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Ref. KCC-17/2516

July 30, 1973

H. E. Field Marshal
Prapass Charusathiara
The Minister
Ministry of Interior
Bangkok

Your Excellency:

Subject: Kra Canal/Ports Industrial Zone
Progress Report No. 8

Further to my Progress Report No. 7 dated May 8, 1973, I have the honor to report to Your Excellency the following:

1. A combined meeting of the Senior Review Group and the Technical Advisory Group was held at the Imperial Hotel, Tokyo, July 10-12, 1973. This three-day meeting reviewed the progress made to date by the three consultant firms:

Robert R. Nathan Associates
Hudson Institute
Tippetts-McCarthy-Abbett-Stratton, with the participation of the Lawrence Livermore Laboratory and the U. S. Army Engineer Waterways Experiment Station

in preparation of their Preliminary Survey Report which is to be submitted to the Thai authorities on September 1, 1973.

The meeting was chaired by H. E. Pote Sarasin. Other members of the Thai reviewing group were:

H. E. Dr. Malai Huvanandana, Deputy Interior Minister
H. E. Dr. Boonrod Binson, Minister of State Universities
Dr. Svasti Srisukh, Secretary General, Office of Atomic Energy for Peace
Mr. Paul Sithi-Amnuai, The Bangkok Bank

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Other members of the two groups from the United States, Japan, France, The Netherlands and Germany, also participated in the meeting. (A complete list of attendees is attached as Inclosure 1.)

Dr. Edward Teller and Dr. Willard Libby, both nuclear scientists of world repute, made major contributions to the discussions. Former U. S. Ambassador to Viet Nam, Mr. Frederick Nolting, gave an important insight into the international financial aspects based on his experience with the English Channel tunnel project, mentioning the treaty agreement between England and France, and the fact that the long term Channel tunnel bonds were guaranteed by the two governments.

As the draft prepared by the three consultant firms consisted of a basic report plus four supporting appendices, totaling more than 600 pages, a summary document entitled, "Some Tentative Factors and Perspectives Concerning the Kra Canal/Ports Industrial Zone" was circulated to all members at the combined meeting for their review and comments. (See Inclosure 2.)

An illustrated brochure entitled, "Thailand's Kra Canal Project," prepared in Bangkok by the Kra Canal Survey Office staff, was also circulated as background for the benefit of the three consultant firms and the participants at the conference. (See Inclosure 3.)

In accordance with the Agenda for the meeting (see Inclosure 4), members of the Senior Reviewing Groups from the different countries, speaking in a personal and unofficial capacity, expressed certain comments as guidance to the three consultant firms in the preparation of their final report. See the following inclosures:

Inclosure 5: Comments by the Thai members

5A - Remarks by H. E. Pote Sarasin
5B - Remarks by Mr. Chow Chowkwanyun
5C - Remarks by H. E. Dr. Boonrod
5D - Remarks by Dr. Svasti Srisukh

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Inclosure 6: Comments by the European members

6A - Mr. A. AuPrince
6B - Dr. Ir. H. Hoog
6C - Prof. Ir. P. Ph. Jansen
6D - Dr. H. L. Beth

Inclosure 7: Comments by the Japanese members

7A - Mr. H. Kaifu
7B - Dr. Kooichi Aki
7C - Mr. Makoto Watanabe
7D - Dr. Sadakazu Iijima

Inclosure 8: Comments by the American members

8A - Prof. Edward Teller
8B - Prof. Willard Libby
8C - Mr. Robert R. Nathan
8D - Mr. A. T. Downey

A press release (Inclosure 9) was distributed at a press conference held by Mr. Chow the afternoon of July 12th. Illustrative world-wide wire service accounts of the meeting are shown at Inclosure 10.

2. At the conclusion of the combined meeting, the results of the three days' discussions were summarized as follows:

-The Kra Canal/Ports Industrial Zone is an unconventional project, giant in physical size and in its impact on future history.

-It is technically feasible; the geology of southern Thailand is favorable to its construction; and there appear to be no harmful ecological consequences.

-Plowshare construction (nuclear excavation) of part of the western portion of the canal is both feasible and safe. If used, Plowshare construction would reduce estimated costs by more than $2 billion and would shorten construction time by from two to four years. However, political and public sensitivities to the peaceful use of nuclear explosives need to be taken into consideration and dealt with through a sound public information program.

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-Plowshare is an attractive engineering tool which should be used if political considerations permit. However, the canal's construction is not dependent on Plowshare. It can and should proceed by conventional means if nuclear excavation is not politically acceptable.

-Thailand's Kra Canal/Ports Industrial Zone is financially feasible with the proper combination of public, private and international development financing.

-The span of economic projections through the year 2000 is extremely wide. Estimated canal revenues vary by a factor of ten between the most optimistic and most pessimistic combination of major relevant assumptions for that time frame. Additional data and study is required to narrow the differences between these projections.

-The canal contributes to the mutual self interests of a number of nations throughout the world. Its financing is a matter for governments as well as for banks.

-Based on the information presented, the general conclusion at this point appears to be that the project will warrant moving ahead into the next phase, to include more detailed feasibility studies.

3. H. E. Pote Sarasin made the following points in his closing remarks:

-It seems clear that there are no technical or engineering problems which would hinder the canal's construction.

-Credit must be given to Mr. Chow who has single-handedly borne the costs of the Preliminary Survey. His patriotic motivation, vision and noble aims are to be commended by all.

-It seems clear that the canal is a prerequisite to the full development of the industrial zone. Once built it would provide great benefits to southern Thailand.

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-The Plowshare aspects of the canal's construction would, of course, have to be discussed with the U. S. Government. He is confident that the U. S. Government would never authorize use of nuclear explosives in Thailand unless it was absolutely convinced such use was completely safe. Even then, a major program of education and public relations will be required to convince the Thai people and the governments of neighboring countries that Plowshare construction is safe. Perhaps Dr. Teller can assist in explaining the technical and safety considerations to the Thais and to neighboring countries.

-Relocation of people is always a sensitive political problem. The relocation of up to 200,000 people, if the Plowshare construction concept is implemented, presents certain political and logistic obstacles which must be dealt with. Special legislation will be required for the temporary appropriation of land within the relocation area.

-National security considerations, although different from what they were ten years ago, will still be paramount.

-As the next stage in the Kra Canal project could cost twenty times that which has already been expended, the final recommendations to the Thai Government must be definite and specific. Actions required by the Government must be spelled out as must the responsibilities of any Kra Canal corporation established to construct and operate the canal/ports industrial zone.

-Once the Royal Thai Government takes formal action on the recommendations forwarded with the Preliminary Survey Report, then it will be appropriate for bi-lateral discussions to begin with the Japanese, U. S. and other governments. As the Kra Canal would provide a shorter, safer, alternate sea route for their oil shipments from the Middle East, it is hoped that the Japanese Government would be sympathetic in its support for the project.

-At that time, the Royal Thai Government will also study the desirability of forwarding a copy of the Preliminary Survey Report to the World Bank for their review and blessing.

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Continuation 6

-The Thai delegation has taken pains to emphasize the difficulties inherent in a construction program of the magnitude of the Kra Canal. However, this should not be interpreted as reflecting a negative attitude on the part of the Thai delegation. On the contrary, he personally would like to see the project succeed and believes this view is fully shared by all his Thai colleagues present at this historic meeting.

4. The final report of this Preliminary Survey, which has studied the economic and technical feasibility of constructing a sea-level canal across the southern portion of the Thai Isthmus, will be forwarded to Your Excellency on September 1, 1973. At that time, specific implementing proposals will be submitted for the approval of His Majesty's Government.

Respectfully yours,

Chow Chowkwanyun

Incs.

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INCLOSURE NO. 1

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7

KRA JOINT ECONOMIC & TECHNICAL REVIEW MEETING

10th - 12th JULY 1973

TOKYO

LIST OF PARTICIPANTS

Attendants from U.S.A.

1.	Prof. Edward Teller	-LLL, Livermore, California
2.	Prof. Willard Libby	-University of California
3.	Mr. Fred Holtzer	-LLL, Livermore, California
4.	Mr. Wilson V. Binger	-TAMS, N.Y.
5.	Mr. Horace A. Johnson	-TAMS, N.Y.
6.	Mr. Robert R. Nathan	-RRNA, Washington D.C.
7.	Mr. Jerome Jacobson	-RRNA, Washington D.C.
8.	Mr. Gerard J. Forney	-BECHTEL Corp.
9.	Mr. F. Nolting	-Morgan Guaranty Trust Co., an Former U.S. Ambassador to Vietnam
10.	Mr. A.T. Downey	-Counsel
11.	Mr. Gordon Calder	-Lehman Bros.
12.	Lt. Gen. E.M. Reyno, RCAF (RET.)	-The LTV Corp.

Attendants from Europe

1.	Mr. A. Auprince	-CITRA, Paris
2.	Mr. R. Richard	-CITRA, Paris
3.	Dr. Ir. H. Hoog	-Consultant Engineer, The Hag
4.	Prof. Ir. P. Ph. Jansen	-Consultant Engineer, The Hag

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5. Dr. H.L. Beth	-Consultant Engineer, Bremen
6. Mr. H. Jeandet	-Former Advisor to European Investment Bank.

Attendants - Thailand

1. H.E. Pote Sarasin	-Former Prime Minister Present, Advisor to Prime Minister
2. H.E. Dr. Malai Huvanandana	-Deputy Minister of Interior
3. H.E. Dr. Boonrod Binson	-Minister of State Universities
4. Dr. Svasti Srisukh	-Secretary General, Office of Atomic Energy for Peace
5. Mr. Paul Sithi-Amnuai	-Special Advisor
6. Mr. Kanung Luchai	-Public Prosecutor
7. Mr. Theh Chongkhadikij	-Editor, Bangkok Post
8. Gen. Edwin F. Black	-Coordinator, KRA Canal Project
9. Mr. I.S. Nadler	-Managing Director Thai Petrochemical Co., Ltd.
10. Mr. K.Y. Chow	-T.O.R.C.
11. H.E. Suphot Phiansunthon	-Thai Ambassador in Japan
12. Mr. Amoraksa Huvananda	-Secretary to H.E. Malai

Attendants - Japan

1. Dr. Kooichi Aki	-Professor at Takushoku Universi and Advisor to the Prime Minist on Reginal Development

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2.	Prof. Dr. Hidetake Kakihana	-Director, Research Laboratory of Nuclear Reactor Tokyo Institute of Technology
3.	Mr. Hachiro Kaifu	-Senior Managing Director Nissho-Iwai Co., Ltd.
4.	Dr. Hajime Sato	-Director General of The Japan Port & Harbour Association
5.	Mr. Gengoh Tsuboi	-President of Tokyo Tanker Co.,Ltd
6.	Mr. James S. Kagami	-Director of Tokyo Tanker Co.,Ltd.
7.	Mr. Keiji Yura	-Assistant General Manager, International Operations Dept. Maruzen Oil Co., Ltd.
8.	Mr. Makoto Watanabe	-Vice-President, The Shoko Chukin Bank. (The Central Bank for Commercial & Industrial Co-Operations)
9.	Dr. Sadakazu Iijima	-Executive Director Japan Industrial Location Center
10.	Mr. Yuzo Takahashi	-Assistant Chief Project General Office Machinery Div. Nissho-Iwai Co., Ltd.

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INCLOSURE NO. 2

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10

Some Tentative Factors and Perspectives

concerning the

Kra Canal/Ports Industrial Zone

July 1973

(Circulated for review and comment by the Senior Review Group and the Technical Advisory Group at their combined meeting at the Imperial Hotel, Tokyo, Japan on July 10-12, 1973)

For supporting data see:

Appendix B: Engineering Studies
Appendix C: Economic Studies
Appendix D: Preliminary Assessment of Nuclear Excavation Practicality

Other supporting materials as well as conclusions will appear in the Final Report, scheduled for completion on 1 September 1973.

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H I G H L I G H T S

The Kra Canal/Ports industrial zone is not a conventional project. It is important to Thailand and to Japan's energy lifeline. It could yield tangible and intangible benefits to the Southeast Asian region. To the world's naval and maritime powers these will be considerable though not all will be quantifiable. It could allay fears about problems of freedom of passage in the region. There is no rate-of-return analysis that can give adequate credit to these important tangible and intangible factors.

The project faces no insuperable physical obstacles. The indicated canal would be one-lane, capable of handling 500,000-d.w.t. vessels. The estimated cost would be $5.6 billion with conventional excavation and $3.5 billion with partially nuclear excavation. About $200 million would be added initially for the ports and industrial complex. (Financing costs during construction would depend upon the type of funds which might be available, and would be additive.)

Of the several canal sizes studied, the one-lane, 500,000-d.w.t. capacity canal shows the highest return on investment. Using optimistic assumptions for each variable considered, calculations show a 13.8-percent return if calculated over a 67-year period for a one-way, 500,000-ton canal using conventional excavation. With part nuclear excavation and under these same optimistic assumptions and time span, the return rises to 15.7 percent.

The 67 year time span, at first glance, of course discourages any serious investors in the project. However, due to the unconventional nature of the project, further work must be done to package the financial aspects of this project in such a manner that the time span will be brought down to a realistic level.

By postulating optimistic assumptions on cargo movements, price changes, and tolls, the revenues for the 500,000-ton, one-way canal could begin in 1988 at an annual level of $592 million, expanding rapidly to $2.8 billion in the year 2000. Under the least optimistic assumptions, revenues for this same canal configuration would begin at $141 million, reaching only $305 million in 2000.

At the present stage of the study the variation between optimistic and pessimistic projections is extremely wide. Advice and suggestions are solicited to narrow the projection span to determine the most realistic basis for future planning.

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I. Technical Considerations bearing on Canal Design

Size and Configuration of Canal

Six potential routes for the canal were identified for consideration, and from among these, the route known as 5-A was selected. It lies in the south of the Kra Isthmus and runs from Songkhla on the east to a point about 30 kilometers north of Satun on the west.

The choice was made after consideration of the following major factors: proximity to national boundaries, cost, availability of port and industrial sites, environmental considerations, and number of persons that would be affected if nuclear excavation were used.

Canals of the following sizes were costed:

1. One that would accommodate tankers of 500,000 d.w.t. --- the coming generation of tankers.

2. One to accommodate a tanker of 250,000 d.w.t., for which many orders are currently being placed; it is also the largest tanker that presently can be handled at all but one of Japan's ports.

3. A canal to accommodate ships of 150,000 d.w.t., which would include many present-day tankers, and the present generation of container ships, large bulk carriers, and general cargo vessels. Preliminary estimates revealed a negligible rate of return for this canal configuration.

4. A smaller canal for ships of 50,000 d.w.t. and less, which would include the present generation of container ships, bulk carriers, and general cargo vessels.

For each canal, costs were estimated for one lane, two lanes, and two lanes at each end narrowing to one lane in the central 60 kilometers. In this central segment the ground elevation is higher, and costs per cubic meter of excavation are also high because of the hard rock encountered.

Construction costs were estimated for excavation by both conventional and nuclear means. To the costs of the latter was added the estimated cost of evacuating about 200,000 persons from the area which would be subject to shock waves or to temporary radioactive fallout. The cost of evacuation, on a permanent basis, is estimated to be approximately $60 million.

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The construction costs of different canal configurations (exclusive of financing charges) are summarized as follows:

Canal size (largest ship transiting in d.w.t.)	All conventional construction			Part nuclear construction		
	1 lane	1 & 2 lanes	2 lanes	1 lane	1 & 2 lanes	2 lanes
	-------- bil. of dol. (in 1973 prices) --------					
500,000.....	5.65	7.50	11.10	3.54	5.18	6.22
250,000.....	4.25	5.40	8.35	2.73	3.71	4.45
50,000.....	2.84	3.10	4.65	2.06	2.30	2.60

All canal configurations examined are technically feasible with conventional construction. The excavation of a portion of the canal by nuclear methods, utilizing techniques already developed, appears to be technically feasible. However, the political problems of using nuclear devices are complex and are both national and international in scope. Yet the great savings in cost made possible by nuclear excavation warrant serious study of this alternative.

The porject faces no insuperable physical obstacles. The indicated canal would be one-lane, capable of handling 500,000-d.w.t. vessels. Estimated construction costs would be $5.6 billion with conventional excavation and $3.5 billion with partially nuclear excavation. About $200 million would be added initially for the ports and industrial complex.

See the attached tables:

Table III - 8
Table III - 12
Table III - 15

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Table III - 8

ROUTE 5-A QUANTITIES AND COSTS – CONVENTIONAL EXCAVATION

Material	Method of Construction	Unit Price $/m³	500 000 DWT SHIP 2-LANE Quantity m³/10⁶	2-LANE Cost $/10⁶	PART 1-LANE Quantity m³/10⁶	PART 1-LANE Cost $/10⁶	ONE WAY Quantity m³/10⁶	ONE WAY Cost $/10⁶
Land Section								
Sand/Clay	Dredging	0.555	710	395	710	395	350	195
Soft Rock	Dredging	1.815	175	320	175	320	70	125
Common	Shovel/Truck/ Rail Car	1.230	15	20	15	20	10	10
Soft/Medium Rock	Shovel/Truck/ Rail Car	1.585	1575	2500	960	1520	820	1300
Medium/Hard Rock	Shovel/Truck/ Rail Car	1.860	1830	3400	920	1710	920	1710
Subtotal			4305	6635	2780	3965	2170	3340
Sea Approaches								
West Coast								
Sand/Clay	Dredging	0.75	595	450	595	450	350	265
Soft Rock	Dredging	2.65	55	145	55	145	25	65
Medium Rock	Dragline/Scow	3.70	25	95	25	95	–	–
Subtotal			675	690	675	690	375	330
East Coast								
Sand/Clay	Dredging	0.75	530	400	530	400	250	185
Soft Rock	Dredging	2.65	55	145	55	145	25	65
Medium Rock	Dragline/Scow	3.70	30	110	30	110	–	–
Subtotal			620	655	620	655	275	250
TOTAL(1)			5600	7980	4075	5310	2820	3920

(1) 25% Contingency to be added

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Table III - 12

CAPITAL COST – KRA CANAL ROUTE 5A – (CONVENTIONAL EXCAVATION)
COST IN U.S. $/10^6

Cost Item	500 000 DWT			250 000 DWT			150 000 DWT			50 000 DWT		
	2-Lane	Part 1-Lane	One Way	2-Lane	Part 1-Lane	One Way	2-Lane	Part 1-Lane	One Way	2-Lane	Part 1-Lane	One Way
Excavation	7980	5310	3920	5920	3730	2890	4950	3100	2630	3180	2040	1830
Flood Control, Jetties Hydraulic Structures	100	100	100	100	100	100	100	100	100	100	100	100
O & M Facilities	110	110	110	110	110	110	110	110	110	110	110	110
Canal Crossings & Relocations	110	80	80	110	80	80	100	70	70	90	70	70
R/W	10	10	10	10	10	10	10	10	10	10	10	10
Subtotal	8310	5610	4220	6250	4030	3190	5270	3390	2925	3490	2330	2120
Contingencies 25% ±	2080	1400	1060	1560	1010	800	1320	850	730	870	580	530
Subtotal	10390	7010	5280	7810	5040	3990	6590	4240	3650	4360	2910	2650
Engineering & Administrative 7% ±	730	490	370	540	360	280	460	300	250	310	200	190
Total	11120	7500	5650	8350	5400	4270	7050	4540	3900	4670	3110	2840
Construction Period Years	14	13	12	13	12	11	13	12	11	12	11	10

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Table III - 15

CAPITAL COST – KRA CANAL ROUTE 5A – PART NUCLEAR Km 11-56
COST IN U.S. $/10^6

Cost Item	500 000 DWT			250 000 DWT			150 000 DWT			50 000 DWT		
	2-Lane	Part 1-Lane	One Way	2-Lane	Part 1-Lane	One Way	2-Lane	Part 1-Lane	One Way	2-Lane	Part 1-Lane	One Way
Excavation (Conventional)	7980	5310	3920	5920	3730	2890	4950	3100	2630	3180	2040	1830
Conventional Excavation Eliminated by Nuclear Excav.	4330	2390	2180	3520	1910	1760	3050	1700	1580	2100	1240	1180
Subtotal	3650	2920	1740	2400	1820	1130	1900	1400	1050	1080	800	650
Flood Control, Jetties, Hydraulic Structures	100	100	100	100	100	100	100	100	100	100	100	100
O & M Facilities	110	110	110	110	110	110	110	110	110	110	110	110
Canal Crossing & Relocations	110	110	80	110	110	80	100	100	70	90	90	70
R/W	10	10	10	10	10	10	10	10	10	10	10	10
Subtotal	3980	3250	2040	2730	2150	1430	2220	1720	1340	1390	1110	940
Contingencies 25% ±	1000	810	510	680	540	360	560	430	340	350	280	240
Subtotal	4980	4060	2550	3410	2690	1790	2780	2150	1680	1740	1390	1180
Engineering & Administrative 7% ±	350	290	180	240	190	130	190	150	120	120	100	80
Total	5330	4350	2730	3650	2880	1920	2970	2300	1800	1850	1490	1260
Cost of Nuclear Excavation	885	825	810	795	825	810	780	825	795	735	810	795
Total Cost Using Nuclear	6215	5175	3540	4445	3705	2730	3750	3125	2595	2595	2300	2055
	12	11	10	11	10	9	11	10	9	10	9	8

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II. Economic Considerations Bearing on Canal Design

Return on Investment

The internal rate of return (IRR), also referred to as the "financial rate of return", has been selected as the standard which enables us to rank the projects and describe their financial feasibility quickly. The IRR is a measure of the rate of return on an investment, not unlike the rate of interest that is paid on a bond or savings account. It is that rate of interest which equates the sum of the discounted costs in each year with the sum of the discounted revenues in each year. The IRR is the generally accepted standard for judging project feasibility used by the IBRD (World Bank), the Asian Development Bank and other international lending institutions.

The financial rate of return is the measure of the project's profitability, with construction costs incurred in the early years being set off against later revenues. Because of the many canal alternatives (different sizes, number of lanes, and methods of construction) and the many varying revenue assumptions, numerous rates of return have been calculated.

Of the several canal sizes studied, the one-lane, 500,000-d.w.t. capacity canal shows the highest return on investment. Using optimistic assumptions for each variable considered, calculations show a 13.8 percent return over a 67-year period for a one-way, 500,000 ton canal with conventional excavation. With part nuclear excavation and under these same optimistic assumptions and time span, the return rises to 15.7 percent.

The optimistic assumptions posit a very high rate of growth of GNP for Japan and other countries in the Pacific region; a continued high dependence of Japan on crude oil for its energy and on the Middle East for supplies; the closing of the Straits of Singapore and Malacca to tankers of 200,000 d.w.t. or more; and continuation of inflationary forces and their impact on operating costs of ships, the value of time savings for users of the Kra Canal, and therefore of the tolls that can be charged on passages. The pessimistic assumptio encompass lower GNP growth, continued access of the Straits of Singapore and Malacca to tankers and constant prices.

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The rates of return for the one-lane, 500,000 d.w.t. capacity canal with conventional excavation, under varying sets of assumptions, calculated over a period of 67 years, are as follows:

GNP	Malacca Straits	Inflation (pct. per year)	Rate of return (pct.)
High	Closed to tankers	6	13.8
High	Open to tankers	6	12.4
High	Closed to tankers	none	7.3
High	Open to tankers	none	6.2
Medium	Closed to tankers	6	12.6
Medium	Open to tankers	6	11.4
Medium	Closed to tankers	none	6.2
Medium	Open to tankers	none	5.0
Low	Closed to tankers	6	10.8
Low	Open to tankers	none	4.0

Note the effect that modest changes in the assumptions have on the rate of return. Reducing Japan's growth rate from 10 to 7 percent, with similar reductions in the other countries' growth rates, drops the rate of return from 13.8 percent to 10.8 percent. If in place of inflation we assume constant prices, the rate drops from 13.8 to 7.3 percent. If Malacca is open to all tankers, the return falls from 13.8 percent to 12.4 percent. Assumed inflation of 6 percent per year makes a major contribution to revenues and increases the rate of return about 6 percentage points above rates calculated with an assumption of constant prices. Not shown in the table, but important, is the reduction from 13.8 percent to about 12 percent if we retain the high GNP growth rates, but reduce the role of petroleum in the region's economies and their dependence on Middle Eastern crude oil.

The course of inflation, the feasibility of nuclear excavation, and the future of the Strait of Malacca are all highly uncertain, and hence the calculated rates of return show wide variations.

See the attached tables:

Table VII - 5
Table VII - 4

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Table VII-5. Revenues and Expenditures for a Complex With 500,000-D.W.T. Canal With One Lane, Conventional Construction, Internal Rate of Return of 13.8 Percent for 1974-2000, 2010, 2020, 2030 and 2040

(In millions of dollars)

Year	Canal		Transshipment port		Industrial land		Ship operations		Total[a]	
	Exp.	Rev.	Exp.	Rev.	Exp.	Rev.	Exp.	Rev.	Exp.	Rev.
1974..	5	--	--	--	--	--	--	--	5	--
1975..	6	--	--	--	--	--	--	--	6	--
1976..	146	--	--	--	--	--	--	--	146	--
1977..	304	--	--	--	--	--	--	--	304	--
1978..	757	--	--	--	--	--	--	--	757	--
1979..	883	--	--	--	--	--	--	--	883	--
1980..	888	--	--	--	--	--	--	--	888	--
1981..	989	--	--	--	--	--	--	--	989	--
1982..	1,000	--	--	--	--	--	--	--	1,000	--
1983..	1,113	--	--	--	--	--	--	--	1,113	--
1984..	1,182	--	--	--	--	--	--	--	1,182	--
1985..	1,136	--	64	10	--	--	--	--	1,200	10
1986..	843	--	7	12	--	--	--	--	851	12
1987..	255	--	8	13	--	--	--	--	264	13
1988..	72	592	10	15	--	--	--	--	82	607
1989..	76	672	11	18	127	--	--	--	214	689
1990..	81	764	11	18	--	16	12	3	104	801
1991..	86	869	13	21	--	17	--	3	99	910
1992..	91	992	15	24	--	18	--	3	106	1,038
1993..	96	1,129	17	28	--	19	--	3	114	1,179
1994..	102	1,283	20	32	170	20	--	3	292	1,339
1995..	103	1,461	20	32	--	58	--	4	123	1,555
1996..	115	1,663	23	36	--	61	--	4	137	1,765
1997..	122	1,895	181	42	--	65	--	4	303	2,006
1998..	129	2,156	30	48	--	69	--	4	158	2,277
1999..	137	2,457	34	55	228	73	--	5	398	2,590
2000..	145	2,798	33	54	--	155	22	10	200	3,017
2010..	259	7,534	105	168	--	498	39	27	403	8,226
2020..	464	20,986	927	532	--	1,991	244	87	1,634	23,596
2030..	831	55,872	970	1,554	--	7,668	561	255	2,361	65,349
2040..	1,488	144,355	1,820	2,921	--	13,731	--	456	3,308	161,464
Total[b]	34,599	1,560,174	29,155	37,718	2,351	172,896	1,635	5,476	67,740	1,776,264

Note: Assumptions of (1) high GNP growth rates, (2) inflation of 6 percent per year, (3) Strait of Malacca closed to tankers, (4) toll equal to 80 percent of shipping gains, (5) 50 percent of petroleum carried in 500,000-d.w.t. tankers and balance in 200,000-d.w.t. tankers.

a/ Totals may not add due to rounding.

b/ Totals are for all years in the 67-year period 1974-2040.

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Table VII-5. Revenues and Expenditures for a Complex With 500,000-D.W.T. Canal With One Lane, Conventional Construction, Internal Rate of Return of 13.8 Percent for 1974-2000, 2010, 2020, 2030 and 2040

(In millions of dollars)

Year	Canal		Transshipment port		Industrial land		Ship operations		Total[a]	
	Exp.	Rev.	Exp.	Rev.	Exp.	Rev.	Exp.	Rev.	Exp.	Rev.
1974..	5	--	--	--	--	--	--	--	5	--
1975..	6	--	--	--	--	--	--	--	6	--
1976..	146	--	--	--	--	--	--	--	146	--
1977..	304	--	--	--	--	--	--	--	304	--
1978..	757	--	--	--	--	--	--	--	757	--
1979..	883	--	--	--	--	--	--	--	883	--
1980..	888	--	--	--	--	--	--	--	888	--
1981..	989	--	--	--	--	--	--	--	989	--
1982..	1,000	--	--	--	--	--	--	--	1,000	--
1983..	1,113	--	--	--	--	--	--	--	1,113	--
1984..	1,182	--	--	--	--	--	--	--	1,182	--
1985..	1,136	--	64	10	--	--	--	--	1,200	10
1986..	843	--	7	12	--	--	--	--	851	12
1987..	255	--	8	13	--	--	--	--	264	13
1988..	72	592	10	15	--	--	--	--	82	607
1989..	76	672	11	18	127	--	--	--	214	689
1990..	81	764	11	18	--	16	12	3	104	801
1991..	86	869	13	21	--	17	--	3	99	910
1992..	91	992	15	24	--	18	--	3	106	1,038
1993..	96	1,129	17	28	--	19	--	3	114	1,179
1994..	102	1,283	20	32	170	20	--	3	292	1,339
1995..	103	1,461	20	32	--	58	--	4	123	1,555
1996..	115	1,663	23	36	--	61	--	4	137	1,765
1997..	122	1,895	181	42	--	65	--	4	303	2,006
1998..	129	2,156	30	48	--	69	--	4	158	2,277
1999..	137	2,457	34	55	228	73	--	5	398	2,590
2000..	145	2,798	33	54	--	155	22	10	200	3,017
2010..	259	7,534	105	168	--	498	39	27	403	8,226
2020..	464	20,986	927	532	--	1,991	244	87	1,634	23,596
2030..	831	55,872	970	1,554	--	7,668	561	255	2,361	65,349
2040..	1,488	144,355	1,820	2,921	--	13,731	--	456	3,308	161,464
Total[b]	34,599	1,560,174	29,155	37,718	2,351	172,896	1,635	5,476	67,740	1,776,264

Note: Assumptions of (1) high GNP growth rates, (2) inflation of 6 percent per year, (3) Strait of Malacca closed to tankers, (4) toll equal to 80 percent of shipping gains, (5) 50 percent of petroleum carried in 500,000-d.w.t. tankers and balance in 200,000-d.w.t. tankers.

a/ Totals may not add due to rounding.

b/ Totals are for all years in the 67-year period 1974-2040.

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Table VII-4. Revenues and Expenditures for a Complex With 500,000-D.W.T. Canal With One Lane, Conventional Construction, Internal Rate of Return of 5.0 Percent for 1974-2000, 2010, 2020, 2030 and 2040

(In millions of dollars)

Year	Canal		Transshipment port		Industrial land		Ship operations		Total[a]	
	Exp.	Rev.	Exp.	Rev.	Exp.	Rev.	Exp.	Rev.	Exp.	Rev.
1974..	5	--	--	--	--	--	--	--	5	--
1975..	5	--	--	--	--	--	--	--	5	--
1976..	123	--	--	--	--	--	--	--	123	--
1977..	241	--	--	--	--	--	--	--	241	--
1978..	565	--	--	--	--	--	--	--	565	--
1979..	622	--	--	--	--	--	--	--	622	--
1980..	592	--	--	--	--	--	--	--	592	--
1981..	622	--	--	--	--	--	--	--	622	--
1982..	592	--	--	--	--	--	--	--	592	
1983..	622	--	--	--	--	--	--	--	622	--
1984..	622	--	--	--	--	--	--	--	622	--
1985..	565	--	32	5	--	--	--	--	597	5
1986..	396	--	3	6	--	--	--	--	399	6
1987..	113	--	4	6	--	--	--	--	117	6
1988..	30	(141)	4	6	--	--	--	--	34	148
1989..	30	151	4	7	50	--	--	--	84	157
1990..	30	160	4	7	--	6	5	1	39	174
1991..	30	170	5	7	--	6	--	1	35	185
1992..	30	182	5	8	--	6	--	1	35	197
1993..	30	194	5	9	--	6	--	1	35	209
1994..	30	207	6	9	50	6	--	1	86	223
1995..	30	220	6	9	--	16	--	1	36	246
1996..	30	235	6	10	--	16	--	1	36	261
1997..	30	251	45	10	--	16	--	1	75	278
1998..	30	267	7	11	--	16	--	1	37	296
1999..	30	286	8	12	50	16	--	1	88	315
2000..	30	305	7	11	--	32	5	2	41	350
2010..	30	434	12	19	--	58	5	3	47	514
2020..	30	652	60	34	--	129	16	6	106	820
2030..	30	964	35	56	--	277	20	9	85	1,306
2040..	30	1,395	37	59	--	277	--	9	67	1,740
Total[b]	7,275	31,897	1,373	1,601	300	6,564	79	219	9,026	40,281

Note: Assumptions of (1) medium GNP growth rates, (2) no inflation, (3) Strait of Malacca open to tankers, (4) toll equal to 80 percent of shipping gains, (5) 50 percent of petroleum carried in 500,000-d.w.t. tankers and balance in 200,000-d.w.t. tankers.

a/ Totals may not add due to rounding.

b/ Totals are for all years in the 67-year period 1974-2040.

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III. Projected Canal Revenues

Methodology

The following steps were involved in estimating canal revenues: (1) estimating present cargo movements that might use a canal at Kra if one were there now; (2) projecting these cargo movements to the year 2040; (3) estimating the portion of this cargo that might transit the canal, and assigning the cargo to different sizes and types of vessels; (4) estimating the shipping gains that would result for each type of ship through its use of the canal; (5) determining what the toll charges could be; and (6) multiplying the number of tons carried through the canal by the toll per ton to arrive at projected revenue.

Cargo Movements

In 1970, approximately 266 million tons of cargo moved across a line for which passage through the Kra Canal would represent the shortest distance. That is, had there been a canal in that year and had distance been the controlling determinant of the route used, theoretically 266 million tons of cargo could have moved through the Kra Canal. About 95 percent was in cargo from west to east, and almost two-thirds of that was in the form of crude oil moving to Japan. General cargo accounted for 17 percent of trade movements in 1970. Bulk shipments of iron ore to Japan from India and Africa were only a small percentage of total canal movements. The only other countries for which canal-affected trade was of any consequence are Korea and Mainland China.

By the year 2000, cargo moving in the area will expand greatly as the economies of the region enjoy growth rates of 6 to 12 percent. Japan's petroleum imports will dominate the potential trade movements through the canal. By the year 2000 Japan is expected to import between 0.6 and 2.3 billion tons of crude oil from the Middle East. By the year 2020, the figure could be as high as 4.6 billion tons. The range of estimates is extremely wide. If we posit a high rate of growth of the Japanese GNP (and for other countries in the area), a high ratio of petroleum in energy consumption, and continued dependence upon crude oil from the Middle East, then huge quantities of oil moving through the canal would generate large revenues. Modest or low assumptions for all these factors would lead to much smaller oil movements and revenues.

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Canal Revenues

Based on preliminaty calculations made to date it appears that canal revenues may account for about 85 percent of all revenue from the complex.

Common features of these preliminary canal revenue projections are:

1. Canal revenues continue to grow exponentially over the life of the project. Under conditions of inflation they expand at a much faster pace.
2. The canal earns no revenues until 10 to 14 years after the initial expenditures for construction.
3. For most canal configurations the bulk of the canal's revenue --- almost 85 percent in the year 2000 --- is from petroleum movement. General cargo is the next largest earner, accounting for about 9 percent.

By postulating optimistic assumptions on cargo movements, price changes, and tolls, the revenues for the 500,000-ton, one-way canal could begin in 1988 at an annual level of $592 million, expanding rapidly to $2.8 billion in the year 2000. Under the least optimistic assumptions, revenues for this same canal configuration would begin at $141 million, reaching only $305 million in 2000.

See the following:

Plate IV - 1
Table IV - 4
Appendix C, Plate 1

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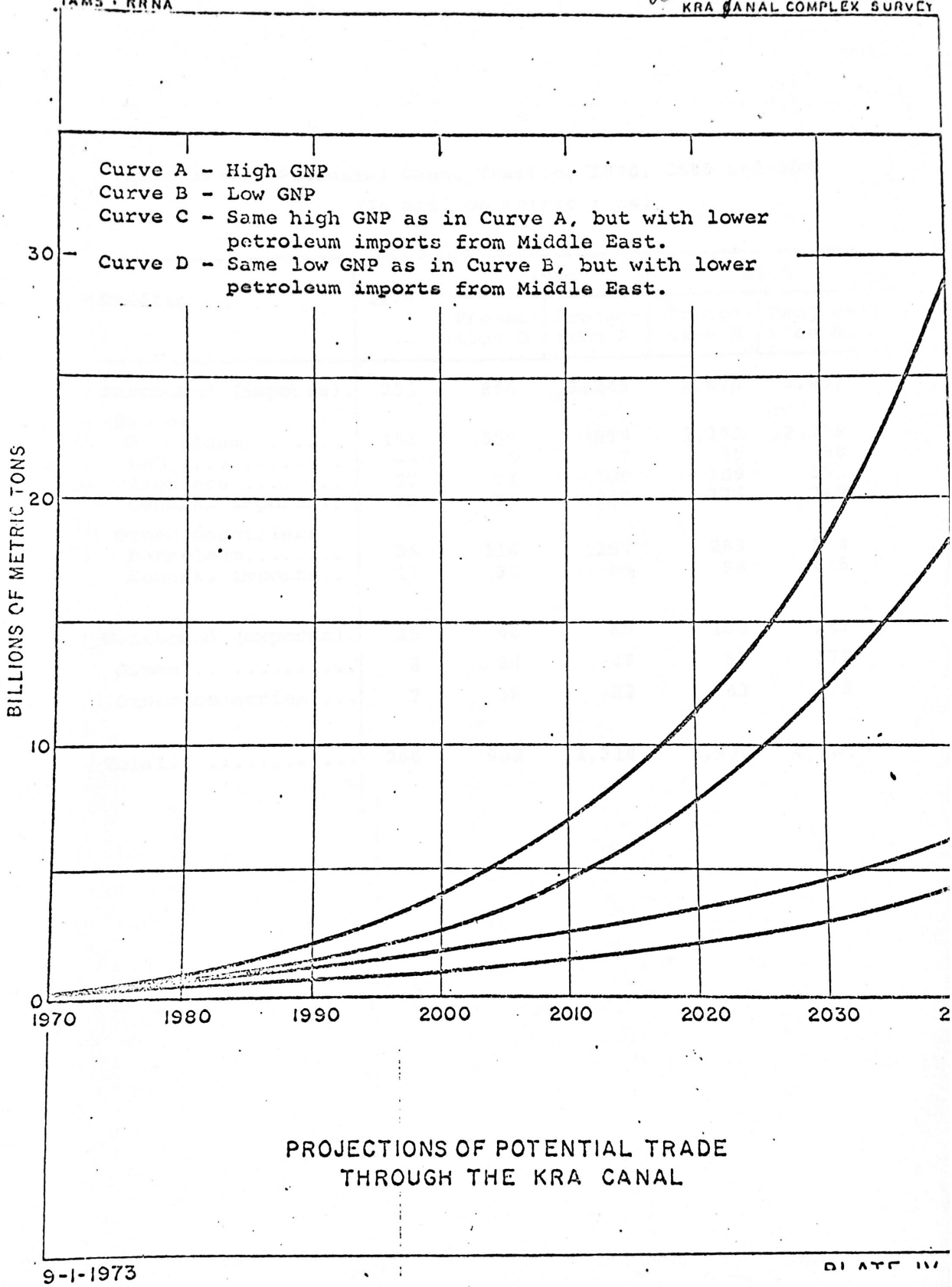
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IV-40

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KRA CANAL COMPLEX SURVEY



PROJECTIONS OF POTENTIAL TRADE
THROUGH THE KRA CANAL

9-1-1973

PLATE IV

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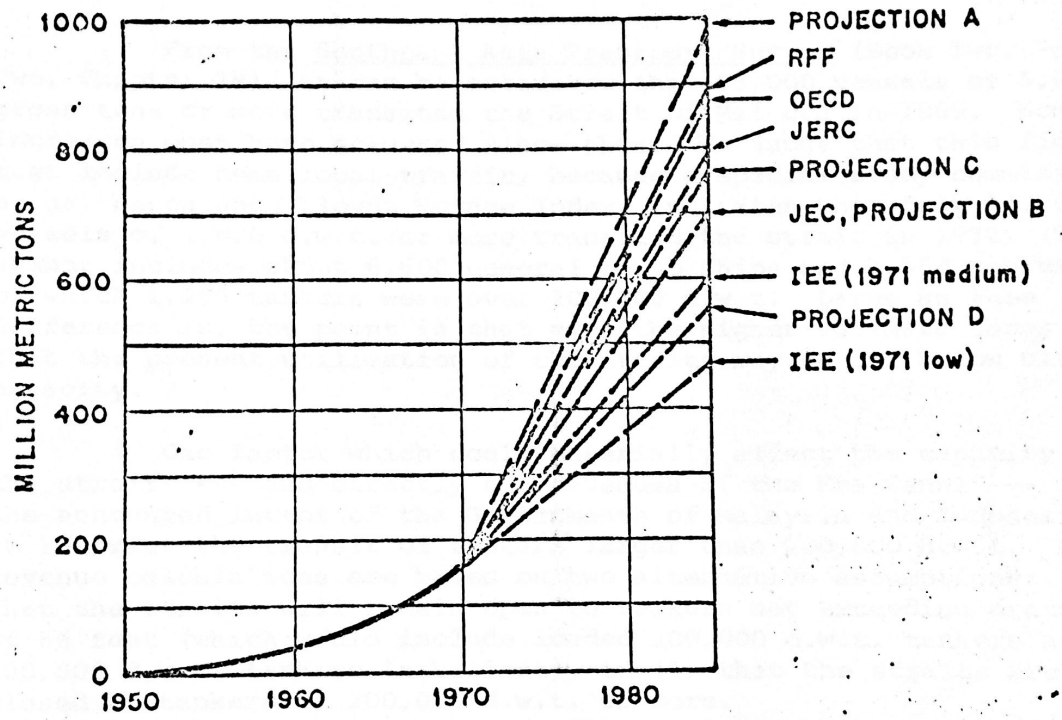
Table IV-4. Potential Canal Traffic, 1970, 1985 and 2000
(In million metric tons)

Traffic	1970	1985		2000	
		Projection B	Projection A	Projection B	Projection A
Eastbound (imports).	251	856	1,249	1,870	3,857
Japan:	158	559	814	1,171	2,258
Petroleum.....	--	5	7	35	68
LNG.....	27	71	100	109	193
Iron ore.....	20	73	110	176	349
General imports..					
Other countries:	35	116	164	283	564
Petroleum.....	11	32	54	96	425
General imports..					
Westbound (exports).	15	46	69	100	247
Japan.....	8	28	47	57	172
Other countries....	7	18	22	43	75
Total.....	266	902	1,318	1,970	4,104

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RFF = Resources for the Future (United States)
OECD = Organization for Economic Cooperation and Development
JERC = Japan Economic Research Center
JEC = Japan Overall Energy Council
IEE = Institute for Energy Economics (Japan)

PROJECTIONS OF JAPANESE PETROLEUM IMPORTS

APPENDIX C
PLATE 1

9-1-1973

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2

Congestion in the Straits of Singapore and Malacca

As the Straits of Malacca and Singapore become more congested, there is a stronger case for a Kra Canal, because vessels up to, say, 250,000 tons presently using these straits would have to go farther south through the Strait of Sunda. There is, however, confusion on the present levels of traffic and the effective capacity of the straits.

From the Southeast Asia Transport Survey (Book Two, Part Two, Chapter IV), it can be estimated that 23,000 vessels of 5,000 gross tons or more transited the Strait of Malacca in 1969. Some increases must have occurred since then. We judge that this figure must include some local traffic, because a special study commissioned by us, based upon Lloyds Voyage Index, indicates that only 14,500 vessels of 1,000 d.w.t. or more transited the strait in 1972. This number includes about 6,600 general cargo ships and 5,500 tankers, of which 1,295 tankers were over 100,000 d.w.t. Large as this difference is, the point is that even the higher estimate shows that the present utilization of the straits may be far below ultimate capacity.

One factor which could materially affect the capacity of the straits --- and directly the revenues of the Kra Canal --- is the announced intent of the Governments of Malaysia and Indonesia to restrict the transit of tankers larger than 200,000 d.w.t. Our revenue calculations are based on two alternative assumptions: (1) that the straits will remain open to tankers not exceeding drafts of 66 feet (which would include loaded 200,000 d.w.t. tankers and 500,000 d.w.t. tankers in ballast), or (2) that the straits are closed to tankers of 200,000 d.w.t. or more.

See the following:

Table 31

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Table 31. Estimated Number of Vessels Passing Through Strait of Malacca by Type of Vessel and Type of Call, 1972

Vessel type	Size	Calling for loading or discharging		Calling for bunkering or repair	Not calling	Total
		Passing through area	Area voyages			
	-- d.w.t.--					
Liners.....	1/20,000	2,238	1,144	277	217	3,876
Container ships...	10/20,000	28	28	--	--	56
	above 20,000	14	14	--	--	28
Tramps.....	1/10,000	110	774	286	228	1,398
	10/20,000	182	425	458	169	1,234
Bulk carriers.....	10/35,000	36	146	181	800	1,163
	35/100,000	--	--	73	410	483
	100/160,000	--	--	--	12	--
Combined carriers.	10/35,000	--	--	--	12	12
	35/100,000	--	48	12	156	216
	100/160,000	--	24	24	180	228
	160/250,000	--	--	--	12	12
Tankers.....	10/35,000	--	604	573	737	1,914
	35/10,000	--	512	316	1,574	2,402
	100/160,000	--	85	--	720	805
	160/250,000	--	100	50	340	490
	above 250,000	--	--	--	--	--
	-- $m.^3$ ----					
Gas carriers.....	10/50,000	--	--	10	60	70
	above 50,000	--	--	--	50	50
Total.....		2,608	3,904	2,260	5,677	14,449

Note: Excluded local traffic between ports in the Malacca Strait area and Indonesian coastwise traffic.

Source: Shipping Consultants, A/S, Estimates of Traffic Through the Straits of Malacca, Sunda and Lombok, in 1968 and 1972 Relevant to the Planning of a

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Shipping Gains

Ship operators will decide whether to carry their cargo though the Kra Canal and what tolls they will be willing to pay depending on the transport savings they realize. The revenue per ton saved will vary with the type of ship and cargo carried and the time and distance saved for different sizes and types of vessels.

Considerable savings in shipping costs, particularly for huge tankers and slow-moving general cargo vessels. On a voyage from the Persian Gulf to Japan, by using the Kra Canal, a vessel would save 327 nautical miles over use of the Strait of Malacca, 903 nautical miles over the Strait of Sunda (both suitable for 200,000 d.w.t. tankers), and 1,491 nautical miles over the Strait of Lombok, which larger tankers must use.

These gains per ton vary from $o.013 per ton per round trip for a 200,000 d.w.t. tanker using a one-lane canal if the Strait of Malacca is open to tankers, to $0.726 per ton for an 11,000 d.w.t. general cargo vessel (which has a very high operating costs per ton of cargo) using a two-way canal.

See the following:

Table IV - 8

Table IV-8. Ship Operators' Savings Per Ton Per Round Trip When Using the Kra Canal

(In U.S. dollars per ton)

Type of ship	Strait of Malacca open to tankers			Strait of Malacca closed to tankers		
	1 lane	1 and 2 lane	2 lanes	1 lane	1 and 2 lane	2 lanes
500,000 d.w.t. tanker..	.278	.256	.301	.277	.367	.407
200,000 d.w.t. tanker..	.013	--	.039	.169	.278	.329
40,000 d.w.t. bulk.....	.114	.101	.224	.114	.101	.224
48,500 d.w.t. container.....	.071	--	.169	.071	--	.169
11,300 d.w.t. liner....	.337	.264	.726	.337	.264	.726
125,000 $m.^3$ LNG.....	.368	.219	.725	.368	.219	.725

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IV. Benefits to Thailand

A. Industrial Zone

The Kra Canal and ports could encourage industrialization in the area, in turn generating revenues from the sale or leasing of industrial land. The efficient waterborne transportation brought to the region could join up with Thailand's labor force and the Kra area's available land to encourage industrialization along these lines:

1. Large and basic industries to serve the markets of Southeast Asia, such as fertilizer, iron and steel, petrochemicals and glass.

2. Labor-intensive export industries (textiles, electronics, plastic goods, etc.) along the models of Taiwan, Korea and Singapore.

3. Pollution-intensive industries which Japan and other advanced countries want to export.

4. Secondary industries to serve the above industries and the needs of the canal, ports, and regional economy.

Within 15 to 20 years of the canal's opening, land requirements could reach 20,000 acres. If this land were sold, revenues -- net of the costs of development -- would be approximately $450 million. Other revenues from industrialization include canal tolls on the incremental trade of these industries and the possible transfer of tax revenues generated by these industries.

Industrial development will have to be planned. Major infrastructural requirements will be needed in power, water, transportation. Social services, housing and other urban facilities for a large labor force will be needed. Commercial and financial institutions must be established. And above all, industrial policies, including pollution controls, appropriate to the status of the Kra complex will have to be designed.

The Kra Canal industrial zone could have a significant favorable impact on the Thai economy. The magnitude of expenditures alone suggests this. During the period of construction, annual direct employment on the largest canal is estimated to be around 7,000; the operation of the canal would provide 3,000 continuing jobs; and by the year 2010 employment in industries and the Kra ports could reach 180,000. This employment in turn is likely to generate additional jobs through a multiplier effect.

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IV. Benefits to Thailand

A. Industrial Zone

The Kra Canal and ports could encourage industrialization in the area, in turn generating revenues from the sale or leasing of industrial land. The efficient waterborne transportation brought to the region could join up with Thailand's labor force and the Kra area's available land to encourage industrialization along these lines:

1. Large and basic industries to serve the markets of Southeast Asia, such as fertilizer, iron and steel, petrochemicals and glass.

2. Labor-intensive export industries (textiles, electronics, plastic goods, etc.) along the models of Taiwan, Korea and Singapore.

3. Pollution-intensive industries which Japan and other advanced countries want to export.

4. Secondary industries to serve the above industries and the needs of the canal, ports, and regional economy.

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Industrial development will have to be planned. Major infrastructural requirements will be needed in power, water, transportation. Social services, housing and other urban facilities for a large labor force will be needed. Commercial and financial institutions must be established. And above all, industrial policies, including pollution controls, appropriate to the status of the Kra complex will have to be designed.

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A. Industrial Zone (continued)

The canal industrial zone could also be a substantial earner of foreign exchange for Thailand. New foreign exchange earnings during construction could reach $50 million or more per year, with continued earnings from the operation of the canal, the port system, and the industrial complex of a similar magnitude.

The canal's construction, industrial development, and the ports are likely to add significantly to Thailand's domestic product. There may be other benefits as well: accelerated development and gtowth of income in Thailand's southern region, the potential emergence of a large urban center offering a viabl alternative urban complex to Bangkok; and the further development of the Thai construction industry and the acquisition of skills by a large segment of the work force.

See the following:

Table VI - 2
Plate III - 14
Plate III - 15

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Table VI-2. Projected Revenue from Industrial Land
(All values in millions of dollars except price per acre)

Year	Acres	Development costs	Market value of land		Revenue from leasing	Net revenue
			Per acre[a] ($)	Total		
1989...	5,000	50				-50
1990...			20,000	100	6	6
1991...				100	6	6
1992...				100	6	6
1993...				100	6	6
1994...	5,000	50		100	6	-44
1995...			26,800	268	16	16
1996...				268	16	16
1997...				268	16	16
1998...				268	16	16
1999...	5,000	50		268	16	-34
2000...			35,800	537	32	32
2001...				537	32	32
2002...				537	32	32
2003...				537	32	32
2004...	5,000	50		537	32	-18
2005...			48,000	960	58	58
2006...				960	58	58
2007...				960	58	58
2008...				960	58	58
2009...				960	58	58
2010...				960	58	58
2011...				960	58	58
2012...				960	58	58
2013...				960	58	58
2014...	5,000	50		960	58	8
2015...			85,800	2,145	129	129
2016...				2,145	129	129
2017...				2,145	129	129
2018...				2,145	129	129
2019...				2,145	129	129
2020...				2,145	129	129
2021...				2,145	129	129
2022...				2,145	129	129
2023...				2,145	129	129
2024...	5,000	50		2,145	129	79
2025...			153,500	4,605	276	276
2026...				4,605	276	276
2027...				4,605	276	276

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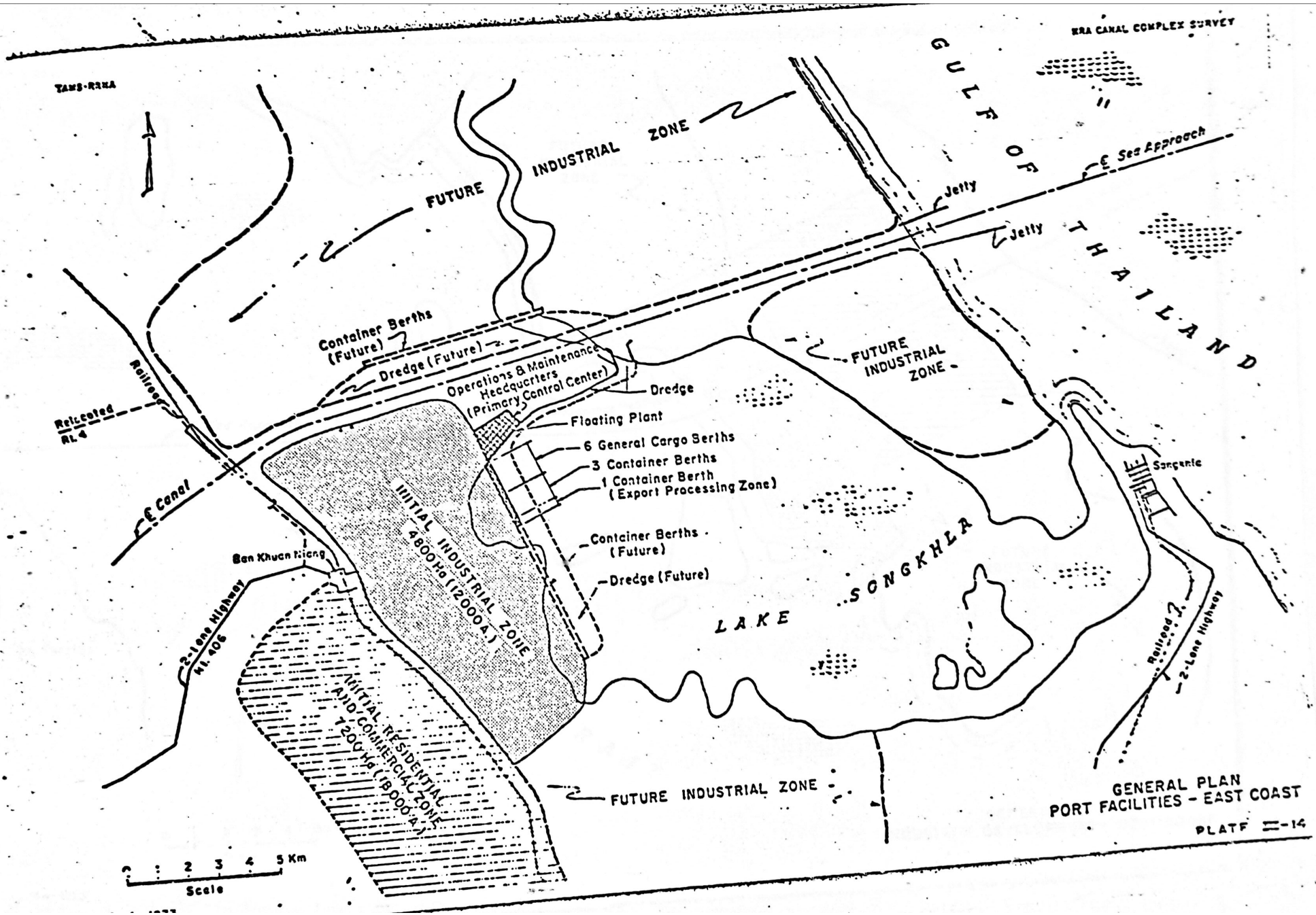
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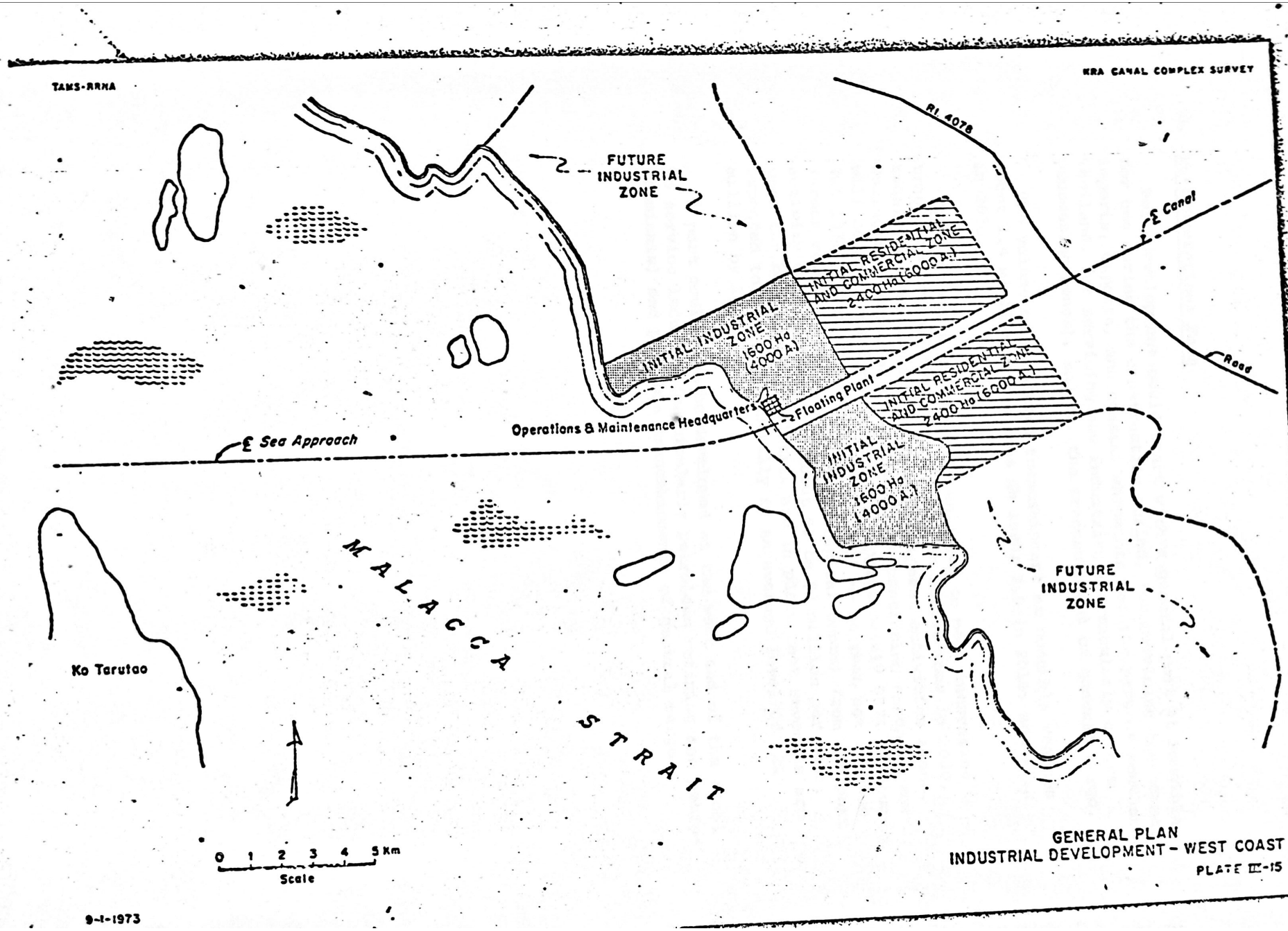
Table VI-2. continued--

Year	Acres	Development costs	Market value of land		Revenue from leasing	Net revenue
			Per acre[a/] ($)	Total		
2028...				4,605	276	276
2029...				4,605	276	276
2030...				4,605	276	276
2031...				4,605	276	276
2032...				4,605	276	276
2033...				4,605	276	276
2034...				4,605	276	276
2035...				4,605	276	276
2036...				4,605	276	276
2037...				4,605	276	276
2038...				4,605	276	276
2039...				4,605	276	276
2040...						

a/ Market value per acre is increased by 6 percent annually to the year 2025 but it is assumed that revaluation takes place only at the time new land is developed.

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B. Port Operations Fees

Port development could start with a general port at Songkhla for use during the construction period, for servicing the normal imports, exports, and coastal shipments for the part of southern Thailand, for servicing new industries (particularly export processing zones), and for the transshipment of general cargo.

The volume of projected transshipment at Songkhla reaches about 1.4 million metric tons in 1990; 3.9 in 2010; and 11.2 in 2030.

The port would be gradually enlarged to meet increasing transshipments of possibly 11 million metric tons in 2030, requiring over 36 berths for transshipment activities alone. During the period of expansion, large continuing expenditures will be required for new berths -- approximately $374 million (at 1973 prices) between 1985 and 2031 -- so that net revenue (gross revenue less operating and capital costs) from the port activity will average only about $1 to $2 million per year. Once the basic port facilities are in place, net revenues are expected to rise substantially to an average level of $22 million by 2032.

A port could also be developed at the west end of the canal to service industry (particularly petroleum refining and petrochemicals) and possible transshipments of general cargo.

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C. Trans-shipment Charges

The Canal Authority could engage in a major transshipment activity. It could procure all-purpose general cargo vessels of about 4,500 d.w.t. for moving cargo between Kra and the various feeder ports in Southeast Asia, thus enabling countries with small river ports to capture some of the gains from new techniques of waterborne transport (large ships, containers, etc.) without investing in large, expensive international ports. These countries might receive half of the net revenue from the operation of the feeder ships as a further inducement to forestall large uneconomic port expansion. If two-thirds of the transshipments went in these vessels, the number of Authority ships required would rise from four in 1990 to 36 in 2030. The total capital cost for these shuttle ships is estimated to be $158 million. The number of ships required is small because of the short distances traveled in intraregional trade and the speed and efficiency of the vessels. The net revenue accruing to the Canal Authority would increase from about $1 million per year in the early years of the project to $7 million per year by 2030.

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V. Benefits to Japan and the Middle East

Japan and the Middle East oil-exporting countries have particular reasons to extend special grant or low-cost financing to the project -- for Japan, the savings in transport costs; and for oil suppliers, the long-term protection of their Japanese oil market. The savings to Japan could be considerable. If the shipping savings were $0.22 per ton of oil, with the Canal Authority collecting 75% and the remainder going to Japan, it would save $170 million in the year 2000 alone; this saving would increase with the impact of rising shipping costs. The present value of the total saving by Japan over the life of the project could range from around $250 million to $1 billion, depending on the assumptions employed. In other words, if Japan advanced capital of these magnitudes today, it would regain the equivalent in saved transportation costs in the years 1990-2040.

It is projected that the Middle Eastern countries will have $25 billion per year available for external investment by 1985. To hold down the delivered costs of petroleum, the Middle Eastern countries might make capital available to the Kra Canal complex, either as grants or on relatively soft terms. This would help protect inroads over the long run on their market from competitive energy sources.

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I. Financial Considerations

Based on current estimates, the Kra project shows a reasonable rate of return when the most optimistic assumptions for each of the key parameters used in the study to date are combined.

Thus, for a one-way 500,000 d.w.t. canal with conventional excavation, total debt (in 1973 prices and assuming an interest rate of 10 percent) at the opening of the canal would be $9.8 billion -- $5.6 billion in construction costs and $4.2 billion in interest charges. A lower interest rate (say, 7 1/2 percent) made possible by some public financing would reduce the total debt at the canal's opening to $8.6 billion.

Thus, there is a need for special financing which would take the form of either grants or long-term loans carrying nominal rates of interest, and with extended grace periods. Private financing then becomes possible for part of the total costs.

For example, if the cost of the canal were approximately $8 billion and if about half of this cost were financed through grants or loans with a 25 year grace period, with no private capital expenditures until the last 5 years, the canal would start off with an accumulated debt of about $5 billion, including interest during construction. Revenues would exceed interest payments within 18 years and the loan would be repaid within 25 years, thus making partial private financing plausible.

Because of current world financial instability, financing even for conventional-length maturities carries interest rates that are rather high by past standards. The extraordinary length of maturities required for Kra suggest a need for a very special class of security, possibly having a variable interest rate pegged to world price levels and offering some protection against wide changes in currency values.

See the following:

Table VIII - 3

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Table VIII-3. Maximum Private Financing for the Kra Canal with Varying Rates of Return

(Costs in millions of dollars)

Item	Rates of return[a]		
	13.8 pct.	9.3 pct.	5.0 pct.
Number of years that could be privately financed.....	Last 8	Last 5	Last 3
Construction costs in those years.....	7,410	3,676	1,096
Total construction costs...	9,511	8,059	5,707
Private financing as a percent of total costs....	78	46	19
Balance of construction cost requiring non-private financing.....	2,101	4,383	4,611

Note: The terms of private financing are assumed to be an interest rate of 10 percent, a maturity of 25 years, and a grace period to the opening of the canal.

a/ These rates of return incorporate assumptions, respectively, of (1) high GNP and 6 percent inflation, (2) medium GNP and 4 percent inflation, and (3) medium GNP and no inflation.

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Areas of Uncertainty

Additional data is needed to narrow the issues of uncertainty, particularly those that are fundamental to the revenue estimates for the canal. A more extensive research and analytical effort than was possible to date should be made on the following matters:

1. Projections of the economic growth rate in Japan and selected other Asian countries, particularly over the next 30 years. These rates will determine the imports that would transit the Kra Canal.

2. Estimates of the energy that these countries will consume and the extent to which oil will come from the Middle East.

3. Estimates of future changes in ship operating costs.

This study has dealt with these three issues, yet the range of uncertainty which prevails among experts leads to wide variations in the revenue estimates for the canal. The range of uncertainty needs narrowing.

The issue of freedom of passage through the Straits of Singapore and Malacca needs clarification. Perhaps it will be clarified in the Conference on the Law of the Sea next year. Whether passage is free or not has an important bearing on the canal's revenues.

Finally, financial experts should address themselves to the question of whether very unusual financing packages could be assembled under various hypotheses as to the rates of return, revenue flows, and other characteristics of the canal. The opinions of financiers should influence the nature of these further studies.