IV Appendices to Chapter 5-1

Appendix 5-1-1 Vessel Size and Berth Dimensions of General Cargo Vessels

The number of general cargo vessels that called at Mina Qaboos was 214 in 1988. The proportion to the total calling vessels was 20.3 per cent. The average vessel size was 7,037 GRT and the maximum size was 28,005 GRT. The average overall length was 115.0m and the maximum overall length of general cargo vessels was 193m. The average entering draft was 6.1m and the maximum entering draft was 10.5m.

The long and heavy cargoes carried by general cargo vessels were timber, iron and steel, the size of vessels that carry these cargoes was greater than the size of vessels which carry other general cargoes. The average size of general cargo vessels excluding vessels which carried timber, iron and steel was 4,736 GRT.

On the other Hand, the average size of general cargo vessels around the world was 3,659 GRT, which has not changed during the past 10 years. The average size of general cargo vessels around the world was 3,561 GRT in 1979.

Comparing the vessel size distribution at Mina Qaboos with that around the world, the vessel class between 1,500 DWT and 7,500 DWT in Mina Qaboos was far less than world wide.

This is because the vessels calling at Mina Qaboos comprise only international trade vessels and not domestic trade craft.

After completion of the New Port, the vessel size distribution of general cargo vessels be the same as that of Mina Qaboos at present. The largest class of general cargo vessels around the world is around 25,000GRT, so the largest class of vessels already calls at Mina Qaboos. The overall length of this class of vessels is 198m and the breadth of this class of vessel is 28m. So the necessary berth length is between 226 and 247m. Accordingly, if we think of a single berth for this class of vessel, the required berth length would be about 250m. The maximum draft of this class of vessel is about 11.7m,

Presently, the maximum draft of vessel calling at Mina Qaboos is 10.5m, but the draft is not the full loaded draft. So the required depth will be -13.0m.

In considering continuous berths, we usually take a objective vessel that 70 percent of the total vessels do not exceed the size of. The objective vessel size in this case is about 25,000DWT, and its overall length is 175m and its breadth is bout 24.4m. So the required length of one of continuous berths will be 22.0m.

The objective vessel size and berth dimension are summarized as follows:

Maximum Vessels	: 40,000DWT, Lo = 198m, B = 28.2m, Dr = 11.7m
Objective Vessels	: 25,000DWT, Lo = 175m, B = 24.4m
Single Berth	: L = 250m, D = -13.0m
Continuous Berth	: Lo = 220m, D = -13.0m

Appendix 5-1-2 Vessel Size and Berth Dimensions of Container Vessels

The number of full container vessels calling at Mina Qaboos in 1988 was 404, 38.3 percent of the total calling vessels. The average vessel size was 15,420GRT and the maximum vessel size was 33,761GRT. The average overall length was 160.9m and the maximum was 228.0m. The average entering draft was 7.74m and the maximum was 10.6m.

From the report published by NYK (Nippon Yusen Kabushikigaisha), the maximum vessel size calling at ports in the Gulf Region is 3,010TEU type full-container vessels at Fujairah.

The average vessel size of full-container vessels around the world was 19,829GRT in 1988, compared with 16,828GRT in 1979. The average vessel size has increased at a rate of 1.8 percent since 1979.

The average vessel sizes by route are 32,584GRT (2,170TEU type) for the Far East and North American routes, 31,295GRT (1,975TEU type) for the Far East and Europe route, 27,500GRT (1,766TEU type) for the Europe and North America route, 18,312GRT (1,083TEU type) for the Australia route, 23,479GRT (1,776TEU type) for the Middle East route, 22,223GRT (1,320TEU type) for the South America route, 17,182GRT (963TEU type) for the Africa route and 18,419GRT (1,250TEU type) for the Indian route in 1988. The average vessel size of the Middle East route is the fourth-biggest, followed by the Far East and North America route, the Far East and Europe route and the Europe and North America route.

In 1988, the container vessel having the following dimension appeared on the Far East and North America route of American President Limes:

President Adams : 61,926GRT, 4,340TEU type, 24.2 knots,
$(L, B, D_r \doteqdot 275.2m, 39.4m, 12.0m)$[1)]

Also, over-3000-TEU-type full-container vessels with the following dimensions appeared on the Far East and Europe route of NYK in 1988:

Kaga : 51,047GRT, 3,618TEU type, 23.0 knots,
$(L, B, D_r = 289.5m, 32.2m, 13.0m)$

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1) L, B and Dr stnad for the overall length, the breadth and the full-load draft of the said vessel.

On the Europe and North America route, over-3000-TEU-type full-container vessels having the following dimensions had already appeared in 1984:

Sea-land Atlantic : 58,943GRT, 3,400TEU type, 18.0 knots,
(L, B, D_r = 289.5m, 32.2m, 12.6m)

On the around-the-world route, over-4,000-TEU-type full-container vessels having the following dimensions appeared in 1988:

Maersk Tokyo : 52,191GRT, 4,000TEU type
(L, B, D_r = 294.3m, 32.2m, 13.5m)

The number of over-3,000-TEU-type full-container vessels is 55 at present and their distribution is as follows:

3,000 ~ 3,500TEU type	3,500 ~ 4,000TEU type	Over4,000TEU type
45 (82%)	3 (5%)	7 (13%)

The length distribution is as follows:

240 ~ 260m	260 ~ 280m	280 ~ 300m
17(31%)	21(38%)	16(29%)

The number of third-generation full-container vessels (2,000 - 3,000TEU type) was 173 in 1988. The vessel size distribution of the third-generation vessels is as follows:

(Unit : TEU)

2,000~2,200,	2,200~2,400,	2,400~2,600,	2,600~2,800,	2,800~3,000
35(20%)	11(6%)	50(29%)	52(30%)	25(14%)

The length distribution of the third generation vessels is as follows:

200 ~ 220m,	220 ~ 240m,	240 ~ 260m,	260 ~ 280m,	280 ~ 300m
25(15%)	25(15%)	75(44%)	36(21%)	10(6%)

In 2015, the New Port should become a hub port. Accordingly, it should be fully developed to be suitable for the current big vessels in the Far East and North America route. In order to be competitive with other ports in the Arabian Gulf, the New Port should have enough capacity to accommodate the biggest vessels operating in the Arabian Gulf and Oman Gulf. The biggest vessels are now of the over-3,000-TEU type at Fujaila. Presently, 85% of the over-3,000-TEU type vessels have capacities less than 3,500TEUs. Accordingly, the maximum vessel size is assumed to be as follows:

Maximum Vessel Size : 50,000GRT, 3,500TEU type
(L, B, D = 290m, 32.2m, 12.7m)

Berth dimensions shall be as follows:
Length = 324 ~ 346m, Depth = -14m

Accordingly, the standard berth length will be 350m. But the probability of two maximum vessels calling at the same time seems to be very small and it is necessary that a mother vessel and a feeder vessel call simultaneously, so we take the smaller berth length as follows:

Berth Dimension : Length ; 320m : Depth; -14.0m

The vessel size of feeder vessels is considered to be as follows:

Feeder Vessel Size : 18,000DWT, 1,000TEU type
Length; 175m

Appendix 5-1-3 Vessel Size and Berth Dimensions of Grain Bulk Carriers

Presently, the Oman Flour Mill Corporation is using grain bulk carriers of the 25,000DWT type. They hope to use 50,000 DWT type bulk carriers to reduce transportation costs.

The cargo volume of bulk grains handled at Mina Qaboos in 1988, was 135,400 tons. In 2000, Mina Qaboos will handle 250,300 tons of bulk grains.

The capacity of the silos is 120,000 tons at present. The capacity of silos can generally be calculated by the following formula;

$$C = \frac{W}{N} \div a$$

Where C : Capacity of Silos (tons)

W : Handling Volume p.a. (tons)

N : Turnover Times of Sailo p.a.

d : Efficiency Rate

The turnover times of silo per annum is usually between 7 and 9, but 4 are used for a stockpile. The efficiency rate is usually 0.63. Accordingly, a silo can handle the following volume:

$$W = 120,000 \times 4 \times 0.63 = 302,400 \text{ tons}$$

The forecast volume of bulk grains in 2015 is 456,000 tons. The shortage of silo capacity can be calculated as follows:

$$C = \frac{456,000 - 302,400}{4} \div 0.63 = 60.952 \text{ tons}$$

The allocated volume of bulk grains to Mina Qaboos was 250,300 tons, but it is possible to allocate up to 302,400 tons judging from the present silo capacity.

The bulk carriers are now using berth No.3 at Mina Qaboos. The berth is located at the end of a slip, so the maximum vessel length is limited to 171.0m, which is the overall length of 25,000 DWT type carriers although the length of berth No.3 is 228m.

We consider the following two alternatives in handling bulk grains in 2015:

(1) Handling all bulk grains at Mina Qaboos (Alternative 1)
(2) Handling the volume of bulk grains up to the existing silo capacity at Mina Qaboos and the rest at the New Port (Alternative 2)

(1) Alternative 1

The forecast demand of bulk grains is 456,000 tons.

Bulk carriers of 25,000 DWT can carry a volume of bulk grains up to 25,000 tons. So the number of calling vessels is calculated as follows:

$$N = 456,000 \div 25,000 = 18.24$$

The average arriving rate will be as follows:

$$\lambda = 18.24 / 365 = 0.05 \text{ vessel / day}$$

The cargo handling volume per day is 4,000 tons at present. So the volume of bulk grains in one carrier can be handled with in the following time:

$$\frac{1}{\mu} = 25,000 \div 4,000 = 6.25 \text{ days}$$

If we assume the preparation time for cargo handling is 0.1 day, the berthing time for one carrier will be as follows:

$$\frac{1}{\mu} = 6.25 \text{ days} + 0.1 \text{ day} = 6.35 \text{ days}$$

The berth occupancy rate can be calculated as follows:

$$\rho = \frac{\lambda}{\mu} = 0.05 \times 6.35 = 0.3175$$

The berth of No.3 is mainly used by bulk grain carriers and the scheduling of bulk carriers is conducted by the Oman Flour Mill

Corporation, so the above berth occupancy rate does not create any problems.

From the analysis of actual berthing time and handling volume, the present cargo handling volume, the present cargo handling volume per berthing day is found to be 3,055 tons / day.

By using this productivity, the berthing time of 25,000 DWT bulk grain carriers is calculated as follows:

$$\frac{1}{\mu} = 25{,}000 \div 3{,}055 = 8.18 \text{ days}$$

The berth occupancy rate will be as follows:

$$\rho = \frac{\lambda}{\mu} = 0.05 \times 8.18 = 0.4092$$

In this case, there are no major problems for berth utilization, considering the use of bulk grain carriers only. But we are thinking to allocate No.3 berth also to other vessels which calls Mina Qaboos as a courtesy visit. The time for other vessels is assumed to be 2,628 hrs. Then, the berth occupancy rate comprising the use of bulk grain carriers and other vessels will be 71 per cent.

The value of this berth occupancy rate, 0.71 will be very high, even if the scheduled calls of bulk grain carriers is possible. It will not be possible to handle all bulk grains at No.3 only of Mina Qaboos in 2015, accordingly.

We planned mult-purpose berths at No.1 and No.2 of Mina Qaboos. The allocated cargo volume to these berths in 2015 is 211,100 tons of general cargoes and 70,580 boxes of containers. The average berth occupancy rate of No.1 and No.2 is 33.8 per cent. The average waiting time can be calculated by the M/M/S model[1] as follows:

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1) M/M/S model: This stands for the expression way of mathematical queueing model. The distribution of the inervals of arriving vessels is an exponential distribution and the distribution of the berthing time is also an exponential distribution by the expression of M/M/. S stands for the number of berths.

The number of general cargo vessels which carry steel : 24.421
The number of general cargo vessels which carry timber : 19.231
The number of Ro-Ro vessels : 288.667
The number of livestock carriers : 45.217
The number of general cargo vessels which charry other general cargoes: 26.526
The number of container vessels : 255.725
The total number of vessels : 659.787

The average arrival rate, λ = 659.787/365 = 1.8076

The average berthing time of steel carrying vessels : 1.500 days
The average berthing time of timber carrying vessels : 1.3037 days
The average berthing time of Ro-Ro vessels : 0.3056 day
The average berthing time of livestock carriers : 0.4928 day
The average berthing time of other general cargo vessels : 0.7597 day
The average berthing time of container vessels : 0.3875 day

Then the average berthing time is as follows:

$$\frac{1}{\mu} = \frac{1}{659.787} (24.421 \times 1.5 + 19.231 \times 1.3037 + 288.667 \times 0.3056 + 45.217 \times 0.4928 + 26.526 \times 0.7597 + 255.725 \times 0.3875)$$
$$= 0.4417$$

The berth occupancy rate can be calculated as follows:

$$\rho = \frac{\lambda}{\mu s} = 1.8075 \times 0.4417/2 = 0.3392$$

From Table A-5-1-1, the average queue length is as follows:

$$Lq = 0.1514$$

The average waiting time can be calculated as follows:

$$Wq = Lq/\lambda = 0.08378 \text{ day} = 2.0 \text{ hrs}$$

If we allocate 250,300 tons of bulk grains to No.3 berth and 205,700 tons to No.1 and No.2 berth in Mina Qaboos, the berth occupancy rate of No.3 berth and the average berth occupancy rate of No.1 and No.2 berth are as follows:

The berth occupancy rate of No.3 : 47.3 per cent

The number of bulk grain carriers : 4.114[1)]

The average berthing time of bulk grain carriers :

$$50,000 \div 3,055 = 16.367$$

The average arrival rate, $\lambda = 663.901/365 = 1.8189$

The average berthing time,

$$\frac{1}{\mu} = \frac{1}{663.901}(659.787 \times 0.4417 \times 4.114 \times 16.373) = 0.5404$$

The berth occupancy rate can be calculated as follows:

$$\rho = \frac{\lambda}{\mu s} = 1.8189 \times 0.5404/2 = 0.4915$$

From Table A-5-1-1, the average queue length is as follows:

$$Lq = 0.3155$$

The average waiting time can be calculated as follows:

$$Wq = Lq/\lambda = 0.1735 \text{ day} = 4.16 \text{ hrs}$$

Comparing the berthing time of container vessels, viz 9.3 hrs with the average waiting time, the ratio of the average waiting time to the berthing time is 0.45, then the container vessels deter for use these berths.

If we allocate 250,300 tons o bulk grains to No.3 berth and 205,700 tons to No.2 berth only in Mina Qaboos, the berth occupancy rate of No.2 berth is as follows:

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1) We are thinking the vessel size is 50,000 DWT at No.1 and No.2 berths.

The average arrival rate,

$$\lambda = \frac{659.787 - 255.725 + 4.114}{365} = \frac{408.176}{365} = 1.1183$$

The average berthing time,

$$\frac{1}{\mu} = \frac{1}{408.176}(24.421 \times 1.5 + 19.231 \times 1.3037 + 288.667 \times 0.3056$$
$$+45.217 \times 0.4928 + 26.526 \times 0.7595 + 4.114 \times 16.367)$$
$$= 0.6362$$

The berth occupancy rate is as follows:

$$\rho = \frac{\lambda}{\mu} = 1.1183 \times 0.6362 = 0.7115$$

From Table A-5-1-1, the average queue length is as follows:

$$Lq = 1.7721$$

The average waiting time can be calculated as follows:

$$Wq = Lq/\lambda = 1.5846 \text{ day} = 38.03 \text{ hrs}$$

Accordingly, it is not possible to handle all bulk grains in Mina Qaboos in 2015 without reallocating general cargoes and container cargoes.

The capacity of the existing silo is 302,400 tons. If this volume is carried by 25,000 BWT bulk grain carriers and handled at No.3 berth, the berth occupancy rate of No.3 berth is as follows:

$$N = 302{,}400 \div 25{,}000 = 12.096$$
$$\lambda = 12.096/365 = 0.0331 \text{ day}$$
$$\frac{1}{\mu} = 8.18 \text{ days}$$
$$\rho = \frac{\lambda}{\mu} = 0.0331 \times 8.18 = 0.27$$

Accordingly, the berth occupancy rate of No.3 berth is 57 per cent. This berth occupancy rate is rather high for one berth compared with the recommended berth occupancy rate for one berth by UNCTAD, viz 40 per cent, but it seems to be possible to manage to cater for such volume, considering that it is possible for the Flour Mill corporation to schedule the delivery of bulk grain carriers.

Table A-5-1-1 Table of Average Queue Length and Average Waiting Time of M/M/S Model

	ρ \ S	1	2	3	4	5	6	7	8	9	10
	0.05	0.0026316	0.0002506	0.0000268	0.0000030	0.0000004	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	0.10	0.0111111	0.0020202	0.0004115	0.0000883	0.0000195	0.0000044	0.0000010	0.0000002	0.0000000	0.0000000
	0.15	0.0264705	0.0069054	0.0020095	0.0006152	0.0001939	0.0000622	0.0000203	0.0000067	0.0000022	0.0000007
	0.20	0.0500000	0.0166667	0.0061643	0.0023952	0.0009579	0.0003903	0.0001612	0.0000671	0.0000282	0.0000119
	0.25	0.0833333	0.0333333	0.0147058	0.0068026	0.0032364	0.0015684	0.0007702	0.0003818	0.0001908	0.0000958
	0.30	0.1285713	0.0593406	0.0300124	0.0158783	0.0086310	0.0047770	0.0026783	0.0015159	0.0008646	0.0004959
	0.35	0.1884614	0.0977209	0.0551502	0.0324715	0.0196176	0.0120599	0.0075070	0.0047172	0.0029858	0.0019012
Lq	0.40	0.2666667	0.1523808	0.0941177	0.0604664	0.0398012	0.0266349	0.0180395	0.0123297	0.0084877	0.0058765
	0.45	0.3681817	0.2285267	0.1522433	0.1051636	0.0742993	0.0533285	0.0386932	0.0283270	0.0208813	0.0154781
	0.50	0.4999999	0.3333332	0.2368420	0.1739129	0.1303712	0.0991431	0.0764919	0.0590439	0.0460495	0.0361052
	0.55	0.6722218	0.4770612	0.3583213	0.2771985	0.2184850	0.1744714	0.1406848	0.1142986	0.0934247	0.0767408
	0.60	0.8999995	0.6749996	0.5321165	0.4305652	0.3542270	0.2948487	0.2475801	0.2093126	0.1779353	0.1519485
	0.65	1.2071413	0.9510816	0.7823020	0.6582095	0.5618827	0.4845898	0.4211627	0.3682574	0.3235758	0.2854705
	0.70	1.6333327	1.3450978	1.1488033	1.0001937	0.8816218	0.7839477	0.7017226	0.6314069	0.5705473	0.5173713
	0.75	2.2499988	1.9285705	1.7037845	1.5283735	1.3853669	1.2649558	1.1613845	1.0709428	0.9910498	0.9198325
	0.80	3.1999995	2.8444402	2.5887643	2.3857301	2.2164484	2.0710884	1.9437498	1.8305795	1.7288867	1.6367206
	0.05	0.0526316	0.1002507	0.1500268	0.2000031	0.2500004	0.3000000	0.3499999	0.4000000	0.4500000	0.5000000
	0.10	0.1111111	0.2020202	0.3004114	0.4000883	0.5000196	0.6000044	0.7000008	0.8000003	0.8999995	0.9999995
	0.15	0.1764705	0.3069055	0.4520096	0.6006152	0.7501939	0.9000621	1.0500203	1.2000067	1.3500023	1.5000007
	0.20	0.2500000	0.4166667	0.6061643	0.8023951	1.0009579	1.2003904	1.4001611	1.6000670	1.8000282	2.0000118
	0.25	0.3333333	0.5333333	0.7647058	1.0068026	1.2532363	1.5015684	1.7507703	2.0003818	2.2501909	2.5000955
	0.30	0.4285713	0.6593406	0.9300124	1.2158783	1.5086309	1.8047769	2.1026784	2.4015159	2.7008647	3.0004960
	0.35	0.5384614	0.7977209	1.1051501	1.4324715	1.7696176	2.1120599	2.4575069	2.8047171	3.1529855	3.5019010
L	0.40	0.6666668	0.9523808	1.2941177	1.6604664	2.0398013	2.4266348	2.8180395	3.2123295	3.6084877	4.0058766
	0.45	0.8181817	1.1285267	1.5022433	1.9051635	2.3242992	2.7533338	3.1886931	3.6283270	4.0708813	4.5154782
	0.50	0.9999999	1.3363332	1.7368420	2.1739129	2.6303711	3.0991431	3.5766387	4.0590438	4.5460493	5.0361051
	0.55	1.2222217	1.5770612	2.0083213	2.4771984	2.9684850	3.4744713	3.9906848	4.5142983	5.0434248	5.5767410
	0.60	1.4999995	1.8749996	2.3321165	2.8305653	3.3542269	3.8948486	4.4475803	5.0093124	5.5779350	6.1519484
	0.65	1.8571413	2.2510815	2.7323020	3.2582094	3.8118828	4.3845898	4.9711626	5.5682573	6.1735756	6.7854707
	0.70	2.3333326	2.7450977	3.2488032	3.8001938	4.3816218	4.9839476	5.6017222	6.2314070	6.8705473	7.5173735
	0.75	2.9999987	3.4285704	3.9538230	4.5283796	5.1353669	5.7649557	6.4113845	7.0709427	7.7410497	8.4198324
	0.80	3.9999995	4.4444400	4.9887644	5.5857302	6.2164484	6.8710886	7.5437498	8.2305795	8.9288863	9.6367209

Note: ① On the above-table, the parameters represent the following factors

S : Number of Berths

ρ : Utilization Factor

Lq: Average Queue Length

L : Average Vessel Number in the System

$L = Lq + a, \quad a = \frac{1}{\mu}$

(2) Alternative 2

From the above analysis, Mina Qaboos can handle up to a volume of 302,400 tons which is the capacity of the existing silos. So the cargo volume and the required silo capacity in the New Port are as follows:

a. Required Silo Capacity : 60,000 tons
b. Cargo Volume : 153,600 tons

The maximum vessel size is assumed to be between 50,000 DWT and 60,000 DWT, whose dimensions are as follows:

c. Bulk Carrier Dimensions

	L	B	D	Dr
50,000 DWT	208.0m	33.0m	22.2m	11.2m
60,000 DWT	218.5m	35.4m	23.7m	11.6m

So the berth dimension is as follows:

50,000 DWT	L = 241 ~ 265m	D = -13.0m
60,000 DWT	L = 254 ~ 280m	D = -13.0m

If this berth is constructed as a single berth, the required berth length for 50,000 DWT carriers is as follows:

50,000 DWT , L = 250m , D = -13.0m

If the berth is constructed as a continuous berth, the length would be reduced to 220m.

The capacity of unloaders is assumed to be 400 tons / hr., and an efficiency rates is 0.8, so the required time for unloading 50,000 tons is as follows:

$$\frac{1}{\mu} = \frac{50,000}{400 \times 24 \times 0.8} = 6.51 \text{ days}$$

The number of calling vessels is as follows:

$$N = 153,600 / 50,000 = 3.072$$

The average arriving rate will be as follows:

$$\lambda = 3.072 / 365 = 0.00842 \text{ vessels / day}$$

The berth occupancy rate can be calculated as follows:

$$\rho = \frac{\lambda}{\mu} = 0.055$$

Appendix 5-1-4 Vessel Size and Berth Dimensions of Ro-Ro Vessels

The number of Ro-Ro vessels that called at Mina Qaboos in 1988 was 154. The proportion to the total calling vessels was 14.6%. The average vessel size was 16,790GRT, and the maximum vessel size was 53,578GRT. The maximum length overall was 200.0m and the maximum entering draft was 10.0m.

The existing maximum Ro-Ro vessels which carry vehicles around the world is about 30,000 GRT, so the above vessels do not seem to carry vehicles. The length of Ro-Ro vessels is almost constant, at around 200m for 20,000 to 30,000 GRT. The breadth of Ro-Ro vessels is also constant at 32.2m. The full-load draft does not exceed 10.0m. Accordingly, the maximum vessel size and the required berth dimensions are as follows;

a. Maximum Vessel Size : 30,000 GRT
   (L, B, Dr) = (200m, 32.2m, 10.0m)
b. Single Berth Dimension :
   Length = 240m, Depth = -11.0m
c. Dimension of Continuous Berths :
   Length = 220m, Depth = -11.0m

Appendix 5-1-5 Vessel Size and Berth Dimensions of Livestock Carriers

The number of livestock carriers that called at Mina Qaboos in 1988 was 23, or 2.2 percent of the total calling vessels. The average size was 18,915 GRT, and the maximum size was 34,082 GRT. The average vessel length was 178.2m and the maximum length was 195.0m. The average entering draft was 8.4m and the maximum draft was 10.7m.

Livestock carriers are very special vessels and demand for livestock carriers is thus limited. So we assumed the vessel size in the future would be as same as that at present, as follows:

Maximum-size Livestock Carriers		: 34,000 GRT
	Length	: 195.0m
	Full-load Draft	: 10.7m
Berth Dimensions :	Length	: 220m
	Depth	:12.0m

Appendix 5-1-6 Vessel Size and Berth Dimensions of Petrochemical Products

The petrochemical products are as follows:

(1) Ammonia 57,000 tons
(2) Urea 174,000 tons
(3) Methanol 500,000 tons
(4) MTBE 10,000 tons
(5) SMDS 500,000 tons

Ammonia and methanol are transported by chemical tankers. The maximum size of chemical tankers in Japan is around 22,000 DWT for domestic transportation. In the USA, methanol is transported by chemical tankers of around 50,000 DWT. Methanol can also be transported by clean oil tankers. Petroleum product tankers of between 40,000 DWT and 60,000 DWT are very popular in international fleets. Special vessels carring urea can scarcely be found at present. So we assume urea will be transported by general cargo vessels at around the 10,000 DWT class. We assumed also the following vessel sizes:

(1) Ammonia : Chemical Tankers around 5,000 GRT
(L, B, Dr) = (123m, 8.3m, 7.8m)
(2) Urea : General Cargo Vessels around 25,000 DWT
(L, B, Dr) = (174m, 24.4m, 10.9m)
(3) Methanol, MTBE and SMDS : Product Tanker around 50,000 DWT
(L, B, Dr) = (170.7m, 32.2m, 11.3m)

In order to export the above product volume, the required number of vessels can be calculated as follows:

(1) Ammonia : N = 57,000 / 8,500 = 6.7 ships / year
(2) Urea : N = 174,000 / 25,000 = 6.96 "
(3) Methanol : N = 500,000 / 50,000 = 10 "
(4) MTBE : N = 100,000 / 50,000 = 2 "
(5) SMDS : N = 500,000 / 50,000 =10 "

Chemical tankers for ammonia can be accommodated at the existing jetty. General cargo vessels for urea can be accommodated at the general cargo berths. Special berths for petroleum products must be constructed.

Appendix 5-1-7 Vessel Size and Berth Dimensions of Fishery Boats and Vessels

According to the report of the "Study for development of fishery harbour facilities along the coastline of Oman" by Hochtief, the sizes of modern trawling vessels were as follows:

(L, B, Dr) = (30m, 8m, 4m)

The size of small dhows was not described clearly but their draft was 2.2m. The proposed schedule of the development of a fishery harbour in Sohar was made in 1988. The target year of the development plan was not clear, but two berths for modern trawling vessels and 8 small dhows were planned. From the draft of the small dhows the vessel size seems to be as follows;

Small Dhows : 30 GT
(L, B, Dr) = (20m, 4.2m, 2.3m)

As described in Appendix 4-3-8, the total required volume for fish unloading is as follows:

in 2000	in 2015
300,000 tons	567,300 tons

In Sohar, the share of fish unloading was 2.8 percent of the total required volume in 1985. If the proportion does not change in future, the volume of fish unloading would be as follows;

in 2000	in 2015
8,600 tons	16,000 tons

The volume of fish unloading per trawling vessel was 947.7 tons, that per one small fishing boat was 5.9 tons.

We assume the volume per one 30 GT dhow is 220 tons.

In order to catch 8,600 tons, the number of respective vessels required is as follows:

Trawling Vessels	: 7	(7 x 947.7 = 6,634 tons)
30GT Dhows	: 8	(8 x 220 = 1,760 tons)
1 ~ 2 GT Boats	: 34	($\frac{8,600 - 6,634 - 1,760}{6}$ = 34)

The required manpower will be as follows:

Trawling Vessels	: 30 x 7 =	210 persons
30GT Dhows	: 15 x 8 =	120 "
1 ~ 2 GT Boats	:	34 "
		364 "

In order to catch 16,000 tons, the number of respective vessels required is as follows:

Trawling Vessels	: 14	(14 x 947.7 = 13,268 tons)
30GT Dhows	: 13	($\frac{16,000 - 13,268}{220}$ = 13)

The required manpower will be as follows:

Trawling Vessels	: 30 x 14 =	420 persons
30GT Dhows	: 15 x 13 =	195 "
		615 "

The required width of the entrance is as follows:

5 x B = 5 x 8 = 40m

The required water area for one vessel is as follows:

Berthing along the faceline of quay

	Length (1.15L)	Width (1.5B)
1 ~ 2 GT Boats :	8.05m	3.0m
30GT Dhows :	23.0m	6.3m
Trawling Vessels :	34.5m	12.0m

Berthing perpendicular to the quay faceline:

		Length (1.5B)	Width (2.1L)
1 ~ 2 GT Boats	:	3.0m	14.7m
30GT Dhows	:	6.3m	42.0m
Trawling Vessels	:	12.0m	63.0m

The required time for unloading and the rate of utilization of unloading facilities per day are as follows:

		Time	Rate
1 ~ 2 GT Boats	:	10 minutes	12 times
30GT Dhows	:	40 "	15 times
Trawling Vessels	:	60 "	10 times

The required berth length for unloading is as follows;

In 2000:

1 ~ 2 GT Boats : 8.05 x 34 / 12 = 22.8m → 24.15m
30GT Dhows : 23.0 x 8 / 15 = 12.3m → 23.0m
Trawling Vessels : 34.5 x 7 / 10 = 24.15m → 34.5m
Total 81.65m

In 2015:

30GT Dhows : 23.0 x 13 / 15 = 19.9m → 23.0m
Trawling Vessels : 34.5 x 14 / 10 = 48.3m → 69.0m
Total 92.0m

The effective working day per year will be 300 days. So the volume of unloading per day is as follows:

In 2000:

1 ~ 2 GT Boats : (6 / 300) x 34 = 0.68 ton
30GT Dhows : (220 x 300) x 8 = 5.84 tons
Trawling Vessels : (947.7 / 300) x 7 = 22.12 tons
Total 28.64 tons

In 2015:

30GT Dhows	:	(220 / 300) x 13 = 9.49 tons
Trawling Vessels	:	(947.7 / 300) x 14 = 43.96 tons
		Total 53.45 tons

The required area for fish treatment is calculated as follows:

In 2000 28,640 Kg / (20 ~ 40) = 716 ~ 1,432 m^2, 1500 m^2

In 2015 53,450 Kg / (20 ~ 40) = 1,336 ~ 2,673 m^2, 3000 m^2

The required time for preparation and the rate of utilization are as follows:

		Time	Rate
1 ~ 2 GT Boats	:	20 minutes	24 times
30GT Dhows	:	30 "	16 "
Trawling Vessels	:	40 "	12 "

The required quay length for preparation works is calculated as follows;

In 2000:

1 ~ 2 GT Boats	:	8.05m x 2 = 16.1m
30GT Dhows	:	23.0m x 1 = 23.0m
Trawling Vessels	:	34.5m x 1 = 34.5m
		Total 73.6m

In 2015:

30GT Dhows	:	23.0m x 1 = 23.0m
Trawling Vessels	:	34.5m x 2 = 69.0m
		Total 92.0m

The required quay length for laying is calculated as follows:

In 2000:

1 ~ 2 GT Boats	:	3.0m x 34 = 102.0m
30GT Dhows	:	6.3m x 8 = 50.4m
Trawling Vessels	:	12.0m x 7 = 84.0m
		Total 236.4m

In 2015:

30GT Dhows : 6.3m x 13 = 81.9m

Trawling Vessels : 12.0m x 14 = 168.0m

Total 249.9m

The required length is summarized as follows:

In 2000	Depth	Unloading	Preparation	Sub-total	Laying	Total
1 ~ 2 GT Boats	-1.5m	24.5m	16.5m	41.0m	102m	143.0m
30GT Dhows	-3.0m	23.0m	23.0m	46.0m	50.4m	96.4m
Trawling Vessels	-5.5m	34.5m	34.5m	69.0m	84.0m	153.0m
Total		82.0m	74.0m	156.0m	236.4m	392.4m

In 2015	Depth	Unloading	Preparation	Sub-total	Laying	Total
30GT Dhows	-3.0m	23.0m	23.0m	46.0m	82.0m	128.0m
Trawling Vessels	-5.5m	92.0m	92.0m	184.0m	168.0m	352.0m
Total		115.0m	115.0m	230.0m	250.0m	480.0m

The required area for maintenance and repairing is calculated as follows:

In 2000:	Painting	Repairing	Total
1 ~ 2 GT Boats	$20m^2 \times \frac{34 \times 2 \times 2}{288}$ $= 9.4m^2 \rightarrow 20m^2$	$20m^2 \times \frac{34 \times 3 \times 2}{288}$ $= 14.2m^2 \rightarrow 20m^2$	$40m^2$
30GT Dhows	$110m^2 \times \frac{8 \times 2 \times 7}{288}$ $= 42.8m^2 \rightarrow 110m^2$	$110m^2 \times \frac{8 \times 3 \times 4}{288}$ $= 36.7m^2 \rightarrow 110m^2$	$110m^2$
Trawling Vessels	$250m^2 \times \frac{7 \times 2 \times 7}{288}$ $= 85.1m^2 \rightarrow 250m^2$	$250m^2 \times \frac{7 \times 3 \times 4}{288}$ $= 72.9m^2 \rightarrow 250m^2$	$250m^2$
		Total	$400m^2$

Considering the effective rate of area, the requiring area is $800m^2$, so the slip way dimensions are 30m x 30m.

In 2015:	Painting	Repairing	Total
30GT Dhows	$110m^2 \times \frac{13 \times 2 \times 7}{288}$	, $110m^2 \times \frac{13 \times 3 \times 4}{288}$	$220m^2$
	$= 69.5m^2 \rightarrow 110m^2$	$= 59.6m^2 \rightarrow 110m^2$	
Trawling Vessels	$250m^2 \times \frac{14 \times 2 \times 7}{288}$	, $250m^2 \times \frac{14 \times 3 \times 4}{288}$	$500m^2$
	$= 170.1m^2 \rightarrow 250m^2$	$= 145.8m^2 \rightarrow 250m^2$	
		Total	$720m^2$

Considering the effective rate of area, the requiring area is $1,440m^2$, so the slip way dimensions are 50m x 30m.

The plans of fishery ports are illustrated in the following figures:

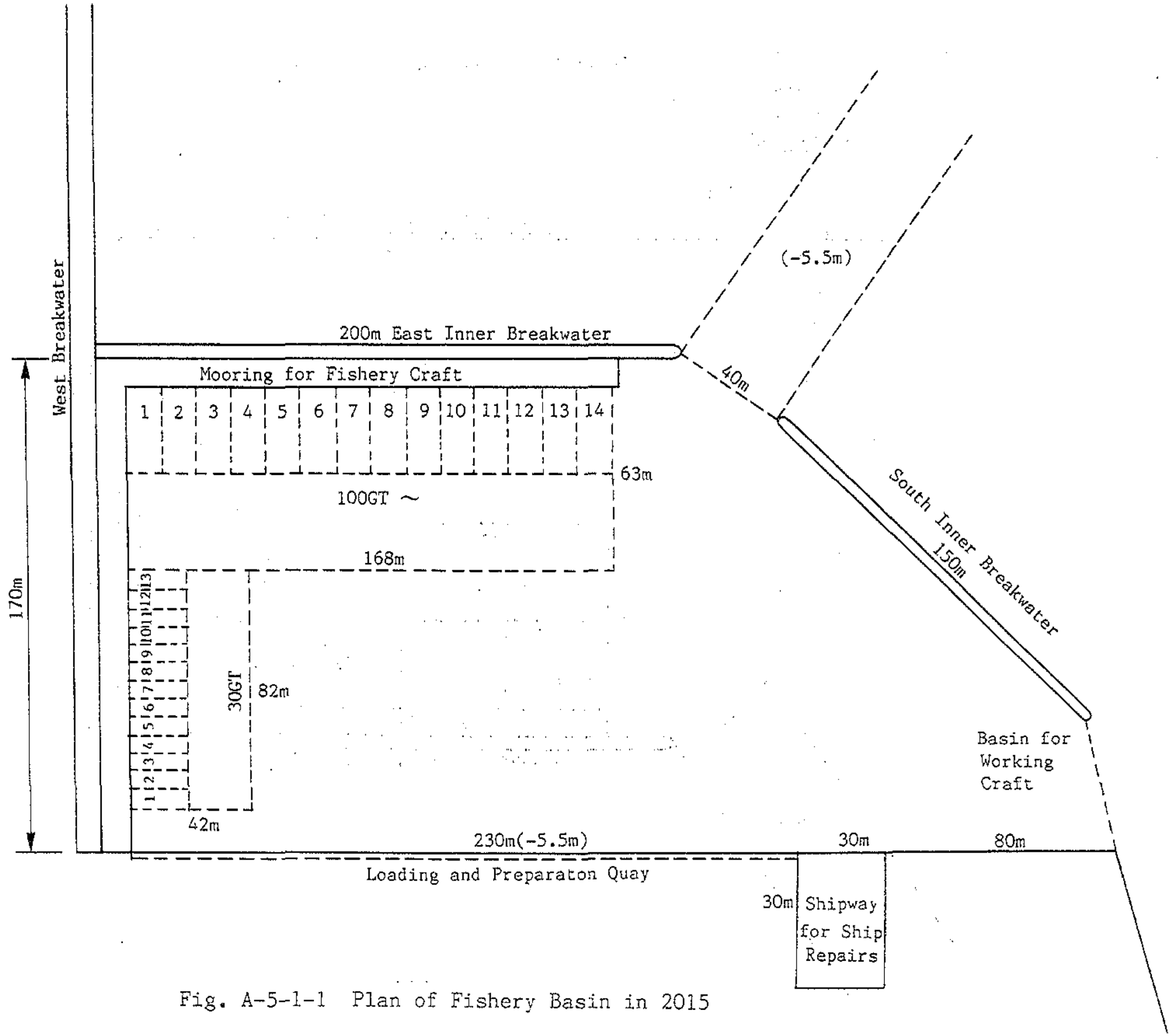


Fig. A-5-1-1 Plan of Fishery Basin in 2015

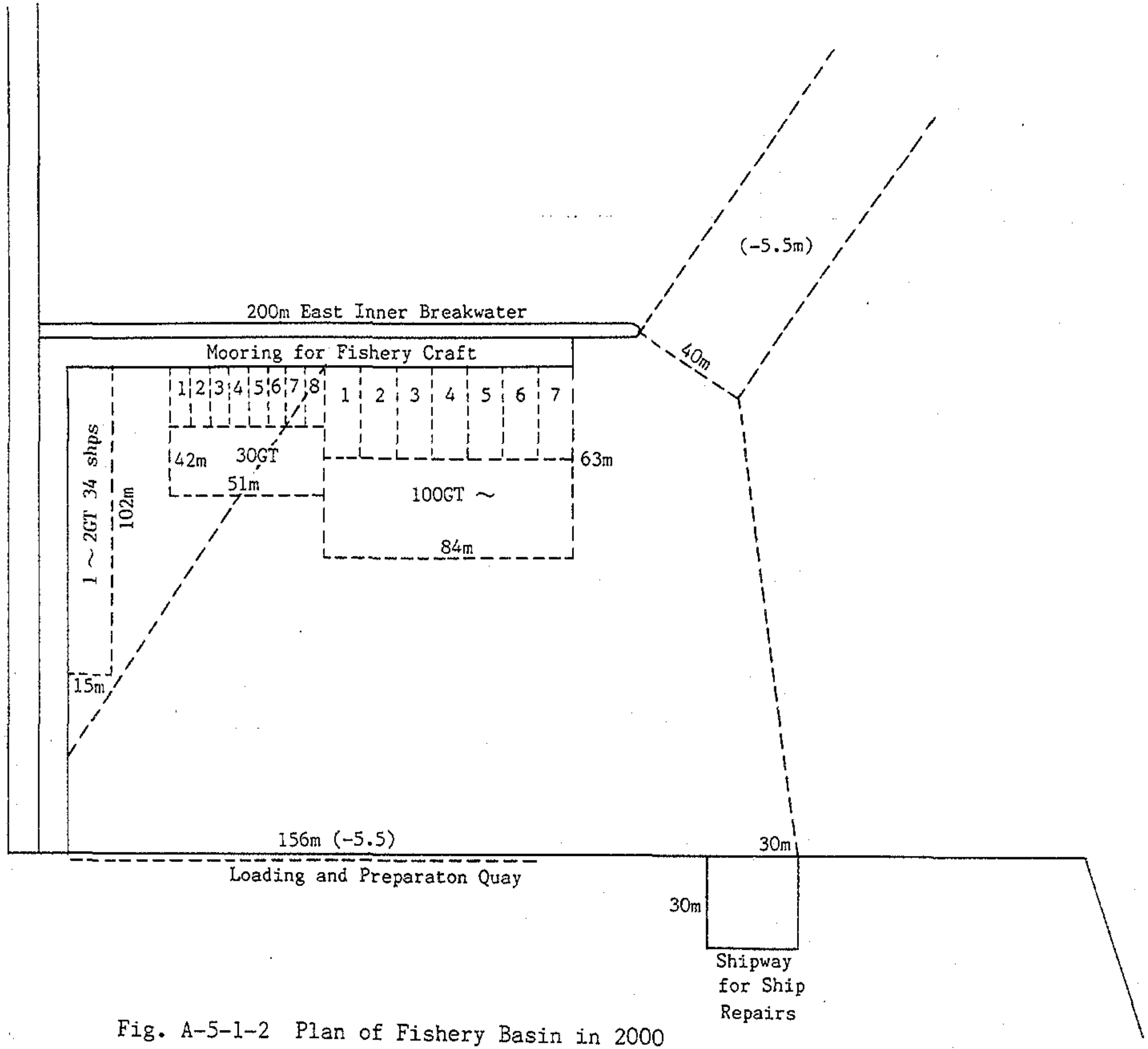


Fig. A-5-1-2 Plan of Fishery Basin in 2000

V Appendices to Chatper 5-2

Appendix 5-2-1 Balance of the Volume of the Dredged Material with the Reclamation Volume

The sea-bottom gradient is 1/180 from the coastline up to the contour line of -10m. The gradient is 1/200 between -10m and -15m contour lines. The length from the coastal line to -10m contour line is 1,800m and that from -10m contour line to -14.5m contour line is 900m. The depth of the entrance channel should be -14.5m considering the maximum draft. The breakwater should be extended up to the -7.5m contour line. The depth of the in-port basin will be -14.0m.

(1) For the 250m channel: 4,612.5m^3/m x 250m = 1,153,000m^3
(2) For the 290m channel: 4,612.5m^3/m x 290m = 1,338,000m^3

The volume of the dredged material in the inner basin can be calculated as follows:

(3) For the inner basin: 13,837.8m^3/m x580m = 8,026,000m^3

Accordingly the total volume of the dredged material is 9,179,000m^3 tentatively and 9,364,000m^3 in the long term.

The crown height of the reclamation land is assumed to be + 4.5m. In order to reclaim the sea from the coast line to the offshore area up to the following distances, the required volumes of dredged material are as follows:

(1) Up to 1,000m : 7,280m^3/m
(2) Up to 800m : 5.376m^3/m
(3) Up to 500m : 2,945m^3/m

Therefore, the following reclaimed land can be obtained by using the dredged materials:

(1) Case 1 : up to 1 km offshore and 1.3 km along the shoreline or

(2) Case 2 : up to 1 km offshore and 1 km along the shoreline, and up to 500m offshore and 500m along the shore line, or

(3) Case 2 : up to 1 km offshore and 1 km along the shoreline, and up to 800m offshore and 400m along the shore line.

On the other hand, the volume of the excavated land area up to -14.0m for the 450m channel is as follows:

$$450m \times (14.0m + 2.5m) = 7.425m^3/m$$

This volume is almost the same volume of the reclamation up to 1,000m to the offshore area. Accordingly, one meter excavation of the land area will create the materials for one meter along the shore lime and 1km for offshore side reclamation.

Appendix 5-2-2 Cost Comparison of Alternative 3 and 4

The rough cost estimates are implemented for the alternative reclamation plans shown in Fig A-5-2-1 and the excavation alternative. The results are listed in Table A-5-2-1.

Table A-5-2-1 Rough Cost Estimates

Item	Alternative 3			Alternative 4		
	Quantity	Unit Cost R.O/m	Total Million R.O.	Quantity	Unit Cost R.O/m	Total Million R.O.
Breakwater (A)	600m	6,552	3.920	600m	6,552	3.920
(A')	-	-	-	1,060	2,916	3.091
(B)	250	6,522	1.638	1,035	2,896	2.997
Resentment (A)	1,500	3,270	4.905	-	-	-
(A')	1,000	2,180	2.180	-	-	-
(B)	2,500	3,270	8.175	-	-	-
(B')	800	2,180	1.744	-	-	-
Quaywall (-14m)	1,330	8,483	11.282	1,380	8,483	11.706
(-13m)	1,620	8,148	13.200	1,520	8,148	12.385
Sub-total			47.044			34.099
Dredging						
	x1,000m^3	R.O/m^3		x1,000m^3	R.O/m^3	
Offshore	14,990	2.0	16.938	13,682	1.13	15.460
Onshore(up to + 1)	3,496	3.0	3.950	9,276	1.13	10.481
(up to present level)	1,165	1.4	1.165	2.903	1.00	2.903
			22.053			28.844
Total of Direct Cost			69.097			62.943

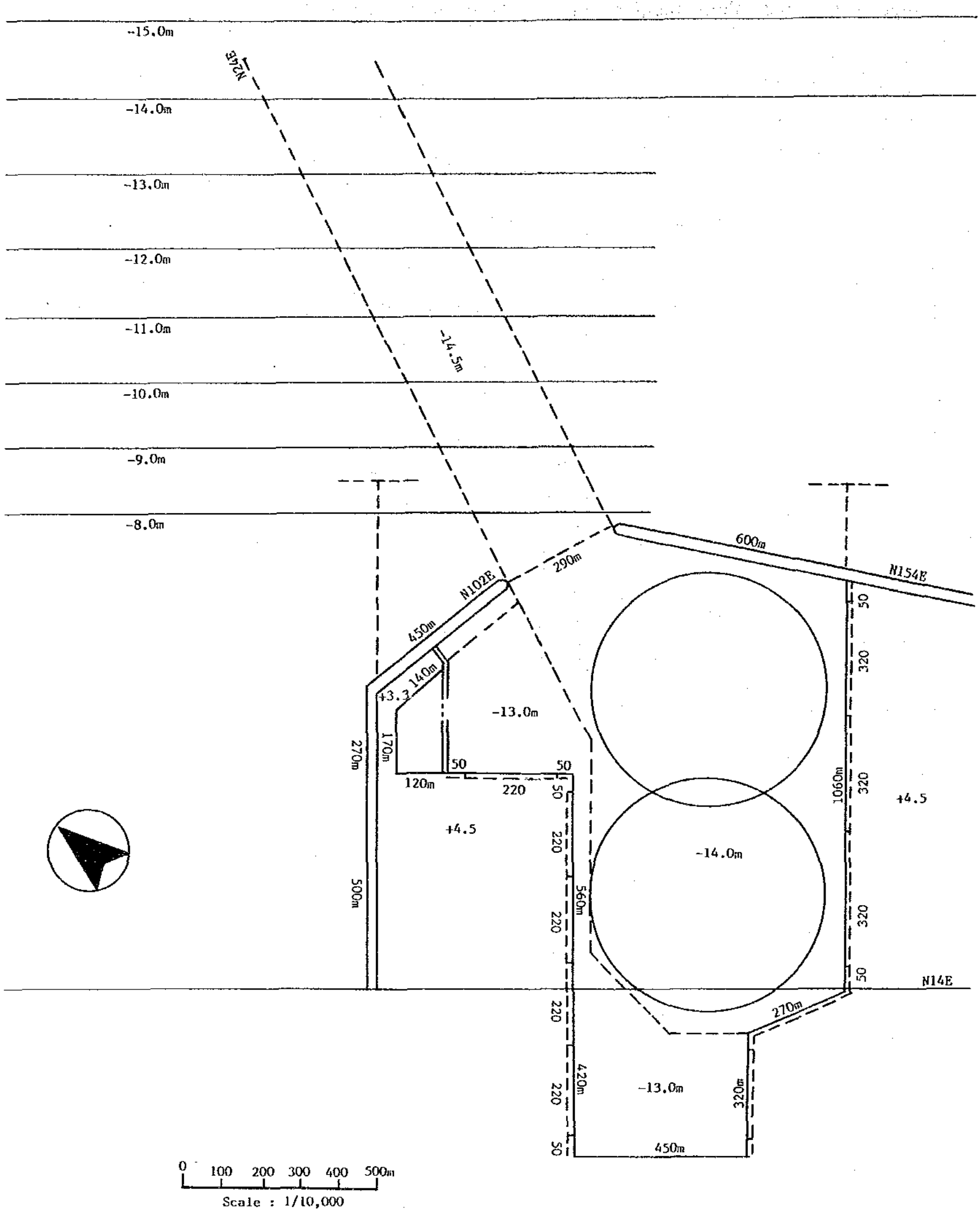


Fig.A-5-2-1 Alternative of Reclamation Plans

VI Appendix to Chapter 5-3

Appendix 5-3-1 Results of Wave Diffraction Calculation

The wave directions affecting the new port are NNW, N, NNE, NE, ENE, E, ESE and SE. Fig A-5-3-1 shows the ratios of wave height within the port area to the wave height at port entrance. Based on this analyses, the degrees of calmness in the port area are summarized as shown in Fig. 5-3-3. These figures show the excellent availability of port facilities at the new port.

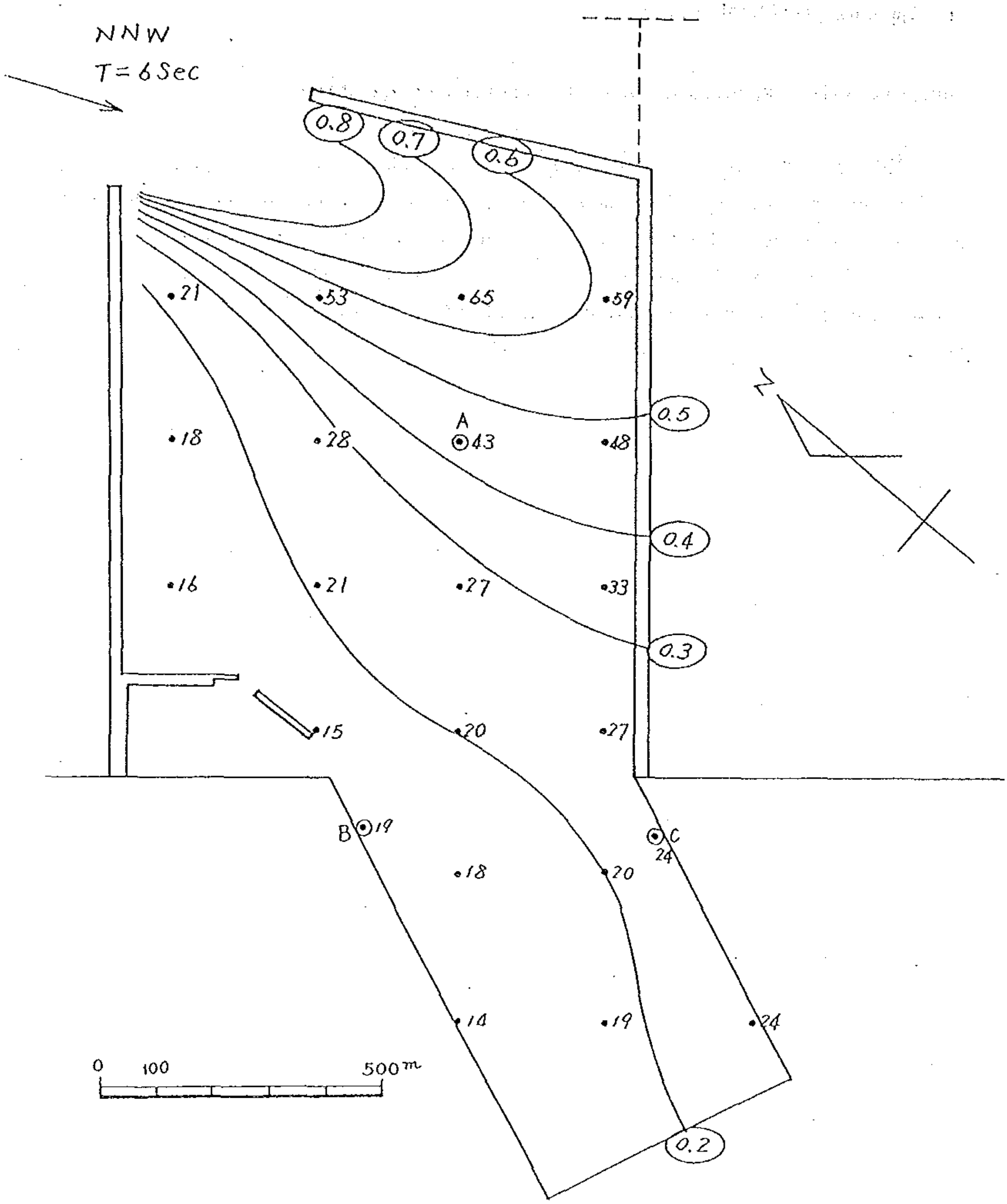


Fig. A-5-3-1(1) Diagram of Wave Diffraction

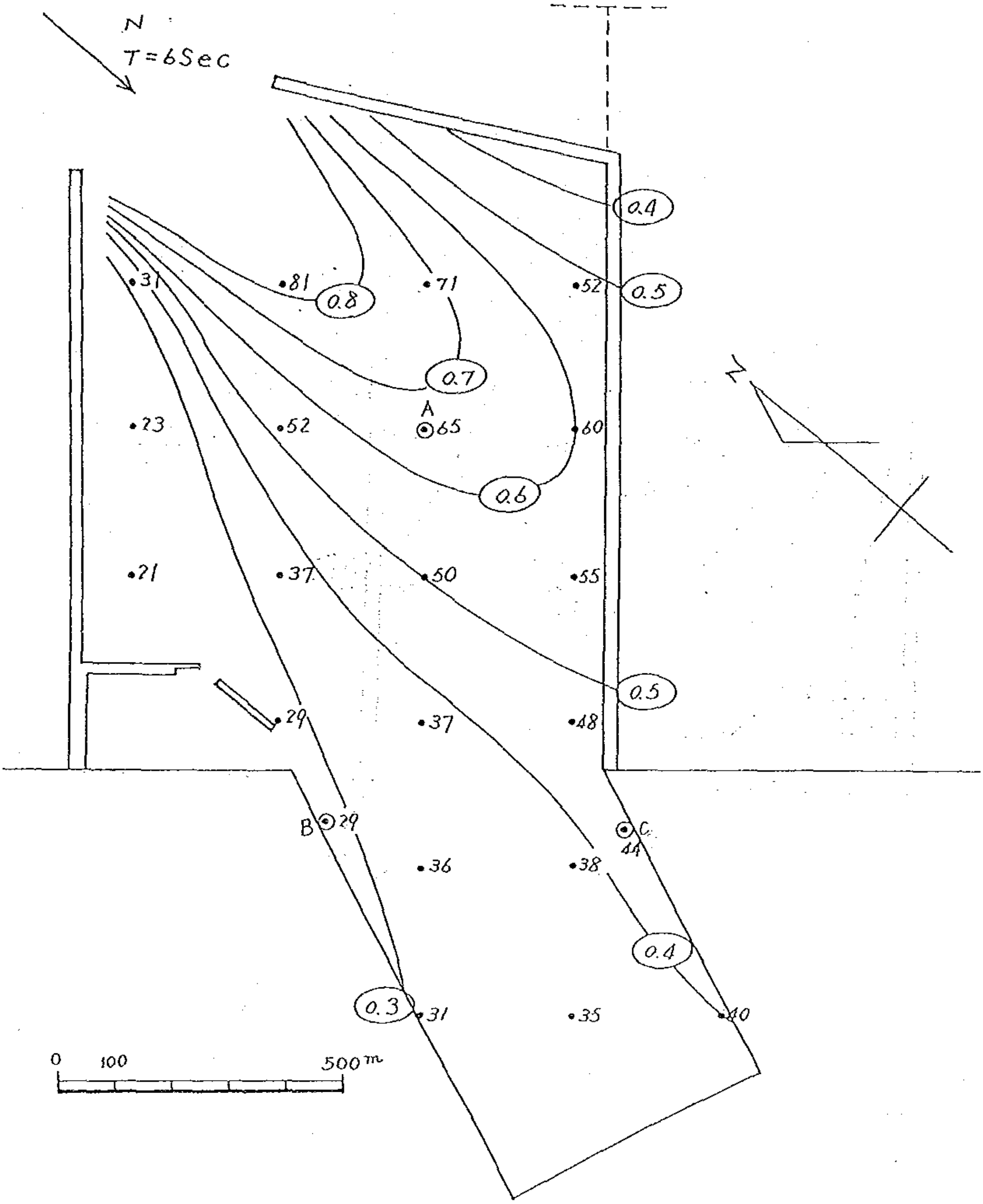


Fig. A-5-3-1(2) Diagram of Wave Diffraction

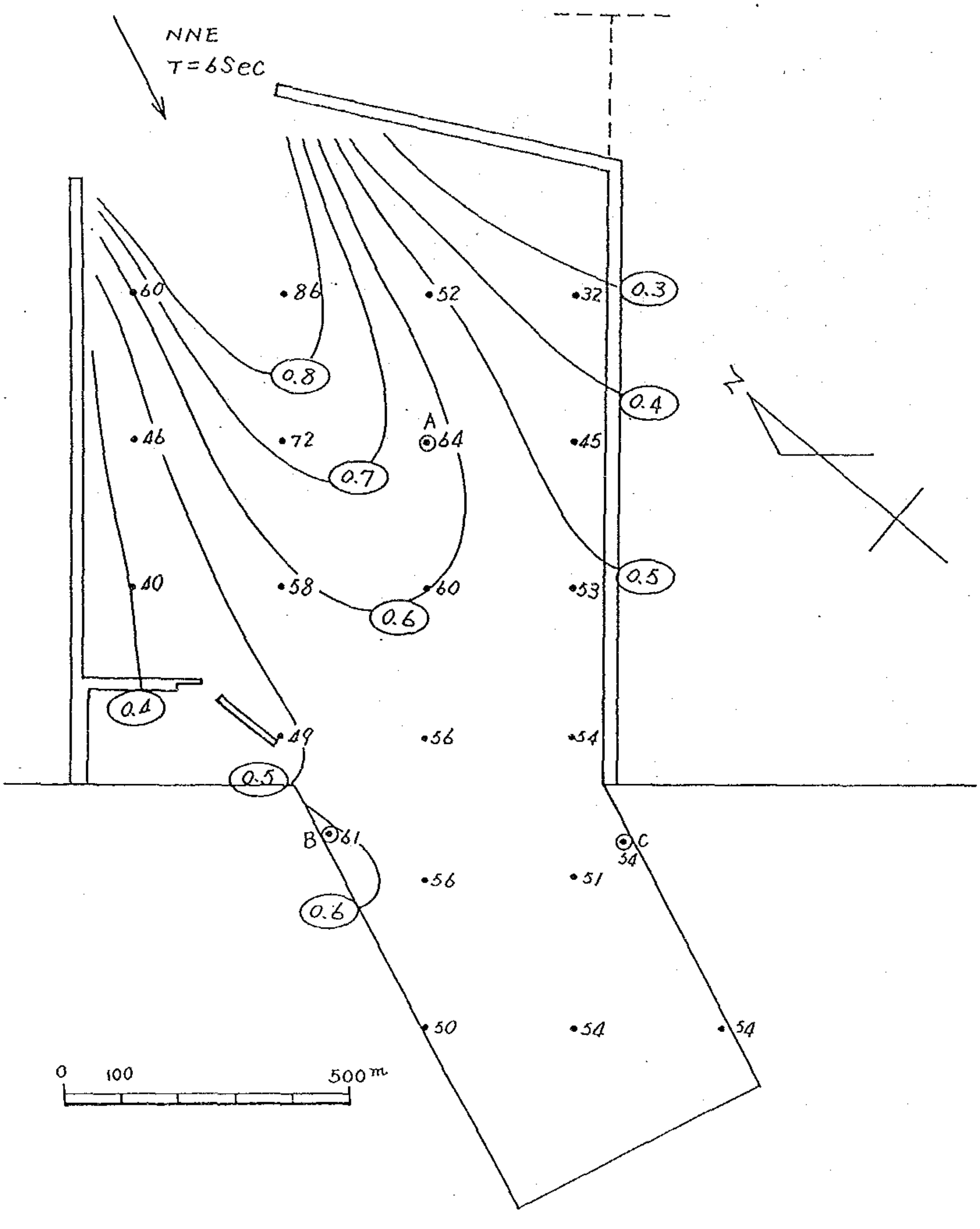


Fig. A-5-3-1(3) Diagram of Wave Diffraction

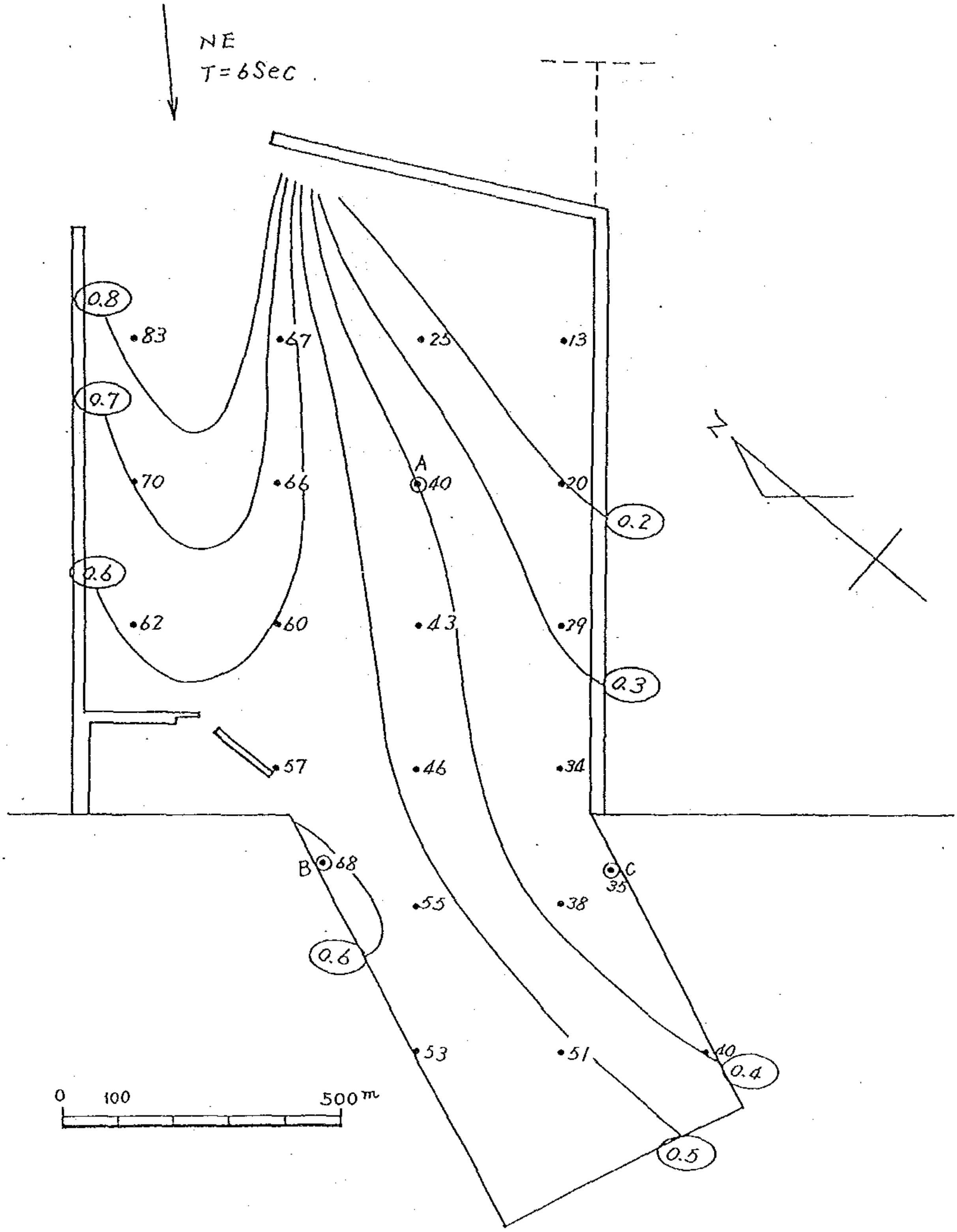


Fig. A-5-3-1(4) Diagram of Wave Diffraction

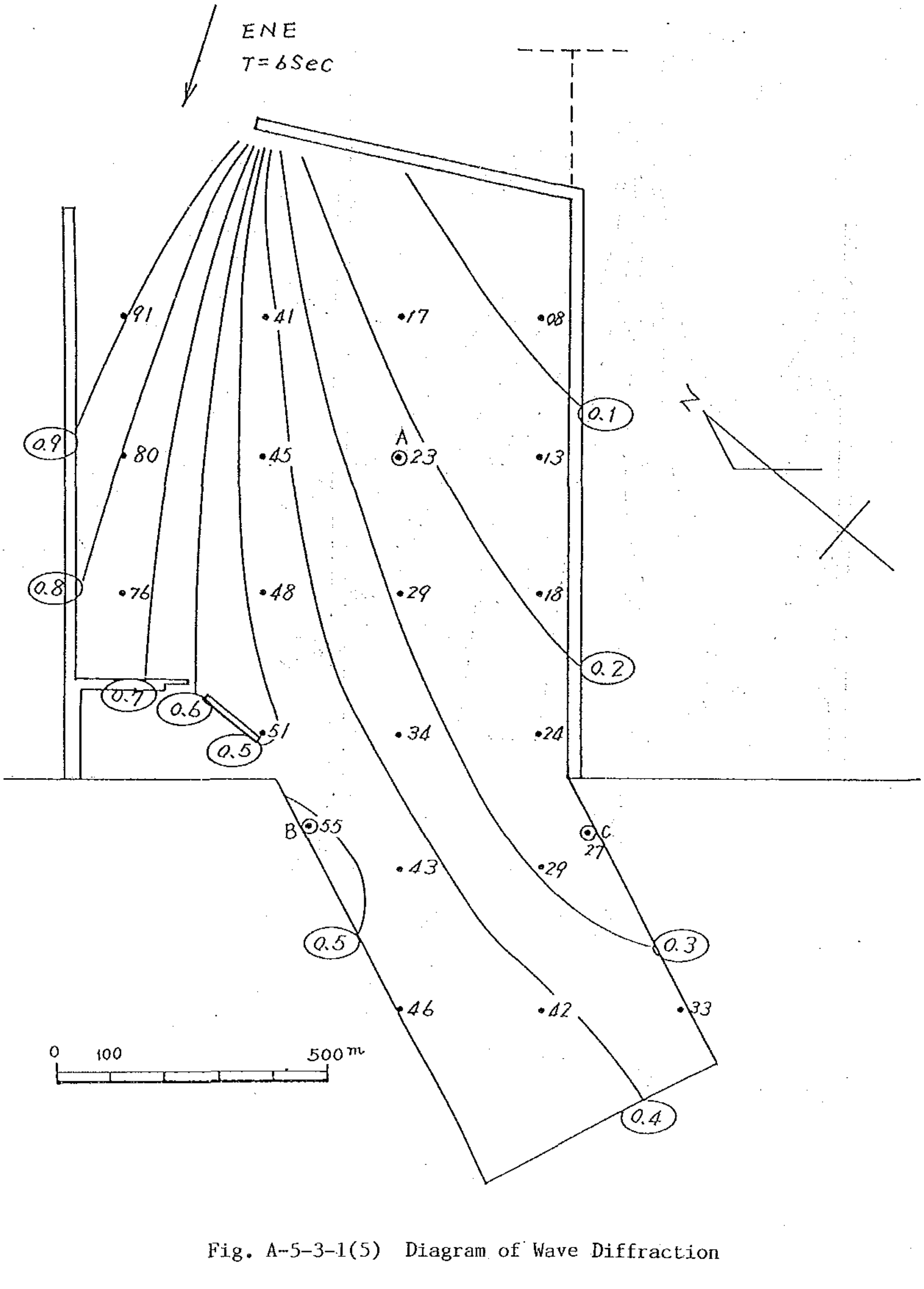


Fig. A-5-3-1(5) Diagram of Wave Diffraction

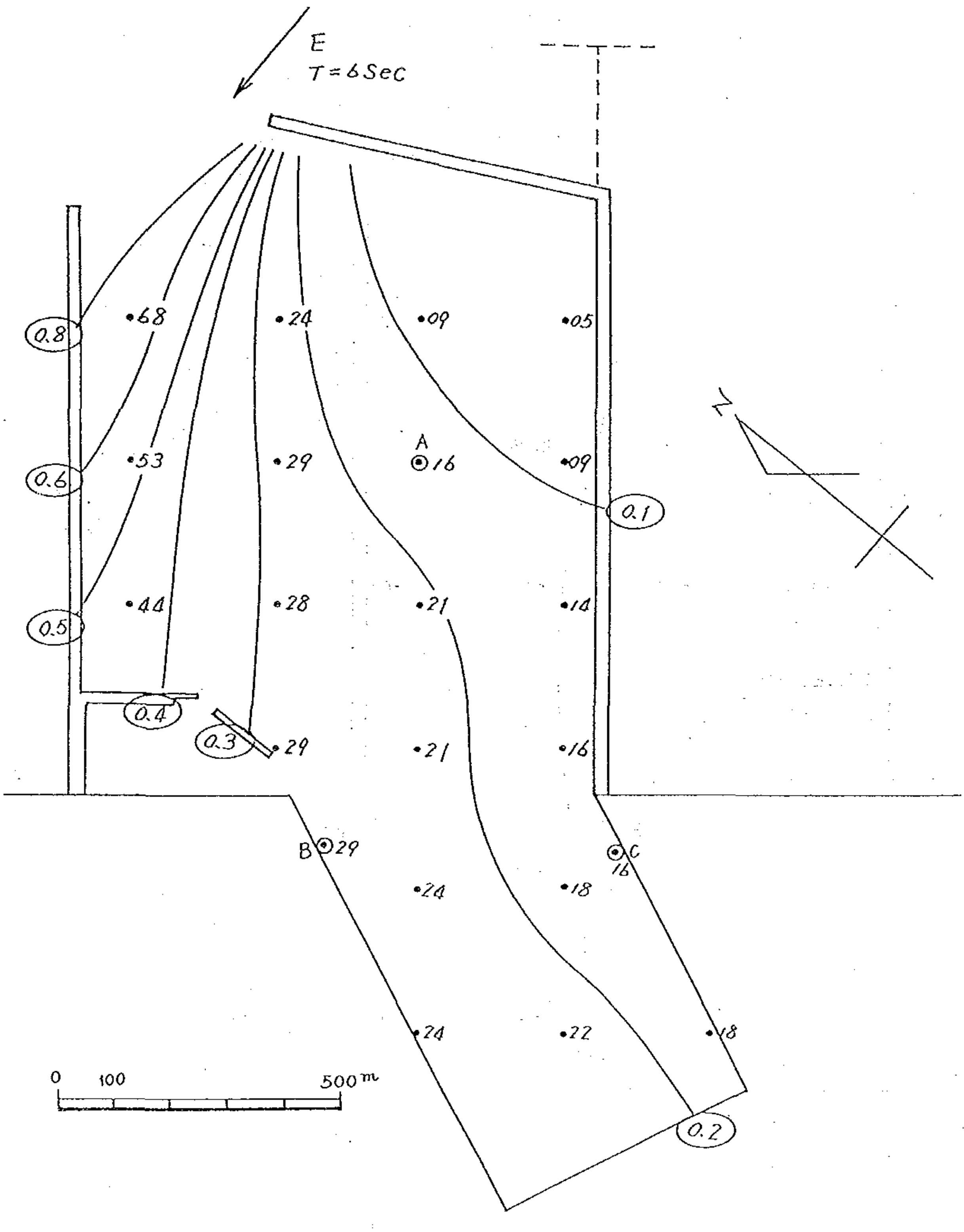


Fig. A-5-3-1(6) Diagram of Wave Diffraction

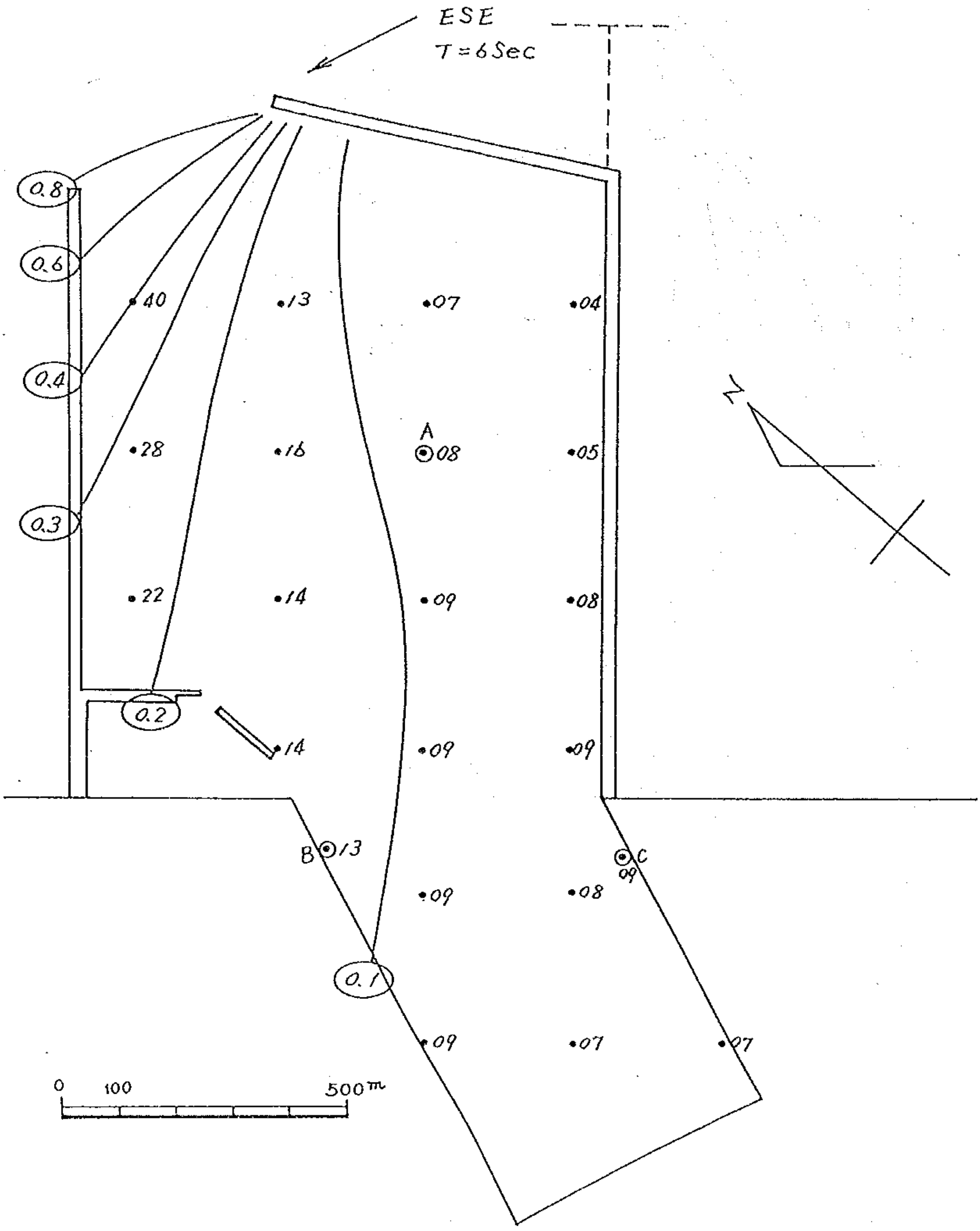


Fig. A-5-3-1(7) Diagram of Wave Diffraction

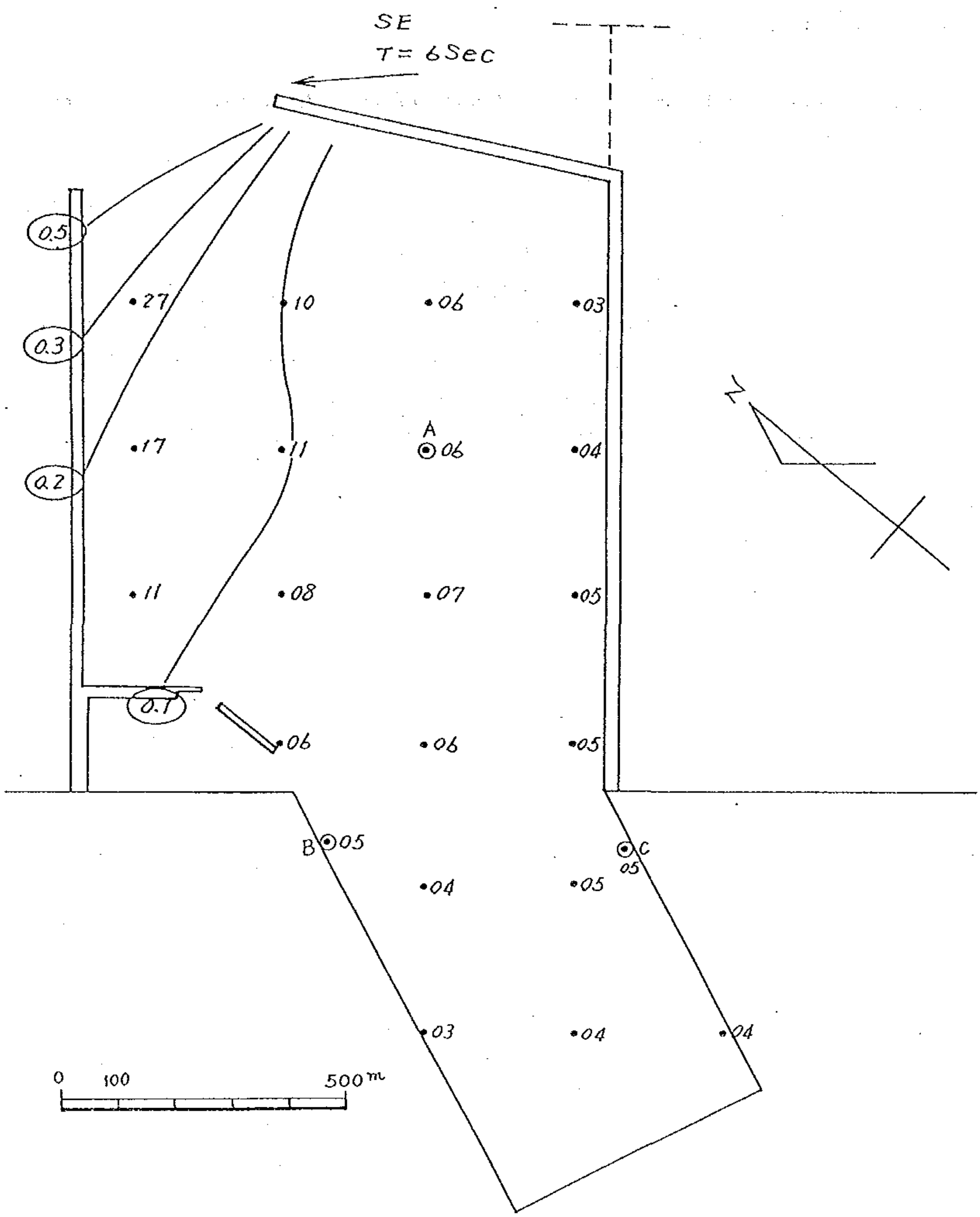


Fig. A-5-3-1(8) Diagram of Wave Diffraction

VII Appendix to Chapter 5-7

Appendix 5-7-1 Revision of the Desalination/Power Plant Site in the Sohar Structure Plan

In the Sohar Structure Plan, the desalination/power plant wa planned at the east side of the existing jetty as shown in the following figure.

The proposed site of the desalination/power plant is located at the commercial terminal and the FTZ of our plan. We would like to recommend to revise the plant site to shift to the heavy industrial area as shown in Fig.A-5-7-2 because the desalination/power plant consumes much oil/natural gas and should be located remote from the habitant area of Majis from the enbironmental aspect.

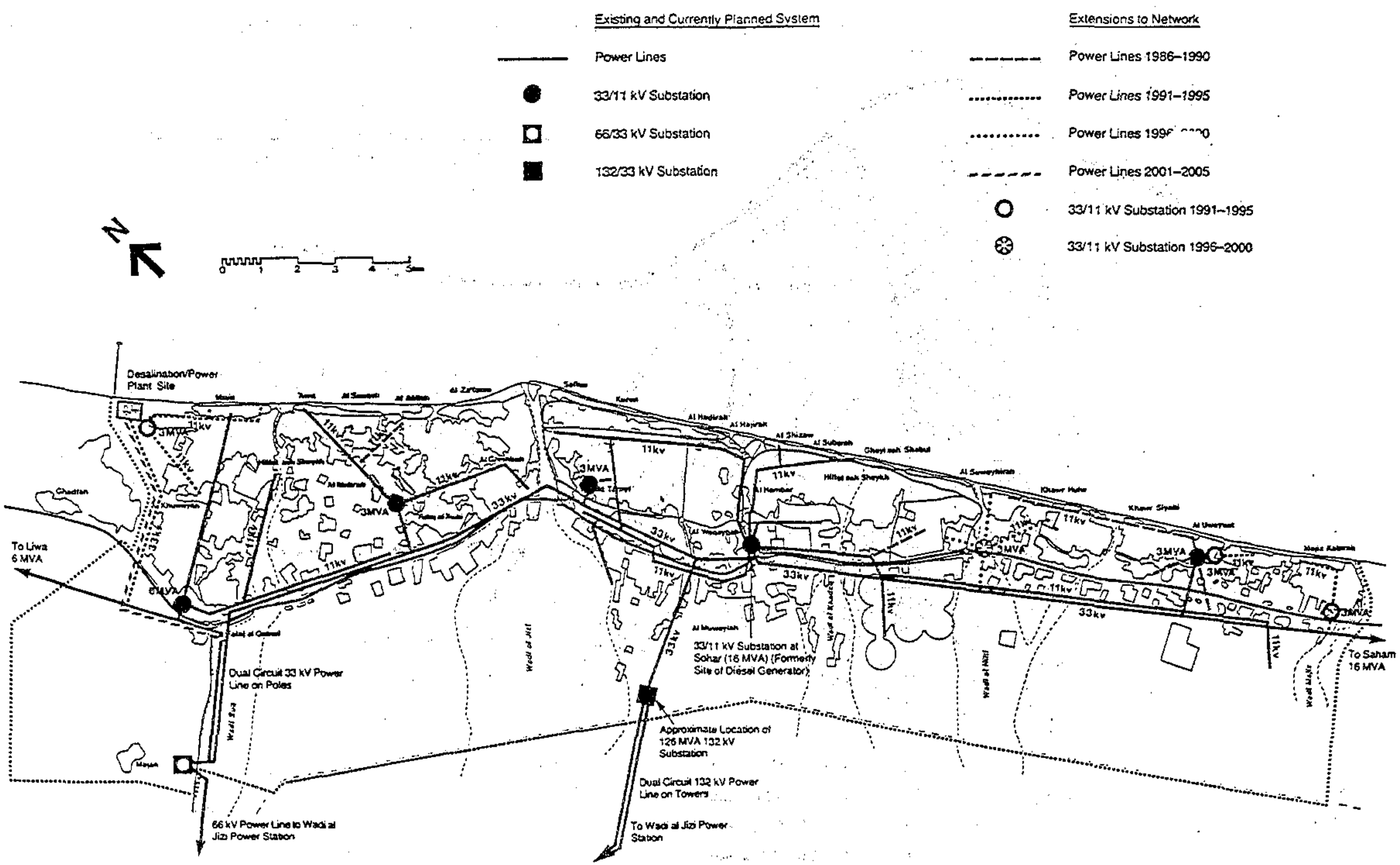


Fig. A-5-7-1 Proposed Desalination/Power Plant Site in the Sohar Structure Plan

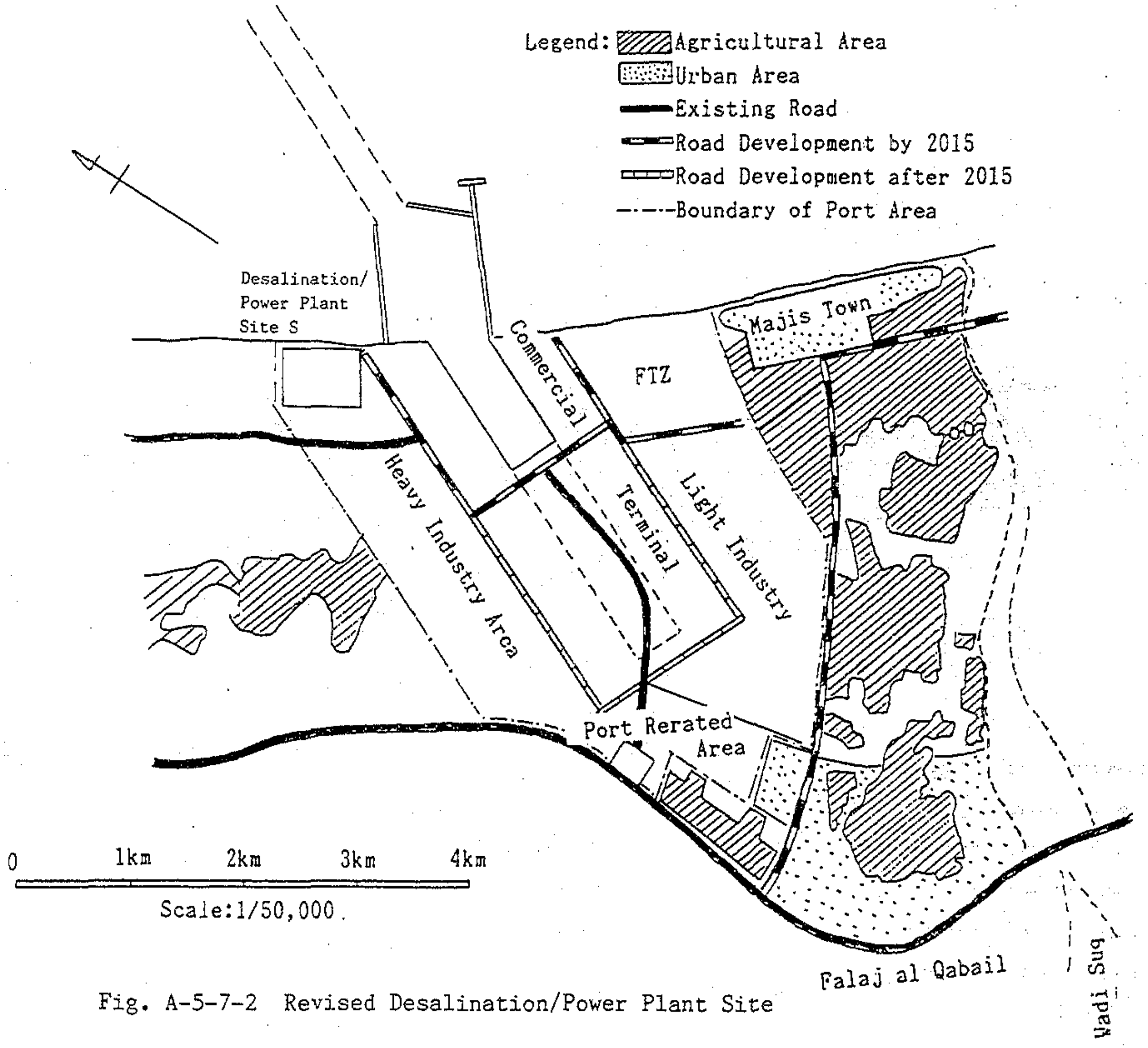


Fig. A-5-7-2 Revised Desalination/Power Plant Site

VIII. Appendices to Chapter 6-3

Appendix 6-3-1 Indirect Cost

In general, the ratio of indirect cost/administration cost against direct cost is as follows:

Indirect Cost (in site)	
Delivery	0.2 - 1.0%
Preliminaries	0.3 - 0.5%
Security	0.1%
Technical control	0.3 - 0.4%
Temporary facilities	0.7 - 1.1%
Management of construction	10.7 - 11.7%
Administration (including profit)	9.4%
Total:	21.7 - 24.2%

In this project, the total ratio is fixed at 20% of the direct cost, taking into consideration the amount of the direct cost.

Appendix 6-3-2 The Timing and the Items of Detailed Design for the New Port

The construction schedule by year for the new port is shown in table of this report. According to this schedule, the construction of the project is to start in 1996 and be completed by 1999. Therefore the detailed design shall be prepared in 1994/1995.

The costs of the detailed design, which are shown in Table 6-3-2 under the title of 11 (2) Consultation/Technical Cooperation are estimated one million R.O., and include following items:

(1) Field Survey	
I) Sub-soil Survey	
(a) Off-shore boreholes	22 Nos
(b) On-Land boreholes	22 Nos
II) Topographic Survey	4Km * 4Km
III) Hydrographic Survey	1.5Km * 1.5Km
IV) hydraulic Survey	
(a) Wave Observation	1 set
(b) Tide Observation	1 set
V) Meteorological Survey	1 set
(2) Detailed Design	
Facility design	1 set
(3) Preparation for Tendering	
Tender Documents	1 set

Among these items, the cost for (1) Field Survey is estimated approximately 300,000 R.O.

IX. Appendix to Chapter 7-4

Appendix 7-4-1 The Effect from the New Port Development on GDP of Oman

There are many studies associated with economic benefits derived from the development of transportation facilities. Some of them evaluate the economic effects by the amount of added value that can be imputed to the project. (Another way is shown in the cost-benefit analysis in Chapter 7 of this volume.) The effect on GDP can be measured based upon this added value.

However, such methods have not yet become established or common, and besides, they require such a large amount of statistical figures, which are not always available.

Therefore, in this Study, very simplified models based upon some studies and models carried out and developed by the Port and Harbour Research Institute of Japan are introduced and rough estimation of the effect on the GDP of Oman is attempted.

Added value created by ports can be classified into three categories: The first one is created by port investment, that is, construction of a port itself. The second one is produced by the port service industries located in or near the port. The third one is caused by the industries that depend upon seaborne cargoes.

1. Investment Effect

The process of the analysis is shown in Fig. A-7-4-1.

Although some information is provided in the "Statistical Year Book", in the absence of an input/output table and the other necessary data, some figures are impossible for us to calculate and some analyses should be made partly upon assumption.

1) The cost estimation is presented in Chapter 6 in this report, but breakdown into intermediate input and added value is not shown. On the other hand, the "Statistical Year Book" presents GDP (i.e. added value) and compensation in the employees of construction sector. According to these statistics, the ratio of compensation of employees to GDP has been 50% for the last four years. From this ratio, added

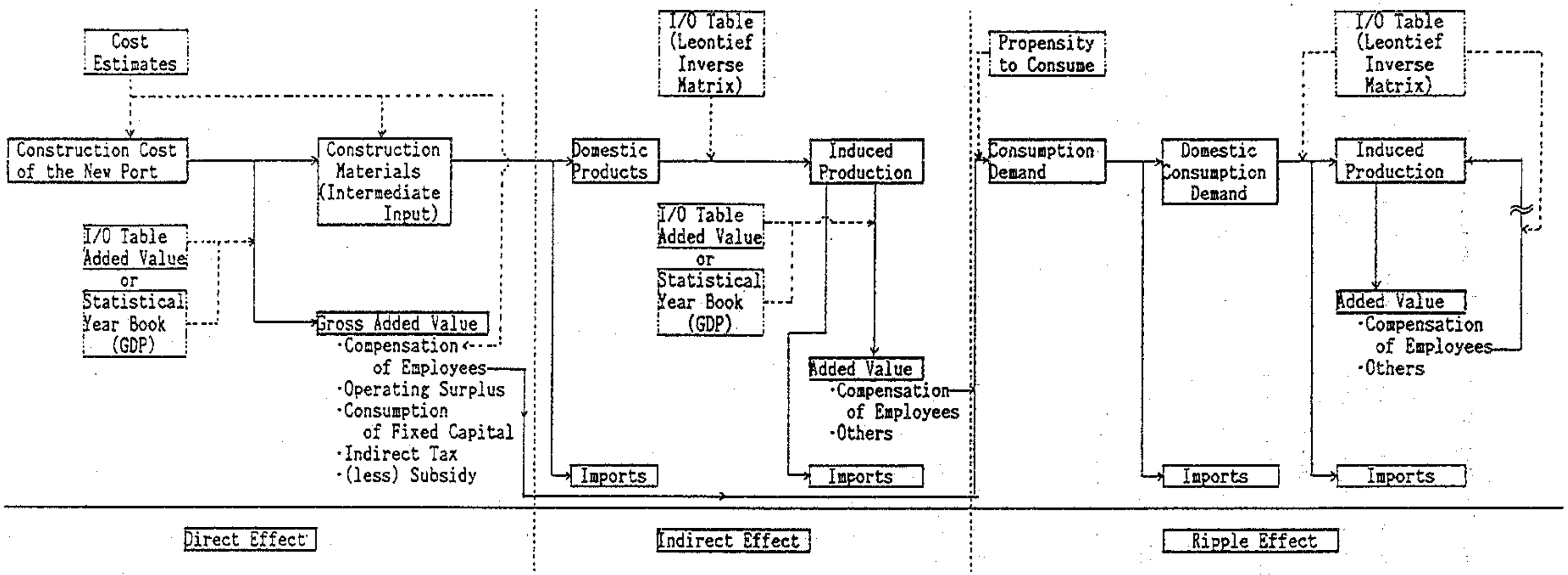


Fig. A-7-4-1 Process of Analysis of Investment Effect value produced by this investment can be assumed to be RO 3,238,000, considering that the compensation of employees in the cost estimation is RO 1,619,000. (All the figures are rounded off to the nearest thousands.)

2) Of the construction materials, the value of domestic products is RO 30,495,000: RO 3,017,000 for cement and RO 27,478,000 for others. Value added by production of cement can be estimated based upon the actual value-added ratio of the cement industry (53%), some data for which the Study team has acquired from the Development Council. (The ratio of compensation of employees to GDP can also be estimated to be 22%.)
It is impossible to calculate the added value to be created by other domestic products, no breakdown of which is shown in Chpater 6. Therefore, in calculating the added value in the other domestic products, the GDP ratio of all industries except the oil sector (54%), which is available in the "Statistical Year Book", is applied. (The ratio of compensation of employees to GDP is assumed to be 55%.)
Since an I/O table is not available in Oman, there is no way to calculate the induced production that will be brought about by the production of the domestic products inputted into the project.
The results of the calculation show that the added value and the compensation of employees in these items are RO 16,437,000 and RO 8,513,000 RO, respectively.

3) Next, added value to be produced by the compensation of employees should be calculated. The formula used to calculate this added value is as follows:

$$\boxed{\text{Compensation of Employees}} \times \boxed{\text{Propensity to Consume}} \times \left(1 - \boxed{\text{Percentage Consumed to Imports}}\right) \times \boxed{\text{Added-Value Ratio of Consumption-Related Industries}}$$

The sum of the compensation of employees in 1) and 2) above is RO 10,132,000.
Since no statistical information about the propensity to consume is available in Oman, the figure is assumed to be 70%, taking into account that the figures for propensity to consume used in similar

analyses in Japan and Egypt were 79.3% and 80%, respectively, and that the propensity to consume in Oman is not likely to be so high because of low propensity of foreign labourers.

It is not also known what percentage of the consumption is made up of domestic goods and services. Based upon the degree of dependence on imports of Oman for the past few years, this percentage is assumed to be 70% in this Study.

From the "Statistical Year Book", we can assume that the value-added ratio of the industries related to personal consumption is 68%.

Using the above figures, the added value in this item can be estimated to be RO 3,376,000. (including compensation of employees of RO 1,114,000 which is assumed to be 33% of the added value.)

However, it should be considered that the compensation of employees in this added value will create another consumption demand that will create some further added value and compensation of employees. Since this process will take place repeatedly, the final added value to be produced by the compensation of employees in 1) and 2) above can be obtained by the following formula:

$$\sum_{k=1}^{\infty}(0.7X0.7X0.68)X(0.7X0.7X0.68X0.33)^{k-1}XY_0 \fallingdotseq 0.3332X1.1235X10,132,000$$
$$= RO\ 3,793,000$$

The summation of the added value in 1), 2) and 3) above gives the total added value to be produced by the construction of the new port.

The procedure and the results of the calculation are shown in Fig. A-7-4-2.

This added value does not occur in a single year. Though there may be some time-lag, particularly in terms of the indirect effect and ripple effect, in this Study the added value is allocated in each year according to the annual disbursement of the construction costs (from 1996 to 1999).

Table A-7-4-1 shows the estimated annual added value by the construction of the new port.

(Unit: '000 RO)

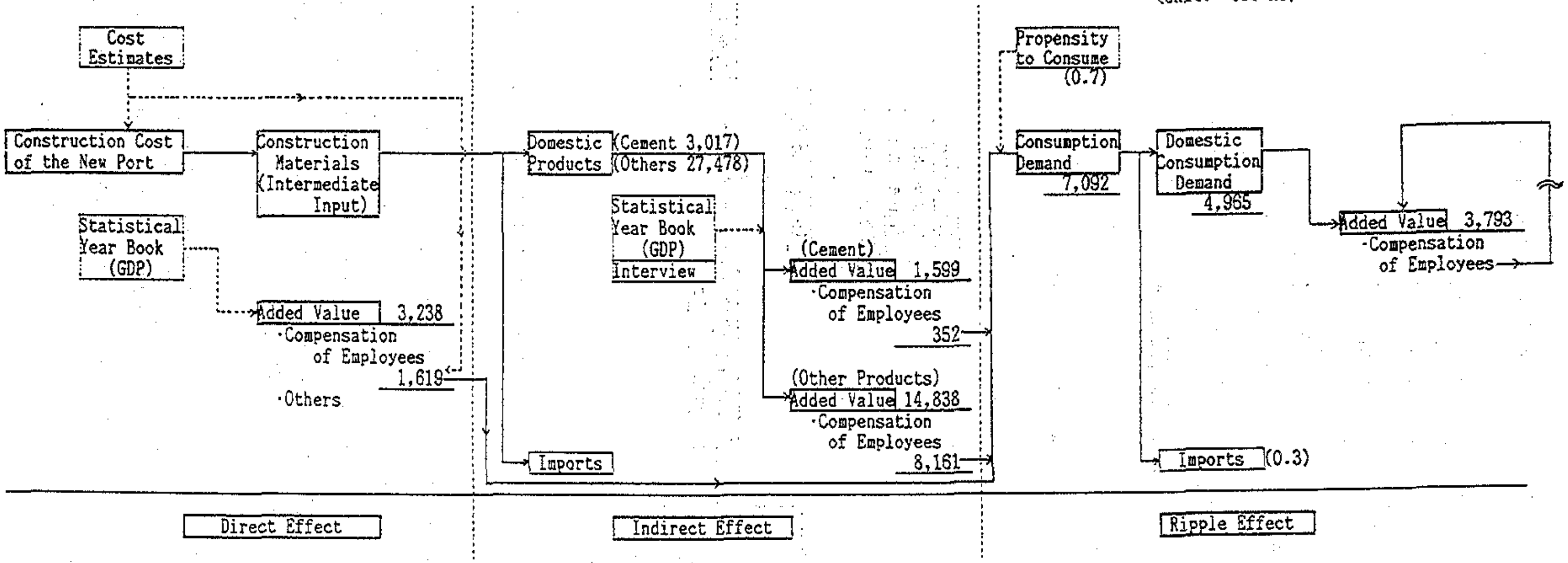


Fig. A-7-4-2 Procedure and Calculation of Added Value

Table A-7-4-1 Annual Added Value in Investment Effect

Year	Added Value ('000 RO)
1996	3,260
1997	4,322
1988	6,023
1999	9,863
Total	23,468

2. Effect on Port Service Industries

The process of the analysis is shown in Fig. A-7-4-3.

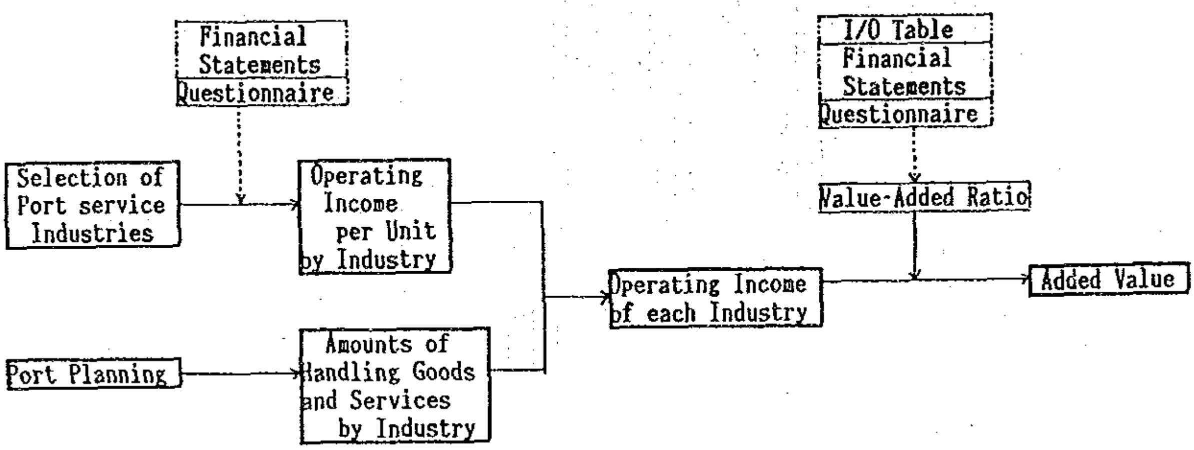


Fig. A-7-4-3 Process of Analysis of Effect on Port Service Industries

Port service industries are those industries which are located in or near the port and which provide services of sea transport, handling of seaborne cargo, storage in the port area and so forth (e.g. stevedoring, shipping agencies, forwarding agencies, warehousing, land transporters, marine insurance, service industries for calling ships, etc.).

However, the financial statement of the Port Service Corporation is the only one that has been provided to the Study team, and financial statements of the other companies, such as shipping agencies and land transporters, have not been made available.

Therefore, taking into consideration that at Mina Qaboos a considerable part of port services is provided by the Port Service Corporation, only the added value created by the port management body for the new port, which can be calculated based upon the results in Chapter 8, is evaluated in this report.

Table A-7-4-2 shows the annual value added by the port service industries (from 2000 to 2005):

Table A-7-4-2 Annual Added Value in Port Service Industries

Year	Added Value ('000 RO)
2000	2,889
2001	3,557
2002	4,313
2003	5,154
2004	6,088
2005	6,713

3. Effect on Industries Dependent upon Seaborne Cargo

The process of the analysis is shown in Fig. A-7-4-4.

These industries are commerce, manufacturing and other industries which take out/in cargoes to/from port through their activities.

Since an I/O table is not available and no investigation has carried out in Oman, it is impossible to be specific regarding these industries. Besides, no details of industries which will be located in Sohar following the new port are not known.

Under the present circumstances, the analysis would have to be made mostly upon assumption and the results would be inevitably accompanied by total uncertainty. Therefore, in this report no calculation is made about the added value created by the industries dependent upon seaborne cargo.

It should be noted that in this analysis no consideration has been given to other important effects, such as price inflation or increase of imports, that will result from this project.

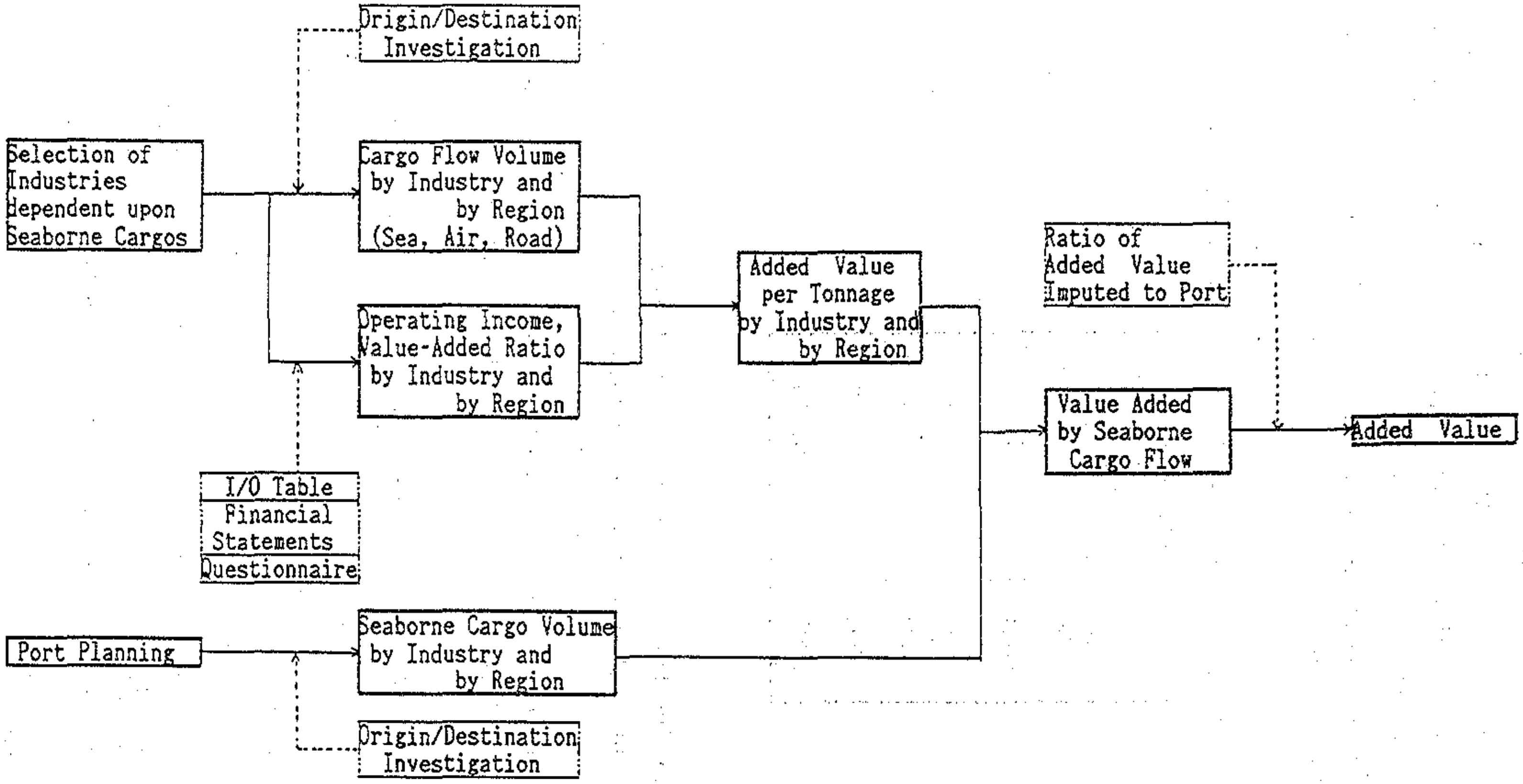


Fig. A-7-4-4 Process of Analysis of Effect on Industries Dependent upon Seaborne Cargo

X. Appendix to Chapter 8-2

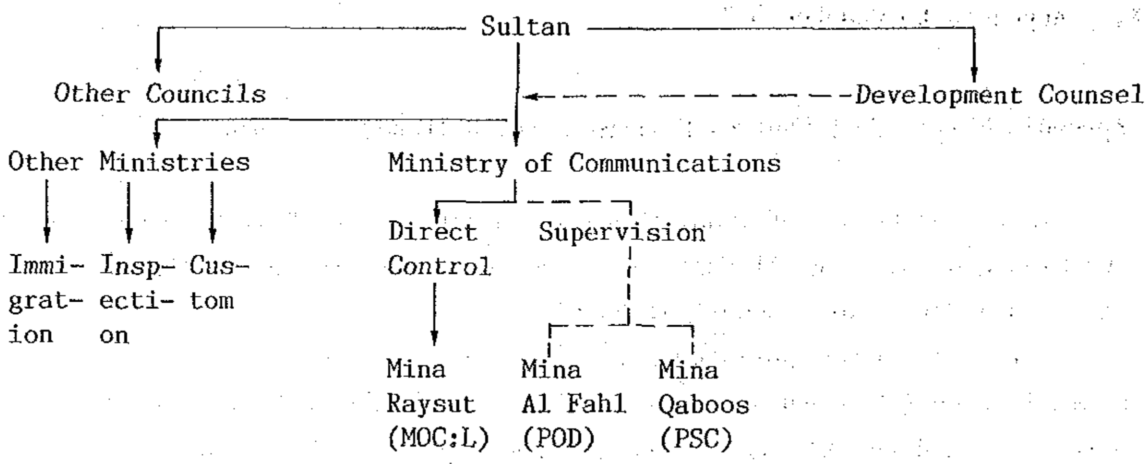
Appendix 8-2-1 Port Control System in the Sultanate of Oman

In the Sultanate of Oman, there are 3 ports: Mina Raysut, Mina Al Fahl and Mina Qaboos. Mina Al Fahl is a forwarding port for petroleum, and Mina Raysut and Qaboos are commercial ports.

The government port/maritime agency in Oman is the Ministry of Communication (MOC) and it controls the port of Raysut by its local office directry. And the MOC supervises the whole ports. The management body of Mina Al Fahl is Petroleum Development Oman (PDO). The management body of Mina Qaboos is Port Services Corporation Limited (PSC). These two companies are half-owned by the government, with the rest owned by private investors.

PSC carries port construction, maintenance, navigation regulation, financial management and supplies of cargo handling services.

The port control system in Oman are shown in Fig. A-8-2-1 and Fig. A-8-2-2. The present organization of the PSC is shown in Fig. A-8-2-3.



Note 1 : MOC:L = Local Office of Ministry of Communications
PSC = Port Services Corporation Limited
PDO = Petroleum Development Oman

Fig. A-8-2-1 Port Control Organizations in the Sultanate Oman

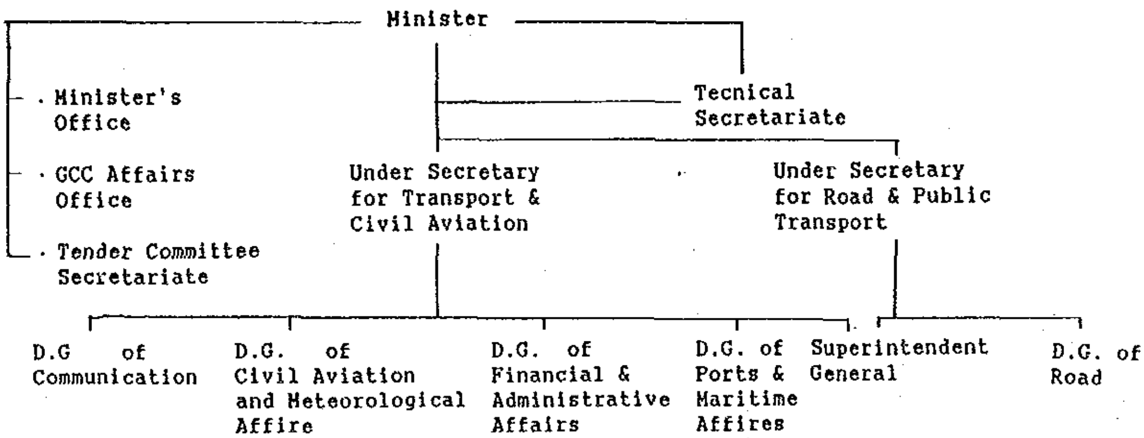
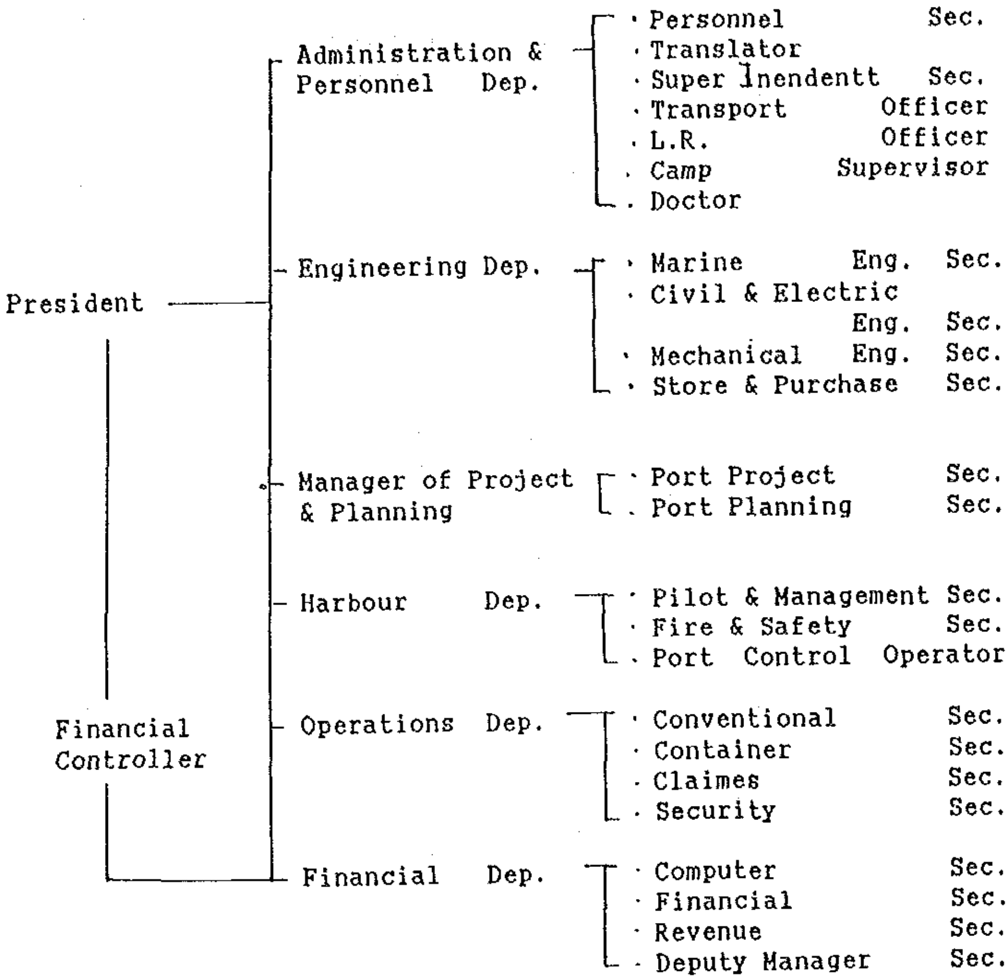


Fig. A-8-2-2 Organizational Structure of the Ministry of Communication



Note 1 : L.R. = Labour Ralation
Camp = Labour Camp

Fig. A-8-2-3 Organization Chart of PSC

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