, and 130 km up to Robertsport. This difference is not so significant.

5.2.2 Natural Condition

As briefly mentioned in the previous chapter, Monrovia port, located in the well sheltered area against the prevailing waves, and further protected by two breakwaters (southern and northern), is one of good artificial ports. Robertsport site, like Monrovia port, is provided with the sea ground well sheltered by Cape of Robertsport. However, this area is not spacious enough to develop a large-scale port. A large-scale port development shall be staged along the coast south of Cape Mount. To accommodate large ore carriers, deep water depth is necessary in channel and berthing area. At the Robertsport site, a new port can make full use of natural water depth, while the existing port area in Monrovia port is so shallow as to require a considerable amount of dredging. As to the hinterland of port, Robertsport site has little limitation for allocating the ore terminal facility, while in Monrovia, the allocation of a new berth requires coordination with the undergoing port expansion program.

5.2.3 Availability of Construction Materials/Equipment

Monrovia site has no problem in obtaining foreign construction material equipment and plant on account of good access to the existing port. Rock materials such as aggregate and rip-rap are also available within and economical reach of transportation. Construction craft can be moored both inside and outside the port.

Robertsport site is approximately 100 km away from the Monrovia site, say 2 or 3 hours drive by truck. There is no jetty or pier for construction materials to be unloaded near Robertsport. All the construction equipment, plant and materials shall be transported by road at the first stage of construction. Local materials such as rock, timber and aggregate are easily obtained near by. As the construction proceeds, construction jetty is essential for unloading heavy seaborn goods and mooring the construction crafts.

5.2.4 Regional Development

In terms of shiploading cost of iron ore, ore handling terminal shall be constructed with least cost. To meet with this requirement, using the idle space or pier in Monrovia port may be more favorable rather than constructing a new port in less developed land in Robertsport. Though, in much broader sense, it is preferable that the Wologisi Project helps smooth out the regional benefit to be gained by National Projects.

Monrovia site is most developed area in Liberia, while Robertsport site is in retard in socio/economical development. The port development at Robertsport is expected to fill this regional gap to a great extent.

At present, Mano River Union (Sierra Leone - Liberia) is promoting the development of forest resources in Mano River region. As this development proceeds, the coastal trading between two countries will increase, necessitating functional port near Sierra Leone. Futhermore, Robertsport has good potential for exporting logs and timber transported from the inland area.

CHAPTER VI

ALTERNATIVE STUDY FOR MONROVIA SITE

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ALTERNATIVE STUDY FOR MONROVIA SITE

6.1 NATURAL CONDITION

6.1.1 Wind

Wind data obtained in '75 & '76 at Spriggs Payne Airport which is located inland about 7 km southeast of Monrovia Port can be used for this alternative study. The data is summarized as below.

Table 6.1 Wind Record/Spriggs Peyne Airport (1975)

Month	Prevailing winds	Av. wind velocity(knot)	Max. wind velocity(knot)
Jan.	SW	6.7	20
Feb.	SW	0.8	-
Mar.	NW	7.4	15
Apr.	SW	6.9	-
May	SSW	7.4	20
June	SSW	8.4	18
July	SSW	9.7	18
Aug.	SSW	0.9	15
Sept.	SW	8.4	20
Oct.	SW	7.7	25
Nov.	SW	0.7	-
Dec.	SSW	6.9	25

(1976)

Month	Prevailing winds	Av. wind velocity(knot)	Max. wind velocity(knot)
Jan.	SW	6.3	-
Feb.	SW	7.8	-
Mar.	WSW	7.7	-
Apr.	SW	7.3	20
May	SW	7.2	15
June	SSW	8.2	17
July	SSW	8.4	17
Aug.	SSW	8.2	15
Sept.	SSW	7.9	20
Oct.	SSW	8.5	-
Nov.	SSW	7.9	20
Dec.	WNW	6.8	-

6.1.2 Wave

Due to the existence of the breakwaters there is no important wave activities inside the harbour under normal conditions.

6.1.3 Tide

The port has a tidal difference during spring tide of 1.10 m between MHWS and MLWS and 0.60 m between MHWN and MLWN during neap tide.

6.1.4 Current

Due to existence of the breakwaters there is no significant current at the berth location.

6.1.5 Subsoil

The test boring inside the port area is being carried out by the German Consultant. The location and engineering logs of boring are attached in APPENDIX B. According to the engineering logs of boring, the following can be said: the seabed is covered with muddy silt of about 1 m thick, which overlies loose sand of 4 to 5 m thick. Under this sandy soil, there lies medium to dense sand with N value of around 10, sometimes 2 - 3 m thick clay is inserted between these sand.

As the depth increases, not always the relative density of this sandy soil gets higher. In front of the B.M.C. pier, there lies rock beds 5 to 8 m below the seabed. This gives complicate situation to port development around this area. The boring data obtained about 300 m inside the northern breakwater shows the existence of firm sandy soil with N value of 15 to 18 in the water depth of 15 - 25 m, which gives good subsoil condition for pier foundation.

In the vicinity of the southern edge of the general cargo berths, the content of silty and clayed soil mixture can be often found together with organic fragment.

The penetration of test boring is not deep enough to reveal the supposed bed rock likely to be underlying the firm sandy soil.

6.2 PRINCIPAL FEATURES OF SELECTED ALTERNATIVES

6.2.1 Background

Monrovia Port is now in the process of the ongoing rehabilitation and future expansion program. (Fig. 6.1) Some proper space is likely to be obtained inside northern/ southern breakwaters for construction of a new iron ore loading berth. Selection of new iron ore berth only for Wologisi Project is required to pay due consideration to avoidance of blocking the future port expansion program envisioned by N.P.A. Under these conditions, two alternatives are selected as follows;

Alternative I: Taking-over and extension (120 m) of the existing L.M.C. pier

Alternative II: New berth construction just inside of the northern breakwater

6.2.2 Alternative I

1) Berth Location

On completion of exploitation of Bomi Hills Mine, the L.M.C. pier, which was being used to export iron ore, remains idle at present serving only as an waiting berth. As previously mentioned in section 5.2.8, the L.M.C. pier is capable of accommoditing ore carrier up to 50,000 DWT class and is installed with a loader conveyor rated at the nominal capacity of 2,000 t/h. Though slightly short in loading capacity, the foundation of pier can suffice to accommodate the 120,000 DWT class ore carrier by minor improvement. The rehabilitation plan of L.M.C. pier has been closen as Alt. I for the Wologisi ore berth.

2) Berth Improvement

To cater for berthing of 120,000 DWT vessels in place of 50,000 DWT vessels, the water depth of berthing area shall be deepened, and the breasting dolphins and mooring dolphins shall also be upgraded. Additionally, the shiploader shall be replaced by a new one with a loading capacity of 6,000 t/h.

Though it is expected that a new shiploader is much heavier than the existing one, the foundation can be left untouched without any reinforcement in such a manner that additional number of wheels are installed to take care of surplus weight of new shiploader, resulting in no increase in the load per pile.

On top of the berth facility, the turning basin and approach channel shall be upgraded. The major parts of improvement are tabulated as follows:

Table 6.2 Improvement Plan/Monrovia/Alt. I

	Before Improvement	After Improvement
Water Depth of Approach Channel	-14.5 m	-19.5 m
Width of Approach Channel	150 m	180 m
Water Depth of Turning Basin	-14.0 m	-18.5 m
Radius of Turning Basin	250 m	280 m
Water Depth of Berth Area	-13.5 m	-18.5 m
Breasting Dolphin	-	4 nos.
Mooring Dolphin	-	1 no.
Loader Foundation	-	120 m

3) Berth Layout

The pier for the shiploader's foundation should be extended 120 m offshore so that the new shiploader can cover the total hatch length of 120,000 DWT ore carrier. The mooring dolphins and breasting dolphins shall be located for every size of ore carrier expected to be docked and moored smoothly and safely. The existing breasting dolphins are left untouched, serving as sub-breasting dolphins, between which one main breasting dolphin is provided. Along the tender line of extension area, are located another main breasting dolphin and two sub-breasting dolphins. A new mooring dolphin is located 50 m away from the edge of the new loader pier so as to increase mooring effect.

4) Breasting/Mooring Dolphins and Shiploading Pier

Structually speaking, vertical piles are employed for the foundation of the breasting dolphins so that part of docking energy may be shared by both piles and fender system. On the contrary, batter piles are employed for the foundation of the mooring dolphins so that a great deal of horizontal force from mooring lines can be transfered to the axle loads. The piles foundation of shiploader is designed in the form of combination piles (vertical and batter) to cope with heavy vertical and horizontal loads of shiploader. The main dimensions of above structure are tabulated as follows:

Table 6.3 Main Features of Dolphins and Shiploading Pier Alt.I

	Main Breasting Dolphin	Sub Breasting Dolphin	Mooring Dolphin	Ship-loader Pier
Diameter of Piles	ϕ 1219.2	ϕ 508	ϕ 711	ϕ 508
Number of Piles	6	4	16	160
Attendant Appurte-nance	Fender	Fender	Borrard	-

5) Dredging

The existing berth area, turning basin and channel are upgraded as shown on Table 6.2. (See Fig. 6.2. The estimated amount of dredging is approximately 4.0 million m^3 inside the breakwater and 3.7 million m^3 outside the breakwater; 7.7 million m^3 in total. The dumping area is expected north of the northern breakwater.

6) Other Major Facilities

On completion of dredging work, the navigation facility shall be relocated or newly installed to mark the new waterway. To cater for maneouvering of 120,000 DWT ore carrier inside the port, at least four 2000 HP tugboats or three 2,500 HP tugboats are required.