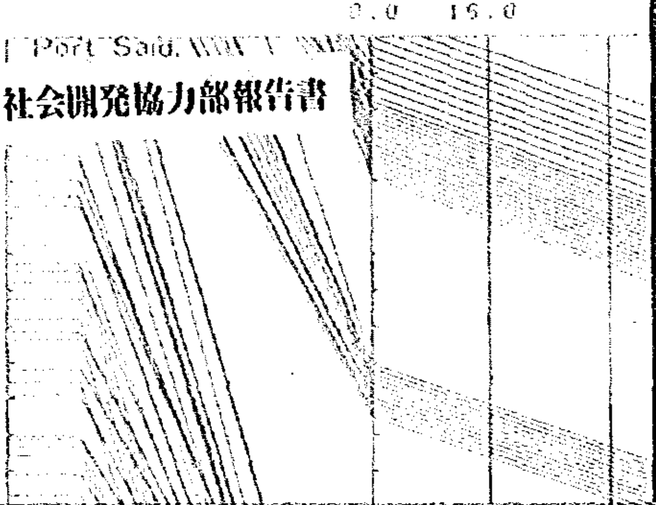
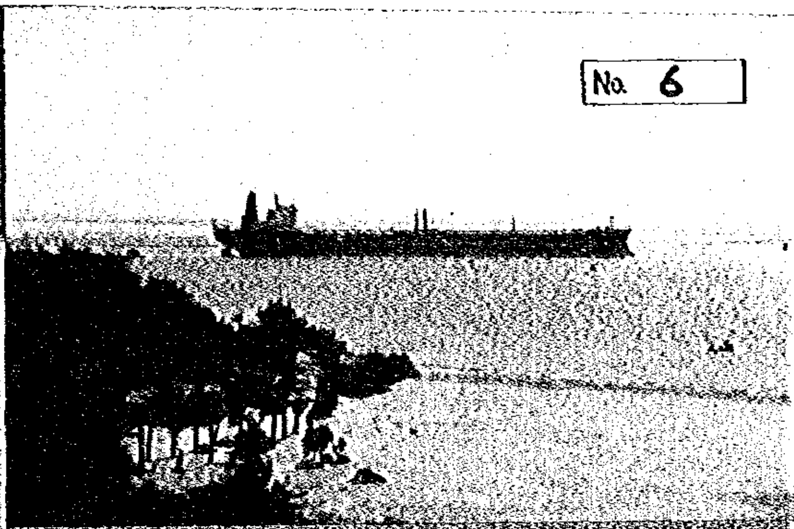
No. 6

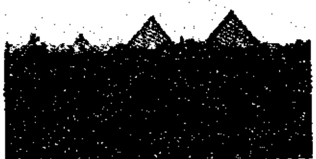
社会開発協力部報告書





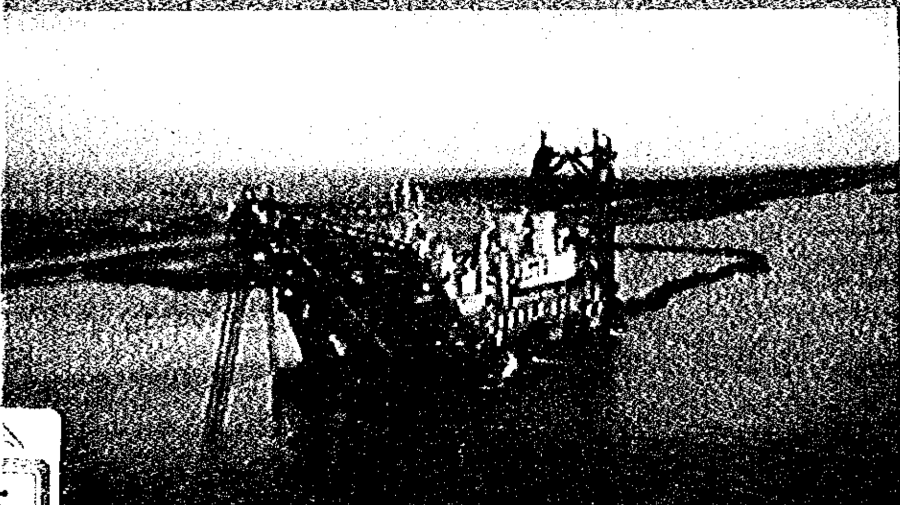
ARAB REPUBLIC OF EGYPT

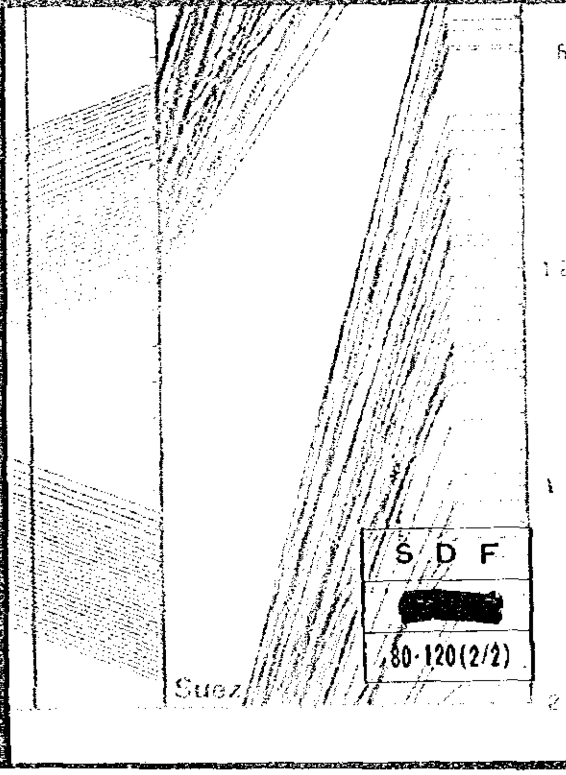
FEASIBILITY STUDY REPORT ON THE SECOND STAGE DEVELOPMENT PROJECT OF THE SUEZ CANAL



JULY 1980

SUPPLEMENTARY REPORT





JAPAN INTERNATIONAL COOPERATION AGENCY

ARAB REPUBLIC OF EGYPT

FEASIBILITY STUDY REPORT ON THE SECOND STAGE DEVELOPMENT PROJECT OF THE SUEZ CANAL

JULY 1980

SUPPLEMENTARY REPORT

The results of additional studies on the development project of the Suez Canal are contained in this report. These additional studies were conducted in response to the comments and questions which were made by the SCA on the Draft Report submitted in March, 1980 (see the Record of Discussion, the SCA chairman's letter addressed to the Japanese Ambassador to Egypt and the comments of the Planning and Research Department of the SCA).

His Excellency the Ambassador of Japan
Japanese Embassy
Cairo

Excellency,

I would like to thank you for your kind cooperation and for the efforts exerted in preparing the "Feasibility Study" concerning the "Second Stage Development". Moreover we found that the tech. study is very sophisticated and interesting & fulfills and the tech. requirements of the Suez Canal. But it seems to be that – three important points which are summarized here after need more analysis and discussions.

1- The size of ships is increasing and the average transit number is quasi-constant from 1976 uptil now. It reached a mean of 60.9 during the first quater of 1980. Also the Canal can allow in particular condition 75 ships per day.
2- It appears from literature and periodicals that the balance of tanker world fleet will occur the middle of 1983 and VLCC's will continue to cruise with such economic speed of 12 knots and this will absorb a part of the surplus.
3- The Suez Canal tugs will escort the loaded VLCC's of more than 100.000 D.W.T. and more than 250.000 D.W.T. in ballast. The spacing between two tankers will be reduced from twelve length of the ships to 5 or 6 length, and that will increase the Suez Canal capacity.

In the meantime I would like to draw your kind attention that we are still preparing the comments of the draft final report. For this reason I will be most obliged if the Japanese Government accepts to kindly send the Japanese team in charge of this "Feasibility Study" to come to Ismailia as soon as possible for exchanging views and more discussions before preparing the final report.

For this purpose I suggest the first week of May would be adequate for this visit.

Thanking you again for this valuable cooperation, with my best regards I remain, Excellency,

Yours sincerely,

CHAIRMAN & MANAGING DIRECTOR
Suez Canal Authority

Signed

(Eng. M. Ahmed Mashhour)

Comments from Planning and Research Department, SCA

1- P. IV-58

It has been mentioned that world coal seaborne trade (energy coal) will increase by 18% up to 1985 to compensate the diversion from oil to coal. At the same time oil is expected to increase with the same rate of energy consumption (Elasticity = 1.0). This percentage is used for Suez Canal traffic forecast. Please explain the causes of this high rate.

2- P. IV-60 Table 4-3-15

The figures of northbound expected volume of coal through Suez Canal in 1978 are not related to our assumptions on P. IV 61 that the volume will be 93% of 6.733 million tons (potential), distributed as 76% as metallurgical and 24% as energy coal.

3- The expected volume of transit cargoes in Suez Canal shown in Tables 4-3-7 for oil, 4-3-11 for iron ore, and 4-3-15 for coal (northbound) are built on the potential volume relevant to Suez Canal in 1978 while for other commodities the expected volume are based on the actual transit through Suez Canal in 1978. Please explain.

4- P. IV-76

Future traffic of nitrogenous fertilizer, the figures, are not based on the way of calculation mentioned in page IV-69. The same remark is noticed for cement and fabricated metals. Please explain.

5- P. IV-101

Other goods by direction and area (Suez)

The other goods for southbound are calculated as the total traffic minus metals, cement, fertilizer and cereals, while iron ore and coal have not been deducted from the total.

As for northbound, you deducted from the total, ores and metals instead of iron ore, coal, cereals and fabricated metals. Please explain.

6- P. IV-133 and 134

Route choice

It has been mentioned that the freight rate in future is approximated by the fluctuating level of the shipping cost per ton of cargo.

$$FR = (a + bd) \times \alpha + \Delta$$

When α = 1.0, FR just covers the shipping costs and the selection among the alternative routes is made by using this freight rate (FR) in each route.

Please explain:

1. What is the value of alpha which is used in this forecast?
2. What is the expected daily number of tankers transiting the Suez Canal based on the value of alpha has been used?

7- P. IV-122, 123, 124

It has been discussed the ship size distribution and some amendments have been made to take the world fleet development into account.

Please send us a table including these amendments.

6- The equation mentioned in page VI –33 related to transit capacity does not realize the theoretical transit stated in Table 6.3.2 and others.

With kindest regards.

Planning & Research Dep.
Dr. Eng. Ammar.

RECORD OF DISCUSSION

on

The Feasibility study for the Second Stage Development Project of the Suez Canal

March 25, 1980

1- A Japanese Team headed by Mr. S. Maeda stayed in Ismailia from March 20, 1980 to March 25, 1980 to explain the final draft report of feasibility study on the second stage development project of the Suez Canal to the Suez Canal Authority (hereinafter referred to as the SCA).

2- After an overall explanation was given by Mr. T. Hazama, a member of the Japanese team; Mr. S. Maeda stated that three alternatives of work programmes has been prepared in the report and each of them is feasible in every aspect, but the selection of the most suitable programme must be done by the SCA.

3- Mr. S. Maeda made the following recommendations to the SCA on the second stage project.

(1) The second stage development project of the Suez Canal should be implemented in the earliest opportunity after completion of the first stage Project because the transit demand appears to increase rapidly in the immediate future and thus the Canal's transit capacity will soon be saturated. In addition such an early start of the Second Stage Project will be economical because many dredgers are kept idle after the First Stage project is over.

(2) It is also recommended that the Second Stage Development Project be finished well in advance of demand forecast in order to meet an unexpected increase of transit traffic. Such an early finish of the doubling project will contribute to the reduction of waiting time for convoy formation at both ends of the Canal and to avoid the total closure of the Canal due to accidents in the Canal. According to our study such an alternative is economically and financially feasible.

4- Mr. S. Maeda proposed to widen a part of the existing Canal which will become the west Channel after the Second Stage Project in order to enable any size of southbound tankers to transit the Canal because an additional investment is not large and additional revenue from increased transit ULCC's can justify such widening works. It was agreed to include this widening in the second stage project as one of the alternative plans.

5- The SCA expressed its doubt about the possibility of traffic increase in future in view of the increasing trend of ships size. In response to the doubt a detailed explanation was given by the Japanese team and it was understood.

6- It was agreed that further comments of the SCA on the report, if any, should be sent to the Japanese Embassy in Cario by April 12, 1980.

7- The SCA expressed its hope that the Japanese team would visit Ismailia to explain the final report and requested the team to send the SCA a few copies of the final report in advance of the team's visit.

8- At the final meeting with the SCA on March 25, 1980 Mr. S. Maeda, leader of the Japanese Team, expressed his thanks for the kind cooperation extended to the Japanese Team by the SCA, particularly by Dr. A. Ammar and his colleagues. His thanks was also due to all the persons of the SCA who worked for the team.

March 25, 1980

Signed	Signed
Dr. Eng. A. Ammar Director of Planning and Research, SCA	Mr. S. Maeda Head of the Japanese Team for the second stage development project of the Suez Canal

Exchange Rate

US$1.00 = LE 0.69 = Yen 240

US$1.30 = SDR 1.00

CONTENTS

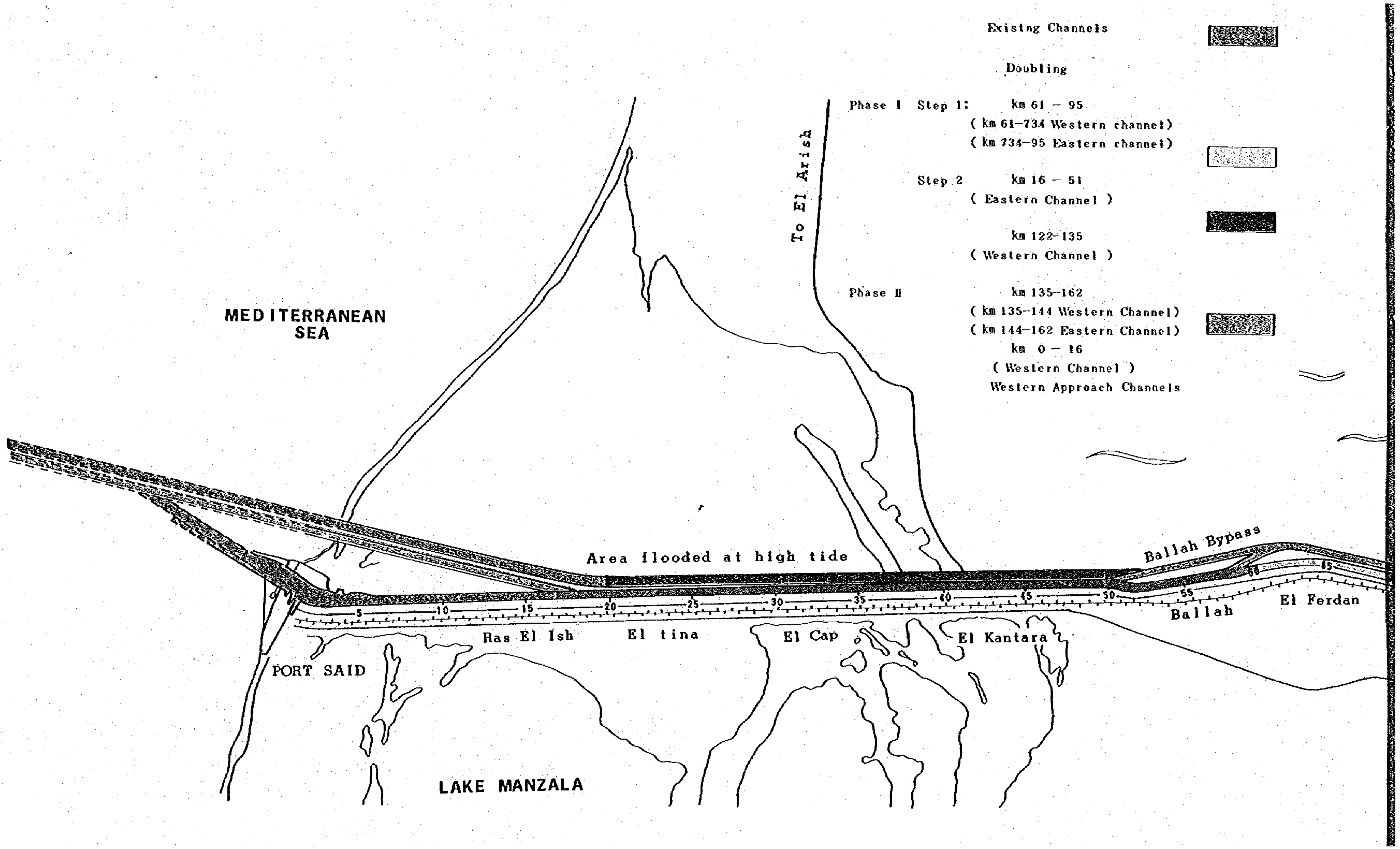
ANNEX

LIST OF TABLES

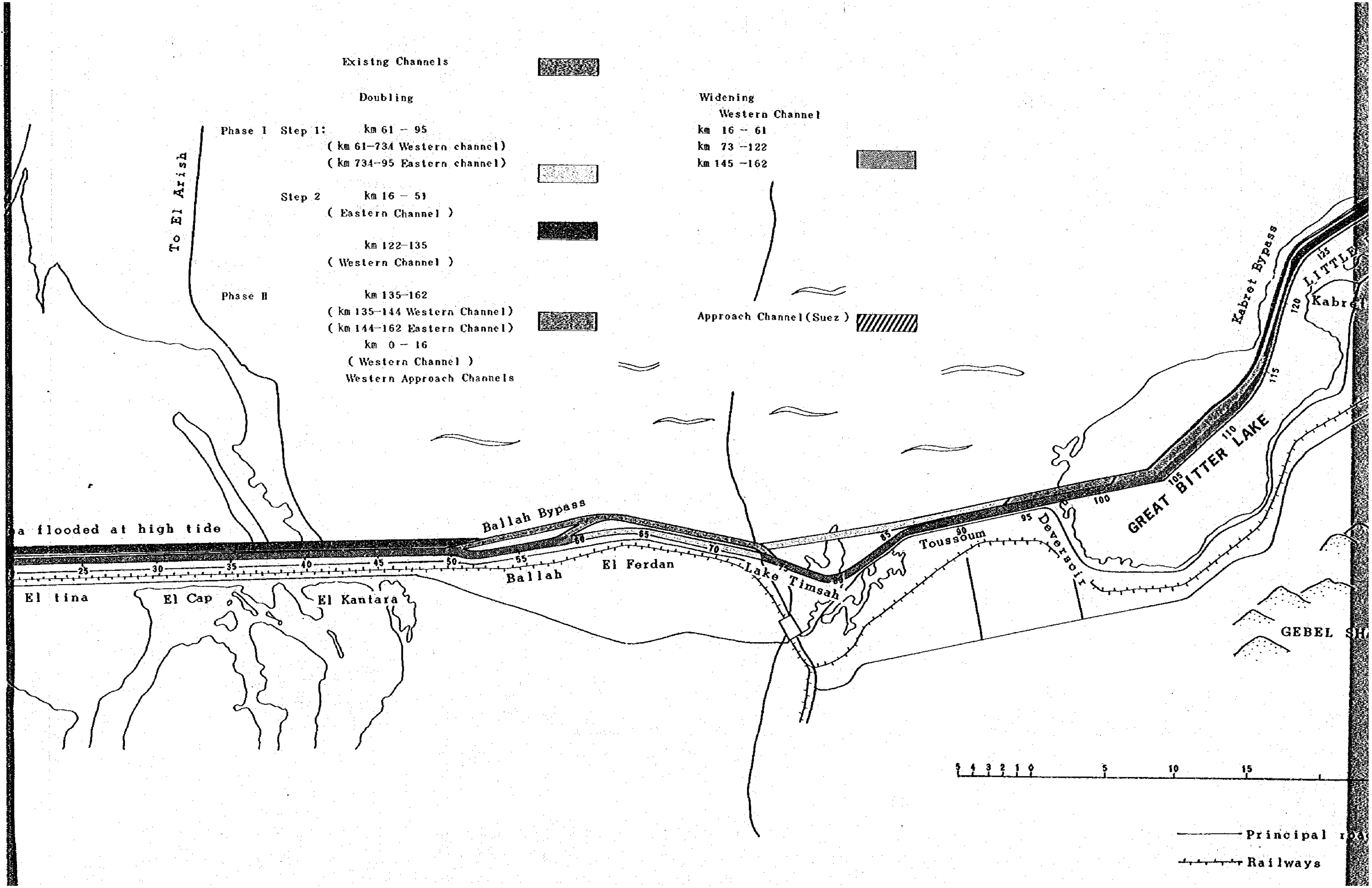
ANNEX

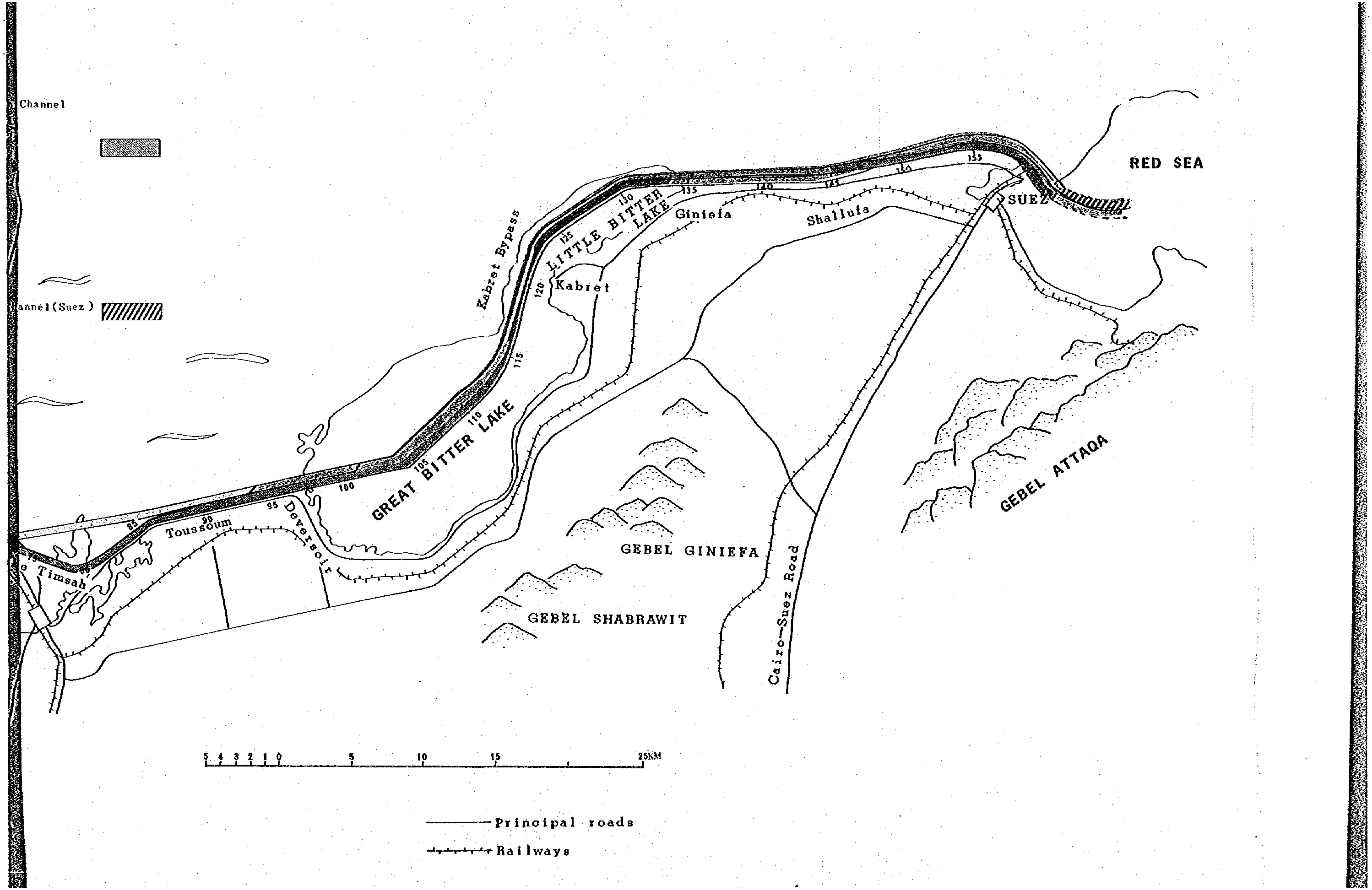
LIST OF FIGURES

ANNEX



Existng Channels
Doubling
Phase I Step 1: km 61 – 95
(km 61–734 Western channel)
(km 734–95 Eastern channel)
Step 2 km 16 – 51
(Eastern Channel)
km 122–135
(Western Channel)
Phase II km 135–162
(km 135–144 Western Channel)
(km 144–162 Eastern Channel)
km 0 – 16
(Western Channel)
Western Approach Channels
To El Arish
MEDITERRANEAN SEA
Area flooded at high tide
Ballah Bypass
Ras El Ish
El tina
El Cap
El Kantara
Ballah
El Ferdan
PORT SAID
LAKE MANZALA


Existing Channels
Doubling
Phase I Step 1: km 61 — 95
(km 61—73½ Western channel)
(km 73½—95 Eastern channel)
Step 2 km 16 — 51
(Eastern Channel)
km 122—135
(Western Channel)
Phase II km 135—162
(km 135—144 Western Channel)
(km 144—162 Eastern Channel)
km 0 — 16
(Western Channel)
Western Approach Channels
Widening
Western Channel
km 16 — 61
km 73 —122
km 145 —162
Approach Channel(Suez)
To El Arish
a flooded at high tide
El tina
El Cap
El Kantara
Ballah Bypass
Ballah
El Ferdan
Lake Timsah
Toussoum
Deversoir
GREAT BITTER LAKE
LITTLE
Kabret
Kabret Bypass
GEBEL SH
Principal
Railways


Channel
annel (Suez)
RED SEA
SUEZ
Giniefa
Shallufa
LITTLE BITTER LAKE
Kabret Bypass
Kabret
GREAT BITTER LAKE
Toussoum
Deversoir
e Timsah
GEBEL GINIEFA
GEBEL SHABRAWIT
GEBEL ATTAQA
Cairo—Suez Road
5 4 3 2 1 0 5 10 15 25KM
Principal roads
Railways

Chapter 1

SUMMARY

Chapter 1 SUMMARY

1-1 Analysis of VLCC/ULCC Traffic Demand and Increase in the Size of Dry Cargo Vessels

1-1-1 Forcast of VLCC/ULCC Supply and Demand

In the Main Report, the time of recovery of the tanker market, which profoundly affects the canal transit of VLCCs, was forecast to come in the second half of the 1980s but here, we calculated the time of recovery of demand/supply balance exclusively with respect to VLCC/ULCCs. Many uncertain factors affecting the demand and supply of shipping were dealt with on the following assumptions (until 1990):

1) As to the oil movement between OPEC and advanced nations, which represents 90% of VLCC/ULCC trade, it is assumed, the Tokyo Summit Declaration, that oil shipments to Europe will gradually decrease while those to the U.S.A. and Japan will gradually increase.

2) Regarding the supply, it is assumed that the scrapping of tankers will gradually decrease with the recovery of the market.

3) It is assumed that the prevailing pattern of tanker operation with the average speed of 12 knots and 12 days of port stay will be gradually improved toward 15 knots and 6 days with the recovery of the market. (1973 level was 16 knots, 4 days.)

Consequently, it is expected that the demand/supply of VLCC/ULCC will recover its balance in 1989 but, if energy conservation is intensified above the present level, the time of recovery will be further delayed.

The above analysis presupposes that no large tankers are built in the meantime but, in reality, orders may be issued gradually for the construction of VLCC/ULCC as the demand/supply balance recovers. We should say, therefore, that the actual balance recovery will be further away.

1-1-2 Selection of Suez and Cape Routes by VLCC/ULCCs

The Main Report employs a model in which the canal traffic of VLCC/ULCCs changes with the tanker market situation. Here, we analyze the effects of various external factors on this route selection and hope that this analysis will contribute toward fuller understanding of the present conditions, the drawing up of a greater variety of forecasts on the future and the establishment of an optimum canal toll system.

Transit through the Suez Canal is economically advantageous for 250,000-ton tankers headed for the Arabian Gulf from the Atlantic coasts of Europe if the freight rates of the next shipment exceed $6.40/ton. This break-even point varies by various factors and its extent is as follows:

1) By areas, freight rates of the break-even are the lowest for the eastern part of the Mediterranean Sea and the highest for the Caribbean Sea, so high that, at the present market rate, it is impossible to attract tankers on the Caribbean run to the Suez route.

2) The direct impact of ship size difference, reduced speed and fuel price on the

break-even point is small. Since, however, the rise of fuel price pushes up the lower limit of the tanker market, the situation is favorable for Suez at a time of depression such as the present.

3) The impact of canal tolls is so great that extensive analysis of environment is necessary in setting tolls. Generally speaking, the level at which VLCCs on the Northwest European run can be attracted brings the largest revenue.

4) The increase of waiting time reduces the advantage of using the canal. An additional 4-days of waiting, for example, produces the same effect as a 35% raise of tolls.

1-1-3 Number of Dry Cargo Ships in Transit and Increase in Ship Size

The Main Report presupposes the rapid increase of dry cargo ships. We have conducted a more detailed analysis following the discussions with the S.C.A.

The number of dry cargo ships using the Suez Canal increased 4.3% annually during the period of 1966/1978 and the average tonnage increased 3.7% annually. Particularly in 1976/1979 after the reopening of the canal, the size of ships rapidly increased by 9.6% annually. But in this demand forecase, dry cargo ships are classified by ship types (bulk carriers, general cargo ships, container ships, etc.), their relations with cargo items are studied and the change by traffic volumes by cargo items is reflected in the change by ship types.

Thus the trend towards larger ship size is analyzed and forecast by ship types but, in actual transit in recent years, the increase in size has been only gradual. In the world fleet also, the increase of the average ship size has slowed down. The size of container ships whose size increase occurred relatively rapidly is gradually leveling off. It is believed that the future size increase by ship types will be slow on the whole. Shift from general cargo ships to container ships is in progress but, from the results of the analysis conducted on cases where the shift will be earlier than forecast in the main report, the impact of the shift will be the decrease of 0.8 vessel per day in 1985 and 7.9 in 2000.

As to the relations between ship types and cargo items, we used data only of the month of July 1978 but, the load factor, was estimated by the tonnage of ships loaded with cargoes and the tonnage of cargoes throughout the whole year of 1978. So, the forecast closely reflects realities. Trial calculations based on the load factor obtained from the data of 4 months of 1979 showed the increase of 0.2 vessel in 1985 and the decrease of 1.0 in 2000.

The aggregate decrease according to the two preceding analyses will have little effect on the general trend indicated in this forecast.

1-2 Transit Capacity and Ship-to-Ship Intervals

The possibility of shortening the ship-to-ship interval for VLCCs to 5-6 L with the support of powerful tugboats was examined. It is our opinion that the SCA should consider shortening the ship-to-ship intervals only after becoming thoroughly experienced in the control of VLCC's transit and after it has made sure of the reliability of the SCVTMS scheduled for soon installation. For the present, as we proposed in the Main Report the SCA should adopt a ship-to-ship interval of 12 x L (16 minutes) to allow for a sufficient stopping distance and a safety interval.

The shortening of the time interval from 16 minutes to 12 minutes would have the effect of postponing the Canal's capacity saturation by a year or so, as is clear from the results of the diagram analysis using standard ships. This period has been confirmed by a simulation test using real ships.

As mentioned above, the shortening of the VLCC ship-to-ship distance will not greatly contribute to the increase of transit capacity. It is desirable that the increase of transit capacity will be made by means of doubling the Canal step by step according to the increase in the traffic demand and the shortening of ship-to-ship intervals should be considered very cautiously from the view-point of navigational safety.

1-3 Widening Plan of West Channel

1-3-1 Traffic Demand Forecast

The method of forecasting the traffic demand in this section is the same to that described in the Main Report, here we forecast both the number of ships and the canal revenue. The results of forecast in both cases of the Doubling and Widening Plan and the Doubling Plan (Main Report) are shown in the following table:

Traffic Number and Canal Revenue: Base Case

Case	Year	1980	1985	1990	1995	2000
Ships/day	Doubling and Widening Plan	68.28	83.89	103.34	120.07	139.63
	Doubling Plan	68.22	83.73	103.10	119.79	139.33
	Difference	0.06	0.16	0.24	0.28	0.30
Revenue/year (10^6 US$)	Doubling and Widening Plan	792.9	1041.7	1320.8	1542.9	1768.0
	Doubling Plan	785.2	1021.6	1290.6	1506.7	1730.5
	Increase	7.7	20.1	30.2	36.2	37.5

The tonnage (DWT) proportion of the ULCCs of 350,000 DWT or over to the whole tankers varies from route to route; i.e. 10–13% on the Arabian Gulf – Northwest Europe route and Arabian Gulf – North America route and about 5% on the Arabian Gulf – Mediterranean route. However, how many ULCCs go through the Suez Canal depends greatly on the freight market. When the market is brisk, the number of Suez routing ULCCs will increase, but in depression, many ULCCs will divert to the Cape route. Taking this market factor into account, it is estimated that the effect of widening upon the number of transiting vessels would be 0.16 ships per day in 1985 and 0.30 ships per day in 2000. The increase in the annual revenue would be 20 million US dollars in 1985 and 38 million US dollars in 2000.

The effect of the transit of ULCCs is appreciable in the market boom period; it is estimated to be about 2% of the total Canal revenue or about 6% of the revenue from tankers.

1-3-2 Implementation Plan

The implementation of the Doubling and Widening Plan which combines the doubling of the Canal as proposed in the Main Report and the widening of the western channel to accommodate 500,000DWT ballast tankers is examined here.

The soil volumes are as follows:

	Soil from doubling	Soil from widening	Total soil
Doubleing (Phase I) and Widening	329.3 $10^6 m^3$	36.2 $10^6 m^3$	365.6 $10^6 m^3$
Doubling (Phase II) and Widening	555.8	44.6	600.4

Phase I doubling is to be completed in 1986, Phase II in 1994, and the Canal widening in 1984 to meet the forecasted demand of the Base Case. For the execution of this dredging work, the SCA is to deploy nine pump dredgers of its own, totalling 44,650 HP, of which four dredgers (35,500 HP) will work for the doubling of the section north of Km 58 and five dredgers (9,150 HP) for the widening. In addition, a total of twelve contract dredgers (73,000 HP), eight (56,000 HP) for doubling the section south of Km 58 and four (17,000 HP) for widening, are to be deployed.

The dredging costs are as follows:

	Doubling	Widening	Total
Doubling (Phase I) and Widening	83.0 10^6 LE + 231.0 10^6 \$	17.0 10^6 LE + 41.5 10^6 \$	100.0 10^6 LE + 272.5 10^6 \$
Doubling (Phase II) and Widening	132.2 + 442.6	18.3 + 46.2	105.5 + 488.8

The total costs of doubling and widening are as follows:

	Local currency	Foreign currencies	Total
Doubling (Phase I) and Widening	294 10^6 LE	348 10^6 \$	773 10^6 \$
Doubling (Phase II) and Widening	458	589	1,252

These costs are based on 1979 prices, computed at the exchange rate of 0.69LE = US\$1 = ¥240, plus 10% added for contingency.

1-3-3 Economic and Financial Evaluation

1) Economic evaluation

The economic evaluation of the Doubling and Widening Plan was carried out using the same method as the Main Report. The internal rate of return was computed from the costs and benefits of the Doubling and Widening Plan and was compared with that of the Doubling Plan. Evaluation here was made only from the standpoint of national economy.

For the Doubling and Widening Plan under study, the two-phased plan, Phase I and the doubling of the entire length, was employed as in the case of the Doubling Plan of the Main Report.

Costs include the construction costs of doubling and widening, maintenance, operation and administration costs; benefits include toll revenue from ballast tankers of over 350,000 DWT in addition to the benefits of the Doubling Plan. The toll revenue of Phase I are unchanged, however, as it will not increase until the entire length of the Canal is widened. Thus, only the benefits of the doubling plan are considered.

The internal rate of return in each case is computed as follows:

	Doubling and Widening Plan	Doubling Plan
Phase I	22.7%	24.2%
Phase I + Phase II	23.4%	23.8%

Economic evaluation of the Doubling and Widening Plan may thus be concluded as below:

(1) If the Doubling Plan of Phase I is combined with the plan to widen the western channel for ballast tankers of over 350,000 DWT, there will be a slight fall in profitability compared with the Doubling Plan, nevertheless this plan still has ample economic feasibility.

(2) If the doubling of the entire length of the Canal is combined with the widening of the western channel following the Phase I, profitability similar to that of the Doubling Plan may be expected since the toll revenue from ballast tankers are expected to increase due to the possible passage of over 350,000 DWT tankers.

(3) Judging from the above, the economic feasibility of the Doubling and Widening Plan (combining the widening of the western channel and the doubling plan) does not differ much from the results of the Doubling Plan studied in the Main Report; the conclusion of the economic analysis in the Main Report therefore seems to be applicable to the Doubling and Widening Plan.

2) Financial evaluation

The evaluation of the financial feasibility of the combined plan (Phase I) was carried out by FRR, using the DCF method.

In computing the FRR, the costs include the construction cost with contingency, maintenance cost, administration cost and operation cost. Only the benefits from the doubling are considered since the widening of the entire length of the Canal will not be completed under the Phase I and, therefore, no revenue can be expected from ballast tankers over 350,000 DWT. The FRR thus obtained is as follows:

	Doubling and Widening Plan	Doubling Plan
F R R	15.8%	17.3%

Judging from the above, the costs of doubling and widening will be higher than those of doubling only, but the financial feasibility will not be affected, though there will be a slight fall in the internal rate of return compared with the Doubling Plan.

Chapter 2

ANALYSIS OF VLCC/ULCC TRAFFIC DEMAND AND INCREASE IN THE SIZE OF DRY CARGO VESSELS

Chapter 2 ANALYSIS OF VLCC/ULCC TRAFFIC DEMAND AND INCREASE IN THE SIZE OF DRY CARGO VESSELS

2-1 Forecast of VLCC/ULCC Demand and Supply

2-1-1 Introduction

A wide gap in demand and supply presently exists for the VLCC/ULCCs, which are very important customers of the Suez Canal, though the demand and supply of small tankers is balanced. The point of time in the future that the VLCC/ULCC demand and supply again will be balanced is discussed here.

There are many uncertainties, besides oil seaborne trade, in determining the time of demand and supply balance in the VLCC/ULCC branch. They include, for example, the gradual recovery of navigating speed from the present reduced speed to normal keeping pace with the rise of the tanker market, the increase or decrease of volume of scrapped old-aged tankers, the change of the countries from which crude oil is ordered and the increase or decrease of the Suez Canal's transit volume. All of these uncertainties make it difficult to determine when the demand and supply will be balanced.

In this section (2-1) it is assumed in calculating the time of supply/demand balance that in accordance with the oil seaborne trade forecast in the Main Report,the operational efficiency will gradually improve and the ratio of scrapping of VLCC/ULCC will fall as the supply and demand of VLCC/ULCC approaches a balance and the freight market recovers.

2-1-2 Market Situation and Operating Efficiency

1) Navigating Speed

Navigating speed is closely correlated with the shipping market. It was observed in the past few years that the average navigating speed of VLCC/ULCC ranged from about 11 knots to 14 knots according to the level of freight market.

2) Port Time

In the past two years (1978 and 1979), the average port time per voyage presumably was about 12 days for VLCCs. Port time is also believed to be correlated with the market situation. If the situation improves, port time decreases and will probably approach normalcy (4 days per voyage). However, there is also the likelihood that part cargo trade may increase, therefore the normalcy may not be fully reached.

3) Scrapping

The most decisive factor in the future VLCC/ULCC supply is "Scrapping" of existing ships. Shipowners' decision to scrap ships is based on their forecast of the freight market in the next several years together with the scrap price of the ships.

The scrapping of tanker is increasing now because of IMCO tanker regulations which are expected to become effective in June 1981, and the volume of tanker scrapping in 1980 will reach 10 million DWT. After this special scrapping, the ratio of scrapping of tanker will become lower because of expectation of recovery of the tanker market.

2-1-3 Long-Term Shipping Demand (Seaborne Oil Trade)

In this forecast the results of the Tokyo Summit conference and the IEA communique are used for reference in estimating the long-term VLCC/ULCC shipping demand. President Carter's ambitious energy policy is not taken into account because it is not clear at present to what extent his targets will be attained.

Regional oil imports extrapolated by these are as follows:

Table 2-1 World Oil Imports

(10^6 DWT)

Region	1978 (actual)	1990 (estimate)	Increase or decrease	Annual Increase rate
				(%)
Western Europe	648.2	550.0	△98.2	△1.4
North America	414.5	440.0	+25.5	+0.5
Japan	262.6	300.0	+37.4	+1.1
Total for three regions	1,325.3	1,290.0	△35.3	△0.2
Others	328.1	571.3	+243.2	+4.7
Grand total	1,653.4	1,861.3	+207.9	+1.0

The above indicates that, by 1990, oil imports by Western Europe will decrease while those by North America and Japan will somewhat increase. The total imports by the three major regions decrease by 35 million tons as the decrease in West European imports exceeds increases in the North American and Japanese imports. The grand total will increase by just above 200 million tons or an annual rate of 1.0% because of an annual rate of increase of 4.7% in the oil imports of the "others" regions.

It can be understood from the above table that oil imports by the three major regions with greater opportunities of VLCC/ULCC operation will decrease although those by North America and Japan will slightly increase. Oil imports by the "other" regions will sharply increase but the opportunities of VLCC/ULCC trade there are limited for such reasons as the non-availability of large harbors (with only a few exceptions including Far Eastern Asia, Brazil, etc.) and the fact that the import lots of individual countries are small.

The amount of VLCC-transported oil imports by regions in 1990 may be presumed as follows: (The rate of VLCC transportation is presumed to be 43% for Western Europe, 20% for North America, 44% for Japan and 32% for the "others" regions based on the actual results in 1978.)

Table 2-2 Oil Imports by VLCC/ULCC Transportation

(10^6 DWT)

Region	1990
Western Europe	237.1
North America	87.6
Japan	133.4
Total for three regions	458.1
Others	182.8
Grand total	640.9

VLCC/ULCC requirements may be determined on this basis as follows:

Table 2-3 VLCC/ULCC Demand in 1990

(10^6 DWT)

Importer region	(a) 15 knots • 6 days in port	(b) 12 knots • 12 days in port
Western Europe	49.9	73.4
North America	17.9	27.9
Japan	17.8	24.2
Total for three regions	85.6	125.6
Others	16.0	22.6
Grand total	101.6	148.2

2-1-4 Volume of VLCC/ULCC Supply

VLCC/ULCC tonnage in mid-1978 was as follows:

Table 2-4 Existing VLCC/ULCC (in the middle of 1978)

(10^6 DWT)

VLCC/ULCC (200,000 DWT or more)	192.2
Combination-carrier (")	8.0
Total	200.2

Source: Fearnlly & Egers Chartering Co., Ltd. "World Bulk Fleet July 1978"

It can be seen that the present ULCC/ULCC volume is excessive as against the requirement for these ships in 1990. So, in the VLCC/ULCC branch, the present volume will probably decrease through "supply adjustment", namely, the excess of scrapping over new building.

The excess of the present VLCC/ULCC volume over the 1990 demand is:

15 knots, 6 days in port .... 98.6 (10^6 DWT)

12 knots, 12 days in port 52.0

In 1978, the demand was 110.1 million DWT at the normal efficiency of operation: speed 15 knots and 6 days in port. The volume at the present navigation speed of 12 knots and 12 days in port is 148.2 million DWT. The VLCC/ULCC requirement in 1990 will be approximately the same level as in 1978 with 101.6 million DWT. Thus it can be said that the VLCC demand is stationary.

We shall now study the time of demand/supply balancing from the view-point that, in the idea of "supply adjustment", demand/supply balance recovers with the progress of scrapping. The following is assumed with respect to scrapping:

Table 2-5 Existing VLCC/ULCC (End 1979)

Year built	No.	10^3 DWT
1966~70	115	25957
1971	65	15399
1972	67	16435
1973	86	22313
1974	116	30337
1975	104	28779
1976	85	26018
1977	38	12464
1978	15	4897
1979	8	2668

Source: J.I. Jacobs & Co., Ltd. "World Tanker Fleet Review Feb. 1980"

Table 2-6 Estimated Volume of Scrapping

Yearly volume		Cumulative volume	
	(10^6DWT)		(10^6DWT)
1979	△1.4	1979	△1.4 (*)(1)
80	△0.3	80	△1.7 (*)(1)
81	7.3	81	5.6
82	3.6	82	9.2
83	8.6	83	17.7
84	10.8	84	28.5
85	13.1	85	41.6
86	2.8	86	44.4
87	17.6	87	62.0
88	20.1	88	82.1
89	19.6	89	101.6
90	18.3	90	119.9

(*) (1) Scrap less New building

Table 2-7 Estimated Rate of Scrapping

Age of vessel (year)	Rate of scrapping (%)				
	Estimated			Actual	
	1981	1982~85	1986~90	1979	1973
12	50	30	20	17	0
13	62.5	42.5	30	17	0
14	65	55	40	20	0
15	87.5	87.5	50	33	4
16	100	80	60	47 (16–20)	10 (16–20)
17		85	70		
18		90	80		
19		95	90		
20		100	100		

2-1-5 Time of Balancing of VLCC/ULCC Demand and Supply

Consequently, the time of balancing of demand and supply through "supply adjustment" is believed to be in the second half of 1989. However, if it is supposed that operation at reduced speed becomes semi-permanent because bunker prices will continue to be raised in the future, the time of balancing is calculated to be in 1987.

2-1-6 Other Factors Affecting the Balance

1) As the VLCC/ULCC tonnage balance approaches equilibrium and consequently the freight market recovers, Suez Canal VLCC traffic will increase. The Canal traffic produces the same effect as the increase of tonnage supply because of the saving of time of navigation 10 ~ 14 days per transit.

VLCC traffic in 1990 estimated in the main report is 310 million DWT, which is equivalent to an additional of 10.8 mil. DWT to the existing fleet and compares with the 1978 traffic of 40 mil. DWT or 2 mil. DWT in terms of additional fleet. (Consequently, the supply/demand balance is carried forward by about half a year.)

In other words Suez Canal VLCC traffic produces tonnage supply of about 3.5 ~ 4% of the traffic volume.

2) The VLCC/ULCC demand and supply is also affected by the change of the oil distributing structure, namely, the increase of GG (Government to Government deal) and DD (Direct deal) transactions, the small-ship market which is believed to have already recovered its balance, and the LOOP (Louisiana Offshore Oil Port).

The share of GG and DD transactions in the supply of oil in the whole world increased from 8% in 1973 to 42% in the last quarter of 1979 and is expected to increase further in the future. It has become clear that GG and DD transactions, which comprise smaller lots than past transactions routed via the international oil majors, have cut the demand for large ships. If DD transactions increase, the demand opportunities for medium and small ships will increase and the demand opportunities for large ships will decrease.

If the small ship market steadies as a result, VLCC/ULCCs may enter the small ship market by part cargoes.

3) The LOOP is the first U.S. deepwater oil terminal to be constructed 19 miles off the coast of Louisiana. It is scheduled to be completed in February 1981 (Capacity 70 mil. ton per year). However, its effect on VLCC/ULCCs is considered to be almost negligible, except that the demand for small ships may decrease because of cessation of transhipment from tranship terminals scattered throughout the Caribbean islands.

4) Last but not least are new building orders in the course of recovery of tonnage demand and supply balance. The foregoing analyses disregarded the new building until 1990, but in practice the most probable development is a gradual increase of new building orders prior to the real tonnage balance. The common behavior of major shipowners (including oil companies) in the world is to aim at timely order for new building before the rise in new building price due to the rush of orders.

If it is presumed as an example that the yearly ratio between new building delivery and scrapping will grow from 1986 to reach 100% in the year of the tonnage balance, the new building tonnage of VLCC/ULCC will amount to about 30 million DWT in four years 1986 – 1989 which will have the effect of delaying the tonnage balance by about two years.

2-2 Selection of Suez or Cape Route by Large Tankers

2-2-1 Method Used in This Demand Forecast

In this demand forecast, a general economic principle is applied to the shipping world with respect to the criteria for deciding which to use for large tankers, the Suez route or the Cape route. In the short term, route selection is affected by various factors but in the long term, these factors level off and the above-mentioned economic principle dominates. In fact, there is a clear tendency for the number of south-bound VLCCs in ballast through the canal suddenly to change with the fluctuation of the tanker spot market.

This economic principle is: "A shipping company should select a route where the per-day net income (the remainder reached after subtracting fuel cost, port charges and the canal toll etc. from the freight income) is maximal." In this case, the ship cost and the capital cost are identical on the daily basis no matter which route is taken; so, they do not affect the selection.

As can seen from the above principle, the Suez route requiring a smaller number of days is more favorable if the freight market rises but if, on the contrary, the freight market falls, the Suez route requiring tolls is at a disadvantage. The advantageousness of the Suez route at a certain time can be determined by calculating the "break-even point" where one route is as advantageous as the other and comparing it with the tanker market.

The break-even point for the Cape/Cape route and the Cape/Suez route of Ras Tanura/Rotterdam 250,000-t tankers is $6.40 but the following factors change this value:

1) Geographical location of destination
2) Ship size
3) Speed, therefore, fuel consumption rate
4) Fuel oil prices
5) Canal tolls
6) Number of waiting days at canal

Hereunder is the analysis of the effects of these factors. It is intended to help the understanding of the results of transit demand forecast and to serve for reference in the establishment of the canal toll tariff.

2-2-2 Regional Differences

The break-even point changes according to the distance difference between the Suez route and the Cape route (see Fig. 2-1). It is lowest in the eastern part of the Mediterranean Sea (which means that Suez is at a relative advantage) and highest in the Caribbean Sea. VLCCs on the Caribbean run can hardly be expected to use the Sueze Canal unless the tanker market soars. In fact, only two VICCs on the Caribbean run used the canal in 1978 (see Table 2-8).

2-2-3 Ship Size

The break-even point hardly changes by ship size. (Fig. 2-2) Rather, it is higher with large ships. The tanker market is, of course, high with small ships and low with large ships. At the current toll rates of the canal, therefore, Suez is much more preferable for small ships but not much so for large ships.

2-2-4 Slow Steaming

It is presently a general practice for VLCC/ULCCs to be operated at 3-4 knots less than their design speed of 15–16 knots. In this case, the break-even point somewhat lowers but a change at this level seems hardly to affect the Suez transit volume. (Fig. 2-3)

2-2-5 Fuel Oil Prices

At present, fuel oil prices are approximately $160–$190 per ton but if these rise 50% or 100%, the break-even point will somewhat lower with the price rise, as shown in Fig. 2-4, making Suez slightly more favorable.

But Suez transit is more affected by the rise of fuel oil prices than by this lowering of the break-even point. The situation can be made exceedingly favorable for Suez at a time of market stagnation such as this, by raising the tanker market minimum (generally, lay-up point freight) through the rise of fuel oil prices.

2-2-6 Canal Tolls

The change of canal tolls may greatly affect the induction of VLCC transit. (Fig. 2-5) If the tolls are cut to a half, for example, the canal may well attract VLCCs of the Caribbean run. If, on the contrary, the tolls are doubled, most VLCCs on the Northwest European run will cease to use the canal.

The optimum toll system by which the toll revenue from canal-navigating VLCCs can be maximal should be the level at which VLCCs from Northwest Europe can use the canal under the tanker spot market of the time. By contrast, low tolls catering to the Caribbean Sea or high tolls aimed only at the Mediterranean Sea can cause the decrease of total revenues from VLCCs.

2-2-7 Number of Waiting Days

It is generally understood that the number of days required for canal transit is normally two for VLCCs (including the time to wait for convoy formation and the transit time) and 1.5 for other ships. This forecast also presupposes two days for VLCCs. The effect on the break-even point in the case of a four day increase in this waiting is equivalent to a 27% market rise from $6.40 to $8.13. (Fig. 2-6) This is also equal to the effect of a toll increase by about 35%.

Table 2-8 Southbound Tankers Traffic of 150,000 – 20,000 and over 200,000 DWT

	150,000 – 200,000							over 200,000								
Area of origin port	1 Gr.	2 Ad. Sea	3 W.C.It.	4 Fr.Sp.	5 N.W.Eu.	6 Canada	7 Car. Sea	1 Gr.	2 Ad. Sea	3 W.C.It.	4 Fr.Sp.	5 N.W.Eu.	6 Canada	7 Car. Sea	Total	W.S. *
1978 January		2		1	1				1		1	2			88	20.4
February		1		1	2				1		1	1			7	20.6
March		1			1				1			1			4	19.5
April		2		1	1				1		2	1			8	19.0
May		1		1					2					1	5	20.3
June		2		1							1	1	1		6	21.2
July					1	1			2			2			6	26.3
August		2			3			4	2	3	1	9			24	31.0
September		2		2	1			1	1	2	3	9			21	35.9
October		1	1	1	2			2	2	3	4	19			35	44.9
November		2		2	3			2	2	2	5	21	1	1	41	49.8
December				1				2	4	3	4	15			29	40.0
Total		16	1	11	15	1		11	19	13	22	81	2	2	194	29.1

Area 1: Greece, Turkey 2: Adriatic Sea, Ionian Sea & Sicily 3: West-Coast Italy, Corsica, Sardinia, 4: France, Spain, Morocco, (Mediterranean), Canary Is.
5: N. W. Europe 6: Canada 7: Caribbean Sea, Bahama *: Norwegian Shipping News Tanker Freight Index (VLCC/ULCC)

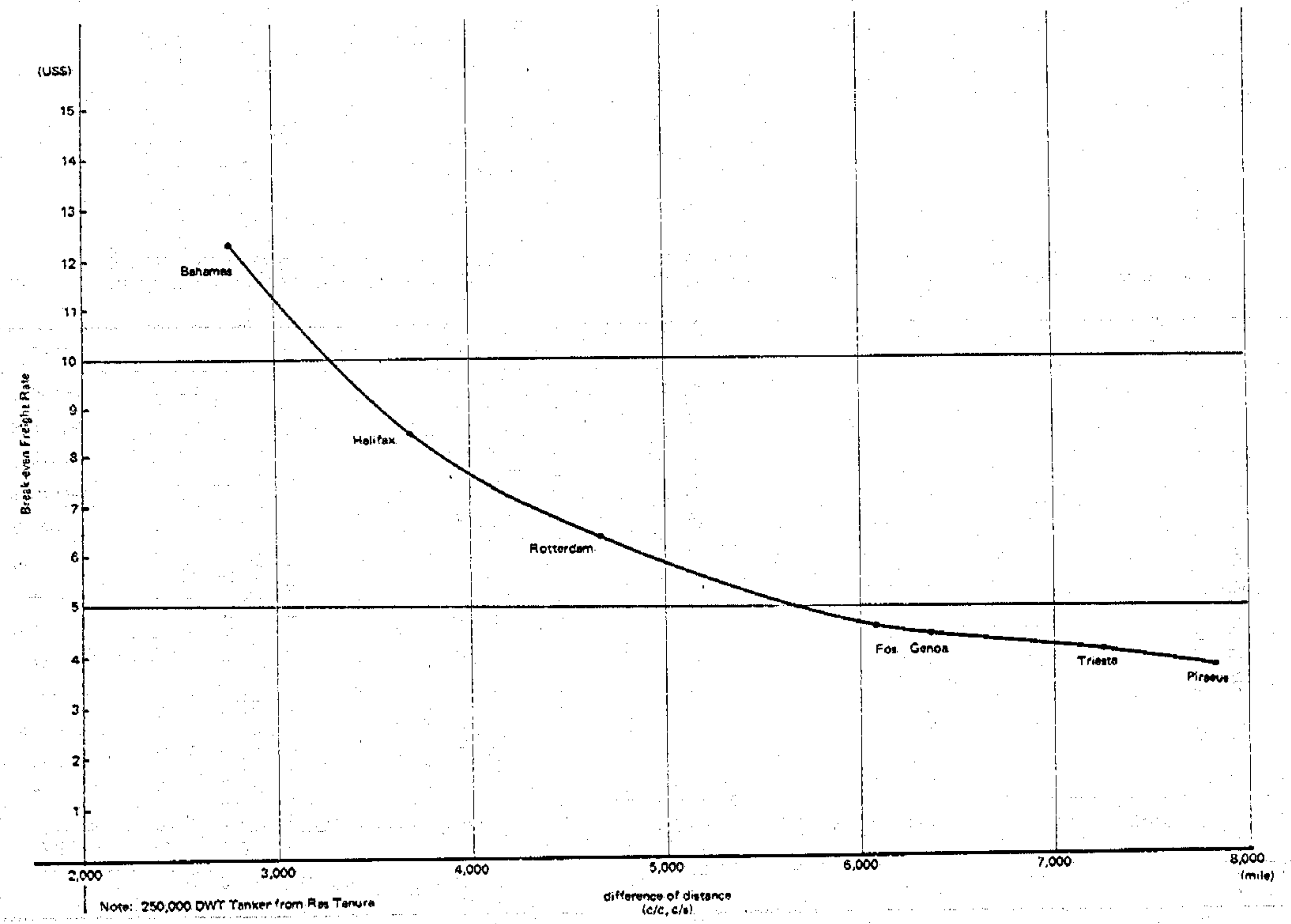


Figure 2-1 Suez/Cape Break-even Freight Rates by Regions

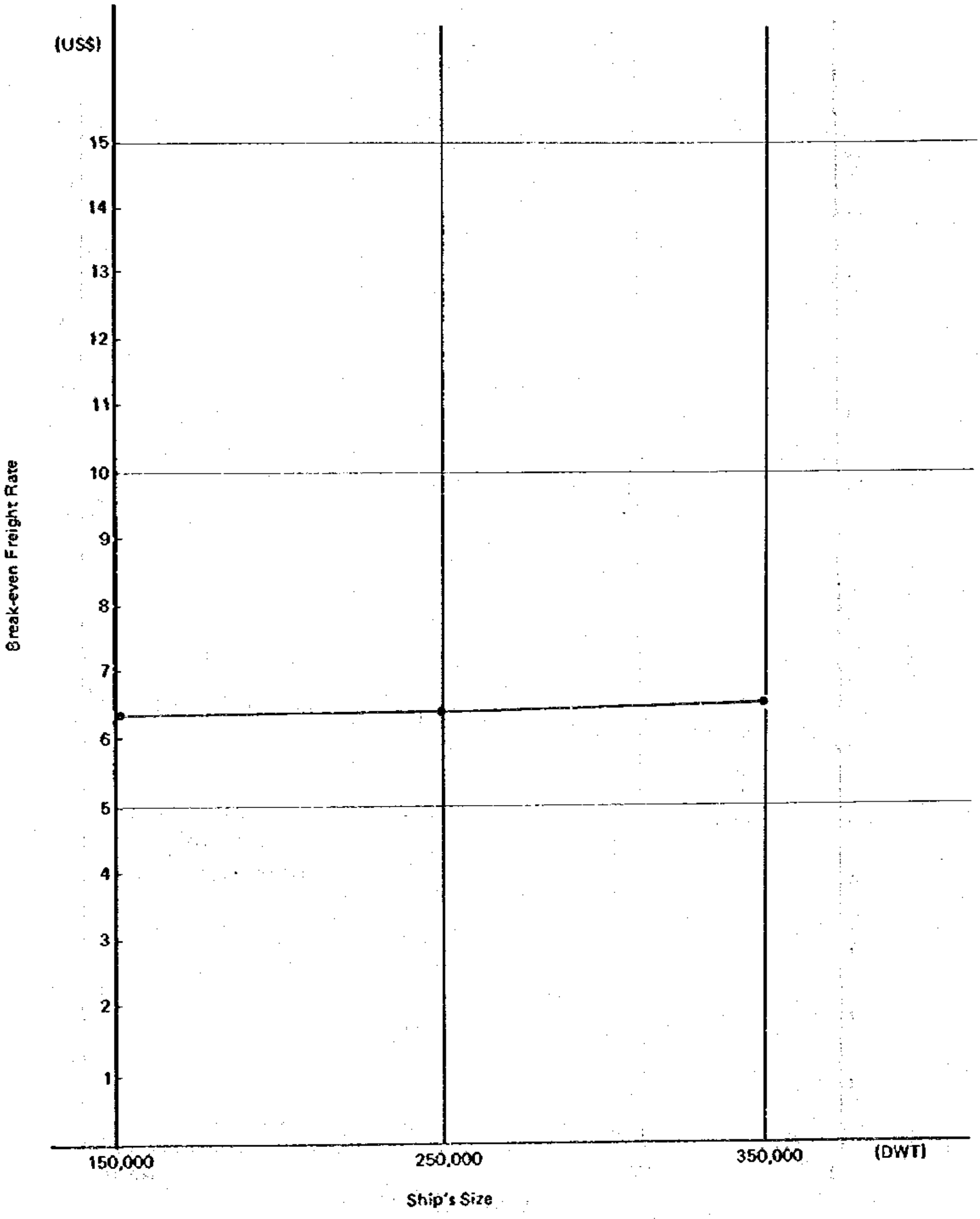


Figure 2-2 Break-even Freight Rates by Ships' Sizes

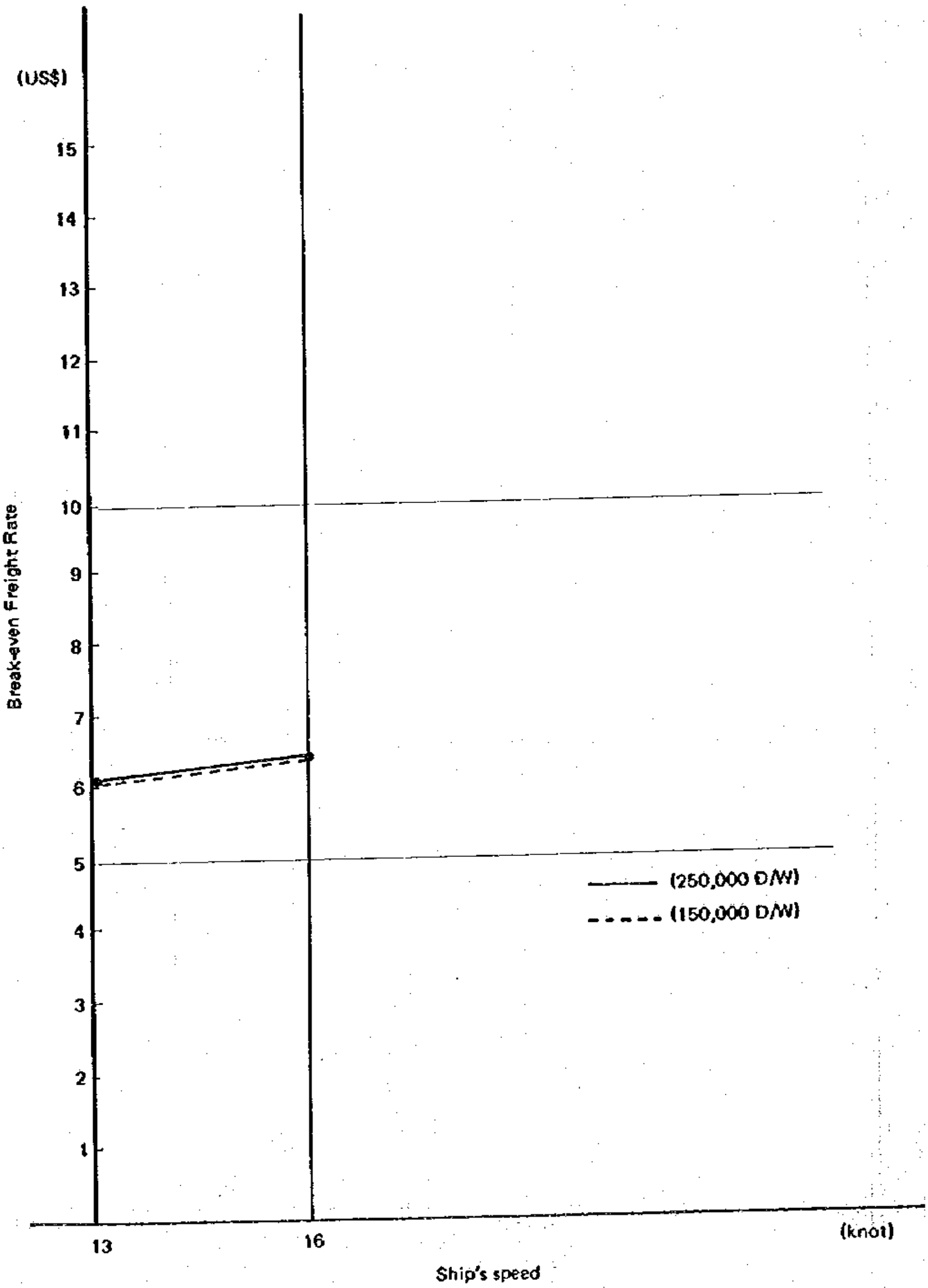


Figure 2-3 Effect of Slow Steaming

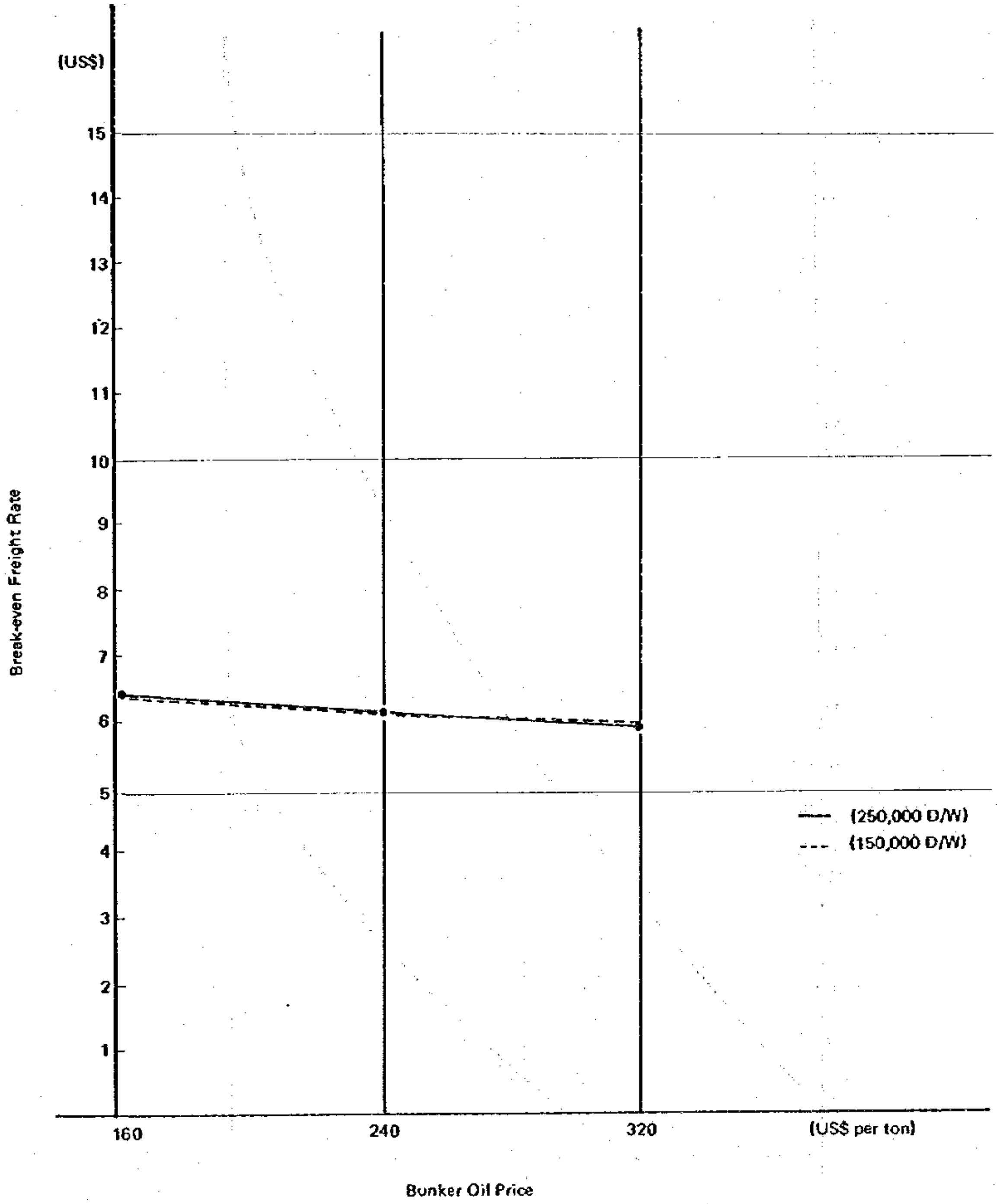


Figure 2-4 Effect of Bunker Oil Price Hike

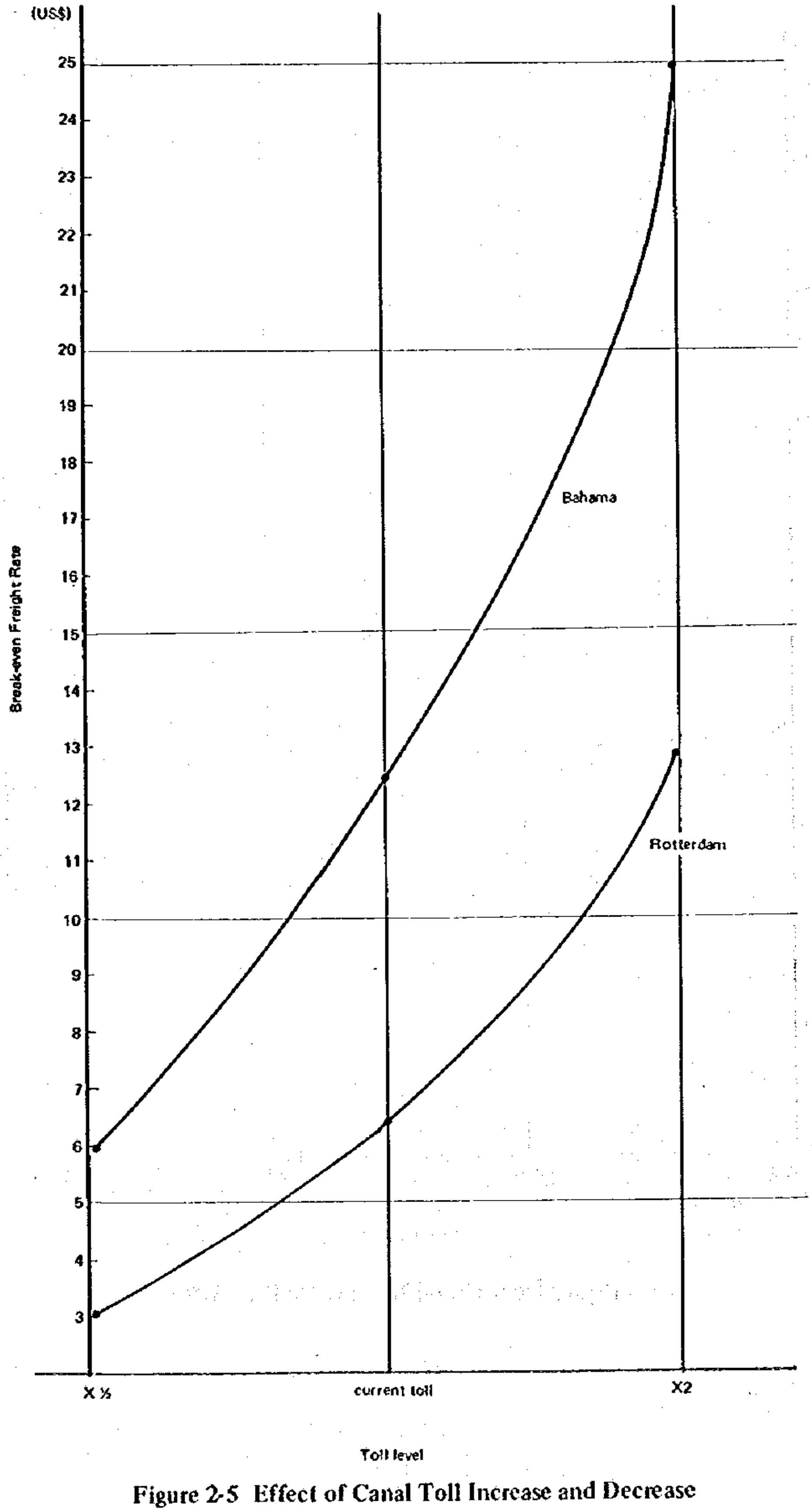


Figure 2-5 Effect of Canal Toll Increase and Decrease

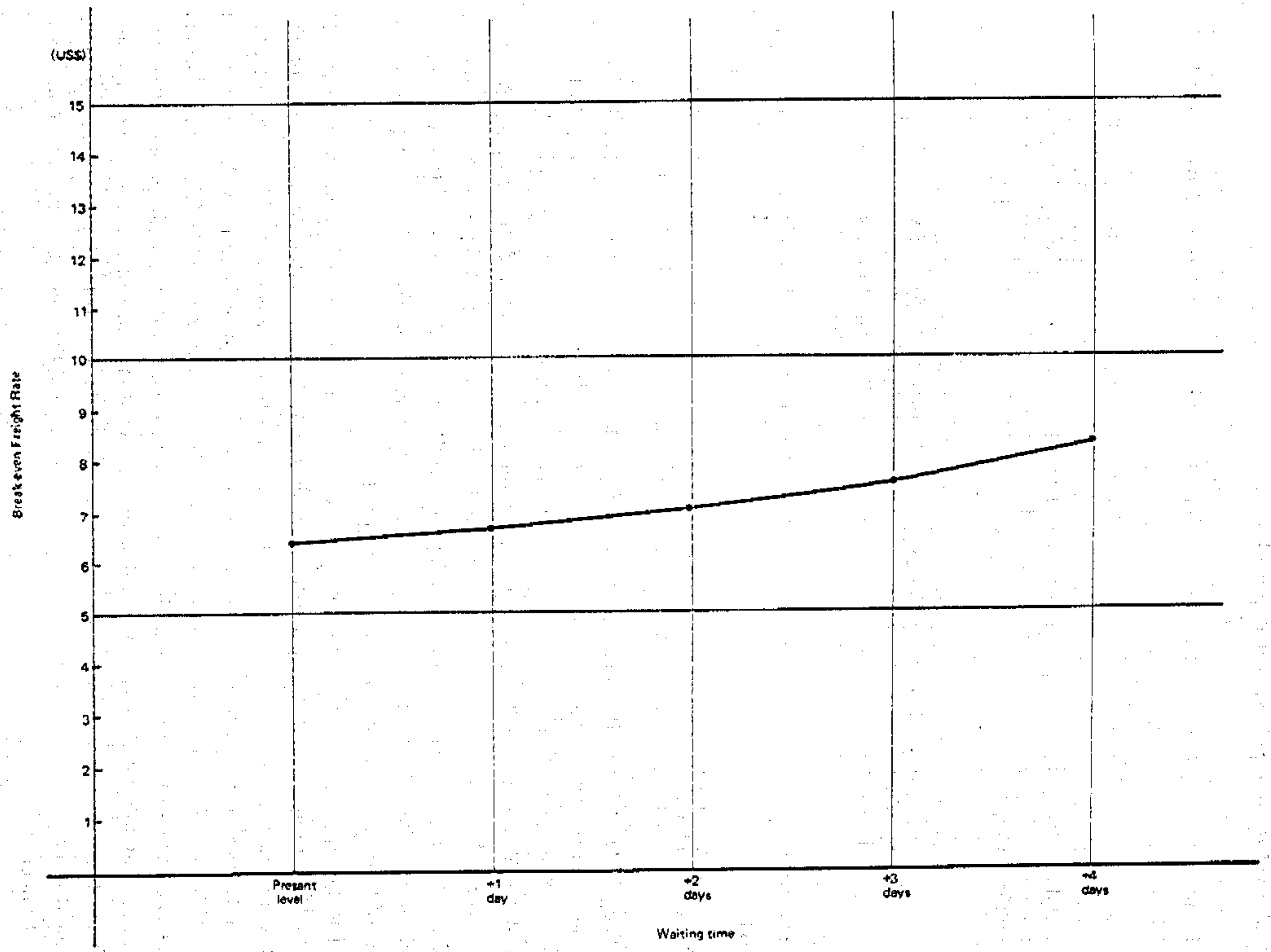
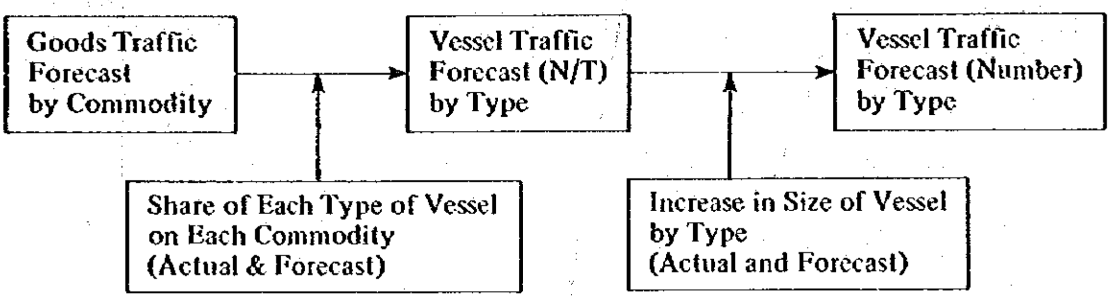


Figure 2-6 Effect of Waiting Increase

2-3 Number of Dry Cargo Ships Traffic and Trend of Increase in Ship Size

2-3-1 Method Used in This Transit Volume Forecast

In this forecast, the transit volume of dry cargo ships was determined by the following method:



Therefore, the number of ships in transit and the increase of ship size were all studied by ship types.

2-3-2 Review of Traffic

See Table 2-9 for the number of dry cargo ships in transit. This number is steadily increasing and the annual increase rate was 4.3% (1959→1978) or 3.7% (1959→1979). Note must be taken of the 1979 decrease from the previous year but it cannot yet be analyzed because no detailed trade data are available now. However, the main cause is the decrease of south-bound cargoes from the previous year due, probably, to the decrease of imports by Iran, and the relative decrease of European exports to the Middle East resulting from the increase of Japanese exports to the Middle East because of the rapidly depreciated yen, and from decreased pressure for export of Europe because of its economic prosperity.

The average size of dry cargo ships greatly increased from 6,017 N/T in 1966 to 10,184 N/T in 1979 (annual rate: 4.1%). Particularly, during 1976–1979 after the reopening of the canal, the annual rate was as high as 9.6%. But when this tendency is analyzed by ship types, the annual rate, as shown in Table 2-10, was rather low with 1.5% for bulk carriers, 2.7% for general cargo ships and 3.0% for container ships and was only high with Ro/Ro (23.5%) and car carriers (9.8%) The cause of this difference in the average size increase (which was high for dry cargo ships as a whole but low by ship types) was due to the fact that bulk carriers and container ships, which are large on the average, increased greatly in number due to the rapidly increased cargo movement of cement, fertilizer, steel and general cargoes and the commissioning of an increased share of full container ships.

2-3-3 World Trend of Ship Size Increase

The size of ships is affected by various factors including total cargo volume, cargo volume by transaction unit and harbor conditions. But the recent general tendency of world shipping clearly shows that the increase of ship size has ceased, at least temporarily. As in Table 2-11, the rate of average size increase by ship types in 1979 over the previous year was 0.2% for bulk carriers, 0.8% for general cargo ships and 3.0% for container ships and is still diminishing. Tankers are even decreasing in size. Such being the case, ship size is considered to increase most slowly in the future.

As to the size increase of container ships. Table 2-12 indicates that the size of container ships operating on major liner routes related to the Suez Canal and container ships already on order has generally leveled off and there is apparently no tendency of size increase at the moment. In short, it is considered that the size increase by three major ship types using the Suez Canal: bulk carriers, general cargo ships and container ships will progress but slowly.

The size increase of dry cargo ships as a whole will be affected by the extent of future increase in trade volume by items but the size increase is likely to slow down in the future, unlike in the past four years, due to the lowering of the share of bulk carriers resulting from the reduced cargo movement of cement and nitrogenous fertilizer and the relatively small increase rate of movement of such cargoes as grains and steel.

2-3-4 Shift from General Cargo Ships to Container Ships

The distribution, by ship types, of the "other cargoes" in 1978 was 61.8% for general cargo ships and 13.3% for container ships. But this forecast is based on the assumption that the share of container ships will increase to 25.5% by the year 2000. (The share of general cargo ships will decrease for that proportion.)

The following are the results of calculation attempted as part of a sensitivity analysis and on the assumption of the case where the share of container ships increases more rapidly to reach 35.5% by 2000:

Increase and Decrease of Number of Vessel Traffic per Day

	1985	1990	1995	2000
General Cargo Ship	△2.0	△4.5	△7.9	△12.9
Container ship	1.2	2.4	3.6	5.0
Total	△0.8	△2.1	△4.3	△7.9

△ : Decrease.

Thus in this case, general cargo ships will decrease while container ships will increase and the balance number of ships will decrease.

However it should be noted that the decrease in 1985 is as little as 0.8 vessel per day and that the decrease of 8 vessels in 2000 (or 9 vessels if the decrease of 1 vessel in 2000 caused by the change of load factor as mentioned later in 2-3-5, is added thereto) causes a delay of only two years 20 years ahead.

2-3-5 Share of Each type of Ship on Each Commodity and Load Factor

In this forecast the vessel traffic volume is calculated through conversion from the estimated goods traffic volume by each commodity. This conversion from goods to vessel is based on the actual traffic in 1978, and as for the share of each type of ship on each commodity, the data of July 1978 is used. Although it may be felt that the data of one month are rather insufficient to represent the whole year, the result of the forecast is considered to be acceptable on the following grounds.

1) As the one month data is used only for distributing the dry cargo traffic data of the whole 1978 into the dry cargo vessel traffic data of the whole 1978, the total load factor of all dry cargo vessels in the year is not changed by the one month data.

2) For confirmation's sake, the data of 4 months of 1979 was applied to produce the load factor of 1979 and to calculate the future dry cargo vessel traffic. The result was, as compared with the "Base" Case, an increase of 0.2 vessel per day in 1985 and a decrease of 1.0 in 2000.

3) In the meantime the total load factor 0.80 (dry cargo M/T per dry cargo vessel N/T) in 1978 is nearly equal to 0.81 in 1976–1978 in average and 0.82 in 1979. The future load factor will tend towards a gradual decline due to increased share of general cargo.

Table 2-9 Non-Tanker Traffic Volume before the Canal's Closure and after Its Reopening

Year	Vessel (No.)	Vessel (10^3 NRT)	Cargo (10^3 ton)	No. of Transit Ships per day
1959	8,520	49,046	47,039	23.3
1962	9,088	55,501	52,215	24.9
1966	11,320	68,116	66,222	31.0
1976	14,197	109,856	83,829	38.8
1977	17,083	144,909	93,748	46.8
1978	18,777	174,336	116,600	51.4
1979	17,665	179,893	124,395	49.4
1979/1966 (%)	156.1	264.1	187.8	156.1

note: Vessel – except Tanker
Cargo – except Petroleum & its Products
source: Suez Canal Report

Table 2-10 Transited Tonnage and Average Ships' Size by Type

Type \ Year	1976 NRT (10^3 N/T)	1976 No.	1976 Av. N/T	1977 NRT (10^3 N/T)	1977 No.	1977 Av. N/T	1978 NRT (10^3 N/T)	1978 No.	1978 Av. N/T	1979 NRT (10^3 N/T)	1979 No.	1979 Av. N/T	Av. N/T Yearly Increase 1976–1979 (%)
Tanker	77,903	2,610	29.848	75,568	2,620	28.843	73,924	2,489	29.700	86,278	2,698	31.979	2.3
Bulk Carrier	23,395	1,608	14.549	26,202	1,818	14.413	36,783	2,513	14.637	36,390	2,393	15.207	1.5
Combined Carr.	4,765	110	43.318	5,722	147	38.925	5,518	144	38.319	4,853	122	39.779	△2.8
General Cargo	59,339	9,789	6.062	66,587	10,970	6.070	74,521	11,721	6.358	69,380	10,562	6.569	2.7
Container	4,545	417	10.899	21,604	1,130	19.119	29,795	1,437	19.903	33,798	1,666	20.287	3.0*
LASH	2,296	69	33.275	2,548	82	30.951	2,117	69	30.681	2,641	91	29.022	△4.5
RO/RO	7,605	1,134	6.706	12,218	1,600	7.636	11,673	1,398	8.350	16,328	1,292	12.638	23.5
Car. Carrier	5,411	258	20.973	5,748	242	23.752	9,805	373	26.287	12,315	444	27.736	9.8
Passager ship	709	55	12.891	1,026	81	12.667	987	87	11.345	996	82	12.146	△2.0
War ship	334	91	3,670	601	100	6.040	405	122	3.320	500	149	3.356	△2.9
Others	1,457	665	2.191	2,660	913	2.913	2,732	853	3.203	2,692	864	3.116	12.5
Total	187,759	16,806	11.172	220,477	19,703	11.190	248,260	21,266	11.674	266,171	20,363	13.071	5.4
Non-Tankers	109,856	14,195	7.739	144,909	17,083	8.483	174,336	18,777	9.285	179,893	17,665	10.184	9.6

Source: Suez Canal Report   *: 1977–1979

Table 2-11 World Fleets – Analysis by Principal Types

Year	Oil Tankers				Ore & Bulk Carriers				General Cargo (Inc. Passenger/Cargo)			
	No.	Tons Gross (1,000)	Av.	Yearly Increase	No.	Tons Gross (1,000)	Av.	Yearly Increase	No.	Tons Gross (1,000)	Av.	Yearly Increase
1970	6,103	86,140	14.114		2,321	38,334	16.516		22,366	72,396	3.237	
1971	6,292	96,141	15.280	8.3	2,520	43,124	17.113	3.6	22,023	71,931	3.266	0.9
1972	6,462	105,129	16.269	6.5	2,754	48,415	17.580	2.7	21,657	70,591	3,260	△ 0.2
1973	6,607	115,365	17.461	7.3	2,954	53,110	17.979	2.3	21,389	69,506	3.250	△ 0.3
1974	6,785	129,491	19.085	9.3	3,111	57,403	18.452	2.6	21,139	68,674	3.249	0
1975	7,024	150,057	21.363	11.9	3,308	61,832	18.692	1.3	21,353	70,399	3.297	1.5
1976	7,020	168,161	23.955	12.1	3,513	66,714	18.991	1.6	21,706	73,608	3.391	2.9
1977	6,912	174,124	25.192	5.2	3,887	74,832	19.252	1.4	22,061	77,088	3.494	3.0
1978	6,882	175,035	25.434	1.0	4,130	80,173	19.412	0.8	22,368	79,675	3.562	1.9
1979	6,950	174,213	25.067	△ 1.4	4,208	81,827	19.446	0.2	22,744	81,678	3.591	0.8

Year	Container Ships (Fully Cellular)				Vehicle Carriers				Total (All types)			
	No.	Tons Gross (1,000)	Av.	Yearly Increase	No.	Tons Gross (1,000)	Av.	Yearly Increase	No.	Tons Gross (1,000)	Av.	Yearly Increase
1970	167	1,908	11.425						52,444	227,490	4.338	
1971	231	2,781	12.039	5.4					55,041	247,203	4.491	3.5
1972	312	4,310	13.814	14.7	125	488	3.904		57,391	268,340	4.676	4.1
1973	394	5,899	14.972	8.4	103	359	3,485	△10.7	59,606	289,927	4.864	4.0
1974	412	6,291	15.269	2.0	127	469	3.693	6.0	61,194	311,323	5.087	4.6
1975	419	6,244	14.902	△ 2.4	142	542	3.817	3.4	63,724	342,162	5.369	5.5
1976	443	6,685	15.090	1.3	166	687	4.139	8.4	65,887	372,000	5.646	5.2
1977	507	7,543	14.878	△ 1.4	114	633	5.553	34.2	67,945	393,678	5.794	2.6
1978	531	8,674	16.335	9.8	159	1,200	7.547	35.9	69,020	406,002	5.882	1.5
1979	594	9,996	16.828	3.0	187	1,588	8.492	12.5	71,129	413,021	5.807	△ 1.3

Source: "Lloyd's Register of Shipping"

Table 2-12 Cellular Container Ships in Service

Year	No.	10^3 GT		10^3 DWT		TEU	
1970. 6	154	1,987.3	(12.9)			98,065	(637)
1971. 7	129	2,212.2	(17.1)	2,283.7	(17.7)	111,431	(864)
1972. 7	184	3,622.8	(19.7)	3,571.1	(19.4)	174,236	(947)
1973. 1	217	4,622	(21.3)	4,498	(20.7)	221,322	(1,020)
1974. 1	256	5,905	(23.1)	5,823	(22.7)	281,651	(1,100)
1975.1	306	6,384	(20.9)	5,952	(19.5)	306,689	(1,002)
1976. 1	325	6,842	(21.1)	6,582	(20.3)	355,323	(1,093)
1977. 1	354	7,459	(21.1)	7,136	(20.2)	389,856	(1,101)
1978. 1	385	8,554	(22.2)	8,187	(21.3)	440,351	(1,144)
1979. 1	463	9,914	(21.4)	10,039	(21.7)	525,625	(1,135)

* Source: Japanese Shipowners' Association "Maritime Transportation Statistics 1980"
*( ) : Av.
TEU: Twenty-footer Equivalent Unit (8'x8'x20' equivalent container capacity)

Table 2-13 Average Size of Full Container Ships on Order by Route

Route	Unit	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Far East/Europe	DWT	36,233	37,121	42,000	23,450	30,000	26,866	27,550	25,500		
	TEU	1,913	1,914	1,900	1,798	1,671	1,629	1,251	1,500		
Far East/Mediterranean	DWT				25,000			24,500	21,000	23,200	
	TEU				1,409			1,436	1,039	1,402	
North America Atl./India,	DWT			39,100		14,200					
Pakistan and Red Sea	TEU			–		528					
Europe/Australia,	DWT	30,000	20,000		22,000	14,900	19,400	38,750	33,700	18,000	18,000
Newzealand	TEU	1,300	1,400		1,400	1,611	1,470	2,079	1,814	941	941
Far East/Middle East	DWT						6,500	15,500			
	TEU						300	1,300			
Europe/India, Pakistan	DWT							21,000			
and South East Asia	TEU							640			
Europe/Middle East	DWT							15,870	14,550	25,000	
	TEU							629	599	–	
Far East/North America/	DWT										22,480
Middle East	TEU										1,703
Total (incl. Other Routes)	DWT	23,963	19,973	23,286	25,263	17,272	16,091	21,245	13,795	12,298	20,256
	TEU	1,152	1,007	1,410	1,289	926	858	1,090	623	624	958

* Source: Fairplay "Ships on Order"

Chapter 3

TRANSIT CAPACITY AND SHIP-TO-SHIP INTERVALS

Chapter 3 TRANSIT CAPACITY AND SHIP-TO-SHIP INTERVALS

This section deals with the additional study conducted on Items Nos. 1 and 3 of the comments in the letter sent to the Japanese ambassador in Egypt in April 1980 by Chairman Mashhour of the Suez Canal Authority concerning the Draft Report.

These comments are as follows:

1- The size of ships is increasing and the average transit number is quasi-constant from 1976 uptil now. It reached a mean of 60.9 during the first quarter of 1980. Also the Canal can allow in particular condition 75 ships per day

2- (Omitted)

3- The Suez Canal tugs will escort the loaded VLCC's of more than 100,000 D.W.T. and more than 250,000 D.W.T. in ballast. The spacing between two tankers will be reduced from twelve length of the ships to 5 or 6 length, and that will increase the Suez Canal capacity.

3-1 Transit Capacity

The transit capacity of the Canal is studied in detail in Part VI and VII of the Main Report. We elaborate on transit capacity in conjunction with the above Item 1, as follows:

The transit capacity of the Canal after the completion of the First Stage Project is estimated below:

	Standard Ships (Ships/day)	Real Ship (Ships/day)
Theoretical Capacity	84	92
Daily Average Capacity	65	72

a. "Standard ships" are ships navigating at intervals of 10 minutes. "Real ships" navigate the Canal at intervals of five to 20 minutes, depending on types and sizes. The relation between real ships and standard ships may be generally regarded as follows:

Transit number of real ships/transit number of standard ships ≑ 1.1

b. The theoretical transit capacity is computed from the daily number of hours available for transit by preparing the Canal transit diagram. This may be considered as the maximum daily number of ships that can transit the Canal.

c. A daily average capacity should agree with the daily number of ships transiting the Canal when one or two queues per month occur at Port Said and Suez.

Thus, a maximum of 92 ships (84 standard ships) can transit the Canal daily after the completion of the First Stage Project. Under these conditions, however, users will experience chronic delays at both ends of the Canal.

If only 72 ships (65 standard ships) transit the Canal daily, there will not be more than one or two queues per month, but, as has been confirmed from the results of the simulation test covered by the Main Report, there will be chronic delays if the number of ships (real ships) exceeds 80.

Therefore, 75 ships (real ships) daily, as pointed out in the letter, is the number of ships that can navigate the Canal daily, but at this level, some queuing at both ends of the Canal will occur. To avoid this outcome, the canal capacity after the completion of the First Stage Project should be increased before the daily ships in transit reaches 72. The Main Report proposes that the Canal capacity be increased by the start of chronic delays, at the latest.

3-2 Method of VLCC Transit

The transit system for VLCCs to navigate the Canal after the completion of the First Stage Project has been studied in detail in Part VII of the Main Report but it may be described again, this time in conjunction with Item 3 of the comments as follows:

1) Escort Tug for VLCCs

Without the support of powerful tugboats, it is impossible for a VLCC navigating the Canal to make emergency stops without running aground on the Canal side slope. Even under the current transit regulations, a tanker of more than 1,000 ft. in length must use tugboat, and the time interval between such tankers is 16 minutes (1.5–2.0 times interval for non-tankers).

Main Report proposes the support of tugboats for tankers navigating the Canal after the completion of the First Stage Project as follows:

Tanker Size DWT	Loaded		In ballast	
	Power HP	No. of Tug	Power HP	No. of Tug
~ 60,000	3000 ~	1	3000 ~	1
60,000 ~ 150,000	3000 ~	2	3000 ~	2
200,000 ~			3000 ~	3

Even with these powerful tugboats ready to support emergency stops, sufficient time intervals should be required to enhance safety.

2) Time Intervals between Tankers

The following time intervals for VLCCs are proposed in accordance with analysis of the current Rules of Navigation, the transit records of the first two weeks of September 1979, and the navigational behavior of VLCCs.

Time Interval between Tankers

Proposed		Rules of Navigation		Actual Record (1 ~ 15/9, 1980)	
0 ~ 60,000 DWT	12 mins	0 ~ 14,000 NRT	10 mins	0 ~ 30,000 DWT	11 mins
~ 150,000	16	14,000 ~	16		
~ 250,000	16				
~ 300,000	16	Ship loaded with fissile material	20	30,000 ~	12 ~ 20
300,000 ~	16				

The proposal of 16 minutes for tankers of more than 60,000 DWT is on the following grounds:

Assuming that the effects of winds and tides are small, a tanker transiting the Canal at the speed of 7 kt must have a stopping distance of at least 4–6 L, even with the aid of a powerful tugboat. When making an emergency stop, a tanker cannot do so while proceeding linearly; normally it turns either right or left during the stop. So, a VLCC must have more than sufficient distance to be able to stop without touching the slopes on either sides of the narrow Canal. Supposing 2.0 as the safety factor for the stopping distance of a 150,000 DWT tanker, the stopping distance is: 12 x L = 3,480 m, which distance corresponds to the time interval of 16.6 minutes. Accordingly, this study proposes 16 minutes as the necessary time interval from the standpoint of navigational safety.

As pointed out in Item 3, it may be possible to use 5–6 L as the time interval for VLCCs, but we cannot agree to adopt such a short interval immediately after the completion of the First Stage Project. Rather, the use of a shorter interval should be considered when the SCA has become thoroughly experienced in the Canal operation of VLCCs and after confirming the reliability of the SCVTMS.

3-3 Effect of Time Interval on Capacity

As stated above, using a short time interval for VLCCs is undesirable from the view-point of navigational safety. Let us now see the extent to which the shortening of time intervals for VLCCs can contribute to the increase of transit capacity.

Assuming 1.5 as the safety factor for the stopping distance, the time interval is about 12 minutes. We have tested the time of saturation of the Canal capacity by standard ships, using 12 minutes as the time interval for VLCCs and using the same method as in Part IV of the Main Report. Fig. 3-1 shows the relation between the transit volume by standard ships and the Canal capacity at each stage of doubling. It indicates that the transit volume reaches the capacity at each stage of doubling when the capacity and the transit volume cross each other. Table 3-1 shows the years in which the capacity will be reached. It indicates that the shortening of time interval from 16 to 12 minutes has the effect of putting off the time of capacity saturation by only a year or so.

This has been confirmed by a real-ship simulation test shown in Figs. 3-2~3-4. The results of the simulation test indicate that, as in the study using standard ships, the serious situation of delays can only be put off for a year or two.

One can see from the above that shortening of the time interval for VLCCs cannot significantly contribute to the increase of transit capacity.

Thus, it is most desirable for transit capacity to be gradually increased by doubling as required by Canal users. The shortening of time intervals should be avoided from the view-point of navigational safety.

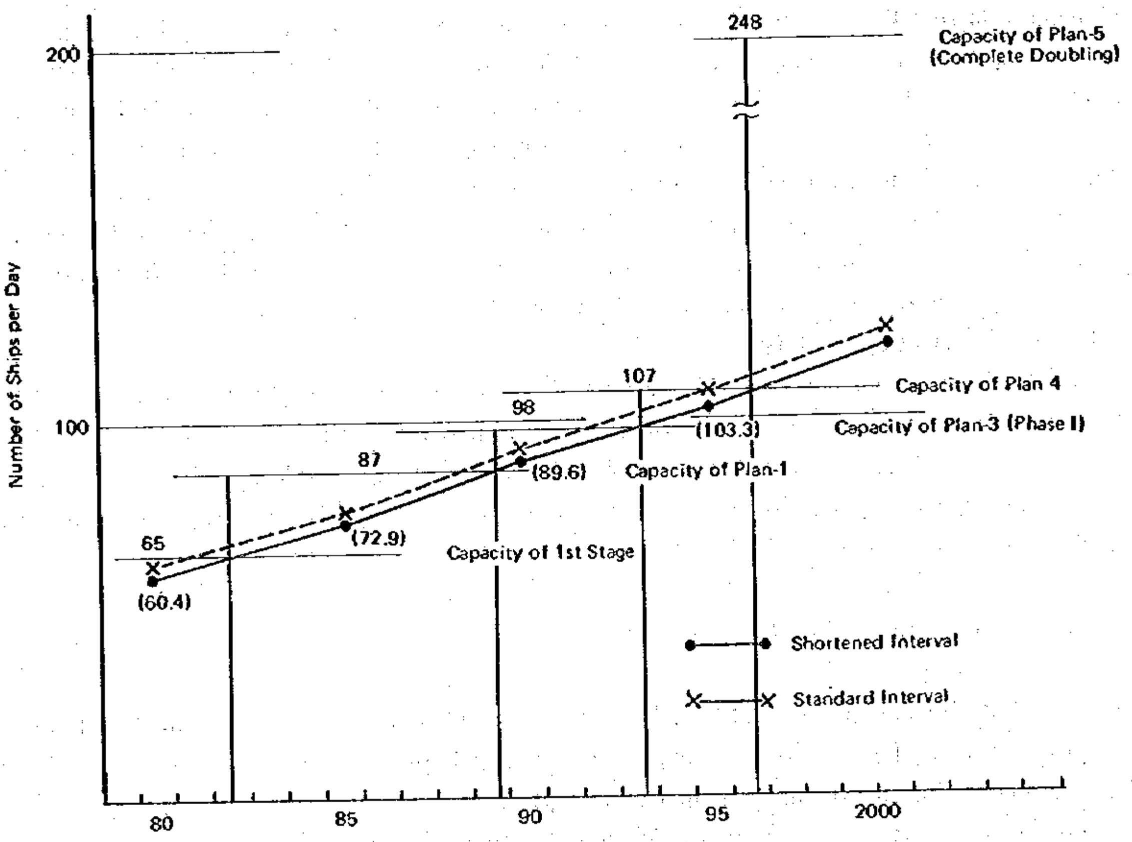


Fig. 3-1 Demand and Transit Capacity
(Standard Ships)

Table 3-1 Saturation Year of the Canal Capacity

	Shortened Interval	Standard Interval
Existing	1982	1981
Plan 1	1989	1988
Plan 3	1993	1992
Plan 4	1996	1995
Plan 5	after 2000	after 2000

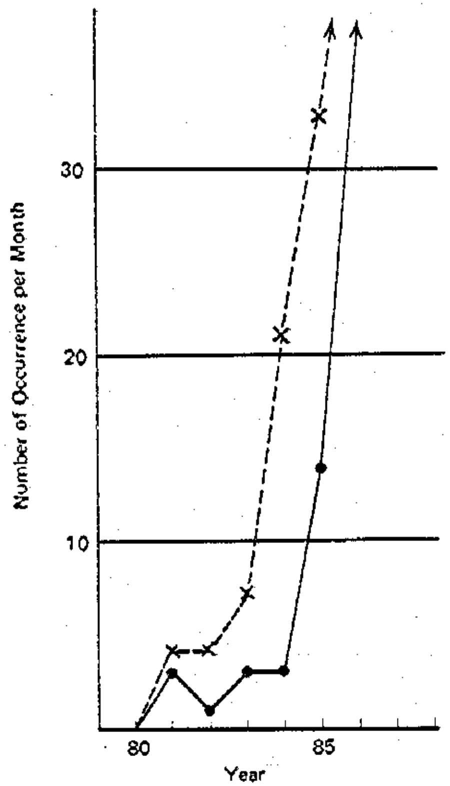


Fig. 3-2 Occurrence of Ship Waiting

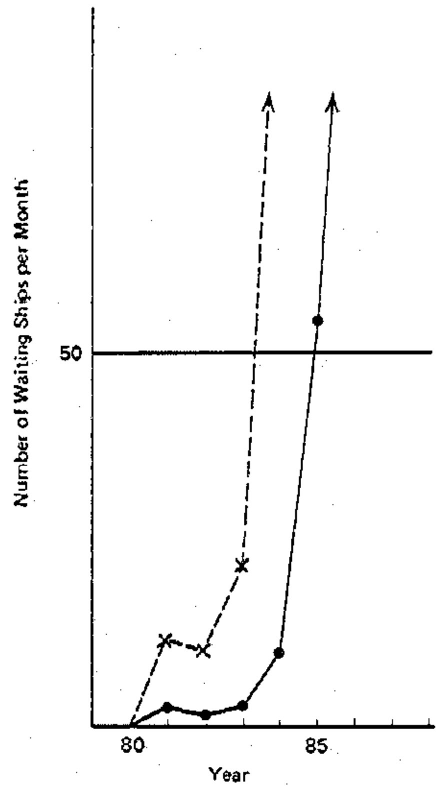


Fig. 3-3 Waiting Ships

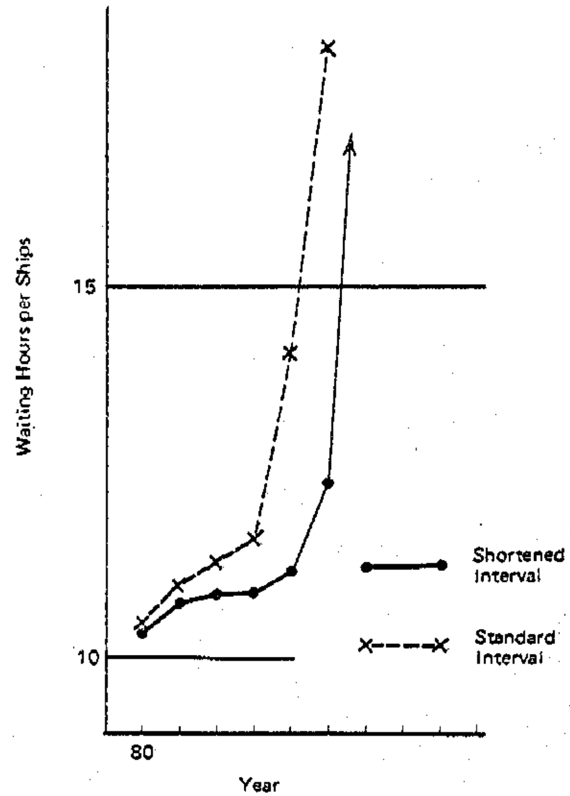


Fig. 3-4 Waiting Hours

Chapter 4
WIDENING PLAN OF WEST CHANNEL

Chapter 4 WIDENING PLAN OF WEST CHANNEL

The Second Stage Project is planned under the policy of doubling the Canal, prior to widening and deepening the section. As a result, the soil of several million m^3 will remain to be dredged in the western channel. However, it is possible that this remaining volume can be dredged under the Second Stage Project, rather than under the Master Plan, and thereby greatly reduce the costs. Accordingly, the supplementary feasibility study is conducted for the Doubling and Widening Plan to dredge the western channel to the section designed under the Master Plan.

4-1 Traffic Demand Forecast

This section describes the forecasted number of ships passing through the Suez Canal and the Canal revenue using the Doubling and Widening Plan.

The forecasting of traffic demand under the Doubling Plan is summarized in the Main Report. Here, the main points of the results of forecasting in this section are described in reference to the results of the forecast set forth in the Main Report.

(1) Traffic forecasting method

The traffic demand forecast is classified broadly into tankers and non-tankers. The Doubling and Widening Plan is to allow the southbound transit of the ULCCs of 350,000 DWT or more along the Canal, the traffic demand of non-tankers is not different from the results of forecasting under the Doubling Plan. That is, the Doubling and Widening Plan is expected to permit the transit of the southbound tankers and contribute to an increase in the number of the transiting tankers and the revenue.

The traffic forecast method employed in this section is the same to that described in the Main Report, except for the input data. The tanker forecasting model is illustrated in Fig. 4-1. From the input data to this model (the maximum navigable ship size) changed as shown in Table 4-1.

Table 4-1 Maximum Navigable Ship Size

	Doubling and Widening Plan	Doubling Plan
Southbound (in ballast)	All Existing Tankers can pass through the Canal.	Maximum 350,000 DWT
Northbound (laden)	Maximum 150,000 DWT	Maximum 150,000 DWT

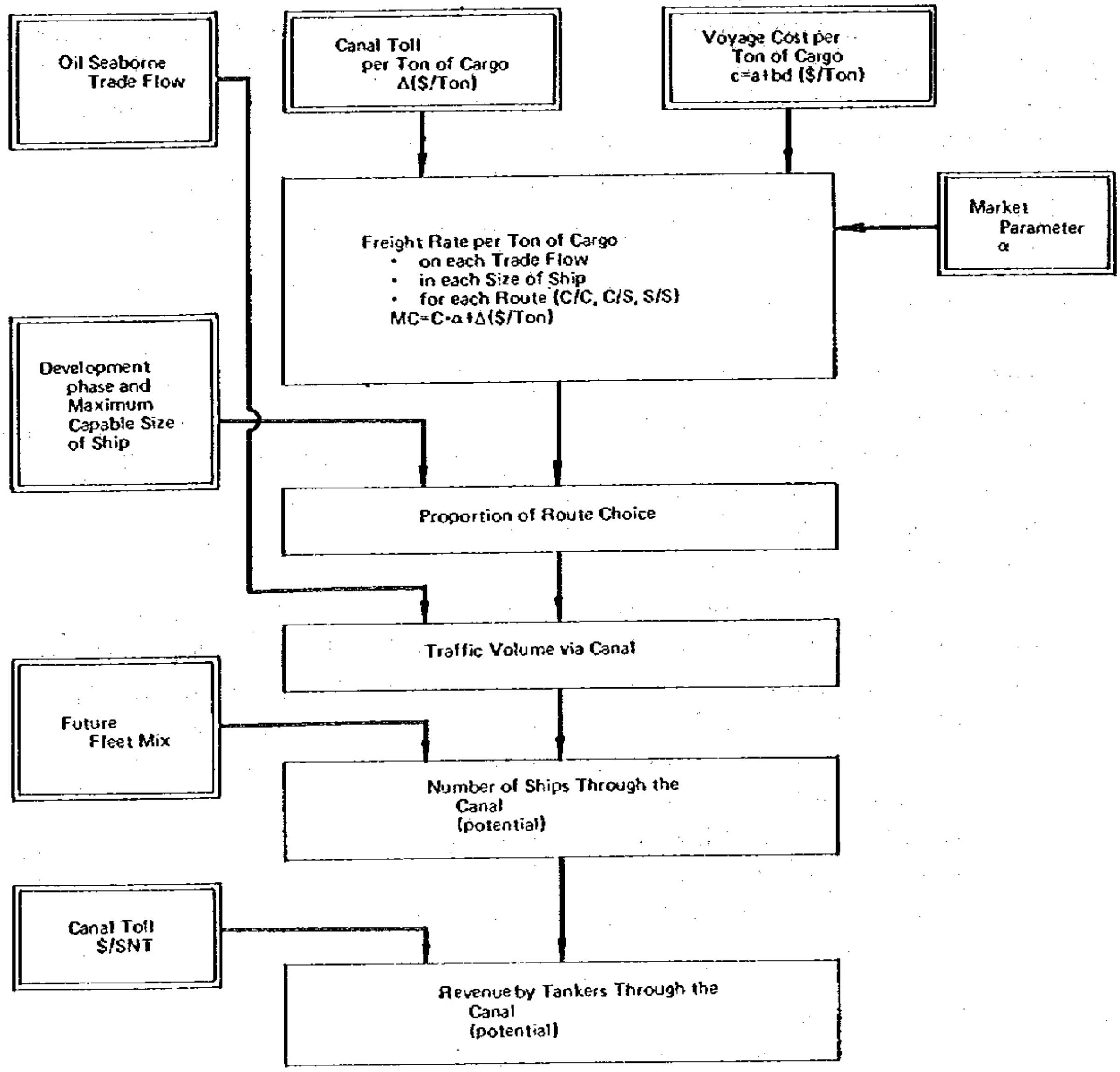


Fig. 4-1 Outline of Tanker Forecasting Model

(2) Result of Traffic forecast

For the High Case, Base Case and Low Case stated in the Main Report, the potential number and potential revenue are forecasted. The result of forecast under the Doubling and Widening Plan is shown in Table 4-2, in reference to that under the Doubling Plan.

Table 4-2 Potential Traffic Number and Potential Revenue

	Case		1980	1985	1990	1995	2000
Potential Number (Ships/day)	Doubling and Widening	High	70.36	91.99	118.39	141.86	171.16
		Base	68.28	83.89	103.34	120.07	139.63
		Low	66.20	76.55	92.64	108.10	125.44
	Doubling	High	70.27	91.76	118.09	141.54	170.84
		Base	68.22	83.73	103.10	119.79	139.33
		Low	66.16	76.47	92.51	107.92	125.28
Potential Revenue (10^6 US$/year)	Doubling and Widening	High	846.5	1154.9	1485.5	1765.0	2086.6
		Base	792.9	1041.7	1320.8	1542.0	1768.0
		Low	734.8	900.6	1141.7	1358.9	1574.7
	Doubling	High	835.0	1126.4	1448.1	1723.9	2045.8
		Base	785.2	1021.6	1290.6	1506.7	1730.5
		Low	730.5	890.9	1125.5	1336.4	1548.4

Differences in the ship number and Canal revenue between the Doubling and Widening Plan and the Doubling Plan are shown in Table 4-3. These differences are indicative of the increments attributable to the transit of ULCC of 350,000 DWT or more. The number of non-tankers and revenue are assumed the same in both plans.

Table 4-3 Increase in Potential Number and Potential Revenue

	Case	1980	1885	1990	1995	2000
Increase in Potential Number (Ships/day)	High	0.09	0.23	0.30	0.32	0.32
	Base	0.06	0.16	0.24	0.28	0.30
	Low	0.04	0.08	0.13	0.18	0.21
Increase in Potential Revenue (10^6 US$/Year)	High	11.5	28.5	37.4	41.1	40.8
	Base	7.7	20.1	30.2	36.2	37.5
	Low	4.3	9.7	16.2	22.5	26.3

Increase = (Doubling and Widening Plan) − (Doubling Plan)

Low Case represents a delay in the recovery of tanker market. Thus, the widening is of little effect with the revenue increase in 1885 at about 10 million US dollars. High Case assumes the recovery of tanker market being accelerated and is, therefore, of the greatest effect of widening with the revenue increase in 1885 at about 29 million US dollars. In each case, the effect of widening is produced with recovery of the market; a revenue increase of 26 to 41 million US dollars is prospected in 2000.

To represent the increases of the number and revenue more minutely, the details are shown in Table 4-4 with respect to Base Case. The year 1980 is listed for comparison purposes.

Table 4-4 Tanker Traffic Number and Tanker Revenue: Base Case

(Ships) (10^6 US$)

Year	Case	Number of Ships/day			Canal Revenue/year		
		North	South	Total	North	South	Total
1980	D/W	4.60	6.84	11.44	91.80	226.29	318.10
	D	4.60	6.78	11.38	91.80	218.64	310.45
	Difference	0	0.06	0.06	0	7.65	7.65
1985	D/W	4.78	7.97	12.75	102.05	323.86	425.91
	D	4.78	7.81	12.59	102.05	303.76	405.81
	Difference	0	0.16	0.16	0	20.10	20.10
1990	D/W	5.46	9.21	14.67	129.54	398.02	527.56
	D	5.46	8.98	14.44	129.54	369.29	498.83
	Difference	0	0.23	0.23	0	30.22	30.22
1995	D/W	5.78	9.80	15.58	142.83	436.73	578.76
	D	5.78	9.52	15.30	142.03	400.58	542.61
	Difference	0	0.28	0.28	0	36.15	36.15
2000	D/W	5.86	9.83	15.69	148.35	439.89	588.24
	D	5.86	9.53	15.39	148.35	402.37	550.72
	Difference	0	0.30	0.30	0	37.52	37.52

In the depressed economic year of 1980, the increase in the number of transits by widening is 0.06 ship a day, and in the revenue is about 7 million US dollars. However, with recovery of the market conditions, the effect of widening begins to appear, and the number increases to 0.3 ship a day with a revenue of about 36 million US dollars in 2000.

(3) Summary

(i) For the Doubling and Widening Plan, which was intended to permit Canal transit of ULCC of 350,000 DWT or more, the transiting ship number and Canal revenue are forecasted.

(ii) The proportion in tonnage (DWT) of the 350,000 DWT or more large tankers to the whole tankers varys from route to route. But, it is at 10–13% in the Arabian Gulf – Northwestern Europe and Arabian Gulf – North America routes and at about 5% in the Arabian Gulf – Mediterranean route. However, whether or not all of these large tankers pass through the Suez Canal is dependent greatly on the market condition. In the boom period, increasing number of tankers use the Suez Canal, and in depressions, use the Cape route.

(iii) Traffic demand forecasting was made of three cases, Base Case assuming that the tanker market will recover in the latter half of 1980's, High Case for earlier recovery and Low Case for later recovery. As the result, the effect of widening on the revenue is 10 million

US dollars (Low Case) to 29 million US dollars (High Case) in 1985, or 26 million US dollars (Low Case) to 41 million US dollars (High Case) in 2000. The effect on the number is about 0.2 ships per day in High Case in 1985 and from 0.2 ship per day (Low Case) to 0.3 ship a day (High Case) in 2000. The effect of securing transit of large tankers is not much in depression but is appreciable in the boom period and is expected to be about 2% of the gross Canal revenue or about 6% of the gross tanker revenue.

4-2 Implementation Plan

4-2-1 Outline

The Second Stage Project and the Master Plan in the Main Report compare as below with respect to the dredging volume.

	Second Stage Project	Master plan
Western channel	$253{,}600 \times 10^3 m^3$	$298{,}200 \times 10^3 m^3$
Eastern channel	$302{,}200 \times 10^3 m^3$	$729{,}800 \times 10^3 m^3$
Total	$555{,}800 \times 10^3 m^3$	$1{,}029{,}000 \times 10^3 m^3$

Most of the remaining volume to be dredged after the Second Stage Project is in the eastern channel, since the western channel will have only about 45 million m^3 dredged, or less than 10% of the total. If the remaining volume in the western channel can be dredged under the Second Stage Project, the maximum vessel size will increase from 350,000 DWT tankers in ballast under the Second Stage to 500,000 DWT tankers in ballast under the Master Plan.

The Second Stage Project is planned under the policy of doubling the Canal, prior to widening and deepening the section, without changing the design ship size under the First Stage Project. As a result, the 45 million m^3 will remain to be dredged in the western channel. However, it is possible that this remaining volume can be dredged under the Second Stage Project, rather than under the Master Plan, and thereby greatly reduce the costs. Accordingly, the supplementary feasibility study is conducted for the Doubling and Widening Plan to dredge the western channel to the section designed under the Master Plan.

4-2-2 Implementation plan

The dredging sections are shown in Fig. 5-2-3 in the Main Report, with the western channel dredged to the section designed under the Master Plan and the eastern channel dredged to that under the Second Stage Project. Table 4-5 shows the volume to be dredged.

Since the sounding map after the First Stage Project is not complete, the dredging volume has been calculated on the basis of the design section of the Second Stage Project. The section dredged under the First Stage Project is naturally larger than the design section both in width and in depth. Accordingly, the dredging volume computed from a sounding map is considered less than the above values. Therefore, while the dredging volume for the section to be doubled is accurate, dredging volume of the sections to be either widened or deepened contains considerable errors.

In particular, the Ballah and Deversoir Bypass sections, where the depth is to be increased by 0.5–1.0m, may already have sufficient depth, and we expect that the required depth will be more easily secured than as predicted. Therefore, we recommend carrying out sounding surveys to ascertain the actual dredging necessities.

The allocation of channel sections to either SCA or dredging contractors should be made on the basis of SCA capacities. In other words, SCA should dredge the easiest sections within the range of its equipment, and contract out the remainder.

Of the pump dredgers owned by the SCA, a total of nine effectively may be deployed for the Doubling and Widening Plan: three are 10,000 HP class dredgers, two are 5,500 HP class and four are 1,700–3,300 HP class. If they are assigned to various dredging sections according to their capacity, i.e., three 10,000 HP class and one 5,500 HP class dredgers work in the doubling sections and the other five in the widening sections, the dredging schedule for doubling will be as shown in Fig. 9-3-1 in the Main Report, and the schedule for the widening of the western channel is shown in Fig. 4-2.

If dredging is carried out according to this schedule, the western channel will be navigable by 500,000 DWT tankers in ballast, the design vessel size in the Master Plan from 1989, when the sections Km 1.5–17 and 135–145 are scheduled for completion.

4-2-3 Dredging costs

Table 4-6 shows the dredging costs for doubling and widening. Of these, the costs of doubling are the same as in the Main Report for the eastern channel; they show an increase for the western channel in proportion to an increase of 0.5–1.0m in depth.

The dredging width is 10–40m, and the dredging thickness is 0.5–1.0m for the sections to be widened, considered to be poor dredging conditions. Consequently, dredging efficiency will be 35–60% of that for the doubling work; dredging unit costs also will be 1.5–3.0 times higher. As in the case of the Main Report, the dredging costs are based on 1979 prices, computed at the rate of 0.69LE = 1 US dollar = 240 Yen. They also include 10% for contingency. Cost disbursement shedules are shown in Tables 4-7 and 4-8.

Dredging costs for doubling and widening

	Doubling	Widening	Total
Doubling (Phase I) and Widening	83.10 10^6 LE + 231.0 10^6 $	17.0 10^6 LE + 41.5 10^6 $	100.0 10^6 LE + 272.5 10^6 $
Doubling (Phase II) and Widening	132.2 + 442.6	18.3 + 46.2	150.5 + 488.8

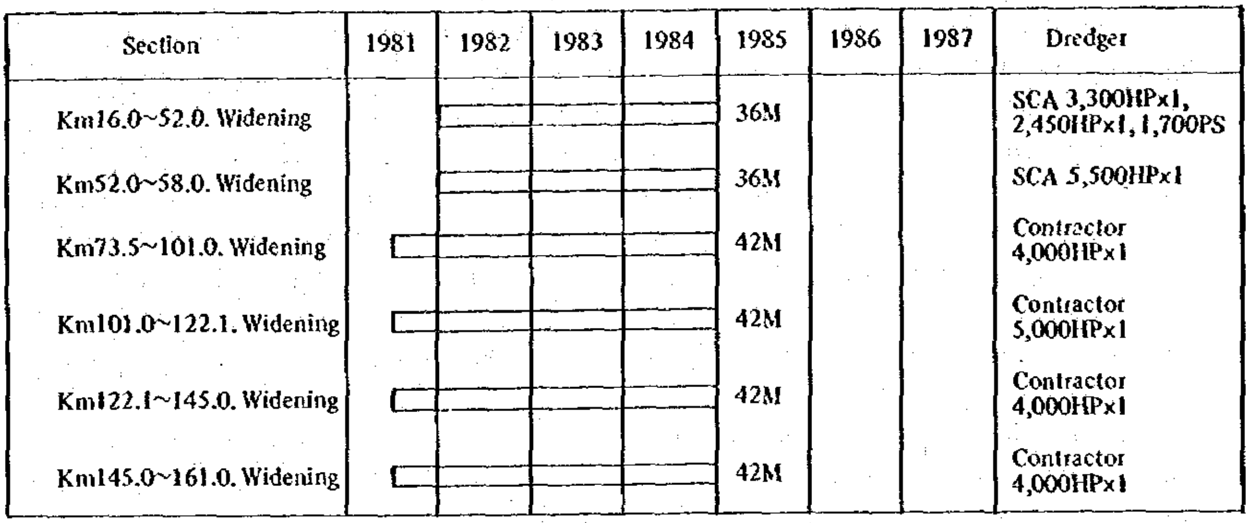


Fig. 4-2 Dredging Schedule

Table 4-5 Dredging Volume

Section	West Channel $10^6 m^3$	East Channel $10^6 m^3$	Remarks
Port Said Approach	51.6		
Km 1.5 – 16.0	61.7		
16.0 – 30.0	4.5	56.7	
30.0 – 42.0	3.9	53.6	
42.0 – 52.0	4.4	41.5	
52.0 – 58.0	4.3		
58.0 – 73.5	57.2		
73.5 – 94.5	4.5	79.6	
94.5 – 101.0	3.0		
101.0 – 109.0	2.8		
109.0 – 114.8	2.5		
114.8 – 122.1	4.1		
122.1 – 134.5	37.9		
134.5 – 145.0	40.3		
145.0 – 161.0	5.0	62.9	
Suez Approach	10.5	7.9	
Total (Phase I)	134.1	231.4	
Total (2nd Stage)	298.2	302.2	

Table 4-6 Dredging Cost

Section	West Channel		East Channel		Remarks
	L.C 10^6LE	F.C 10^6 $	L.C 10^6LE	F.C 10^6 $	
Port Said Approach	7.3	17.6			SCA and Contractor
Km 1.5 – 16.0	15.3	8.6			SCA
Km 16.0 – 30.0	2.2	1.2	17.1	9.6	SCA
Km 30.0 – 42.0	2.4	1.3	20.4	11.5	SCA
Km 42.0 – 52.0	3.0	1.7	17.3	9.8	SCA
Km 52.0 – 58.0	4.5	2.5			SCA
Km 58.0 – 73.5	8.6	62.0			Contractor
Km 73.5 – 94.5	1.2	8.3	11.8	84.1	Contractor
Km 94.5 – 101.0	0.7	4.7			Contractor
Km 101.0 – 109.0	0.6	4.4			Contractor
Km 109.0 – 114.8	0.6	4.1			Contractor
Km 114.8 – 122.1	1.0	6.9			Contractor
Km 122.1 – 134.5	6.7	47.1			Contractor
Km 134.5 – 145.0	7.1	50.9			Contractor
Km 145.0 – 161.0	1.9	13.3	15.9	119.8	Contractor
Suez Approach	2.8	11.1	2.1	8.3	Contractor
Total	65.9	245.7	84.6	243.1	
	100.0×10^6 LE+272.5×10^5 $				Phase I + Widening
	150.5×10^6 LE+488.8×10^6 $				Phase II + Widening

Table 4-7 Cost Disbursement Schedule (Phase I)

Year	Dredging		Civil Works		Total		Remarks
	L.C 10^6LE	F.C 10^6 $	L.C 10^6LE	F.C 10^6 $	L.C 10^6LE	F.C. 10^6 $	
1981	12.1	16.4	34.5	6.7	46.6	23.1	
1982	20.4	65.9	48.4	9.7	68.8	75.6	
1983	20.4	65.9	47.6	9.8	68.0	75.5	
1984	20.8	67.6	47.6	9.9	68.4	77.5	
1985	12.1	28.8	15.5	3.1	27.6	31.9	
1986	14.2	27.9			14.2	27.9	
Total	100.4	272.5	193.6	39.2	293.6	311.7	

Table 4-8 Cost Disbursement Schedule (2nd Stage)

Year	Dredging		Civil Works		Total		Remarks
	L.C 10^6 LE	F.C 10^6 \$	L.C 10^6 LE	F.C 10^6 \$	L.C 10^6 LE	F.C 10^6 \$	
1981	12.1	16.4	34.5	6.7	46.6	23.1	
1982	20.4	65.9	48.4	9.7	68.8	75.6	
1983	20.4	65.9	47.6	9.8	68.0	75.7	
1984	20.8	67.6	47.6	9.9	68.4	77.5	
1985	12.1	28.8	17.6	3.4	29.7	32.2	
1986	12.1	28.8	7.9	1.9	20.0	30.7	
1987	16.1	39.2	11.5	4.2	27.6	43.4	
1988	16.1	39.2	24.9	6.6	41.0	45.8	
1989	2.6	20.0	13.5	2.4	16.1	22.4	
1990	2.6	20.0	13.5	2.4	16.1	22.4	
1991	2.6	20.0	13.5	2.4	16.1	22.4	
1992	4.3	26.4	13.5	2.4	17.8	28.8	
1993	4.3	26.4	13.5	2.4	17.8	28.8	
1994	4.0	24.2			4.0	24.2	
Total	150.5	488.8	307.5	64.2	458.0	553.0	

4-3 Economic and Financial Evaluation

4-3-1 Economic Evaluation

This section analyses the economic effect of doubling and widening, using the same method as that of the Main Report. First, costs and benefits are computed in respect to doubling and widening to obtain the internal rate of return which is then compared with that of the Doubling Plan. Benefits here refer to those from the standpoint of national economy.

1) Study case

The Doubling and Widening Plan has two phases, as in the case of the Doubling Plan: These are Phase I and the doulbing of the entire length of the Canal. The first year of operation under the phased doubling plan is exactly the same as that under the Doubling Plan. The Step 1 of the Phase I is to be ready for operation from 1985 and the Step 2 from 1988. Doubling of the entire length is to be completed in 1994 and ready for operation from 1995.

2) Costs

The construction costs in each case are computed in 4--2. For maintenance and administration costs, there is little difference between the Doubling and Widening Plan and the Doubling Plan, so that the figures under the Doubling Plan are used.

Though the construction costs include 10% for physical contingency, price escalation is not taken into consideration, as in the case of the Main Report. For facilities such as tugs, the planned scale under the Doubling Plan should be sufficient, so the facility costs of the Doubling and Widening Plan are the same as the Doubling Plan alone.

3) Benefits

Since evaluation here is made from the viewpoint of national economy, an increase in Canal revenue to be expected from the Doubling and Widening Plan is the benefit. However, since those ballast tankers of over 350,000 DWT are not navigable in the Phase I, benefit will accrue only for the increase in transit volume. In the case of complete doubling, since the widening of the western channel will be completed in 1988, an increase in revenue from 350,000 DWT ballast tankers may be expected from 1989.

Since the transits of ballast tankers expected after the widening of the Canal will be about 0.3 per day even in 2000, this will hardly contribute to the saturation of the Canal capacity. Accordingly, tolls from those ballast tankers of over 350,000 DWT may be regarded as constituting an increase in revenues due to the widening. In the case of complete doubling, since the Canal will not reach the saturation point even after 2000, Canal revenues are expected to continue to increase during the project life. Canal revenues in major years under the Doubling and Widening Plan in the case of complete doubling are estimated as Table 4-9. After the Canal capacity has reached the saturation point, diversion from the Suez route to the Cape route is assumed to begin with the average vessel size for each year rather than with large vessels. An increase in Canal revenues estimated accordingly (defined as R-1 revenues in Part IX of the Main Report) is the benefit. Only the Base Case demand is covered.

Table 4-9 Additional Revenue Induced by Doubling and Widening Plan

(10^6 US$)

	Increase in revenues due to doubling	Increase in revenues due to widening	Increase in revenues due to doubling and widening
1985	94.2	20.1	114.3
1988	200.0	26.7	226.7
1989	255.7	28.6	284.3
1990	311.3	30.2	341.5
1995	565.4	36.1	601.5
2000	752.6	37.5	790.1

4) Internal Rate of Retern

The internal rate of return under the Doubling and Widening Plan is computed from the costs and benefits so far obtained. In computing the internal rate of return, the project life was set at 20 years, same as the Main Report.

The internal rate of return under the Doubling and Widening Plan is shown below for the Phase I and the complete doubling (Phase II Expansion Program):

	Doubling and widening	Doubling
Phase I	22.7%	24.2%
Phase I + Phase II	23.4%	23.8%

Note: Refer to Part IX of the Main Report.

Under the Doubling and Widening Plan in Phase I, even with the widening of the western channel, work on sections 0–16km and 122–145km will not be completed. Accordingly, the internal rate of return will fall to the extent of the increased widening costs.

With the completion of doubling and widening on sections 0–16km and 122–145km, revenues from tankers of over 350,000 DWT can be expected; internal rate of return, obtained by combining the complete doubling of the Canal and the widening of both channels will thus be slightly higher than that under the Doubling Plan. That is, profitability roughly similar to that under the Doubling Plan may be expected from the revenues of ballast tankers over 350,000 DWT, despite of the costs of widening.

It has been ascertained from the above that the internal rate of return will drop during Phase I if the doubling of the western channel is integrated in the Doubling Plan. On the other hand, it will have no effect on the economic feasibility of the Doubling Plan under the complete doubling plan, which will permit ballast tankers over 350,000 DWT to transit. Tables 4-A-1 and 4-A-2 show the computation of the internal rate of return.

5) Evaluation

Economic evaluation of the Doubling and Widening Plan is concluded as below:

(1) If the Doubling Plan in Phase I is combined with the plan to proceed first with the widening of west channel for ballast tankers of over 350,000 DWT, there will be a slight decrease in profitability compared with the Doubling Plan alone; none the less the economic feasibility is sufficiently ensured.

(2) If the complete doubling of the Canal is combined with the widening of the western channel following Phase I, it will produce roughly the same profitability as the Doubling Plan.

(3) From the above, we conclude that the economic feasibility of the Doubling and Widening Plan (combining the widening of the western channel and the doubling plan) differs little from the results of the Doubling Plan alone, as studied in the Main Report. Therefore the conclusion of the economic analysis made in the Main Report applys to the Doubling and Widening Plan without change.

4-3-2 Financial Evaluation

The financial feasibility of the Doubling and Widening Plan under the Phase I is based on FRR computed by the DCF method, as discussed in this section.

1) Costs and benefits

The construction costs include a price contingency apart from a physical contingency. For the costs of facilities including tugs etc. the scale planned under the Doubling Plan is sufficiently similar to the combined plan. Thus, the costs of facilities under the Doubling and Widening Plan are the same as the Doubling Plan alone for the economic analysis.

Since basically there is no difference in control system between the Doubling and Widening Plan and the Doubling Plan alone the various costs of operation and management under the Doubling Plan, such as maintenance and repairs, general management and maintenance dredging are used. The costs used do not include depreciation costs, interest payable and taxes.

Only the benefits from the Canal doubling are considered in the economic analysis, since in Phase I the entire Canal will not be widened and thus the benefits of the widening are not yet available.

2) FRR and evaluation

The period for computing FRR is to be 16 years after the commencement of work, the same as the Doubling Plan alone. The FRR under the Doubling and Widening Plan is shown below:

	Doubling and Widening Plan	Doubling Plan
Internal rate of return	15.8%	17.3%

Note: Refer to Part XI of the Main Report.

Table 4-A-1 IRR Calculation Sheet

– Doubling and Widening Plan (Phase I) –

IRR = 22.7%

(Unit: 10^6 US$)

No.	Year	COSTS			BENEFITS		Net Profit
		Total	Construction & Equipment	Operation	Total	Increased Revenue	
1	1981	90.6	90.6				△ 90.6
2	1982	175.3	175.3				△ 175.3
3	1983	174.3	174.3				△ 174.3
4	1984	176.6	176.6				△ 176.6
5	1985	104.5	100.0	4.5	94.2	94.2	△ 10.3
6	1986	61.5	56.0	5.5	119.3	119.3	57.8
7	1987	6.6		6.6	144.4	144.4	137.8
8	1988	8.7		8.7	200.0	200.0	191.3
9	1989	11.1		11.1	255.7	255.7	244.6
10	1990	13.5		13.5	311.3	311.3	297.8
11	1991	15.0		15.0	353.6	353.6	338.6
12	1992	16.9		16.9	395.8	395.8	378.9
13	1993	16.9		16.9	395.8	395.8	378.9
14	1994	16.9		16.9	395.8	395.8	378.9
15	1995	16.9		16.9	395.8	395.8	378.9
16	1996	16.9		16.9	395.8	395.8	378.9
17	1997	16.9		16.9	395.8	395.8	378.9
18	1998	16.9		16.9	395.8	395.8	378.9
19	1999	16.9		16.9	395.8	395.8	378.9
20	2000	16.9		16.9	395.8	395.8	378.9
21	2001	16.9		16.9	395.8	395.8	378.9
22	2002	16.9		16.9	395.8	395.8	378.9
23	2003	16.9		16.9	395.8	395.8	378.9
24	2004	16.9		16.9	395.8	395.8	378.9
25	2005	8.2		8.2	195.8	195.8	187.6
26	2006	8.2		8.2	195.8	195.8	187.6
27	2007	8.2		8.2	195.8	195.8	187.6
Total		1,082.0	772.8	309.2	7,211.3	7,211.3	6,129.3

Table 4-A-2 IRR Calculation Sheet

– Doubling and Widening Plan (Phase I + Phase II) –

IRR = 23.4%

(Unit: 10^6 US$)

No.	Year	COSTS			BENEFITS		Net Profit
		Total	Construction Equipment	Operation	Total	Increased Revenue	
1	1981	90.6	90.6				△ 90.6
2	1982	175.3	175.3				△ 175.3
3	1983	174.3	174.3				△ 174.3
4	1984	176.6	176.6				△ 176.6
5	1985	107.8	103.3	4.5	94.2	94.2	△ 13.6
6	1986	72.7	67.2	5.5	119.3	119.3	46.6
7	1987	90.0	83.4	6.6	144.5	144.5	54.5
8	1988	113.9	105.2	8.7	200.0	200.0	86.1
9	1989	56.8	45.7	11.1	284.3	284.3	227.5
10	1990	59.2	45.7	13.5	341.5	341.5	282.3
11	1991	60.7	45.7	15.0	385.3	385.3	324.6
12	1992	71.5	54.6	16.9	428.8	428.8	357.3
13	1993	73.3	54.6	18.7	475.8	475.8	402.5
14	1994	50.6	30.0	20.6	517.2	517.2	466.4
15	1995	22.6		22.6	565.4	565.4	542.8
16	1996	24.9		24.9	610.0	610.0	585.1
17	1997	27.4		27.4	650.6	650.6	623.2
18	1998	30.1		30.1	697.2	697.2	667.1
19	1999	33.1		33.1	746.0	746.0	712.9
20	2000	36.4		36.4	790.1	790.1	753.7
21	2001	40.1		40.1	830.8	830.8	790.7
22	2002	44.1		44.1	870.0	870.0	825.9
23	2003	48.5		48.5	911.3	911.3	862.8
24	2004	53.4		53.4	954.7	954.7	901.3
25	2005	52.2		52.2	800.3	800.3	748.1
26	2006	58.1		58.1	838.1	838.1	779.6
27	2007	64.7		64.7	877.8	877.8	813.1
Total		1,909.3	1,252.2	656.7	13,133,2	13,133.2	11,223.9

As can be seen, the costs of the Doubling and Widening Plan are higher than those of the Doubling Plan alone, while the internal rate of return is somewhat lower than that under the Doubling Plan, though not to the extent of affecting the financial feasibility. From these results, the Doubling and Widening Plan best be carried out with the widening of the south-bound channel at an early date, so that ballast tankers over 350,000 DWT may make transits.

Table 4-A-3 shows the computation of the financial internal rate of return.

Table 4-A-3 FRR Calculation Sheet
– Doubling and Widening Plan (Phase I) –
FRR = 15.8%

(Unit: 10^6 LE)

No.	Year	COSTS			BENEFITS		Net Profit
		Total	Construction & Equipment	Operation	Total	Increased Revenue	
1	1981	71.6	71.6				△ 71.6
2	1982	148.1	148.1				△ 148.1
3	1983	157.4	157.4				△ 157.4
4	1984	171.5	171.5				△ 171.5
5	1985	105.8	102.7	3.1	65.0	65.0	△ 40.8
6	1986	64.3	60.5	3.8	80.4	80.4	16.1
7	1987	4.6		4.6	99.6	99.6	95.0
8	1988	6.0		6.0	133.8	133.8	127.8
9	1999	7.7		7.7	174.6	174.6	166.9
10	2000	9.3		9.3	216.0	216.0	206.7
11	2001	10.3		10.3	242.0	242.0	231.7
12	2002	11.7		11.7	273.1	273.1	261.4
13	2003	11.7		11.7	273.1	273.1	261.4
14	2004	11.7		11.7	273.1	273.1	261.4
15	2005	11.7		11.7	273.1	273.1	261.4
16	2006	11.7		11.7	273.1	273.1	261.4
Total		815.1	711.8	103.3	2,376.9	2,376.9	1,561.8

ANNEX

The Doubling and Widening Plan studied in this supplementary report is to widen a part of the existing Canal, which will become the western channel in the future; the widening of the entire length is to be completed in 1988. However, with supplementary expeditious widening of some sections of the eastern channel, transiting of ballast tankers of over 350,000 DWT will be possible at an earliest date.

Completion of the widening of the southbound channel in 1984, when Step 1 of Phase I should be completed, is discussed in this annex.

ANNEX

1. Analysis of Transit Capacity

Increases in the number of ballast tankers in southbound transit are expected to result from a Doubling and Widening Plan. This section discusses how these increases will affect the time of saturation of the Canal's transit capacity.

The study of transit capacity by standard ships and the study of transit capacity by a simulation test have been conducted from the results of the trnsit demand forecast in 4-1 of main body in this report.

1-1 Study of Transit Capacity by Standard Ship

1) Number in Transit: Standard Ships

As described in the transit demand forecast in 4-1, the Canal Doubling and Widening Plan (to permit navigation of up to 500,000 DWT ballast tankers) has a greater transit capacity than the Doubling Plan alone. The difference is 0.1 tankers per day in 1985, 0.3 in 1990, 0.3 in 1995 and 0.4 in 2000 as shown in Table 4-3. (These values are for the Base Case demand).

To study the year of saturation of the standard-ship transit capacity, the forecast results in 4-1 must be converted into the number of standard ship transits. For conversion to standard ships sixteen minutes was used as the interval for ballast tankers of more than 350,000 DWT.

Ship-to-Ship Interval

Displacement	Time Internal	Displacement	Time Internal
Non-tanker		Tanker	
NRT		0–60,000DWT	12
0–30,000	8	–150,000	16
–60,000	10	–250,000	16
60,000–	12	–300,000	16
		–350,000	16
		–500,000	16

Table A-1 shows the number of ships transit converted to terms of standard ships for the Base and High Case demands. There will be an increase of less than 0.5 daily transits (standard ships) in 2000, compared with the Doubling Plan.

2) Time of Saturation of Transit Capacity

As in Part IV of the Main Report the year of saturation of the Canal's transit capacity is again studied for after the completion of the Phase I project and at each stage of the gradual future passage doubling.

Under the policy mentioned in Part IV of the Main Report, the Canal's present capacity and its capacity planned for each stage of doubling plan are based on the Canal transit capacity when queues occur once or twice a month. Fig. A-1 shows the relation, by years, between the daily number of transiting vessels and the Canal transit capacity. The year of saturation is at the point where the transit capacity and the transiting vessels are equal (at the line intersection). Table A-2 shows the year of saturation under the Doubling and Widening Plan along with the case of the Doubling Plan discussed in the Main Report. According to it, the year of saturation will be little affected by widening of the western channel for the use of ballast tankers of more than 350,000 DWT, because the number of tankers of this class is limited. Specifically, the number of transiting ships will reach the transit capacity in 1981 (1980 in the case of a High Case demand) for the present Canal, 1988 (1986 in the case of a High Case demand)for Phase I, Step 1, and 1992 (1988 in the case of High Case demand) for the Phase I, Step 2. Thus, the situation is exactly the same as in the Doubling Plan.

Table A-1 Daily Number of Standard Ships

	Real Ship		Standard Ship	
	Base Case	High Case	Base Case	High Case
1977	53.9		49.2	
78	58.2		53.2	
1980	68.4 (68.2)	70.4 (70.3)	62.5 (62.4)	63.9 (63.8)
85	84.1 (83.9)	92.0 (91.8)	75.6 (75.4)	82.7 (82.3)
90	103.5 (103.3)	118.4 (118.1)	92.9 (92.6)	105.5 (105.0)
95	120.4 (120.1)	141.8 (141.5)	107.3 (106.9)	125.1 (124.6)
2000	139.9 (139.6)	171.1 (170.8)	123.5 (123.0)	149.0 (148.5)

Note : Figures in brackets show the number of ships under the Doubling Plan.

Table A-2 Saturation Years of the Canal Capacity

	Base Case		High Case	
	Doubling Plan	Doubling and Widening Plan	Doubling Plan	Doubling and Widening Plan
Existing	1981	1981	1980	1980
Plan 0	1984	1984	1983	1983
Plan 1 (Phase I, Step 1)	1988	1988	1986	1986
Plan 2	1990	1989	1987	1986
Plan 3 (Phase I, Step 2)	1992	1992	1988	1988
Plan 4	1995	1995	1990	1990
Plan 5 (Complete Doubling)	after 2000	after 2000	after 2000	after 2000

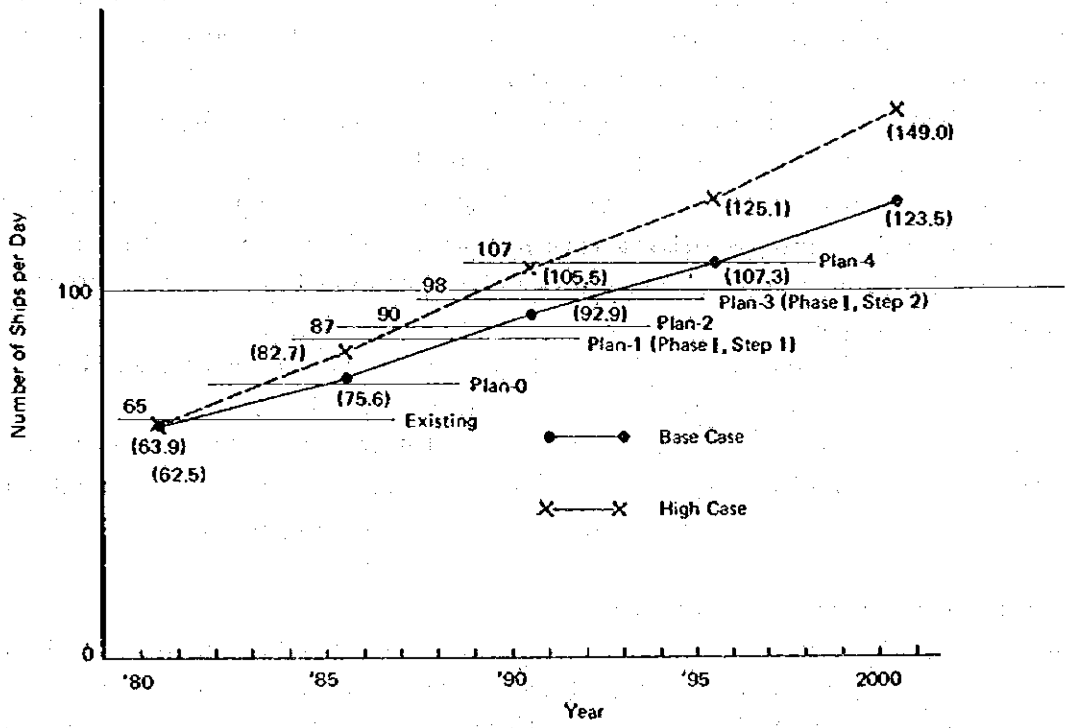


Fig. A-1 Demand and Transit Capacity

1-2 Simulation Test

The Canal's saturation time by real ships was studied by conducting the same simulation test as in Part VII of the Main Report and using the values obtained in the transit demand forecast of 4-1.

The simulation model used was the same as that developed in the Main Report, with all input data (other than for transit volume) the same as that in the Main Report.

The simulation of the Canal's phased doubling plans comprised three cases: existing state and Steps 1 and 2 of Phase I. The transit demand comprised two cases: Base Case and High Case. The cases are as follows:

Demand / Doubling Stage	Base Case	High Case
Existing	O	O
Phase I, Step 1	O	O
Phase I, Step 2	O	O

1) Saturation of Existing Canal

The results of this simulation are shown in Fig. A-2 for the Base Case transit demand and in Fig. A-3 for the High Case transit demand, by the number of monthly queues, the number of waiting ships (monthly), and the average waiting hours per ship.

These results indicate that the queuing in the Doubling and Widening Plan is generally similar to that in the Doubling Plan alone; the results are identical to those of the study by standard ships. If the transit demand continues in the Base Case, queuing starts in 1981 and sharply increases in 1984. In the number of delayed ships also becomes chronic in 1984. This tendency also comes from the fact that the average per-ship wait increases from 1984. These results are the same as in the Doubling Plan.

If the transit demand continues in the High Case, queuing increases in 1982 and becomes chronic in 1983, with these results also agreeing with those in the Doubling Plan.

As above, it has been confirmed that the transiting of ballast tankers of more than 350,000 DWT by the Doubling and Widening Plan will merely result in some increase in the number of queuing ships and not affect the time of saturation of the Canal's transit capacity.

2) *Saturation of the Canal under Phase I*

A similar simulation test was conducted on the stage of Phase I and produced results shown in Fig. A-2 and Fig. A-3. As can be seen from these figures, the queuing situation is nearly the same in the Doubling and Widening Plan as in the Doubling Plan alone, and so, the Canal's saturation year is much the same under the two plans. In Phase I, Step 1, where the 61–95km Canal length is to be doubled, queuing starts in 1988 (1986 in the case of High Case) and chronic delays occur in 1989 (1987 in the case of High Case). In the Canal of Phase I, Step 2 where the 0–135km Canal length is to be doubled, queuing starts in 1989 (1986 in the case of High Case) and chronic delays occur in 1993 (1989 in the case of High Case).

1-3 Evaluation

The Canal's saturation year under the Doubling and Widening Plan is much the same as in the Doubling Plan of the Main Report. From this result of the study it follows that the Doubling and Widening Plan has only to be executed at the same pace as the Doubling Plan. In other words, the opening program of Phase I must be carried on by the schedule below at the latest.

	Section to be doubled	Opening Year
Step 1 (Phase I)	61 ~ 95 km	1985
Step 2 (Phase I)	61 ~ 95 km 16 ~ 51 km	1988

Since waiting is expected to start in 1981, as can be seen from the results of the study, it is desirable for Step 1 to be completed as soon as possible. Work must be started soon after the completion of the First Stage Project. Particularly in the Doubling and Widening Plan (where work on widening sections can be started immediately after the completion of the First Stage Project) work must be performed soon so that doubling work there is not delayed.

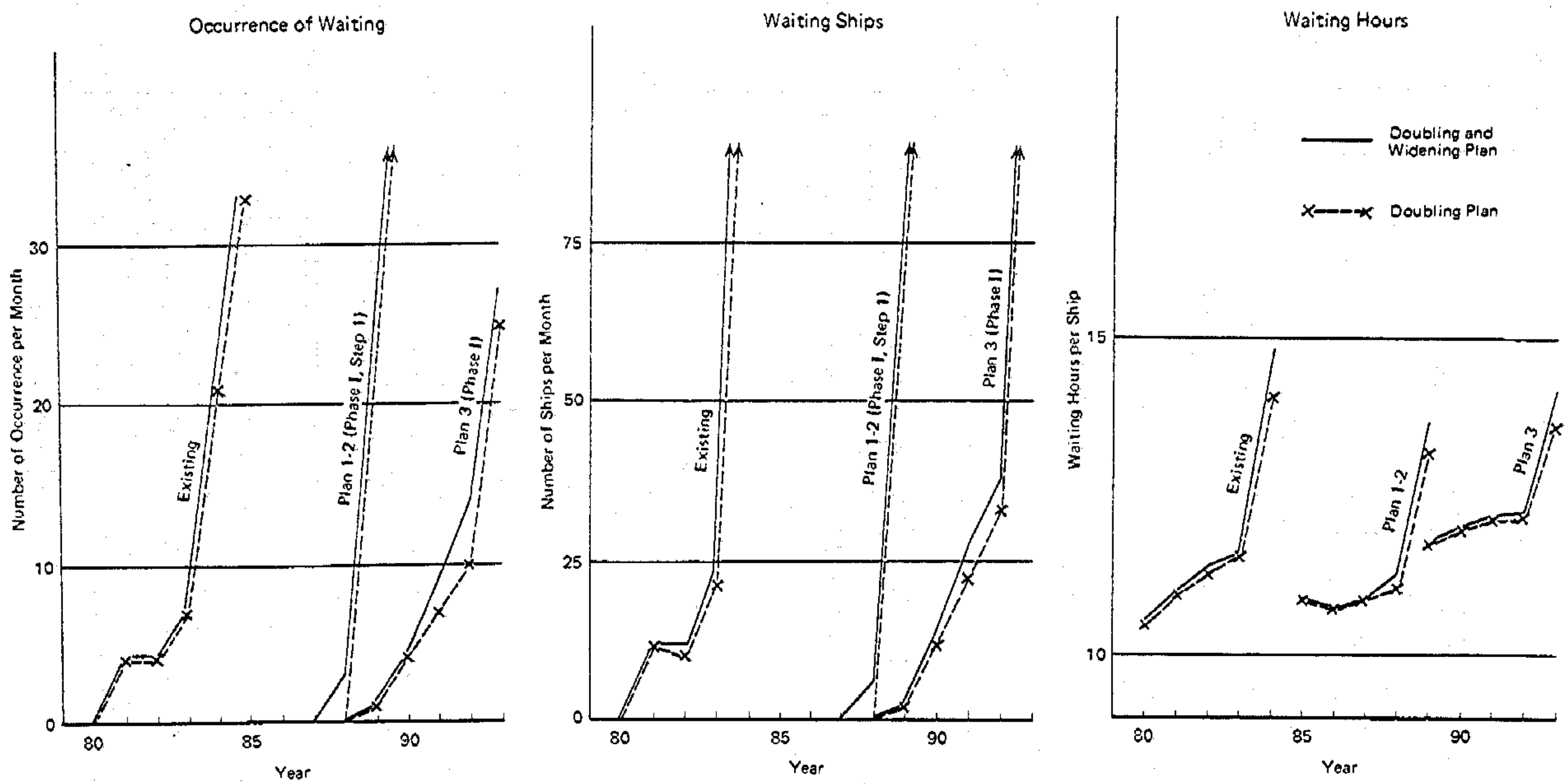


Fig. A-2 Waiting Situation: Base Case

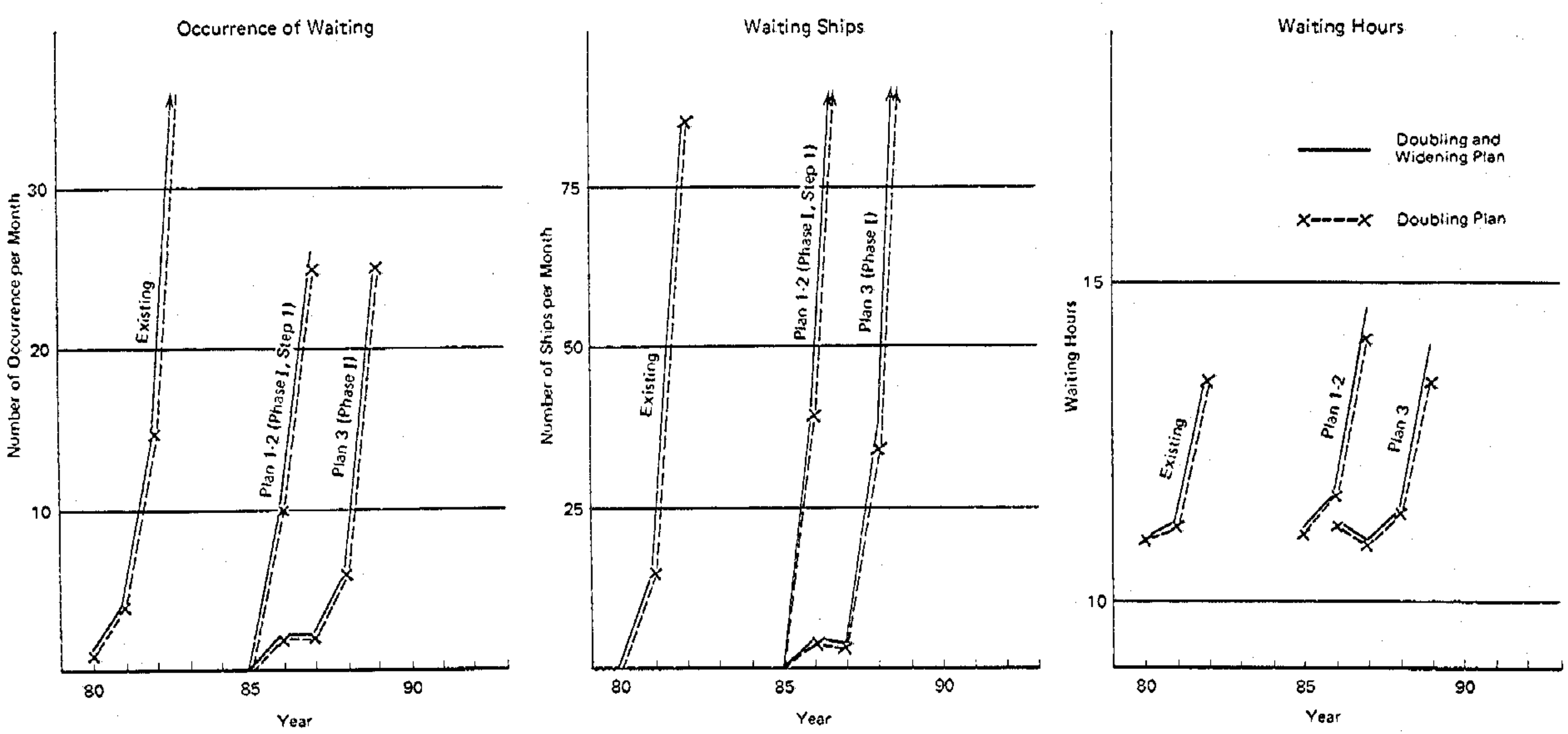


Fig. A-3 Waiting Situation: High Case

2. Implementation Plan

2-1 Dredging Section and Volume

Widening of the entire reach of the Canal to the section under the Master Plan will be completed in 1988 for the Plan of widening the west channel alone. But, if a part of the east channel is supplementally widened, an earlier opening of the Canal for VLCC becomes possible.

For this purpose, following three plans will be examined:

Phase I	Step 1	(km 58–94.5)	....	Doubling-Widening Plan	①
" I	Step 2	(km 16–135)	....	"	②
" II		(km 0–161)	....	"	③

The dredging section and volume for the above plans are shown in Fig. A-4 and Table A-3 and A-4.

Of the dredging volume, 55,522 x 10^3 m^3 in the Doubling and Widening Plans ① and ② and 63,451 x 10^3 m^3 in Doubling and Widening Plan ③ represent the amount of spoil to be dredged for the purpose of widening.

The dredging volume is based on the standard cross sections of the First Stage Project, because the sounding maps after the First Stage Project are not yet ready. The cross sections dredged in the First Stage Project are, of course, wider and deeper than the standard cross section. So, a dredging volume computed from a sounding map is less than in reality. Therefore, the dredging volume for a doubling section is accurate but that for a widening or deepening section is considerably erroneous. Particularly in such sections as the Ballah and Deversoir Bypasses, where the Canal is to be deepened by 0.5–1.0 m, the necessary water depth is believed to have already been secured in most sections except for sporadic places where the water depth is short of the requirement, if areas requiring dredging and their dredging volumes are to be picked up from the sounding maps prepared after the completion of the First Stage Project. It is, therefore, desirable to determine sections for dredging only after confirming the results of this survey.

2-2 Implementation Programme

In dividing dredging work between SCA operated dredgers and contractor dredgers, the SCA operated dredgers will preferentially choose channel sections according to their dredging capabilities, leaving the other sections to be worked by the contracted dredgers.

Of the SCA owned pump dredgers, nine can be effectively used for the Doubling and Widening Plan. There are three 10,000 HP dredgers, (one of the four dredgers of this class sank during the First Stage Project), two 5,500 HP dredgers and four dredgers ranging from 1,700 to 3,300 HP. If the three 10,000 HP dredgers and one of the 5,500 HP dredgers are assigned to the doubling section and the other five are assigned to the widening section permit them to work to their respective dredging capabilities, Km 74.5 in the Doubling and Widening Plan ① will be the construction boundary, and it will be possible to divide the work between the SCA operated dredgers working on the north side of this boundary and the contracted dredgers working on the south.

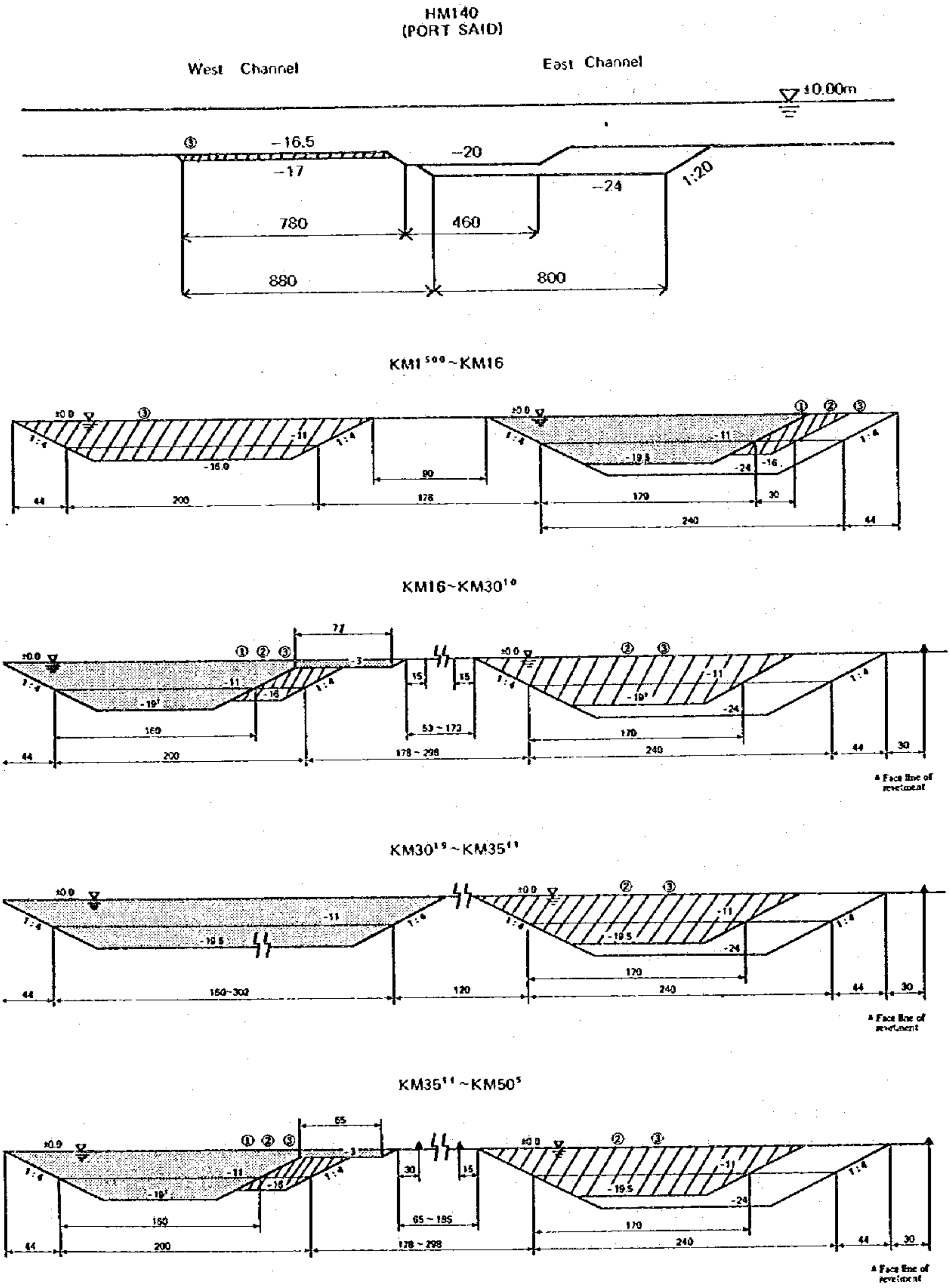


Fig. A 4 Standard Cross Section

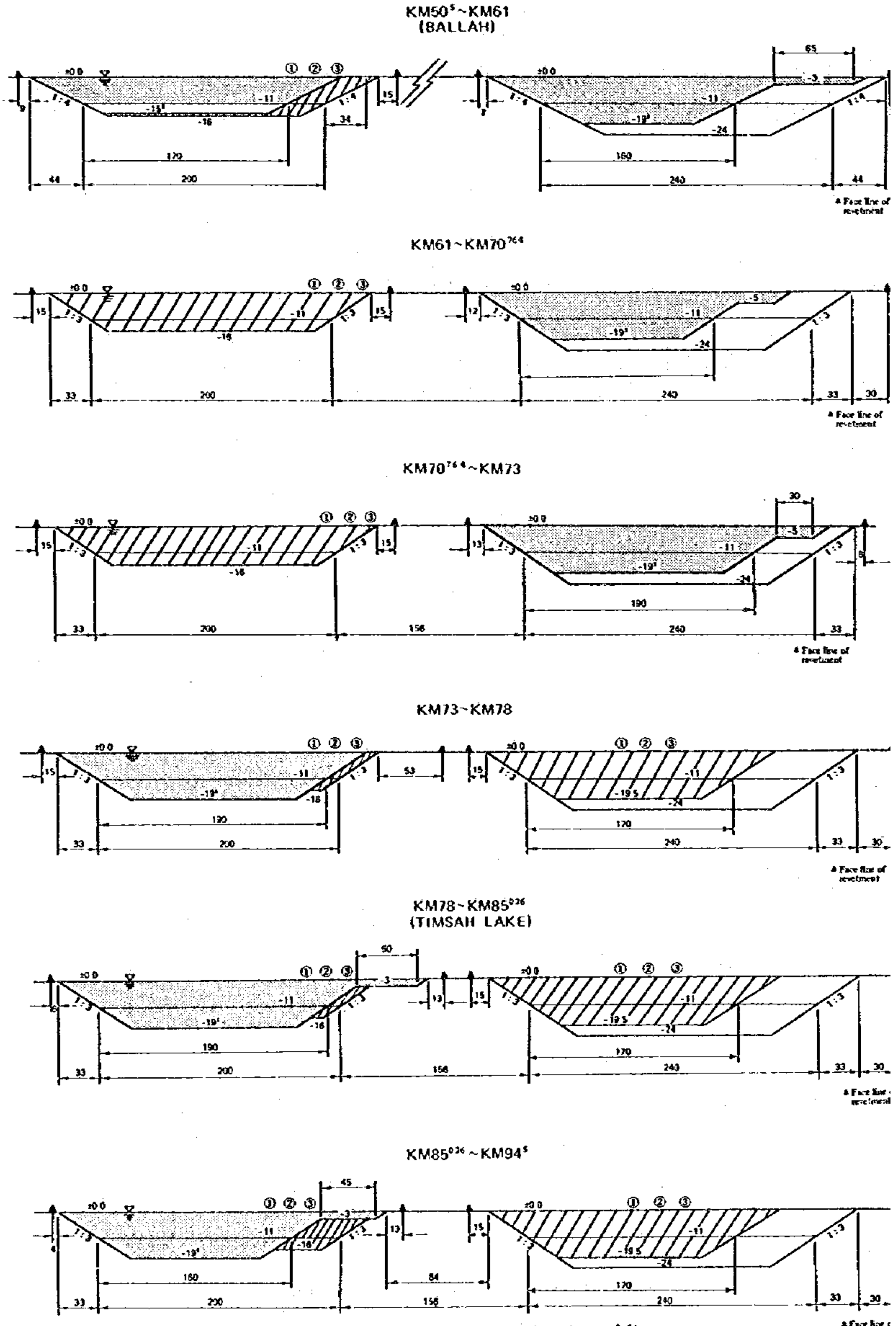
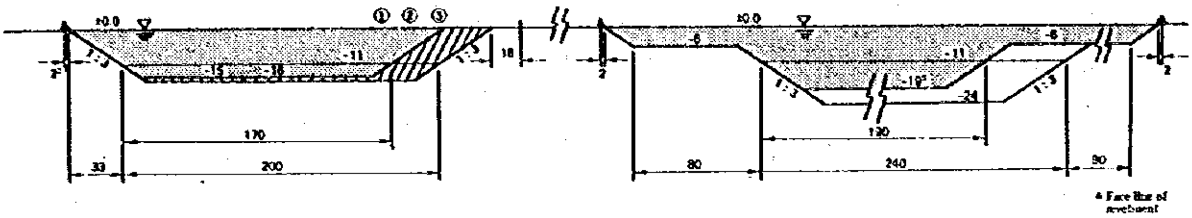
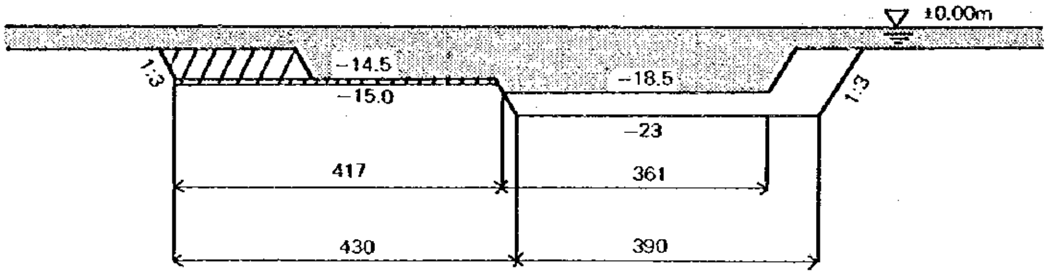


Fig. A-4 Standard Cross Section (cont'd)

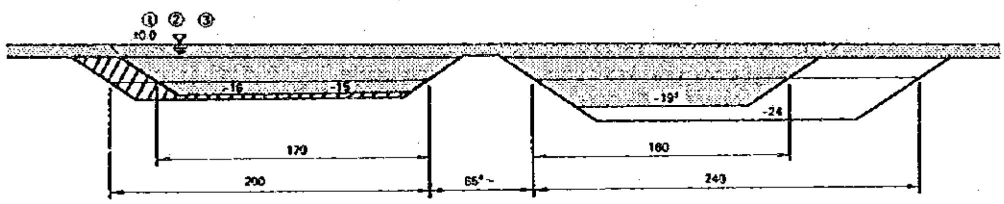
KM94^{5}~KM101^{65}
(DEVERSOIR)



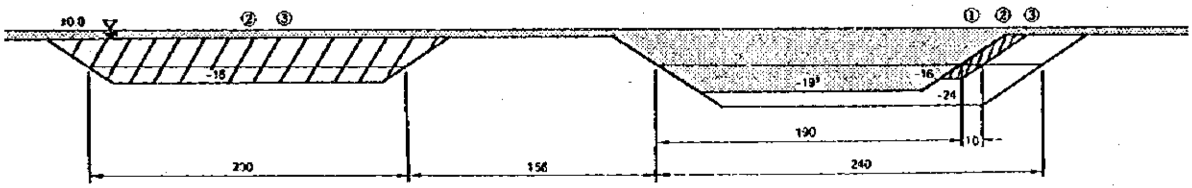
KM103^{7}~KM114^{8}
(GREAT BITTER LAKE)



KM114^{8}~KM122^{1}
(KABRIT)



KM122^{1}~KM133^{175}



KM133^{175}~KM145

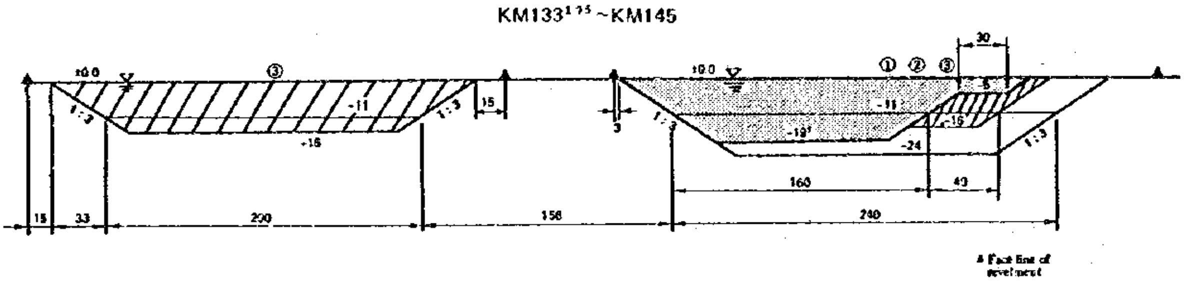


Fig. A-4 Standard Cross Section (cont'd)

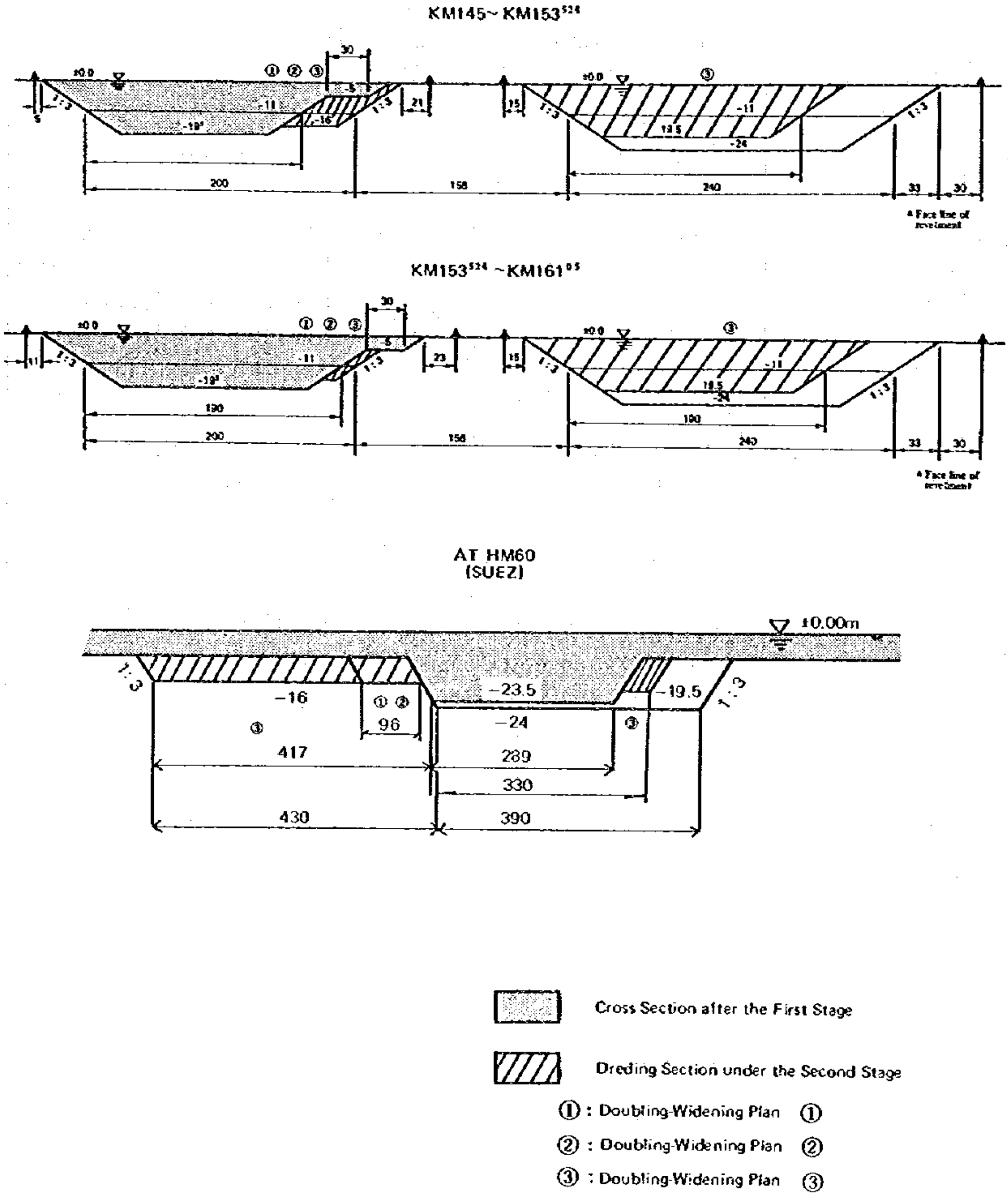


Fig. A-4 Standard Cross Section (cont'd)

Table A-3 Outline of Dredging Works

	Section Dredged	
	Section Doubled	Section Widened
Doubling and Widening Plan ①	Km 61 – 95 (Km 61 – 73.4 West Channel) (Km 72.4 – 95 East Channel)	Km 1.5 – 16 East Channel Km 16 – 61 West Channel Km 73 – 122 west Channel Km 122 – 145 East Channel Km 145 – 162 West Channel Approach Channel (Suez)
Doubling and Widening Plan ②	Besides Doubling and Widening Plan ① Km 16 – 51 East Channel Km 122 – 135 West Channel	Same as Doubling and Widening Plan ①
Doubling and Widening Plan ③	Besides Doubling and Widening Plan ② Km 135 – 162 (Km 135 – 144 West Channel) (Km 144 – 162 East Channel) Km 0 – 16 West Approach Channel (Suez, Port Said)	Besides Doubling and Widening Plan ① Approach Channel (Suez)

Table A-4 Dredging Volume

Section	Doubling-Widening Plan ①		Doubling-Widening Plan ②		Doubling-Widening Plan ③		Remarks
	West Channel	East Channel	West Channel	East Channel	West Channel	East Channel	
	$10^3 m^3$	$10^3 m^3$	$10^3 m^3$	$10^3 m^3$	$10^3 m^3$	$10^3 m^3$	
Port Said Approach					51,558		
Km 1.5~ 16.0		7,040		7,040	61,712	7,040	
16.0~ 30.0	4,485		4,485	56,743	4,485	56,743	
30.0~42.0	3,899		3,899	53,616	3,899	53,616	
42.0~52.0	4,420		4,420	41,468	4,420	41,468	
52.0~58.0	4,264		4,264		4,264		
58.0~ 73.5	57,246		57,246		57,246		
73.5~ 94.5	4,508	79,645	4,508	79,645	4,508	79,645	
94.5~101.0	3,049		3,049		3,049		
101.0~109.0	2,818		2,818		2,818		
109.0~114.8	2,464		2,464		2,464		
114.8~122.1	4,110		4,110		4,110		
122.1~134.5		2,645	37,858	2,645	37,858	2,645	
134.5~145.0		5,250		5,250	40,342	5,250	
145.0~161.0	5,005		5,005		5,005	62,857	
Suez Approach	1,565		1,565		10,456	7,929	
Total	97,833	94,580	135,691	246,407	298,194	317,193	

Of the work schedules for the Doubling and Widening Plan, the doubling work schedule will be executed by Programme 1 (Fig. 9-3-1, Main Report) corresponding to the Base Case of the demand forecast. It is optimum in all cases for the widening work schedule to be completed in 1984 simultaneously with the completion of the Doubling and Widening Plans ①.

The dredging work schedules for the Doubling and Widening Plans ①, ② and ③ are as shown in Fig. A-5. The necessary number of pump dredgers and their total horsepower is as follows:

In Plan ①	SCA dredgers	9 Nos.	55,650 HP
	Contractor dredger	8 Nos.	49,000 HP
In Plan ②	SCA dredgers	4 Nos.	35,500 HP
	Contractor dredger	7 Nos.	56,000 HP
In Plan ③	SCA dredgers	4 Nos.	35,500 HP
	Contractor dredger	3 Nos.	24,000 HP

2-3 Dredging Cost

The cost of dredging under the Doubling and Widening Plan is as shown in Table A-5. Of the total, the cost for the doubling in the east channel is exactly the same as in the Main Report but, in the west channel, the cost increase is for the increase of dredging volume from the 0.5–1.0 m increase in channel depth. In the widening section, the width of the dredging cross-section is 10–40 m and its depth increase is 0.5–1.0 m; the dredging efficiency is 35–60% of the level in the doubling section due to unfavorable dredging conditions. As a result, the dredging unit cost is 1.5–3.0 times the level in the doubling section. The dredging cost is as of 1979, as in the Main Report, and calculated according to the currency exchange rate of 0.69 LE = US$ = 240 yen. It includes a 10% contingency.

The dredging cost for the widening portion of the Doubling and Widening Plan is

$$22.3 \times 10^6 \text{ LE} + 63.2 \times 10^6 \text{ \$}.$$

The apportioning of the dredging cost by years is as shown in Table A-6.

3. Economic Analysis

The economic effects of the Doubling and Widening Plan are analyzed by the same method as in the Main Report. First, costs and benefits involved in the Doubling and Widening Plan are computed and the internal rate of return is determined. Then, these internal rates of return and the internal rates of return under the doubling plan are comparatively evaluated. Here, only benefits for the national economy are involved.

3-1 Study Case

Following two cases are examined:

		Phase I		Phase II
		Step 1	Step 2	
Doubling and Widening Plan ②	Phase I	1981/1984	1985/1986	–
Doubling and Widening Plan ③	Complete Doubling	1981/1984	1985/1986	1987/1994

Plan	Section	Doubling or Widening	1881	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Doubling and Widening Plan ①	Km 1.5 – 52.0	Widening	SCA 3,300HP×1, 2,450HP×1, 1,700HP×2													
	Km 52.0 – 57.5	Widening		SCA 5,500HP×1												
	Km 57.5 – 74.5	Doubling		SCA10,000HP×3, 5,500HP×1												
	Km 73.5 – 94.5	Doubling	Contractor 8,000HP×4													
	Km 74.5 – 101.0	Widening	Contractor 4,000HP×1													
	Km 101.0 – 122.1	Widening	Contractor 5,000HP×1													
	Km 122.1 – 145.0	Widening	Contractor 4,000HP×1													
	Km 145.0 – 161.0	Widening	Contractor 4,000HP×1													
	Suez Approach	Widening				Contractor 9,000m³ (Hopper)×1										
Doubling and Widening Plan ②	Km 17.0 – 32.5	Doubling					SCA 10,000HP×3, 5,500HP×1									
	Km 32.5 – 53.0	Doubling					Contractor 8,000HP×4									
	Km 122.1 – 135.0	Doubling					Contractor 8,000HP×3									
Doubling and Widening Plan ③	Port Said Approach	Doubling							SCA 6,000m³ (Hopper) Contractor 9,000m³ (Hopper)							
	Km 1.5 – 17.0	Doubling							SCA 10,000HP×3, 5,500HP×1							
	Km 135.0 – 145.0	Doubling							Contractor 8,000HP×3							
	Km 145.0 – 161.0	Doubling									Contractor 8,000HP×3					
	Suez Approach													Contractor 9,000m³ (Hopper)		

Table A-5 Dredging Cost

Section	West Channel		East Channel		Remarks
	L.C 10^6 LE	F.C 10^6 \$	L.C 10^6 LE	F.C 10^6 \$	
Port Said Approach	7.3	17.6			SCA and Contractor
Km 1.5 – 16.0	15.3	8.6	2.1	1.2	SCA
Km 16.0 – 30.0	2.2	1.2	21.3*	12.0*	SCA *Km 16.0 – 32.5
Km 30.0 – 42.0	2.4	1.3			SCA
			9.6	68.5	Contractor Km 32.5 – 52.0
Km 42.0 – 52.0	3.0	1.7			SCA
Km 52.0 – 58.0	4.5	2.5			SCA
Km 58.0 – 73.5	30.8	19.0			SCA
Km 73.5 – 94.5	1.2	8.3	11.8	84.1	Contractor
Km 94.5 – 101.0	0.7	4.7			Contractor
Km 101.0 – 109.0	0.6	4.4			Contractor
Km 109.0 – 114.8	0.6	4.1			Contractor
Km 114.8 – 122.1	1.0	6.9			Contractor
Km 122.1 – 134.5	6.7	47.1	0.6	4.0	Contractor
Km 134.5 – 145.0	7.1	50.9	1.1	8.0	Contractor
Km 145.0 – 161.0	1.9	13.3	15.9	119.8	Contractor
Suez Approach	0.4* 2.8△	1.6* 11.1△	2.1	8.3	Contractor * Plan ①, ② △ Plan ③
Total	64.9×10^6 LE + 166.3×10^6 \$ .... Doubling & Widening Plan ① 102.5×10^6 LE + 293.9×10^6 \$ .... Doubling & Widening Plan ② 152.6×10^6 LE + 508.6×10^6 \$ .... Doubling & Widening Plan ③				

Table A-6 Cost Disbursement Schedule

Plan	Year	Dredging		Civil Works		Total		Remarks
		L.C	F.C	L.C	F.C	L.C	F.C	
		10^6LE	10^6\$	10^6LE	10^6\$	10^6LE	10^6\$	
Doubling & Widening Plan ①	1981	4.5	15.2	22.4	3.5	26.9	18.7	
	1982	20.0	49.8	36.3	6.4	56.3	56.2	
	1983	20.0	49.8	32.1	6.4	52.1	56.2	
	1984	20.4	51.5	32.1	6.4	52.5	57.9	
	1981~1984 Total	64.9	166.3	122.9	22.7	187.8	189.0	
Doubling & Widening Plan ②	1984			23.6	5.6	23.6	5.6	
	1985	18.8	63.8	23.6	5.6	42.4	69.4	
	1986	18.8	63.8	23.6	5.6	42.4	69.4	
	1981~1986 Total	102.5	293.9	193.7	39.5	296.2	333.4	
Doubling & Widening Plan ③	1986			9.9	1.9	9.9	1.9	
	1987	14.9	38.6	11.5	4.2	26.4	42.8	
	1988	14.9	38.6	24.9	6.6	39.8	45.2	
	1989	2.6	20.0	13.5	2.4	16.1	22.4	
	1990	2.6	20.0	13.5	2.4	16.1	22.4	
	1991	2.6	20.0	13.5	2.4	16.1	22.4	
	1992	4.3	26.4	13.5	2.4	17.8	28.8	
	1993	4.3	26.4	13.5	2.4	17.8	28.8	
	1994	3.9	24.8			3.9	24.8	
	1981~1994 Total	152.6	508.7	307.5	64.2	460.1	572.9	

Doubling and Widening Plan ② uses the doubling stage as Phase I (doubling of the 0–135 km Canal length) while Plan ③ is for the doubling of the entire length. Step 1 (doubling of the 61–95 km Canal length) is to be performed first and Step 2 will be started after the completion of Step 1. Whereas in the Main Report, Step 1 and Step 2 are to be started simultaneously in 1981. In each case, widening is to be completed in keeping with the completion of Step 1.

3-2 Costs

The construction costs computed in 2, Implementation Plan are used as costs in each study case. For maintenance and operation costs, the values under the Doubling Plan are used because they are practically the same as under the Doubling and Widening Plan.

The construction costs include a 10% physical contingency factor, but does not include price escalation.

Annual investments are shown in Table A-7. The equipment cost for items such as tugboats is the same for both the Doubling and the Doubling and Widening Plans since the equipment scale is the same.

3-3 Benefits

Since the evaluation here is in consideration of the national economy, the benefits consist of increases in Canal revenues by the Doubling and Widening Plan. The revenue increase by the Doubling Plan is as estimated in the Main Report while the revenue increase from the use of the Canal by ballast tankers of more than 350,000 DWT is newly estimated in 4-1: Transit Demand Forecast.

As is clear from the results of transit capacity analysis, the increased number of ballast tankers expected to transit the Canal when it is widened is only about 0.3 (real ship) a day even as late as 2000. Thus, it hardly affects the capacity of the Canal. So, the revenue that can be expected from the increasing number of ballast tankers of more than 350,000 GWT transiting the Canal may be regarded as a revenue increase due to the widening.

In Phase I, the Canal will be saturated in 1992; thus, there will be no increase in Canal revenues starting 1993. In the Doubling and Widening Plan ③, the Canal will not be saturated even after 2000 and so, Canal revenues will continue to increase throughout the project life. Canal revenues in important years in each case are estimated as indicated in Table A-8. Ship that overflow from the Suez route due to saturation of Canal capacity switch to the Cape route. These are listed by the average ship size for each year. The increase in Canal revenue from this source (defined in Part IX of the Main Report as R-1 revenues) is considered as a benefit. Demands was studied only for the Base Case and not for the High Case.

Table A-7 Annual Investment Schedule

(10⁶ US$)

	Doubling and Widening Plan ②	Doubling and Widening Plan ③
1981	57.7	57.7
82	137.8	137.8
83	131.7	131.7
84	173.8	173.8
85	158.9	158.9
86	138.3	154.6
87	—	81.1
88	—	102.9
89	—	45.7
90	—	45.7
91	—	45.7
92	—	54.6
93	—	54.6
94	—	30.4
Total	798.2	1,275.2

Table A-8 Additional Revenue Induced by Doubling and Widening Plan

(10^6 US$)

	(1) Revenue increase by Doubling Plan	(2) Revenue increase by Widening Plan	(3) Revenue increase by Doubling and Widening Plan (1) + (2)
1980	—	—	—
81	—	—	—
85	94.2	20.1	114.3
87	144.4	24.7	169.1
90	311.3	30.2	341.5
92	395.8	33.0	428.8
95	529.3	36.1	565.4
2000	752.6	37.5	790.1

3-4 Internal Rate of Return

The internal rate of return of the Doubling and Widening Plan is computed from the costs and benefits determined in the previous and preceding sections. In computing the internal rate of return, 20-years are taken as the project life, as in the case of the Main Report.

1) Phase I Project

The internal rate of return of the Phase I Doubling and Widening Plan ② is as shown below:

	Doubling and Widening Plan ②	Doubling Plan*
Internal rate of return	26.0%	24.2%

*See Part IX of Main Report

From the above results, it can be seen that the Doubling and Widening Plan can be expected to have even a higher internal rate of return than the Doubling Plan. The widening work requires an extra cost not needed in the construction cost of the Doubling Plan, but a Canal revenue increase can be expected from ballast tankers of more than 350,000 DWT. This will ensure much the same internal rate of return as the Doubling Plan.

From the above, one can see that incorporating widening work in the Phase I Doubling Plan does not affect the economic feasibility of the project at all.

2) Phase II Expansion Project

The internal rate of return of the Doubling and Widening Plan ③ incorporating the widening of the western channel as part of the doubling of the entire length is as shown below.

	Doubling and Widening Plan ③	Doubling Plan*
Internal rate of return	25.5%	23.8%

* See Part IX of the Main Report

From the above results it can be seen that (as in Phase I) the Doubling and Widening Plan ③ – even if the entire length is doubled – can be expected to have slightly higher an internal rate of return as the plan involving doubling only.

From the above, one can see that incorporating widening work in the project of doubling the entire length does not affect the economic feasibility of the project any more than it does in Phase I.

3-5 Evaluation

The economic evaluation of the Doubling and Widening Plan including a part of east channel be concluded as follows:

1) Incorporating the plan to widen the western channel to permit ballast tankers of more

than 350,000 DWT to transit does not affect the economic feasibility of the Phase I doubling. Such Doubling and Widening Plan is as feasible as the Doubling Plan.

2) Economic feasibility of the level of Phase I can be expected from the combined performance of the work of doubling the entire Canal and the work of widening the western channel.

3) The economic reasibility of the Doubling and Widening Plan combining the widening of the western channel with the Doubling Plan is generally identical to the results of the Doubling Plan studied in the Main Report.

Thus, it has been confirmed that the conclusions reached in the economic evaluation in the Main Report can be applied to the Doubling and Widening Plan without any amendments.

4. Financial Evaluation

This section deals with the financial feasibility of the Doubling and Widening Plan. This financial evaluation is based on the FRR computed by the DCF method and does not include any evaluation by financial statements. Both plans were studied in the Main Report and so, study results by financial evaluation can be presumed correct with respect to the Doubling Plan by the evaluation by FRR.

4-1 Study Case

The Doubling and Widening Plan ② is examined in this section.

4-2 Costs and Benefits

The construction costs of the above plan are shown in Table A-9 ~ A-11

Similar to the FRR computation in the Main Report, the construction costs include price and physical contingency factors. Since such equipment as tugboats can be handled by the scale of the Doubling Plan, costs under the Doubling Plan can be used as in the case of economic analysis.

For operation costs, no basic difference in control organization exists between the Doubling and Widening Plan and the Doubling Plan. So, operational, maintenance, repair and general control cost adopted under the Doubling Plan are adopted as well as the cost of maintenance dredging and the cost of revetment repairs. Depreciation, paid interest and taxes are not included in the costs.

For benefits, revenue increases due to transit toll resulting from the Doubling and Widening Plan (R-1) are regarded as benefits similarly to the economic analysis.

4-3 FRR and Evaluation

The period for which FRR was computed was 16 years from the start of construction, as in the Doubling Plan. The FRR for the Doubling and Widening Plan ② is as follows:

	Doubling and Widening Plan ②	Doubling Plan*
FRR	18.1%	17.3%

*See Part XI of the Main Report

From the above results, it can be seen that a slightly higher financial profitability than in the Doubling Plan can be expected from the Doubling and Widening Plan ②. In other words, the increase in construction cost due to the widening work can be covered by the revenue increase from ballast tankers of more than 350,000DWT, and the Doubling and Widening Plan can be as profitable as the Doubling Plan.

Table A-9 IRR Calculation Sheet
– Doubling and Widening Plan ② –
IRR = 26.0%

(Unit: 10^6 US$)

No.	Year	COSTS Total	COSTS Construction	COSTS Operation	BENEFITS Total	BENEFITS Increased Revenue	Net Profit
1	1981	57.7	57.7				△ 57.7
2	1982	137.8	137.8				△ 137.8
3	1983	131.7	131.7				△ 131.7
4	1984	173.8	173.8				△ 173.8
5	1985	163.4	158.9	4.5	114.3	114.3	△ 49.1
6	1986	143.8	138.3	5.5	141.8	141.8	△ 2.0
7	1987	6.6		6.6	169.1	169.1	162.5
8	1988	8.7		8.7	226.7	226.7	218.0
9	1989	11.1		11.1	284.3	284.3	273.2
10	1990	13.5		13.5	341.5	341.5	328.0
11	1991	15.0		15.0	385.3	385.3	370.3
12	1992	16.9		16.9	428.8	428.8	411.9
13	1993	16.9		16.9	430.8	430.8	413.9
14	1994	16.9		16.9	430.8	430.8	413.9
15	1995	16.9		16.9	430.8	430.8	413.9
16	1996	16.9		16.9	430.8	430.8	413.9
17	1997	16.9		16.9	430.8	430.8	413.9
18	1998	16.9		16.9	430.8	430.8	413.9
19	1999	16.9		16.9	430.8	430.8	413.9
20	2000	16.9		16.9	430.8	430.8	413.9
21	2001	16.9		16.9	430.8	430.8	413.9
22	2002	16.9		16.9	430.8	430.8	413.9
23	2003	16.9		16.9	430.8	430.8	413.9
24	2004	16.9		16.9	430.8	430.8	413.9
25	2005	8.2		8.2	204.1	204.1	195.9
26	2006	8.2		8.2	204.1	204.1	195.9
27	2007	8.2		8.2	204.1	204.1	195.9
Total		1,107.4	798.2	309.2	7,873.7	7,873.7	6,766.3

Table A-10 IRR Calculation Sheet
– Doubling and Widening Plan ③ –
IRR = 25.5%

(Unit: 10^6 US$)

No.	Year	COSTS			BENEFITS		Net Profit
		Total	Const-ruction	Operation	Total	Increased Revenue	
1	1981	57.7	57.7				△ 57.7
2	1982	137.8	137.8				△ 137.8
3	1983	131.7	131.7				△ 131.7
4	1984	173.8	173.8				△ 173.8
5	1985	163.4	158.9	4.5	114.3	114.3	△ 49.1
6	1986	160.1	154.6	5.5	141.8	141.8	△ 18.3
7	1987	87.7	81.1	6.6	169.1	169.1	81.4
8	1988	111.6	102.9	8.7	226.7	226.7	115.1
9	1989	56.8	45.7	11.1	284.3	284.3	227.5
10	1990	59.2	45.7	13.5	341.5	341.5	282.3
11	1991	60.7	45.7	15.0	385.3	385.3	324.6
12	1992	71.5	54.6	16.9	428.8	428.8	357.3
13	1993	73.3	54.6	18.7	475.8	475.8	402.5
14	1994	51.0	30.4	20.6	517.2	517.2	466.2
15	1995	22.6		22.6	565.4	565.4	542.8
16	1996	24.9		24.9	610.0	610.0	585.1
17	1997	27.4		27.4	650.6	650.6	623.2
18	1998	30.1		30.1	697.2	697.2	667.1
19	1999	33.1		33.1	746.0	746.0	712.9
20	2000	36.4		36.4	790.1	790.1	753.7
21	2001	40.1		40.1	830.8	830.8	790.7
22	2002	44.1		44.1	870.0	870.0	825.9
23	2003	48.5		48.5	911.3	911.3	862.8
24	2004	53.4		53.4	954.7	954.7	901.3
25	2005	52.2		52.2	800.3	800.3	748.1
26	2006	58.5		58.5	838.1	838.1	779.6
27	2007	64.7		64.7	877.8	877.8	813.1
Total		1,932.3	1,275.2	657.1	13,227.1	13,227.1	11,294.8

Table A-11 FRR Calculation Sheet
– Doubling and Widening Plan ② –
FRR = 18.1%

(Unit: 10^6 LE)

No.	Year	COSTS				BENEFITS		Net Profit
		Total	Const-ruction	Equip-ment	Operation	Total	Increased Transit Toll	
1	1981	45.4	45.4					△ 45.4
2	1982	115.8	115.8					△ 115.8
3	1983	118.4	118.4					△ 118.4
4	1984	167.8	167.8					△ 167.8
5	1985	169.7	135.7	30.9	3.1	78.9	78.9	△ 90.8
6	1986	158.1	145.4	8.9	3.8	95.9	95.9	△ 62.2
7	1987	4.6			4.6	116.6	116.6	112.0
8	1988	6.0			6.0	152.2	152.2	146.2
9	1999	7.7			7.7	194.3	194.3	186.6
10	2000	9.3			9.3	236.8	236.8	227.5
11	2001	10.3			10.3	263.9	263.9	253.6
12	2002	11.7			11.7	295.9	295.9	284.2
13	2003	11.7			11.7	295.9	295.9	284.2
14	2004	11.7			11.7	295.9	295.9	284.2
15	2005	11.7			11.7	295.0	295.9	284.2
16	2006	11.7			11.7	295.9	295.9	284.2
Total		871.6	728.5	39.8	103.3	2,618.1	2,618.1	1,746.5

JICA