Final Report of the Commission for the Study of Alternatives to the Panama Canal

Volume II

Detailed Plan of the Study

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DETAILED PLAN OF THE STUDY OF ALTERNATIVES TO THE PANAMA CANAL

VOLUME II

Comisión de Estudio
de las Alternativas
al Canal de Panamá
CENTRO DE INFORMACION

SUBMITTED TO

COMMISSION FOR THE STUDY OF ALTERNATIVES TO THE PANAMA CANAL

S • I • N • B • O • L

PANAMA
LOMOSA, SA

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Preface

The Detailed Plan of the Study (DPS) of Alternatives to the Panama Canal has been prepared for the Commission for the Study of Alternatives to the Panama Canal. The SINBOL Consortium has prepared the DPS as a consultant to the Commission and under the direction of the Commission's Secretariat.

The DPS consists of two volumes:

Volume I — The description of the overall plan to execute and manage the study, including descriptions of the tasks to be performed by the Feasibility Analysis/Final Report (FA/FR) Contractor and the Component Study contractors.

Volume II — Terms of Reference for the Component Studies to be carried out by contractors other than the FA/FR Contractor and detailed work plans for prescreening tasks to be performed by the FA/FR Contractor.

The DPS has been prepared within the basic guidelines established by the Final Report of the Preparatory Committee on the Panama Canal Alternatives Study and according to guidance provided by the Commission and its Secretariat. The guidance provided by the Commission and the Secretariat includes:

- A directive to schedule the Study to be completed within a 30-month period.
- Restructuring of the Study to include selected Component Studies in the scope of work of the FA/FR Contractor as per the Commission's letter of August 13, 1990. The new study structure is described in detail in the body of Volume I.
- With regard to preliminary cost estimates for the Component Studies, SINBOL has provided its best estimates using as a basis the amounts budgeted and specified in the Preparatory Committee Report.

The ability to meet the 30-month schedule presented in the DPS is subject to the following conditions and understandings:

- The Study Commission and Secretariat will perform review and approval responsibilities in a timely and unified manner.
- All component contracts are completed as scheduled.
- Recognition that delays attributable to other contractors and or the Study Commission are likely to have a significant impact on costs and schedule.

- Although the overall cost of the Study is constrained by the budget proposed by the 1985 Preparatory Committee Report, the cost of the FA/FR Contract will be increased due to the additional manpower required by the FA/FR Contractor in Panama to assist the Secretariat in the Prescreening and other activities of the Study's preliminary phase.

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Introduction

This report represents Volume II of a two-volume report – the Detailed Plan of the Study (DPS) of Alternatives to the Panama Canal. The contents of Volumes I and II are described below:

VOLUME I

Volume I contains a description of the overall study work plan and a description of the major tasks that are to be accomplished. These tasks may be viewed as:

- Tasks associated with the preliminary analysis and prescreening of alternatives and the selection of viable alternatives for further study
- Tasks that will be undertaken by independent contractors, referred to as component studies
- Tasks that will be part of the final feasibility analysis and the selection of the best alternative
- Tasks associated with the detailed study of the best alternative and the preparation of the final report.

VOLUME II

Volume II contains the terms of reference (TOR) for component studies that will be undertaken as part of the overall study and detailed work plans (DWP) for selected prescreening tasks to be carried out by the FA/FR contractor. The component studies will be awarded to independent, qualified contractors, selected through an appropriate tendering process as described in Volume I.

The DPWs are:

- Present Situation in Panama
- Status of the Present Panama Canal
- Historical Trade Analysis
- Future Transportation System and Significance of Panamanian Isthmus in World Trade
- Prescreening and Selection of Alternatives

For implementation purposes, the component studies are grouped into the following categories, for which TORs appear in Volume II (preliminary studies for prescreening activities to be performed by Component Study contractors are incorporated into the TOR's of the component studies marked with an asterisk):

- Commodity and Traffic Projections*
- Engineering and Cost Estimates*
- Operating Characteristics and Capacity Evaluation*
- Background Biological Data and Biological Inventory*
- Financing Scheme and Financial Analysis
- Economic and Impact Analyses
- Environmental Analysis
- Management Arrangements
- Development of Additional Data

Development of additional data will be done as the need for additional information is determined. The work will be done by either the component study contractors or by new contractors, depending on the type of additional data needed.

PURPOSE OF VOLUME II

The purpose of this volume is to present TORs to be provided to qualified contractors selected to submit proposals for component studies and to present the detailed work plans for preliminary studies to be performed by the FA/FR contractor. The information in this volume includes:

- Background material
- Description of alternatives
- Detailed Work Plans (DWPs) for FA/FR Contractor Studies
- Detailed Terms of Reference for the component studies

Also included as a separate bound Appendix for the Commission's discretionary use., is an estimate of the cost to carry out each component study.

ORGANIZATION AND USE OF VOLUME II

This volume is organized into the following sections:

- Introduction
- Project Background
- Discussion of Alternatives
- Detailed Work Plans (for work to be performed by FA/FR Contractor)
- TORs (one for each of the component studies)
- Appendix 1: Budget Estimates (bound separately)
- Appendix 2: Work Plan Flows and Detailed Input/Output Relationships

The sections are designed so that a TOR document for each Component Study may be assembled by combining the appropriate sections. For example, to prepare a complete TOR for the Commodity and Traffic Projections study, copies of the sections Introduction, Project Background and Discussion of Alternatives sections may be assembled with the Commodity and Traffic Projection TOR to form a complete document. Each TOR contains a description of the report requirements. In addition to the written reports, computer diskettes with appropriate DOS Files (WordPerfect, dBase, Lotus, etc.) will be provided to the Commission by the component study contractors.

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Project Background

PROJECT HISTORY BACKGROUND

Construction of the present Panama Canal was started by Ferdinand de Lesseps in 1880 with the intention of creating a sea-level canal. However, work stopped nine years later because of the very harsh construction conditions and endemic diseases such as malaria and yellow fever, combined with financial difficulties. In 1904, the project, which was by then owned by the new Panama Canal Company, was taken over by the U.S. Government under a treaty with Panama, and on August 15, 1914 the canal was completed as a lock canal.

As traffic steadily increased, it became apparent that the capacity of the canal would become inadequate. Accordingly, in 1929, the U.S. Government set up the U.S. Army Interoceanic Canal Board to conduct a study. The Board reported in 1931 with proposals for three long-term alternative solutions:

- To add a third set of locks to the present canal (the Third Locks Plan)
- To convert the present canal to a sea-level canal
- To construct a new lock canal in Nicaragua

These early alternatives serve as the genesis of the alternatives now being considered.

In 1936, the Governor of the Panama Canal was directed to recommend a plan for increasing the capacity of the canal in order to meet the prospective demand. The Governor's Report recommended the Third Locks Plan as previously proposed by the Interoceanic Canal Board. The U.S. Congress accepted the plan and approved construction of the third locks. The purpose of this was not only to increase the canal's capacity, but also to improve the defensive posture of the canal.

In 1942, when excavation for the new locks and design of supporting structures had almost been completed, World War II expanded to the Pacific region, and construction works were suspended and have never been reopened.

In 1945, the U.S. Congress ordered the Governor of the Panama Canal to work out the best means to increase the capacity of the canal and to include a study of the possibility of developing a second canal to improve security.

In 1947, as a result of the aforementioned study, thirty routes were proposed as candidates in "The Isthmian Canal Study 1947." The report concluded that a sea-level canal would be the most desirable and feasible solution.

In 1958, the Board of Consultants on Isthmian Canal Studies investigated a long-term improvement plan for the present canal and submitted a short-term program to increase the capacity of the present canal.

In 1964, discussions took place between the governments of the U.S. and Panama with a view to conclusion of a new canal treaty, and in the same year, a report was prepared entitled "Isthmian Canal Studies 1964." This report reviewed the methods available for improvement of the lock canal in order to increase its capacity and to meet the traffic demand of the canal. The report proposed the following detailed plans:

- Third Locks Plan
- Terminal lake plan
- Sea-level canal plan in the Canal Zone

The report also assessed the traffic capacity of the canal, a prerequisite to formulating a new alternative plan.

In the same year, U.S. President Lyndon B. Johnson signed enabling legislation for the study of an inter-oceanic sea-level canal plan. By 1970, the study had determined the feasibility of an inter-oceanic sea-level canal, had selected construction sites and construction methods, and had produced estimates of cost. The results of the study were summarized in "Inter-oceanic Canal Studies 1970 of the Atlantic-Pacific Interoceanic Canal Study Commission" (known as the Anderson Report). The report recommended Route 10 as the most appropriate route with Route 14S identified as a possible alternative.

Based on the Route 10 plan, several variants have been proposed among which were the Nagano plan and the Vergara plan. In 1977, the Chairman of the Chamber of Commerce and Industry of Japan, Mr. Nagano, submitted his plan for construction of a sea-level canal in order to meet the needs of vessels of increasing size wishing to pass through the canal. The Vergara Plan added engineering modifications in the canal.

In 1982, Lopez and Moreno, Panamanian consultants, submitted "The Atlantic-Pacific Interoceanic Canal - Panamanian Alternative" which proposed major improvements to the present canal in addition to construction of the third locks.

In 1979, it was agreed under the Panama Canal Treaty that a feasibility study on a sea-level canal be implemented by the year 2000 by the United States and Panama. In May 1982, it was confirmed by U.S. President Ronald W. Reagan that the study

would include not only sea-level canal alternatives but also other alternatives. In September of the same year, the Preparatory Committee on Panama Canal Alternatives Study was established between the United States and Panama; Japan joined the Committee soon after.

In October 1982, the U.S. Department of State sponsored a meeting concerning "Future Transportation Alternatives across the Panamanian Isthmus" in order to enable the U.S. Government to obtain necessary information to formulate plans for transportation across the Panamanian Isthmus and also to prepare for the inaugural meeting of the Preparatory Committee held in the same month.

At the sixth meeting of the Committee, held in December 1984 in Tokyo, an agreement was reached regarding the outline of the present study.

The objectives and scope of study were determined as follows:

Objectives:

- To study the possible alternatives to the present Panama Canal
- To recommend the best alternative to the participating governments

Scope:

- Analysis of present situation of Panama and the present canal
- Prospects of future transportation systems
- Forecast of traffic demand
- Prospects of the present canal
- Identification of alternatives to the canal
- Feasibility analysis of each alternative
- Selection of the best alternative
- Detailed investigation of the best alternative

In June 1985 the Committee prepared its Final Report. Based on the recommendations of the Final Report and the note of exchange between Panama, the US, and Japan, the Commission for the Study of Alternatives to the Panama Canal was established in 1986 to conduct the study of the alternatives in accordance with the terms of reference contained in the Final Report.

PARTICIPANTS

The present participants involved in studying alternatives to the Panama Canal are discussed below.

Commission for the Study of Alternatives to the Panama Canal

The Commission consists of commissioners from each of the member nations (Panama, United States, and Japan) and a Secretariat composed of technical staff from the member nations.

SINBOL

The Consortium selected by the Commission to perform the Feasibility Analysis/Final Report (FA/FR) study. The Consortium consists of the following members:

- S - Stone & Webster Engineering Corporation, USA
- I - Industrial Bank of Japan, LTD, Japan
- N - Nippon Koei Co., LTD, Japan
- B - Bechtel Corporation, USA
- O - Overseas Coastal Area Development Institute, Japan
- L - Lomosa, SA, Panama

Feasibility Analysis/Final Report (FA/FR) Study

SINBOL, under the direction of the Secretariat, is responsible for performing the overall study of alternatives to the Panama Canal. The work items and schedule for the overall study are shown on Figure 1, Overall Work Plan Flow. This figure shows the interrelationships of the various tasks including the Component Studies. Figure 2 shows the proposed schedule for the completion of the study.

Component Study Contractors

The component study contractors are outside subcontractors who will be selected by the Commission to perform studies and/or provide data needed by SINBOL to complete the FA/FR study. These component studies are listed below and their interrelationship to the other tasks are shown in Figure 1.

- Commodity and Traffic Projections
- Engineering and Cost Estimates
- Operating Characteristics and Capacity Evaluation
- Biological Inventory
- Financing Scheme and Financial Analysis
- Economic, and Impact Analyses
- Environmental Analysis
- Management Arrangements
- Development of Additional Data

PRESCREENING AND SELECTION OF ALTERNATIVES

The Prescreening and Selection of Alternatives phase of the work will be performed by SINBOL. The prescreening study will use available data which has been collected and evaluated to prescreen the list of alternatives and to select a "short list" of alternatives which have the best potential.

The criteria for prescreening will be:

Engineering Soundness - Each alternative will be evaluated in terms of the practicality and degree of risk involved in its engineering approach.

Ability to Fulfill Potential Demand in a Timely Manner - The preliminary demand analysis will project future demand. The capability of each alternative to meet the potential demand will be determined.

Capital Cost for Each Alternative - A preliminary estimate of the capital cost of each alternative will be developed.

Approximate Cost and Benefit Comparison - For each alternative the benefits considered will be limited to the direct benefits accruing from transportation

(increased number of vessels transiting the canal and reduction of transit time). This will include a Financial, Managerial and Operational Assessment.

Relative Environmental/Social/Economic Impacts - A qualitative comparison of the relative impacts of all alternatives on the environment and the socio-economic situation will be made.

Short-term Impact on the Existing Canal - The relative degree of impact on or interruption of the operation of the existing canal will be assessed for each alternative.

The prescreening will provide the basis for a sound decision by the Commission to eliminate from further detailed examination those alternatives which are clearly not competitive on the basis of capital cost and/or which have serious adverse impacts.

The screening process designed to narrow the list of alternatives will be coordinated with the prequalification of the potential study contractors and their preparation and submittal of proposals. Thus, selected proposals may be prepared without the final list of alternatives to be studied. This narrowed list and appropriate supplementary information will be supplied to the component study contractors as soon as it becomes available.

A detailed discussion of the alternatives that will be included in the prescreening is contained in the following section.

Description of Alternatives

This section contains a list of the possible alternatives to be studied and analyzed. The possible alternatives may be broadly classified into three categories: improvements to the existing canal, construction of a sea-level canal, and non-canal alternative transportation systems. These are listed below:

- Improvements or enlargements to the existing canal
  - Status quo alternative (includes Gaillard Cut widening)
  - Non-lock improvements
  - Third Locks Plan
  - Terminal Lake Plan and variations
  - Deep Draft Lock Canal Plan
  - Lopez-Moreno Plan
- Sea-level canal
  - 1970 Interoceanic Canal Studies, Route 10
  - 1970 Interoceanic Canal Studies, Route 14S
  - Vergara Plan
  - Nagano Plan
- Non-canal complementary transportation systems
  - Oil pipeline
  - Land bridge systems (railway and highway)
  - Appropriate parts of the Centerport Concept
  - ~~Other~~ (deleted)

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During the prescreening phase, some of the alternatives on this list will be eliminated. The Commission will apply technical, financial, and environmental factors in the elimination process. Eventually, as the study proceeds, the preferred alternative will be selected and a detailed investigation of this alternative will be performed.

The alternatives are briefly described below.

1 STATUS QUO ALTERNATIVE (PRESENT PANAMA CANAL)

This will consider the Panama Canal as it presently exists. If the Panama Canal Commission's Gaillard Cut Widening Project proceeds, this improvement will be included in this base alternative. Similarly, other ongoing modifications such as navigational aids which will increase the capacity and/or efficiency of the present canal will be included in the status quo alternative.

2 NON-LOCK IMPROVEMENTS TO THE PRESENT PANAMA CANAL

These alternatives will include the proposed improvements discussed above if they are not yet approved and funded for construction and installation. Other improvements to the present canal (not including new locks and water level changes) will be addressed as part of this alternative. These possible improvements might include more efficient ship handling facilities which will result in faster transits; improved port facilities and marine support equipment; additional navigational aids to improve transit capabilities during bad weather and at night; additional widening and/or deepening of existing channels; removal of silts; additional or different water supply arrangements for lockage requirements; and improved water management systems.

3 LOCK IMPROVEMENTS TO THE PRESENT PANAMA CANAL

There are at least five lock improvement alternatives to be considered: the Third Locks Plan, the Terminal Lake Plan and its variations, the Deep Draft Lock Canal Plan, and the Lopez-Moreno Plan. Most of these previously published plans will have to be modified to provide for the maximum size and draft of ship selected for the planning of conceptual alternatives.

3.1 The Third Locks Plan

This plan was proposed in 1938 and major excavation was accomplished in 1940-1942. The plan was revised in 1947 and it is this version that will be studied. This plan calls for the construction of one additional lane of larger and deeper locks adjacent to the existing locks. Gatun Lake will remain at its present nominal 25.9 m MSL. Additional lockage water (fresh or possibly sea water) will have to be stored and possibly pumped.

3.2 The Terminal Lake Plan

This plan was initially proposed in 1943. It calls for abandoning the Pedro Miguel Locks, raising Miraflores Locks and constructing one lane of large locks at both Miraflores and Gatun. Gatun Lake will remain at its present level. A number of variations in the Terminal Lake Plan have been proposed. One of these variations replaces the locks at Gatun and Miraflores with two lanes of new large locks: Gatun Lake will be raised by about two meters. Additional lockage water (fresh or sea water) will probably be required.

3.3 The Deep Draft Lock Canal Plan

This plan was proposed in the Interoceanic Canal Studies 1970 (known as the Anderson Report). It consists of adding a lane of new, large, triple-lift locks at Gatun and constructing a separate lane of triple-lift locks at Miraflores together with a bypass around the existing Pedro Miguel locks. Gatun Lake will remain at 25.9 m MSL. Again, additional lockage water will probably be required.

3.4 The Lopez-Moreno Plan

This concept is a more recent proposal. This plan will lower Gatun Lake from 25.9 m to 16.8 m. The upper lift of Gatun Locks and the entire Pedro Miguel Locks will be eliminated. The plan provides for using the remaining existing locks plus adding two new lanes of locks. One lane will accommodate 250,000 DWT ships with drafts of up to 20.4 m. The other new lane will provide locks which are relatively small. This system will permit more efficient use of lockage water. All existing channels will be widened and deepened. Additional lockage water storage will probably be needed.

4 SEA-LEVEL CANAL ALTERNATIVES

The Interoceanic Canal Studies 1970 initially considered 11 sea-level canal alternatives in Panama (plus five in Panama and Colombia). Four of the Panamanian routes (and one of the Panama/Colombia routes) were studied in detail. The recommended sea-level canal alternatives were Routes 10 and 14S. The Report of the Preparatory Committee limits the sea-level canal options for the present study to these two routes.

4.1 Route 10

The Route 10 sea-level canal lies about 16 km west of and generally parallel to the present Panama Canal. The Interoceanic Canal Studies 1970 proposed a design vessel of 150,000 DWT (a 250,000 DWT ship could transit during favorable currents). The 1970 data may have to be revised and updated depending on what design vessel is selected for the present study. Tidal gates or checks will probably have to be installed to limit canal currents to a maximum of two knots. The Route 10 alignment will permit continued operation of the present Panama Canal.

4.2 Route 14

Route 14S follows the general alignment of the present canal and consequently may have less impact on Panamanian infrastructure. The design vessel and tidal current criteria are the same as for Route 10. This routing results in a major lowering of the Gatun Lake, and it could interfere with the operation of the present canal during construction. The present canal would no longer be operable after completion of Route 14S.

4.3 Vergara Plan

The Vergara Plan is a variation on the sea-level canal plan recommended in the Anderson Report, and follows Route 10 with some modifications. The target size of vessels is 250,000 DWT, while the section of the canal is proposed to be 300 m in width and 25 m in depth. The plan also proposes the construction of berths protected by breakwaters at both entrances, instead of tidal gates to check the tidal current. As for excavation works, it recommends use of dredging rather than dry land excavation methods.

4.4 Nagano Plan

The 1982 Route Plan is another variation on the sea-level canal plan though the target size of vessels is increased to 300,000 DWT, and 500,000 DWT at high tide. The channel width will be 200 m and the depth, 33.0 m. Furthermore, in order to accommodate large vessels, an approach channel will be required at each end. The size of these channels will be 400 m in width, 35.8 m in depth, and 35 km in length at the Pacific end and 400 m, 33.4 m, and 5 km at the Atlantic end.

5 NON-CANAL COMPLEMENTARY TRANSPORTATION SYSTEMS

The present Panama Canal could be complemented by non-canal alternatives for moving commodities across the Isthmus. These alternatives include pipelines, land bridges, and other systems. The fundamental concept is to transport the cargoes from a ship on one side of the Isthmus to a ship on the other side in a manner that is more cost effective than expanding the present canal or other canal alternatives discussed above.

It is possible that these complementary systems can at least partially reduce the need for expansion of the present canal or postpone the construction of costly new canal alternatives. Each of these complementary alternatives will require supporting facilities consisting of moorings, port facilities, temporary product storage, processing and handling facilities, and related infrastructure.

A trans-Isthmus petroleum pipeline together with supporting facilities was constructed in 1982. This pipeline significantly reduced the number of daily canal transits. Pipeline alternatives which will augment the existing pipeline will be considered.

Many finished products are moved in standard sea containers or by similar means. An alternative which moves containers across the Isthmus by rail and highway will be considered.

A trans-Isthmus railroad presently connects the ports of Cristobal and Balboa. The Centerport feasibility study proposes improvements to the railroad and two ports. The ports would be used as major load centers for interlining and feeder service and the railroad would supplement the canal's transshipment operations. The project calls for a 10-year period of phased improvements. Appropriate parts of the Centerport concept will be considered as part of the non-canal complementary transportation systems.

Present Situation in Panama

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1 INTRODUCTION

This is a preparatory study for the Analysis of Impact upon Panama.

2 OBJECTIVES

The overall objective of this task is to provide both general and specific scientific information as a basis for performing Component Studies of the alternatives to the Panama Canal. Particular emphasis will be placed on information referring to the impact and environmental analysis. This should serve for the analysis of certain social, economic, and geographic conditions related to the engineering work.

The study will cover, though generally, the whole physical, economic, cultural, and political environment of Panama; from geography to environmental aspects. It will focus particularly on the importance and impact of the present Panama Canal, and the geographic and geopolitical significance of Panama and the Isthmus in the development of world economy and trade. Special research studies, surveys, and investigations will be compiled on the economic, political, social, and geographical conditions in the country. The material will then be systematically classified and interpreted into elements that will be used to project future trends into the early decades of the 21st century.

Special emphasis will be given to the terrestrial and maritime studies with emphasis on the physical and human conditions in the areas which could be affected by future physical work on the Canal such as a third set of locks, a sea-level canal, or other transportation systems. The major elements of this task are described below.

3 SCOPE OF SERVICES

The scope of services to be conducted by the FA/FR contractor for attaining the objectives set out above are summarized below.

3.1 Methodology

This study will consist of a literature search and, if necessary, interviews with PCC, STRI, University of Panama, and Republic of Panama staff located in the Panama City metropolitan area. Emphasis for the following topic areas will be for the Canal, Route 10, and pipeline corridors. If an area or subject matter does not impact on or will not be substantially impacted by any alternative, it will not be subject to data gathering.

3.2 Natural and Physical Conditions

General and specific data on natural and physical conditions of land and sea in and around Panama will be studied and analyzed. Specific data will relate to the present Panama Canal and the alternatives, and the study will be in sufficient detail for this purpose.

The items of the study and analysis will cover, but not limited to:

- Climate and meteorology
- Topography
- Geomorphology, soils, geology, and seismology
- Oceanography, river systems, limnology, and hydrology
- Others

3.3 Terrestrial and Marine Environment/Ecology

In relation to terrestrial and marine environmental aspects and ecology in and around Panama, specific data such as of air and water quality, water temperature, river, lake and sea bed materials, etc. will be reported for further studies such as environmental analysis, formulation of conceptual alternatives, and engineering studies.

3.4 Geographical Aspects

In relation to geography in Panama, basic data (emphasizing the metropolitan areas of Panama City, Colon, Chorrera, and Arrijan) will be collected concerning its special aspects, regional structure, evolution of physical, human and economic geography, endowment of natural resources and various aspects of the historical performance of the Isthmus. These will be analyzed where needed and will be rearranged for further studies, specially for the analysis of impact upon Panama, formulation of conceptual alternatives, and engineering studies.

3.5 Economic and Commercial/Financial Aspects

In relation to economic aspects of Panama, basic data will be collected concerning the following:

- Macro-economy
- Industrial structure
- Employment

- Commodity prices
- Balance of payment
- Characteristics of economic structure
- Development and current situation of economy
- Others

3.6 Socio-cultural Aspects

Together with the study on economic aspects of Panama, basic data in the alternative affected areas on socio-cultural aspects of Panama will be collected concerning population structure, infrastructure, urban and rural societies (i.e., skills and unemployment). Their trends and changes will be analyzed for the use of further studies, such as the analysis of impacts upon Panama.

3.7 Political Aspects

The basic data on the political aspects of Panama such as political system and structure will also be collected, together with other aspects. Their trends and changes will be used for further studies, such as the Analysis of Impact upon Panama.

3.8 Role of Panama in World Trade and Significance of the Panama Canal

In studying various aspects of Panama, analyses will be made to clarify the role of Panama in world trade and the significance of the present Panama Canal in the country of Panama.

The analyses will emphasize the following:

- Panama's geographic location and the historic processes which have given Panama its present status in world trade.
- Influence of the present Panama Canal on the social, demographic, and economic evolution or development of Panama.

The results of the analysis will serve as the baseline for identifying and selecting the alternatives to the present Panama Canal.

3.9 Synthesis and Conclusions

The results of the above tasks will be combined to provide a sense of the past and present economic, social and political situation in Panama and a base on which to evaluate the future evolution of the country. Emphasis throughout this study will be on developing information that will help evaluate the impact of the various canal alternatives if they are implemented.

4 REPORT

The report should present a discussion on the above topics and those listed below.

The effect of the Canal and pipeline on the job force, distribution, and economy should be discussed. In the same context, the elimination of malaria and yellow fever needs presentation.

The economics of the Canal and pipeline should be presented. Condition of the railroad and canal ports should be described.

The fish, banana, and sugar export industries should be reviewed.

The cement industry and its capacity should be assessed for potential involvement in major construction should a third lock be proposed.

Water availability and projected usage will be addressed.

The report will be fully documented.

The report will include generalized maps of the nation showing:

1) Land use
2) 1990 population distribution
3) Altitude isobars
4) Geomorphology
5) Annual precipitation isobars
6) Relative humidity
7) Temperature
8) Forest coverage (past, present, and projected)
9) Historic founding and conquest
10) Colonial shipping to Spain

The report will include maps of the Canal area showing:

1) General layout
2) Hydrographic basins
3) Precipitation gradient
4) Archaeological sites
5) Water quality of Gatun and Madden

The report will include maps of the Gulf of Panama showing:

1) General circulation
2) Water quality parameters (d'Cros, Technipan)
3) Fishing areas by type

The report will include graphs and tables displaying:

1) Value and quantity of marine commercial fish by type by year.
2) Ship movements by canal port and pipeline port for past ten years

The final report shall be compendium of all available pertinent data. The information shall be presented in narrative, graphical, and tabular form. Deliverables will include computer diskettes with appropriate DOS files (Word Perfect, dBase, Lotus, etc.).

5 SCHEDULE

The overall schedule to complete the whole study is 30 months, and the time allocated to complete this Component Study is 4 months. This study will start in the 1st month of the overall schedule for the study and is to be completed by the end of the 4th month, as shown Figure 1. The proposed manning schedule is shown in Figure 2. The major work assignments for this Component Study are shown in Figure 3.

6 STAFFING

The study shall employ the following personnel:

6.1 Project Manager

Accomplished historian and/or geographer with demonstrated experience in similar studies.

6.2 Other

Other skills that will be utilized include:

- Geographer
- Economist
- Sociologist
- Political Scientist
- Cartographer

7 REFERENCES

Basic references are listed below:

- APN Yearbooks
- PCC Annual Reports
- Rep. Pan. 1990 Census
- Papers by d'/Cros
- Technipan Report
- Centerport Study
- Commission Report on Alternatives
- Path Between the Seas
- Atlas on Panama
- Labor Ministry
- Panama in Cifras
- Marad Reports on ANS Shipping

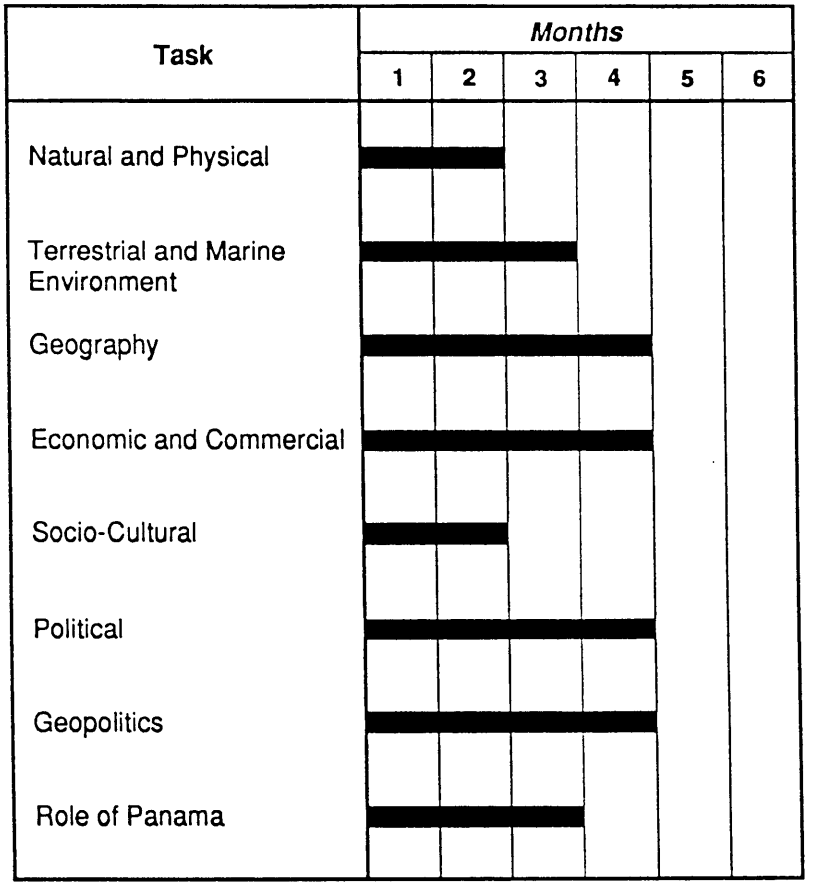

Figure 1 Work Schedule for Present Situation in Panama

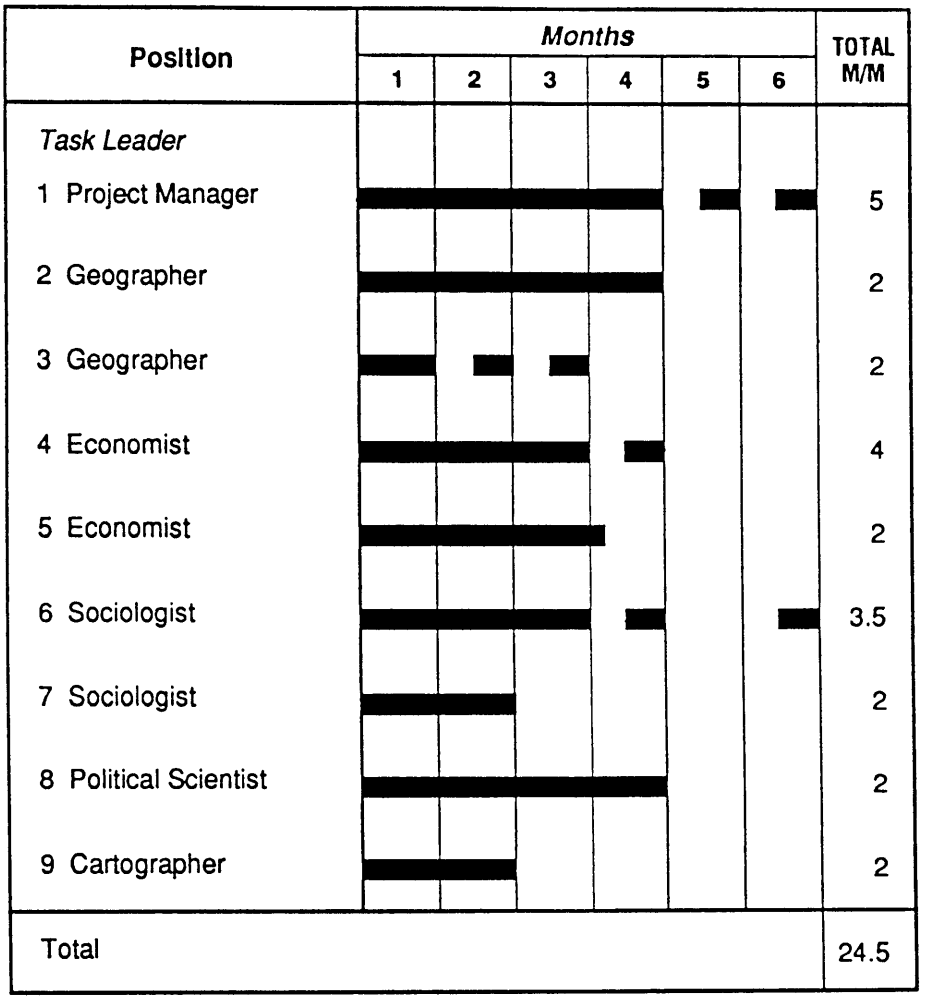

Figure 2 Manning Schedule for Present Situation in Panama

Task	Positions								
	1	2	3	4	5	6	7	8	9
Natural and Physical	P								
Terrestrial Marine Environment		P	S	S					
Geography		P	S	S	S				
Economic and Commercial					P	S			
Socio-Cultural					S			S	
Political		S						P	S
Geopolitics		S	S	S				P	S
Role of Panama Worldwide and Significance of the P.C.					P	S		S	

Figure 3 Position Assignments for Present Situation of Panama

Status of the Present Panama Canal

1 INTRODUCTION

The information collected within this study forms a basis for a number of component studies. This report will be the source of information for existing conditions at the Panama Canal. The main source of information shall be the Panama Canal Commission and the extensive literature and graphical information that already exists on the present canal, as well as cargo statistics developed by the Commission. Notwithstanding, it will be necessary to carry out special investigations, interviews, surveys, and field inspections. The study team will have to make technical evaluations based on direct observations of the physical condition of the main facilities.

2 OBJECTIVES

The main objectives of this study are:

- To collect information relative to the physical and operational characteristics, management structure and cargo statistics of the existing Panama Canal.
- To evaluate the condition and durability of major and supporting facilities.
- To identify physical and operational constraints.

3 SCOPE OF SERVICES

3.1 Collection of Data and Information

All available data and information that describe present conditions at the Panama Canal shall be collected according to the following outline.

3.1.1 Physical Configuration of the Canal

The physical configuration of the existing canal within the geographical context of Panama shall be presented in graphical form. This information shall include not only the general canal configuration and the navigation channel, but also the lakes and rivers conforming the hydrographic basin. Overall description shall be complemented with applicable topographic, geodetic and hydrographic data. This description will also include all existing information on the Third Locks Plan. Illustrations shall include the following:

- Plan of the Panama Canal
- Complete longitudinal sections
- Typical cross sections

3.1.2 Principal Features of Major Structures

The FA/FR Contractor team will prepare a physical description of the major canal structures and will complement it with an evaluation of their present condition. The information will include a discussion of the principal design criteria for each facility, as well as considerations of the particular problems affecting the facilities. Structures to be analyzed include:

- Lock structures
- Lock gates and chain mechanisms
- Water tunnels and culverts
- Dams
- Power stations

3.1.3 Principal Features of Supporting Structures

A physical inventory of the principal support structures will be prepared, including an evaluation of their present condition. The information will include engineering drawings and a discussion of the principal design criteria for each facility, as well as considerations of the particular problems affecting the facilities.

- Anchoring facilities
- Towing locomotives
- Navigation lighting and signaling
- Radio communication system
- Breakwaters
- Roads and bridges
- Utilities
- Operations and management buildings
- Dredge spoil areas

3.1.4 Present Operation Characteristics

Characteristics of present canal operation shall be analyzed, specially in relation to transit vessels.

- Distribution of types and sizes of vessels
- Transit time
- Waiting time
- Interval between vessels
- Anchoring operation
- Lock operation
- Navigation system
- Safety control and accident prevention systems

3.1.5 Management System

The main source of information for this section shall be the Panama Canal Commission. The organizational structure, the work force, the sources of income, and the financial situation of the Commission shall be investigated as part of this task.

- Organization of the Panama Canal Commission
- Number of staff, operators, and workers
- Type and number of permanent assets
- Toll system
- Financial analysis

3.1.6 Maintenance System

A detailed analysis shall be made of the global maintenance system, including major and secondary structures and the waterway itself. The effectiveness of present maintenance and rehabilitation programs will be evaluated as an important factor in the effort to accurately determine the useful life of the existing canal.

- Maintenance programs
- Number of maintenance staff, technicians, and workers
- Type and number of maintenance equipment/machinery

- Management, operation, and maintenance costs of locks
- Slide monitoring, prevention, and rehabilitation

3.1.7 Canal Cargo

The FA/FR Contractor will gather and analyze extensive canal cargo statistics (from 1970 to the present), to the extent not done in the Historical Trade Analysis, generated by the Panama Canal Commission. The information shall be summarized in tabular and graphical form. The statistics will be utilized for the evaluation of the impact of fluctuations and increases of cargo volume in canal operation. The cargo shall be studied by direction according to the following breakdown:

- Statistics of canal cargo in value by cargo type
- Statistics of canal cargo in value by commodity
- Statistics of canal cargo in value by route
- Statistics of canal cargo in value by origin and destination
- Statistics of canal cargo in value by nationality
- Statistics of canal cargo in tonnage by cargo type
- Statistics of canal cargo in tonnage by commodity
- Statistics of canal cargo in tonnage by route
- Statistics of canal cargo in tonnage by origin and destination
- Statistics of canal cargo in tonnage by nationality

3.1.8 Transit Vessels

Panama Canal Commission statistics will be the source for the analysis of transit vessel characteristics. The information will be input into the evaluation of the effect of transit vessels on canal operation. Vessel statistics (total and by direction) shall be grouped according to the following characteristics:

- Statistics of number of transit vessels by type
- Statistics of number of transit vessels by type and size
- Statistics of number of transit vessels by type, size, and nationality

- Statistics on accidents
- Statistics on lockage times by lock, filling/emptying culvert combination, and by ship size

3.1.9 Load Ratio

Load ratio (laden vs. in ballast) information will allow the evaluation of, among other things, the effect on operation efficiency and the determination of the actual maximum capacity under present conditions. The main source of information shall be Panama Canal Commission statistics. Information will be presented in tabular and graphical form, by direction, according to the following categories:

- Statistics of load ratio by type of vessels
- Statistics of load ratio by size of vessels

3.2 Evaluation of Major and Supporting Structures and Facilities

Based on the existing technical information, the field investigations by the FA/FR Contractor and interviews and surveys of qualified Commission personnel, an estimate of useful service life will be prepared for the principal and supporting canal facilities, taking into account their present condition, on-going maintenance and rehabilitation programs, and the physical limitations of the materials and components of each facility.

3.3 Identification of Physical and Operational Constraints

An evaluation shall be made of the inherent limitations in design, configuration, geometric alignment and other specific physical and operational characteristics of the Panama Canal. Important input shall be provided by the Commission staff.

4 REPORT

The final report shall be a compendium of all available Panama Canal data and information. It shall have separate sections dealing with:

- Physical configuration of the Canal
- Major and supporting facilities/structures
- Operational characteristics
- Management system

- Maintenance system
- Canal cargo statistics

The information shall be presented in narrative, graphical, and tabular form. The report shall include evaluations on condition, durability, and performance of each major and supporting facility. A separate section shall deal with the physical and operational constraints of present day configuration.

Deliverables will include computer diskettes with appropriate DOS files (Word Perfect, dBase, Lotus, etc.). The report will include full documentation.

5 SCHEDULE

The overall schedule to complete this component study is 4 months. This task will start in the 1st month of the overall schedule and is to be completed by the end of the 4th month, as shown in Figure 1. The proposed manning schedule for this component study is shown in Figure 2. The major work assignments for this component study are shown in Figure 3.

6 STAFFING

The study shall employ the personnel discused below.

6.1 Project Manager

Registered civil engineer with demonstrated experience in design and operation of civil engineering hydraulic and navigation projects. Shall have knowledge of Panama Canal Commission's organization and operations.

6.2 Civil Engineer

Registered civil engineer with demonstrated experience in the design and operation of civil engineering projects. Shall have knowledge of Panama Canal Commission's organization and operations.

6.3 Others

The following other personnel will be employed:

- Mechanical engineer
- Electrical engineer
- Shipping specialist
- Management specialist
- Geotechnical engineer
- Structural engineer

7 REFERENCES

- PCC Annual Reports
- PCC Analysis of Lockage Times (unpublished)
- PCC Engineering Drawings
- Kearney Report
- PCC Hydrographic Surveys
- Aerial Photographs

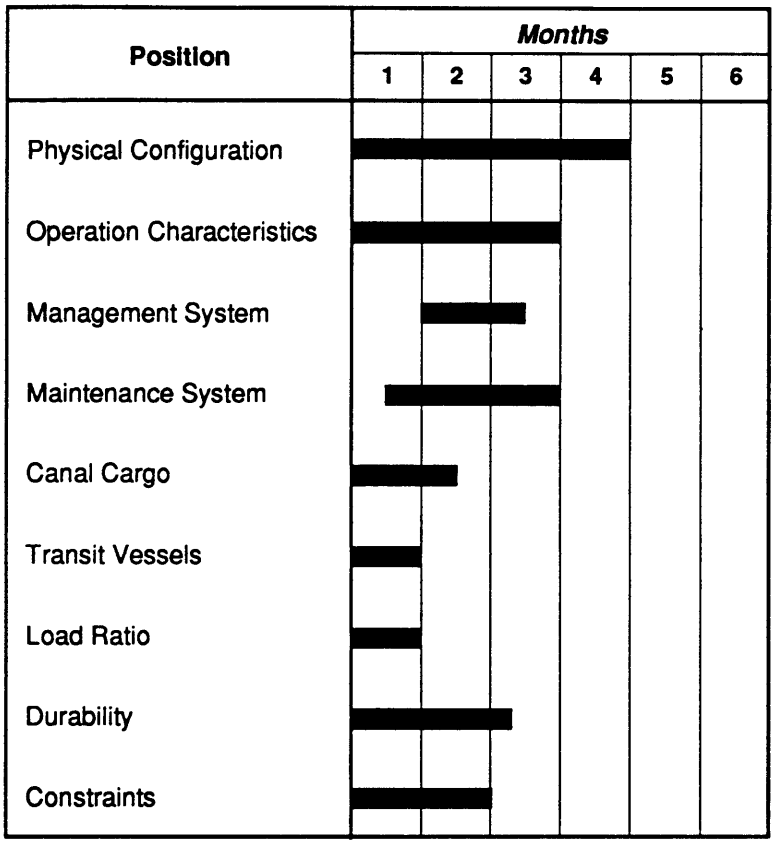

Figure 1 Work Schedule for Status of Present Panama Canal

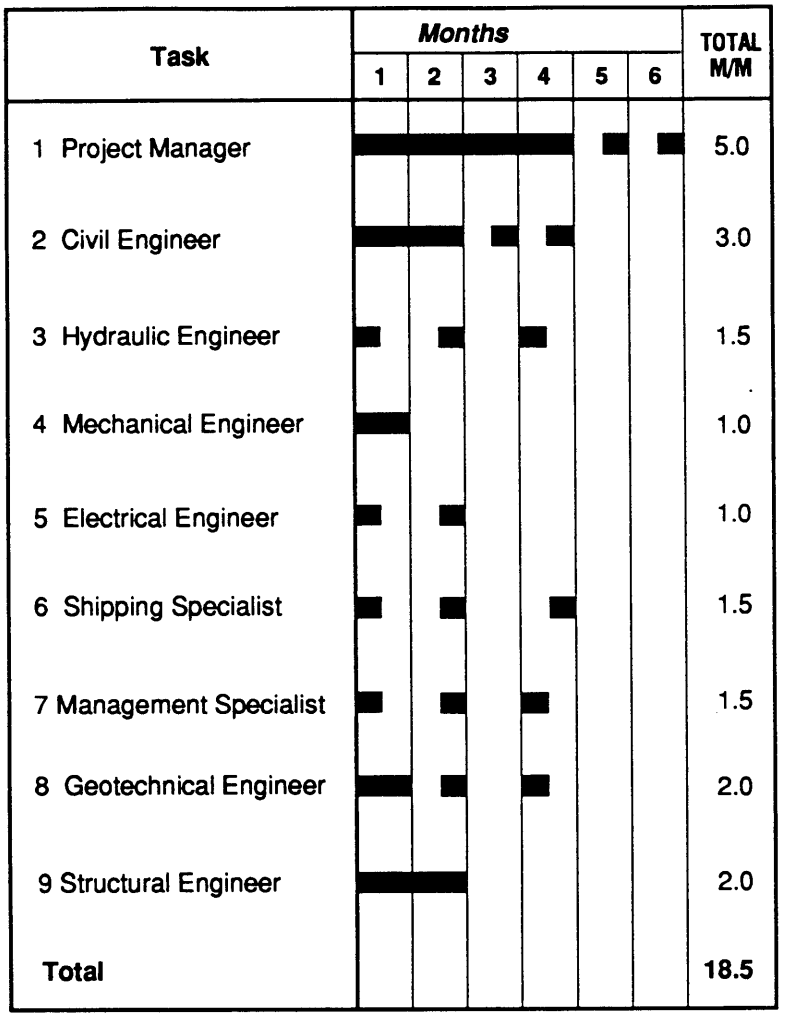

Figure 2 Manning Schedule for Status of Present Panama Canal

Task \ Position	1	2	3	4	5	6	7	8	9
Physical Configuration	P	S						S	S
Operational Characteristics	P		S	S	S				
Management Systems	S					S	P		
Maintenance Systems			S	P	S				S
Canal Cargo			S			P	S		
Transit Vessel		S	S	S		P			
Load Ratio		S	S	S		P			
Durability	P	S	S	S	S			S	S
Constraints	P	S	S	S					S

Legend:
P = Principal
S = Supporting

Figure 3 Position Assignments for Status of Present Panama Canal

Historical Trade Analysis

1 INTRODUCTION

This is a preparatory study for the demand analysis as well as for the analysis of impact upon Canal users. The purpose of the study is to identify the trade and cargo movement in relation to the Panamanian Isthmus within the frame work of economic activities.

Export and import of major commodities will be identified and cargo movement will be identified and quantified as the reflection of activities of the world economy. Major trade routes for maritime and maritime-related transportation systems in relation to the Isthmian route will be identified, and origin-destination (O-D) relationship for major commodity groups will be identified by country or region in relation to the Isthmian route.

Each of the major commodity groups will be treated as an objective of the study. It will need to represent the minimum group of commodities having almost the same kind and level of value for both international trade and maritime transportation and be in sufficient detail so that demand analysis and economic analysis can be conducted.

Trade route identification will first be conducted on the world maritime or maritime-related transportation system as a whole, and then in detail for those related to the Isthmian route. The importance of the trade routes related to the Panamanian Isthmus seems to have changed gradually from decade to decade, but the importance of the Isthmus in relation to the world trade or its route has not changed.

The origin-destination (O-D) relationship of cargo movement for major commodity groups will be identified by country or region, taking into account trade routes to identify which routes are more related to the Isthmus. Historical changes in O-D relationship will be clarified in conjunction with major historical events in the world and regional economy and trade. Data collected for this study will go back almost to 1978, and the base year of the study for future events will be the year 1990.

2 OBJECTIVES

The principal objectives of this study are:

- To collect and identify data and information concerning the world and regional economy and trade
- To clarify foreign trade and movement of major commodities
- To identify trade routes in relation to the Panamanian Isthmus

- To identify recent trends and major ups and downs in the world and regional economy and trade in relation to water borne commerce.

3 SCOPE OF SERVICES

The scope of the services to be conducted by the FA/FR study contractor for attaining the objectives set out above is as follows:

3.1 Collection of Data and Information

All the necessary data and information for the historical trade analysis for the Study of Alternatives to the Panama Canal shall be collected, especially:

(1) Macro-economic indicators, statistics, and other data and information concerning, but not be limited to, the following:

- Population of the world and major countries related to the Istmian route, and Panama and its neighboring countries
- Gross world product (GWP) and its per capita value
- Gross national product (GNP) and its per capita value in major countries, and Panama and its neighboring countries
- Economic activity of major industries of the world and major countries
- Demand and supply, including development, of energy of the world and major counties
- Major recent histrical events since 1978 of the world and regional economy

(2) Statistics, and other data and information on the foreign trade activity concerning, but not be limited to, the following:

- Demand and supply of major commodities in value and quantity in the markets of major counties or regions, and of the world total
- Export and import of major commodities in value and quantity, by major country or region, and of the world total
- Cargo movement of major export and import commodities by transportation modes such as maritime, land, and air transportation *
- Major trade routes of maritime and maritime-related transportation systems

- Origins and desinations of major commodities by trade route in relation to the Isthmian route
- Major historical events of the world and regional trade
- Cargo movement on the Mexican land bridge
- Aggregate cargo movement on the US land bridge

* Air is minimal now, land only in terms of import to or export from U.S. West Coast.

3.2 Identification of Other Economic Activities

Economic activities of major industries and demand and supply of energy of the world and major countries shall also be identified, and their results shall be summarized.

3.3 Identification of Foreign Trade Activity

Foreign trade activities concerning the following shall be identified and their results shall be summarized.

- Demand and supply of major commodities in value and quantity in markets of major country and region, and of the world total
- Export and import of major commodities in value and quantity, by major country and region, and of the world total
- Cargo movement of major commodities by transportation modes such as maritime, land, and air transportation *

* Air is minimal now, land only in terms of import to or export from U.S. West Coast.

Major commodities for the analysis are grouped as follows:

- Petroleum, crude
- Petroleum, products
- Coal and coke
- Ores
- Grains
- Automobiles

- Woods and wood products
- Fertilizers
- Metal and metal products
- Refrigerated cargoes
- Bananas
- Containerized cargos
- Phosphates
- Alumina, bauxite
- Miscellaneous
- Chemicals
- Sugar
- Food and agricultural products

3.4 Identification of Major Trade Routes

Major trade routes for maritime and maritime-related transportations shall be identified in relation to the Isthmian route, and be clarified as to which routes are the most related to the Isthmian route

Examples of major trade routes (both eastward and westward) related to the Panamanian Isthmus are as follows:

- US east coast - US west coast
- US east coast - South American west coast
- US east coast - Far East and Southeast Asia
- US east coast - Oceania
- US west coast - Europe
- US west coast - Africa/Middle East
- US west coast - Caribbean countries/Gulf states
- Caribbean countries/Gulf states - South American west coast
- Caribbean countries/Gulf states - Far East and Southeast Asia
- Caribbean countries/Gulf states - Oceania

- South American west coast - Europe
- South american west coast - Africa/Middle East
- South American east coast - US west coast
- South American east coast - South American west coast
- South American east coast - Far East and South east Asia
- South American east coast - Oceania
- Canadian east coast - Canadian west coast
- Central American east coast - Central American west coast

3.5 Identification of Origin and Destination of Major Commodities

Origins and destinations (O-D) of major commodddities shall be identified for each of trade routes since 1978 clarified in 3.4 above, and annual O-D tables shall be prepared by each of the major commodities.

3.6 Identification of Major Historical Events of World and Regional Economy and Trade

Major historical events of the world and regional economy and trade shall be identified since 1978 with respect to quantitative changes in cargo movement, and the degree of influence of these events on cargo movement shall be reported.

4. SCHEDULE

The overall schedule to complete the whole study is 30 months and the time allocated to complete this component study is 4 months. This study will start in the 1st month of the overall schedule for the study and is to be completed by the end of the 4th month as shown in Figure 1.

The proposed manning schedule for this component study is shown in Figure 2.

The major work assignment for this component study is shown in Figure 3.

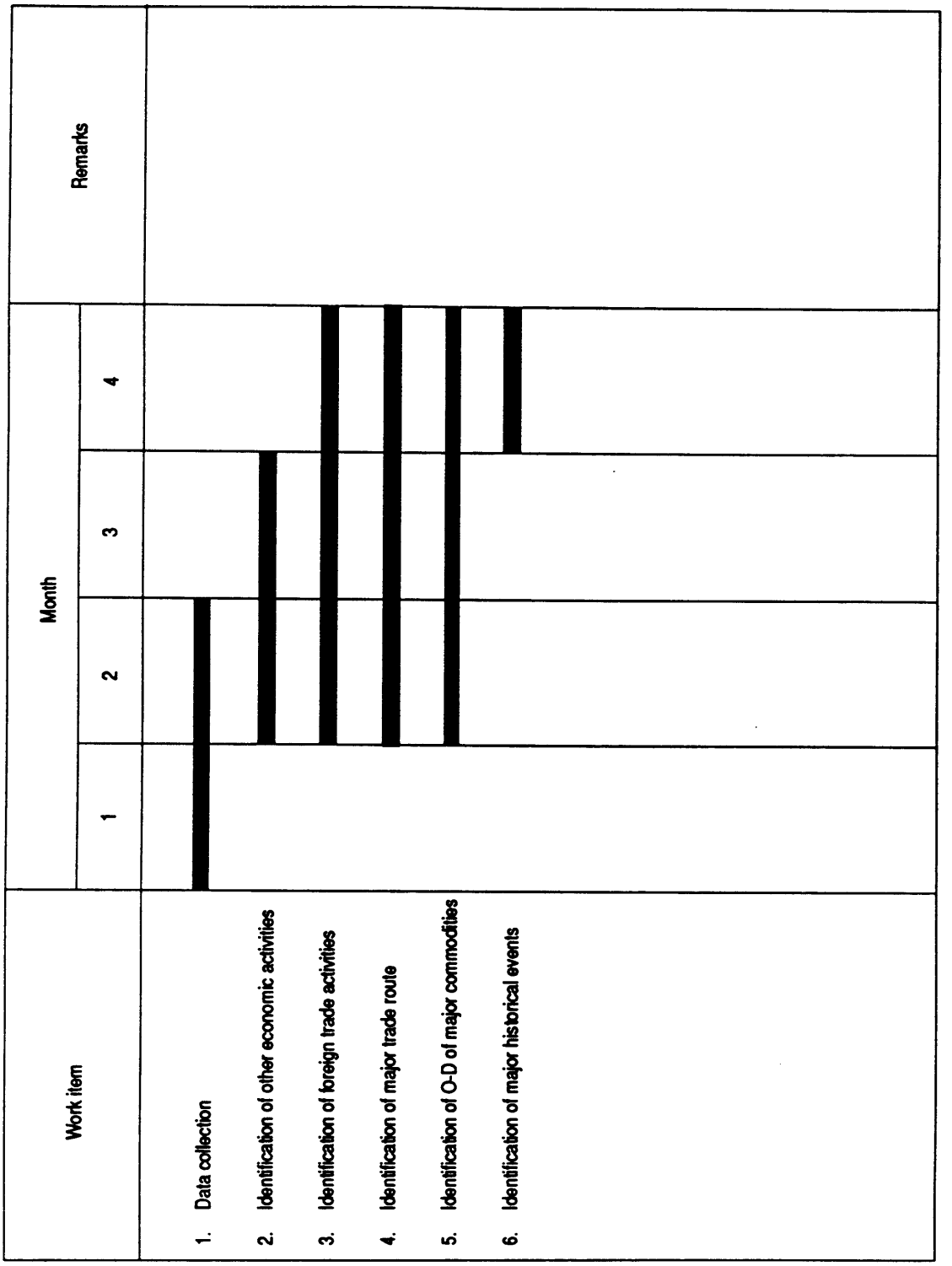

Figure 1. Work Time Schedule for Historical Trade Analysis

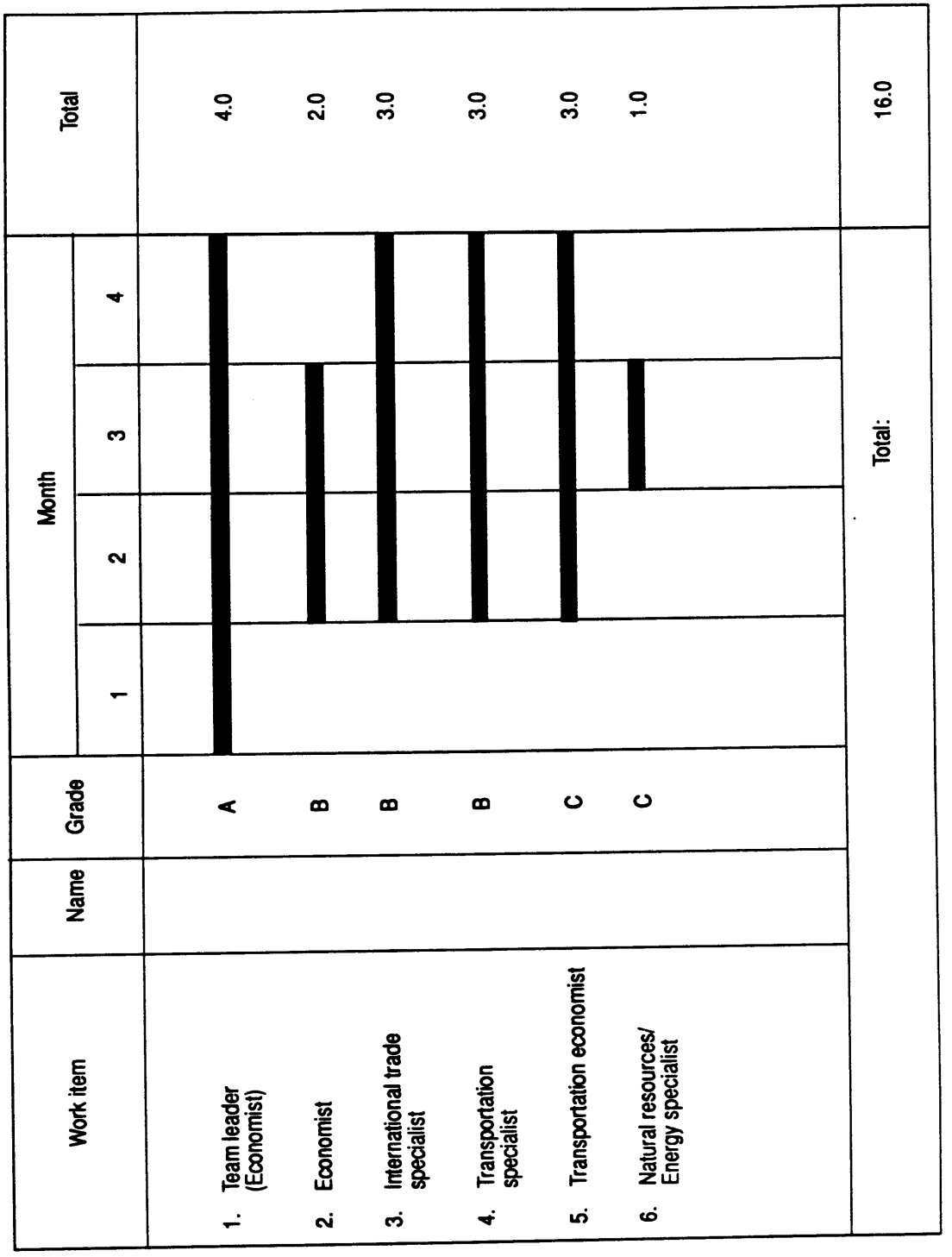

Figure 2. Manning Schedule for Historical Trade Analysis

T2891-171/WO/ma/R3

Work item \ Position	1. Team leader	2. Economist	3. International trade specialist	4. Transportation specialist	5. Transportation economist	6. Natural resources/ Energy specialist	Remarks
1. Data collection	P	S	S	S	S	S	P : Principal S : Supporting
2. Identification of other economic activities	S	S				P	
3. Identification of foreign trade activities	S		P	S	S		
4. Identification of major trade route	S		S	P	S		
5. Identification of O-D of major commodities	S		S	S	P		
6. Identification of major historical events	S	P	S	S	S		

Figure 3. Major Work Assignment for Historical Trade Analysis

5. DELIVERABLES

The deliverables for this component study will be, but not be limited to, the following:

(1) A list of all collected data and information with brief comments

(2) Output of studies and analyses with supporting documents concerning:

- Economic indicators
- Economic activities of major industries and demand and supply of energy of the world and major countries
- Demand and supply of major commodities in value and quantity in markets of major country and region, and of the world total
- Export and import of major commodities in value and quaantity, by major country and region, and of the world total
- Cargo movement of major commodities by transportation modes such as maritime, land and air transportation
- Major trade routes
- O-D relationship of major commodities for each of trade routes
- Major historical events of world and regional economy and trade

(3) The report will be fully documented, the text will be in English in hard copy and disks using Word Perfect, Lotus, and Base, etc.. All collected material will be submitted to the secretariat.

References

Basic references include:

- PCC annual reports
- Traffic demand forecast, TBS, April 14, 1989
- Fleet forecasts for the United States to 2020 DRI/TBS/Lloyd's, March 21, 1990
- Drewbry's Seaborne Trade and Transport Reports

- Coal Transportation Conference Ltd's "Coal Transportation 1989 Conference Proceedings"

Future Transportation System and Significance of Panamanian Isthmus in World Trade

1 INTRODUCTION

This is a preparatory study for the demand analysis as well as for the analysis of impact upon Panama Canal users. The purpose of the study is to identify the present status of the maritime transportation system, to assess its future prospects, and to clarify the significance of the Panamanian Isthmus in world trade. The coverage and accuracy required for this study will be detailed enough to forecast the commodity and traffic demand for each of the alternatives and to identify the future significance of the Panamanian Isthmus in world trade.

The study will start with collecting the necessary data concerning the present status and future prospects of the transportation system. Then, it will identify principal roles of the maritime transportation system and the complementary functions of land and air transportation systems, assessing the general prospects for their future developments and assessing possible future technological innovations of the total system. The present status and future prospects of complementary modes of transportation such as the oil pipeline, landbridge, etc., will also be studied and identified as a whole. The geographical importance of the Panamanian Isthmus in world trade will be assessed by determining prospective significance of the Isthmian trade route by comparing realistic traffic through the Panama Canal with potential traffic including shifted cargoes.

Maritime transportation system related to world trade will be identified and studied first, then those related to the Panama Canal will be examined in more detail. This task will include historical trends and future development in type and size of vessels, principal features of the existing major seaports in relation to the Isthmian route and their future development plans, historical trends in technological innovation of oceangoing vessels of the world fleet, and future prospects, and historical trends in cost and freight of maritime transportation. A transportation systems complementary to the Panama Canal and its alternatives will also be studied and identified. In the studies above, the identification of future prospects for maritime transportation and seaport developments will focus on how these developments will affect commodity flow through the ocean trade routes, including the Isthmian route.

In order to examine in detail the commodity flow on the ocean trade routes, the distribution of type and size of vessels of the world fleet and the Panama Canal transit vessels will be identified by each type of commodity group and its corresponding vessel. An example of the vessel types for the study will be the following:

- Dry bulk carrier
- General cargo ship
- Tanker
- Refrigerated cargo ship
- Full containership
- Roll on/roll off ship
- Vehicle carrier
- Combination carrier
- Liquid gas carrier
- Container/Breakbulk
- Cruiser
- Others

The results of this study will provide a sound basis for the demand analysis, together with results of the historical trade analysis, and will furnish basic information to evaluate the capacity of the alternatives.

2 OBJECTIVES

The principal objectives of this study are:

- To collect the data and information concerning the maritime, land and air transportation systems, and identify their future prospects *
- To identify principal roles of maritime transportation system in relation to complementary system including future prospects of technological innovation and trends in transportation costs

- To clarify the significance of the Panamanian Isthmus in world trade

* Air is minimal now, land only in terms of import to or export from U.S. West Coast

3 SCOPE OF SERVICES

The scope of services to be conducted by the FA/FR study contractor for attaining the objectives set out above are summarized below.

3.1 Collection of Data and Information

All the necessary data and information for the study of the present and future transportation system and the significance of the Panamanian Isthmus in world trade shall be collected, especially:

- Present status and future prospects of the maritime, land and air transportation systems
- Air transportation systems with respect to their potential to divert existing seaborne trade
- Historical trends in type and size of vessels of the world fleet and the Panama Canal transit vessels since 1965
- Principal features of existing major seaports in relation to the Isthmian route and their future development plans
- Historical trends in technological innovation of oceangoing vessels of the world fleet and their future prospects including increase in vessel size, specialization, manpower saving, energy saving, environmental protection, etc. since 1980
- Historical trends in cost and freight of maritime transportation since 1970
- Complementary transportation systems to the Panama Canal such as oil pipeline, landbridge, etc.,
- Prospective significance of the Isthmian trade route

3.2 Overview of Present Status and Future Prospects of Maritime, Land and Air Transportation Systems

Principal roles of the maritime transportation system and complementary functions of land and air transportation systems shall be identified in relation to the Isthmian trade route, and their general prospects for future development shall be overviewed. This task shall include identification of traded commodity groups for each system and estimation of their approximate value and quantities, present and future. Possible technological innovation in future shall also be assessed for the total transportation system.

3.3 Identification and Forecasting of Maritime Transportation Systems

Present status and future prospects of maritime transportation system in relation to the Isthmian route shall be forecast in detail, especially:

1) Historical trends in composition of type and size of vessels of the world fleet and Panama Canal transit vessels shall be identified, and changes in future composition of type and size of vessels shall be forecast taking into account the trend of increasing vessel size, specialization, etc.

2) Data and information on existing major seaports channel depths in relation to the Isthmian route by commodity type and their development plans shall be identified, and future prospects of the major seaports shall be identified.

3) Recent historical trends in the technological innovation of oceangoing vessels of the world fleet shall be analyzed, and their future prospects shall be overviewed with reference to existing plans.

3.4 Identification and Forecasting of Trends in Cost and Freight, Historical and Future, of Maritime Transportation

1) Recent historical trends and future prospects in cost of maritime transportation shall be identified by type and size of vessels related to the Isthmian route, and world-wide.

2) Historical trends and future design of ships shall be identified by type and size of vessels as well as by each of the trade routes related to the Isthmian route.

3.5 Study of Complementary Transportation System

Principal features and characteristics of the transportation system complementary to the Panama Canal such as pipeline, landbridge, etc. shall be studied, and their future prospects shall be identified. The identification shall be made by classifying commodity groups, and their future transportation costs shall be overviewed.

3.6 Clarification of the Significance of the Panamanian Isthmus in World Trade

The significance of the Panamanian Isthmus in world trade shall be clarified taking into account the results of analysis on world trade and development of complementary transportation system including the possibility of its competition with the Panama Canal. Geographical importance of the Isthmian route shall be identified by analyzing the future prospects of the maritime and complementary transportation systems to clarify the role of the Panamanian Isthmus in world trade. In particular, the time and distance factors will be reflected in unit transportation saving based upon ship type and fuel consumption.

4 SCHEDULE

The overall schedule to complete the whole study is 30 months and the time allocated to complete this component study is 4 months. This study will start in the 1st month of the overall schedule for the study and is to be completed by the end of the 4th month as shown in Figure 1.

The proposed manning schedule for this component study is shown in Figure 2.

The major work assignment for this component study is shown in Figure 3.

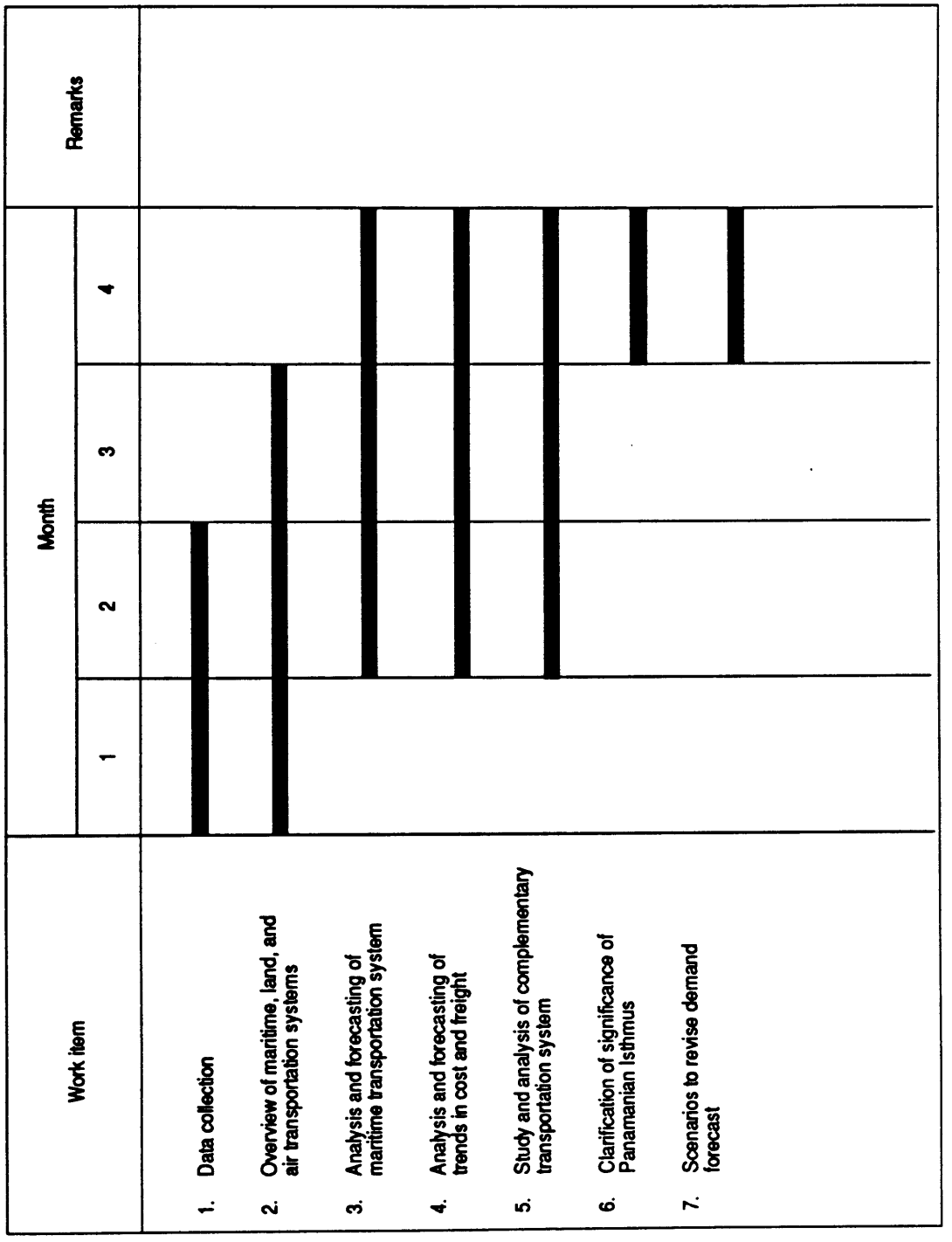

Figure 1. Work Time Schedule for Future Transportation System

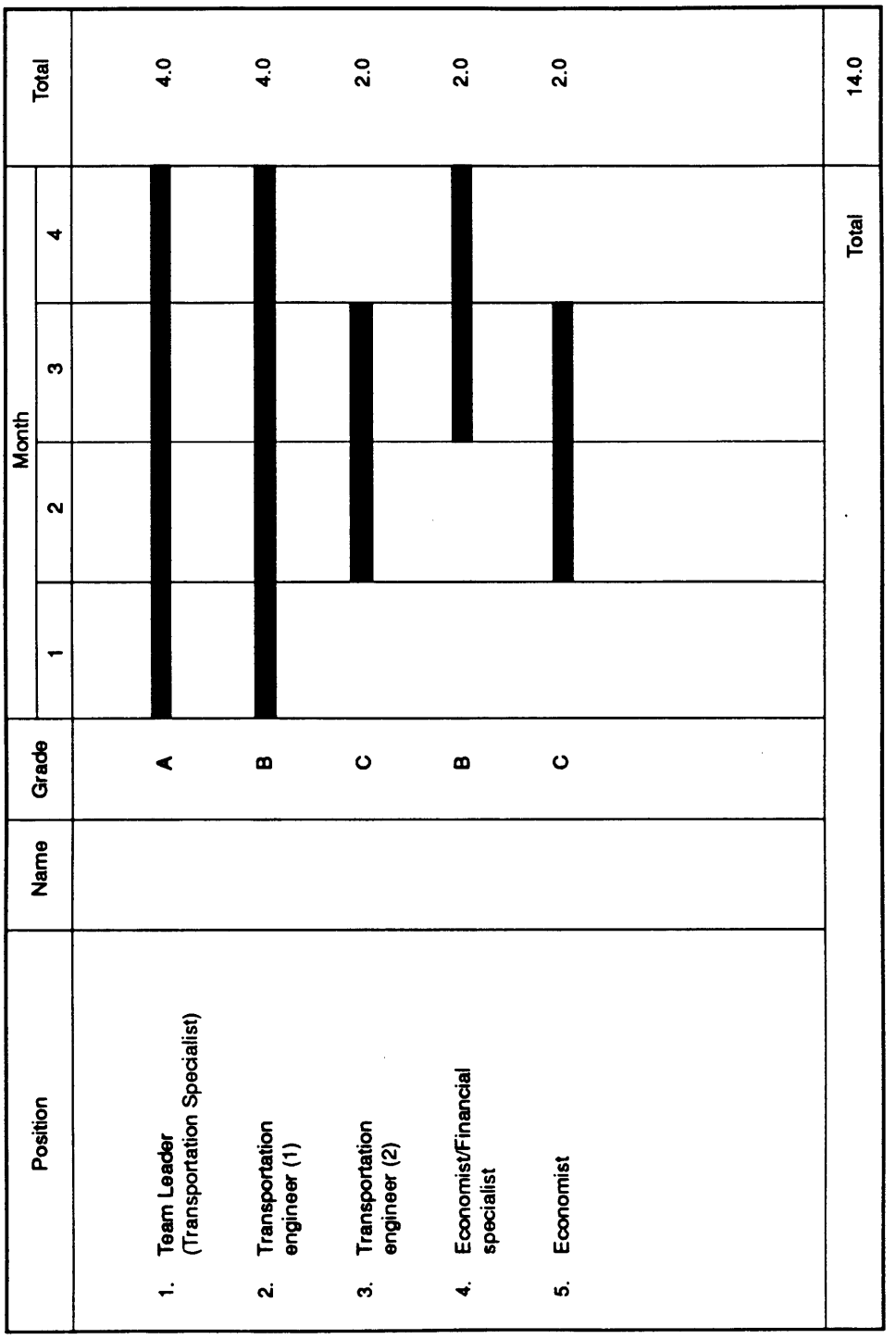

Figure 2 Manning Schedule for Future Transportation System

Work item \ Position	1. Team leader	2. Transportation engineer (1)	3. Transportation engineer (2)	4. Economic/Financial specialist	5. Economist	Remarks
1. Data collection	P	S	S	S	S	P : Principal S : Supporting
2. Overview of maritime, land, and air transportation system	S	P	S	S		
3. Analysis and forecasting of maritime transportation system	S	P	S		S	
4. Analysis and forecasting of trends in cost and freight	S	S		P	S	
5. Study and analysis of complementary transportation system	S	P	S		S	
6. Clarification of significance of Panamanian Isthmus	S	S		S	P	
7. Scenarios to revise demand forecast	S	S			P	

Figure 3. Major Work Assignment for Future Transportation System

5 DELIVERABLES

The deliverables for this component study will be, but not be limited to, the following:

(1) A list of all collected data and information with brief comments

(2) Outputs of studies with supporting documents concerning:

- Principal roles of maritime transportation system and complementary functions of land and air transportation systems in relation to the Isthmian route, present and future
- Traded commodity groups for each transportation system and their approximate value and quantity
- Historical trends in composition of type and size of vessels, and forecasts of their future changes in relation to development of major seaports, technological innovation of ocean-going vessels, etc.
- Historical trends and their forecasting of maritime transportation costs by type and size of vessels
- Present situation and future prospects of the complementary transportation systems including evaluation of their transportation costs

(3) Significance of the Panamanian Isthmus in world trade

(4) Senarios to revise the demand forecast

6 REFERENCES

Basic references include :

- Traffic demand forecast, TBS, April 14, 1989
- Fleet forecast for the U.S. to 2020
- Marad Annual Reports on world fleet
- Drewry's Seaborne Trade and Transport Reports
- Olson - World Port Channel Depths

- Grier Papers on U.S. landbridge
- Ship operating costs, U.S. Army Corps of Engineers, IWR, 1990
- Lloyd's Maritime "Ships-on-Order" on-line data base
- Coal Transportation Conference, Ltd's "Coal Transportation 1989 Conference Proceedings"

Prescreening and Selection of Alternatives

1 INTRODUCTION

In the initial months of the Study it will be necessary to review and classify the various alternatives to the Panama Canal which have been proposed in the past as well as any other alternatives which should be examined at the time of the Study. These alternatives will be analyzed in conjunction with the basic study parameters to provide a definitive list of alternatives as the basis for preliminary engineering, cost estimates, operating characteristics, and capacity evaluation. With the results of the preliminary engineering, cost estimates, operating characteristics, and capacity evaluation, as well as the other preliminary data collection tasks, the list of alternatives will be analyzed to identify those alternatives which clearly have the greatest potential for further examination.

2 OBJECTIVES

- To provide a complete list of alternatives and consistent study parameters to the Preliminary Engineering and Cost Estimates Component Study contractor and the Preliminary Operating Characteristics and Capacity Evaluation Study contractor.
- To recommend a "short list" of approximately three alternatives with the greatest potential for further examination

3 SCOPE OF SERVICES

3.1 Classification of Study Parameters

Historically, the many studies of alternatives to the Panama Canal have used different study parameters such as the "design ship" and the projected transit cargo. In order to establish a rational basis for an initial comparison of alternatives the Contractor will have to examine these parameters in light of more recent information and develop a consistent set of basic parameters.

The FA/FR Contractor will initially review the literature concerning the alternatives to the Panama Canal which have been proposed in the past. These will include at least the following:

- Improvements to the Existing Canal
  - Status quo alternative (including Gaillard Cut widening)
  - Non-lock improvements

  - Third Locks Plan
  - Terminal Lake Plan and Variations
  - Deep Draft Lock Canal Plan
  - Lopez-Moreno Plan (Panamanian Alternative)
- Sea-Level Canal Proposals
  - 1970 Interoceanic Canal Studies, Route 10
  - 1970 Interoceanic Canal Studies, Route 14
  - Vergara Plan
  - Nagano Plan
- Non-Canal Complementary Transportation Systems
  - Oil Pipeline
  - Land bridge systems (railway and highway)
  - Centerport (appropriate improvements to railway and existing ports of Balboa and Cristobal)

For these alternatives, the critical study parameters will be tabulated and classified to include:

- Design ship (where applicable)
- Capacity (cargo and vessels)
- Alignments
- Route/water surface profile
- Navigation style (one lane versus two lanes)
- Cross sections (bottom width, side slopes for various conditions)
- Lock chamber characteristics
- Excavation schemes
- Water usage requirements

Based upon this historical data and the preliminary data provided by the studies of Historical Trade Analysis (A.2.3) and Future Transportation Systems (A.2.4), the FA/FR Contractor will develop and recommend consistent parameters for each major

class of alternatives (e.g., sea-level canal alternatives, lock canal alternatives, canal improvement alternatives).

Following review and approval of these recommendations by the Commission the Contractor will proceed to the Identification of Alternatives.

3.2 Identification of Alternatives

The FA/FR Contractor will next compile a set of alternatives based upon the historical list as shown in 3.1 above and such others as may be proposed by the Commission. The historical alternatives will be modified and possibly consolidated by applying the study parameters developed in 3.1.

For each major class of alternatives it is anticipated that certain parameters will be unique. These would include:

- Ship size or mix of sizes (length, beam, draft, displacement)
- Mix and tonnage of projected cargo

Other parameters may be varied within classes thus leading to a new set of alternatives within each major class. These variable parameters might include:

- Bottom width
- Bottom depth
- Lock chamber dimensions
- Number of lockage lifts
- Tidal control structures for sea-level alternatives

At the conclusion of this process of analysis and synthesis, the FA/FR Contractor will recommend to the Commission a list of alternatives which may include:

- Historical alternatives modified with consistent parameters
- Variations on historical alternatives
- New alternatives (for example, new single-lift locks with water storage basins)

The recommended list of alternatives will cover the complete range of alternatives which the Commission will consider to be appropriate for examination. Of necessity,

this phase of the work will involve intensive interaction with the Commission and Secretariat.

Upon approval by the Commission of the list of alternatives, it will be furnished to the Component Study contractors for the Preliminary Engineering and Cost Estimates and Operating Characteristics and Capacity Evaluation.

3.3 Prescreening

The final step of the preliminary phase of the study is to use the data available which has been collected and evaluated to prescreen the list of alternatives and to select a "short list" of those which have the best potential. Only those alternatives remaining on the short list will be considered further during the Study of Alternatives.

The criteria for prescreening will be:

- **Engineering Soundness.** Each alternative will be evaluated in terms of the practicality and degree of risk involved in its engineering approach.
- **Capacity to Fulfill Incremental Demand in a Timely Manner.** The preliminary demand analysis will project future demand. The capacity of each alternative to meet the potential demand will be determined.
- **Capital Cost for Each Alternative.** A preliminary estimate of the capital cost of each alternative will be developed.
- **Approximate Cost and Benefit Comparison.** For each alternative, the benefits considered will be in limited to the direct benefits accruing from transportation (increased number of vessels transiting the canal and reduction of transit time). This will include a financial, managerial and operational assessment.
- **Relative Environmental/Socio-economic Impacts.** A qualitative comparison of the relative impacts of all alternatives on the environment and the socio-economic situation will be made.
- **Short-Term Impact on the Existing Canal.** The relative degree of impact on or interruption of the operation of the existing Canal will be assessed for each alternative.

The prescreening will provide the basis for a sound decision to eliminate from further detailed examination those alternatives which are clearly unsound, which do not meet demand projections, which are not competitive on the basis of capital cost, which would generate revenue shortfalls that could not reasonably be offset by higher tolls

or other sources of funding or which have adverse impacts the severity of which is obviously much greater than other alternatives. These criteria have been selected to focus on factors with potentially substantial differences.

The methodology will follow these steps:

- **Step One.** During the initial stages of this study a complete list of alternatives will be developed and approved by the Commission. This list of alternatives will be input into the Preliminary Engineering Study (Task B.2.1), Preliminary Cost Estimates (Task B.2.2), and the Preliminary Operating Characteristics Study (Task B.2.3), and other component studies.
- **Step Two.** The preliminary results from the Commodity and Traffic Projections (Task B.3.1) will provide an initial projection of future demand for trans-Isthmian commerce as a function of time before prescreening. This projection will reflect a statistical projection of future traffic through the existing Canal plus an estimate of future demand for vessels which cannot currently use the Canal. The volume and types of commerce which could conceivably use complementary systems such as road or rail landbridges, pipelines, conveyor systems, etc. will be considered as an adjustment to the total projection.
- **Step Three.** The analysis of the status of the present Canal (Task A.2.2) and the Preliminary Operating Characteristics and Capacity Evaluation Study (Task B.2.3) will provide an analysis of the probable maximum capacity of the existing Canal and a confirmation that the useful life of the existing Canal under the present conditions of maintenance will extend to the economic horizon.
- **Step Four.** Combination of the data developed in Steps Two and Three will permit the estimation of the potential future demand which cannot be satisfied by the existing Canal. This increased demand will be stratified by ranges of vessel size to identify future demand for vessels of Panamax size or smaller and appropriate groupings of larger vessels.
- **Step Five.** During the Preliminary Engineering study and the preparation of preliminary cost estimates, all available data on the alternatives will be investigated to assess the soundness of the approach; to validate the existing cost data and to adjust capital costs to provide a comparable set of estimates; and to identify the phenomena which would cause environmental or socio-economic impacts. Concurrently, the impact on the continuity of operations of the existing Canal during implementation

of each alternative will be estimated. The Preliminary Operating Characteristics and Capacity Evaluation Study will also evaluate approximate capacity for each alternative.

- **Step Six.** This step will comprise the analysis of the preliminary data on all potential alternatives and the preparation of a matrix to compare their engineering soundness, capital costs, and relative qualitative impacts. Approximate cost and benefit comparison will be carried out; the benefits considered will be limited to the direct benefits accruing from transportation (increased number of vessels transiting the canal and reduction of transit time). Based upon this body of data and analysis the FA/FR Contractor will recommend to the Commission those alternatives which clearly have the best potential for further investigation. The FA/FR Contractor will prepare a report to document the steps leading to this decision and the basis for the selection.

4 SCHEDULE

The proposed manning schedule is shown on Figure 1. Work flow illustrating the relationship of the prescreening task to other tasks is shown in Figure 2.

5 DELIVERABLES

The deliverables for this study will include, but not be limited to:

- A tabulation of data compiled from all historical alternatives reviewed
- A report presenting the rationale for the recommendation of consistent study parameters
- A report presenting the list of alternatives with supporting data and explanation
- A report on the final prescreening process presenting the methodology, the data used for the analysis, the results of the analysis, and the recommendation for the alternatives to be studied in the remainder of the Study with supporting rationale
- Computer diskettes with appropriate DOS files (Word Perfect, dBase, Lotus, etc.)

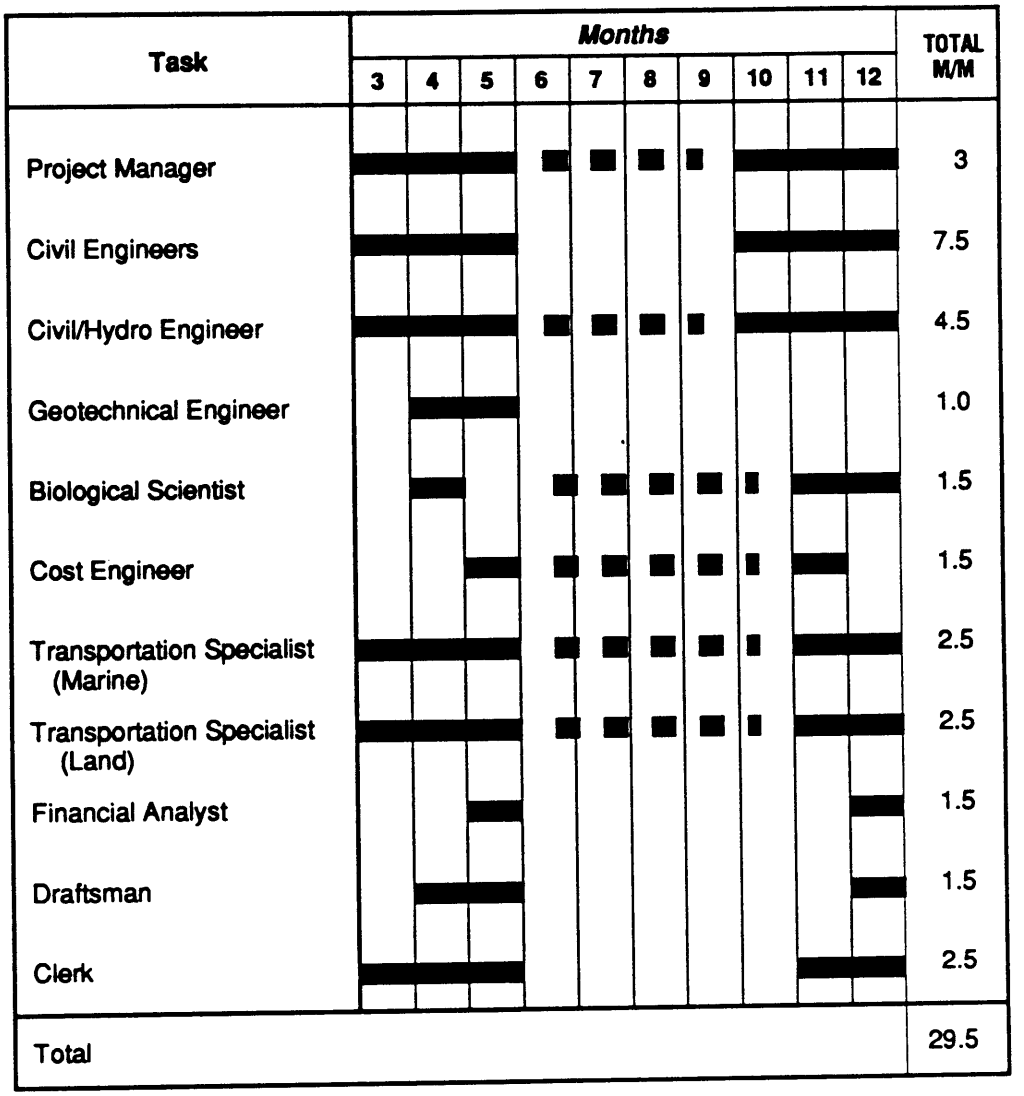

Figure 1 Manning Schedule for Prescreening

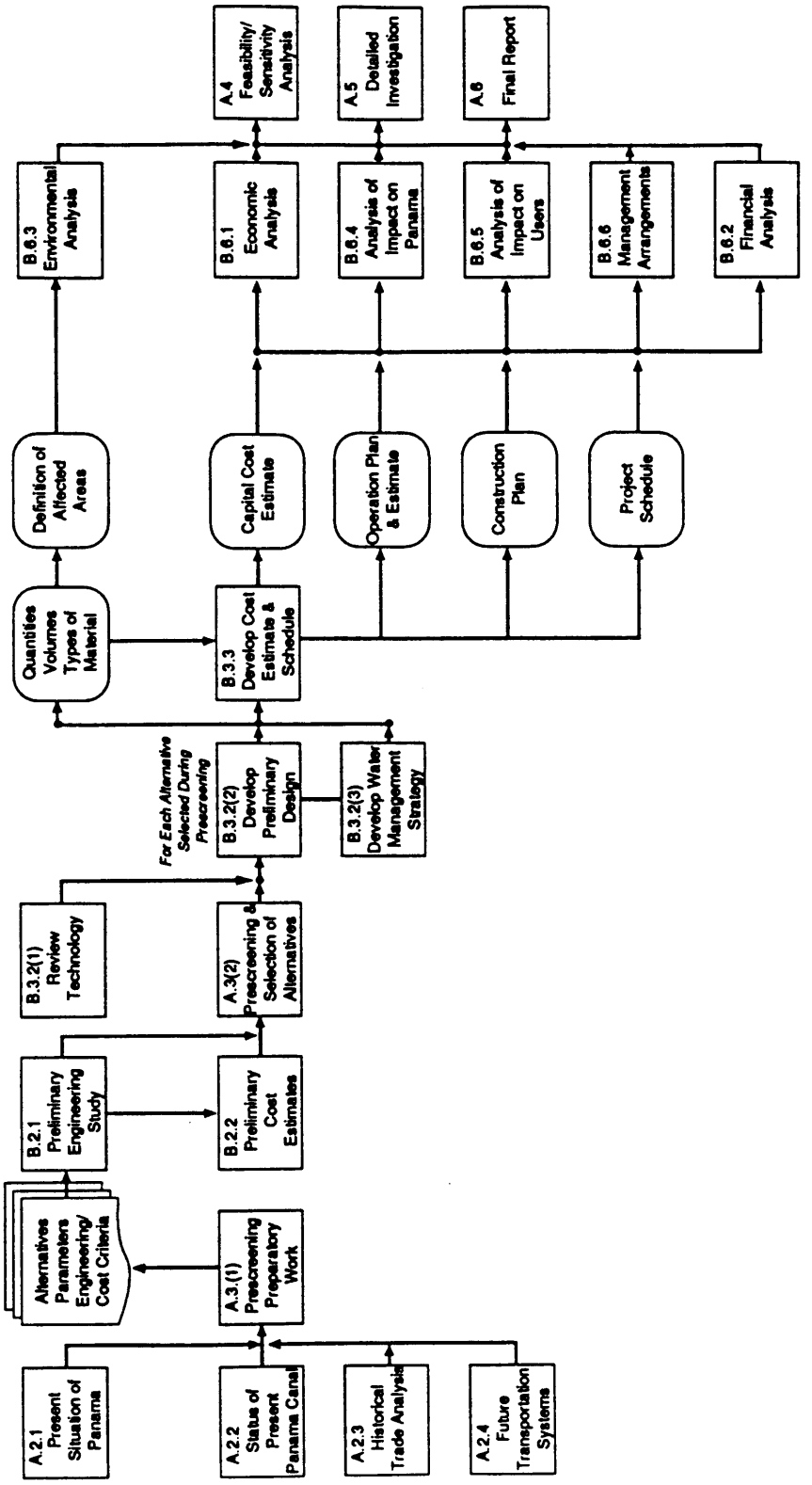

Figure 2 General Flow Chart for Prescreening

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Commodity and Traffic Projections

1 INTRODUCTION

This study will provide the baseline for subsequent studies and analyses. All the prescreened alternatives will be studied, examined, and analyzed based on the results of the demand forecast that will be made by this study. A number of demand forecasts for the existing Panama Canal and the Panamanian Isthmus as a whole have been performed in the past. Periodical demand forecasts for the existing Panama Canal have been made by the Panama Canal Commission (PCC), and its 1989 forecast was issued recently. But the forecast is limited to the existing canal, and its target year is 2010. Due to the dynamic changes of the world economy, these historical forecasts are now obsolete, although they could still be helpful in conducting a new forecast.

In this component study, the demand for commodities and traffic transiting through the Panamanian Isthmus shall be projected. The analysis and forecast will be made not only for commodity movement, but also for transit vessels. All the relevant studies and analyses shall be made except the trade route analysis that will be conducted in the study, "Historical Trade Analysis"; and the analysis of ship mix of type and size, both historical and future, that will be conducted in the study, "Future Transportation System and Significance of Panamanian Isthmus in World Trade". The coverage and accuracy required for this study will be in sufficient detail for evaluating and assessing the prescreened alternatives (which will be decided by the Secretariat in due course) and for analyzing the feasibility of the best alternative which will be selected as a sole objective of the detailed feasibility analysis in a later phase.

The demand analysis will include short-and long-term forecasts of the cargo tonnage and number of transit vessels through the Isthmian route. The short-term forecast will cover a time span of 10 to 20 years from the present. The long-term demand forecast will cover a time span of 30 to 50 years after completion of the project; that is possibly the year 2010 for the case of the sea-level canal which would have the longest construction period. (Determination of target years will be made in the foregoing study, "Historical Trade Analysis", and the figures indicated above will be revised, if necessary.) The base year for the demand forecast will be 1990.

The demand analysis for the study will be performed taking into account major factors influencing the forecast, such as:

- Trends in world and regional economies and trade patterns
- International trade routes
- Trends in the world fleet ship mix

- Technological innovations in oceangoing vessels
- Development of major harbors of the world
- Development of alternative modes of transportation
- Trends in costs of ocean transportation and its competitive alternatives

A canal crossing over the Panamanian Isthmus is considered to be a waterway bridge across the Isthmus, connecting the Pacific and the Atlantic oceans. Alternatives to the Panama Canal, therefore, will have constraints on passage. For instance, the dimensions of the existing locks of the Panama Canal preclude passage of ships longer than 1,000 feet, wider than 106 feet and with a draft greater than 39.5 feet, approximately 65,000 DWT. This size limitation and time required for passage through the locks will become progressively more constraining as the average size of vessels and number of transits increase. In order to clarify realistic volume of cargo tonnage and number of vessels which might use the Isthmian route, a demand analysis shall be made in two steps.

- A forecast of potential cargo tonnage and number of transit vessels through the Isthmian route without any constraints on passage shall first be made.
- A forecast of cargo tonnage and number of transit vessels through the canal under constraints on passage inherent to each of the alternatives shall then be made.

Potential demand will be estimated by identifying shifting cargoes specific to the Panama Canal such as coastal, bypass, and sourcing shifts, in which coastal shifts will be assumed to be shifts of cargo flows by the U.S. coast, e.g., containers moving on an intermodal basis from Asian countries to the U.S. east coast via U.S. west coast ports. Bypass shifts will be assumed to be loss of cargo to the Isthmian route due to deployment of vessels too large to use the canal. Sourcing shifts will be assumed to be changes in product sourcing patterns which involve cargo movements that do not use the Isthmian route. Constrained demand for each of the alternatives shall be estimated by trimming the potential demand, taking into account limitation of maximum passable size of vessel, operational characteristics, toll levels, and other factors related to shifting cargos.

The methods of demand forecast applicable to the Panama Canal and its alternative may be generally classified as aggregate and disaggregate methods. Both methods will have advantages and disadvantages. An aggregate method, which may involve every incident of the demand projections comprehensively, can be used to express

long-term demand trends, while a disaggregate method which may reflect ups and downs of the projection, can be used to forecast short-term demand with fluctuations. Accordingly, it shall be necessary to review thoroughly the demand forecasts of the previous studies and to clarify those advantages and disadvantages inherent to each of the methods. There will be, for instance, an aggregate extrapolation, simple and multiple regression, and ratio methods both for total and for major commodity groups, as well as a disaggregate method based on movement of major commodity groups. The results of these forecasts will be assessed by an outside group of senior economists and specialists, and the forecast for the study will be finally affirmed.

2 OBJECTIVES

The principal objectives of this study are:

- To collect and analyze the data and information concerning the demand analysis for the Study of Alternatives to the Panama Canal
- To estimate the potential cargo tonnage and number of transit vessels through the Panamanian Isthmus if there were no constraints on passage.
- To estimate the realistic cargo tonnage and number of transit vessels through the alternatives under constraints inherent to each of the alternatives.

3 SCOPE OF SERVICES

The scope of the services to be conducted by the component study contractor for attaining the objectives set out above is discussed below.

3.1 Collection of Data and Information

All the necessary data and information including those obtainable from the Information Center as well as the results of the foregoing studies for the demand analysis for the Study of Alternatives to the Panama Canal shall be collected, especially:

- Statistics, data, and information concerning commodity and traffic projections
- Data and information concerning the results of previous demand projections and their methodology

- Results of the foregoing studies, such as "Historical Trade Analysis," "Future Transportation System," etc., which will be undertaken by the FA/FR study contractor as the preparatory studies of the demand analysis
- Other necessary data and information, if any

3.2 Review of Previous Demand Analysis

The results of previous demand analysis, both qualitative and quantitative, and their methodology shall be reviewed, and major factors influencing the demand projections shall be clarified.

3.3 Assessment of Methodology of Previous Demand Analysis

The methodology of previous demand analysis shall be assessed taking into account the factors influencing the demand projections, and the advantages and disadvantages of each methodology shall be clarified.

3.4 Establishment of Methodology for the Demand Analysis

The methodology for demand projection that is most suited to the study shall be established taking into account both short- and long-term projections which shall coincide with the following target years:

- Base year: 1990
- Short-term target years: 2000 and 2010
- Long-term target years: 30 to 50 years after completion of the project, possibly 2040 and 2060

  (In establishing the methodology existing models for demand forecast shall fully be utilized if applicable.)

3.5 Analysis of Statistics for Canal Cargo Tonnage and Number of Transit Vessels

The historical data for Canal cargo tonnage and number of transit vessels shall be analyzed by type of vessels and commodity groups and in total using the appropriate methods such as:

- Interpolation/extrapolation analysis with respect to time (year)-time series.

- Simple regressional analysis with respect to world trade, gross world product (GWP), or trade or GNP of major countries, etc.
- Multiple regressional analysis with respect to world population, per capita gross world product, world trade, etc.
- Ratio analysis with respect to world trade in cargo tonnage for Canal cargo analysis, total movement of world fleet for Canal transit analysis, etc.
- Simulation analysis based on movement of major commodity groups summed up for each of major import countries/regions, etc.

The classification of type of vessels for the above analysis is, for instance:

- Dry bulk carrier
- General cargo ship
- Tanker
- Refrigerated cargo ship
- Full containership
- Roll-on/Roll-off ship
- Vehicle carrier
- Combination carrier
- Liquid gas carrier
- Container/Break bulk
- Passenger
- Others

The classification of major commodity group is, for instance:

- Petroleum, crude
- Petroleum, products
- Coal and coke
- Ores
- Grains
- Automobiles

- Woods and wooden products
- Fertilizers
- Metal and metal products
- Refrigerated cargoes
- Bananas
- Containerized cargoes
- Phosphate
- Alumina and bauxite
- Chemicals
- Sugar
- Food and agriculture products
- Miscellaneous

3.6 Forecast of Canal Cargo Tonnage and Number of Transit Vessels

Future demand of Canal cargo tonnage (by major commodity groups) and number of transit vessels shall be forecast as if the present Panama Canal would have a capacity to transit all the forecast cargo and traffic under the present physical constraints on passage. The forecast may be made by using the method of analysis discussed above in 3.5, and shall be made for the target years as discussed above in 3.4.

3.7 Assessment of Results of Demand Forecasts

Results of demand forecasts (cargo tonnage and number of transit vessels) shall be revised in conjunction with short- and long-term trends as well as future ups and downs of cargo tonnage taking into account the scenarios which are formulated through the studies of "Historical Trade Analysis" and "Future Transportation System and Significance of Panamanian Isthmus in World Trade," and then shall be reviewed jointly by a group of senior economists and specialists. Finally, one unified demand forecast shall be made for Canal cargo tonnage and number of transit vessels.

3.8 Estimation of Future Potential Cargo Tonnage and Number of Transit Vessels

Based on the demand forecast in 3.7 above, future potential cargo tonnage (by major commodity groups) that may transit through the Panamanian Isthmus if any constraints were taken off, shall be estimated for the target years as stipulated in 3.4, taking into account elimination of such existing constraints in the present Panama Canal as size of passable ships, shifted cargoes to the other trade routes or other modes of transportation, their combination, etc. Future potential number of transit vessels through Panamanian Isthmus under no constraints on passage shall be estimated taking into account future average cargo tonnage per ship of world fleet which has been studied in "Future Transportation System.

3.9 Preliminary Estimation of Future Demand of Cargo Tonnage and Number of Transit Vessels Through Restricted Canal

Based on the future potential cargo tonnage and number of transit vessels through the Panamanian Isthmus under no constraints on passage estimated in 3.8 above, future demand of cargo tonnage and number of transit vessels by type and size through each of the restricted canals, or each of the prescreened alternatives, shall be estimated for the target years as stipulated in 3.4 taking into account physical and non-physical constraints inherent to each alternative. In this case, the number of transit vessels may first be estimated by examining how the constraints of each alternative will bring influences to the maximum size of passable vessels, limit in number of transit vessels, etc. Total cargo tonnage shall then be estimated taking into account future average cargo tonnage per ship of world fleet. This estimation will be made together with the analysis of 3.10 after acquiring the results of engineering study.

3.10 Estimation of Future Demand of Cargo Tonnage and Number of Transit Vessels Through Restricted Canal

Based on the cargo tonnage and number of transit vessels by type and size through each of the restricted canals estimated in 3.9 above, future demand for cargo tonnage and number of transit vessels through each of the restricted canals shall be estimated for the target years as stipulated in 3.4 above taking into account the influences of toll levels on the cargo and traffic through the Panamanian Isthmus. Moreover, future demand forecast of the transit vessels shall be made taking into account transits in laden or ballast condition, transits by size and dimension, etc.

3.11 Analyses Pertinent to the Demand Forecast

All the necessary analyses pertinent to the demand forecast shall be made. Those analyses shall be, for instance:

- Laden and ballast transits of vessels
- Load ratio
- Vessel size distribution
- Average vessel size
- Nationality of vessels by registry

4 SCHEDULE

The overall schedule to complete the whole study is 30 months and the time allocated to complete this component study is 6 months in total. This study will start in the 6th month of the overall schedule of the Study and is to be completed by the end of the 10th month for the works 3.1 through 3.8 and in the 18th month for works 3.9 and 3.10 as shown in Figure 1. The proposed manning schedule for this component study is shown in Figure 2.

The major work assignment for the component study is shown in Figure 3.

5 REPORTS

The Reports to be prepared by the component study contractor shall be:

1) Inception Report
2) Interim Report
3) Final Study Report
4) Monthly Report

All reports shall be written in comprehensible English. Units shall be expressed in the metric system. The pages of the text shall be in principle 8-1/2" x 11" with pull-outs a maximum of 11" x 17". Oversized drawings may be placed in a pouch within the text or assembled in a separate appendix.

5.1 Inception Report

The component study contractor shall prepare sixteen (16) copies of an Inception Report for the component study, "Commodity and Traffic Projections," and shall submit this to the Study Commission not later than fifteen (15) days after commencement of the Service. The Inception Report will contain, but not be limited to, the following:

(1) Statistics, data, information, etc. to be collected by the component study contractor including those collected in the studies such as "Status of Present Panama Canal," "Historical Trade Analysis," and "Future Transportation System and Significance of Panamanian Isthmus in World Trade" which will be obtainable from the Information Center,

(2) Methodologies to be adopted for various studies and analyses,

(3) Overview on the results of studies and analyses concerning establishment of the methodology for the Canal traffic forecast, forecast of Canal traffic, estimation of potential and constrained traffics, etc., and

(4) Work flow chart, study time schedule, man-month input, and study budget plan.

5.2 Interim Report

The component study contractor shall prepare ten (10) copies of an Interim Report to be submitted to the Study Commission not later than five (5) months after commencement of the Service. The Interim Report shall contain, but not be limited to the following:

(1) Items of studies and analyses completed during the period and those to be conducted during the subsequent period,

(2) List of collected data and information with brief comments, and

(3) Any major outputs of studies and analyses completed during the period such as:

- Results of review of previous demand analysis and established methodology for demand forecast.
- Results of assessment of forecast demands by various methods
- Results of future demand forecast of Canal cargo tonnage and number of transit vessels

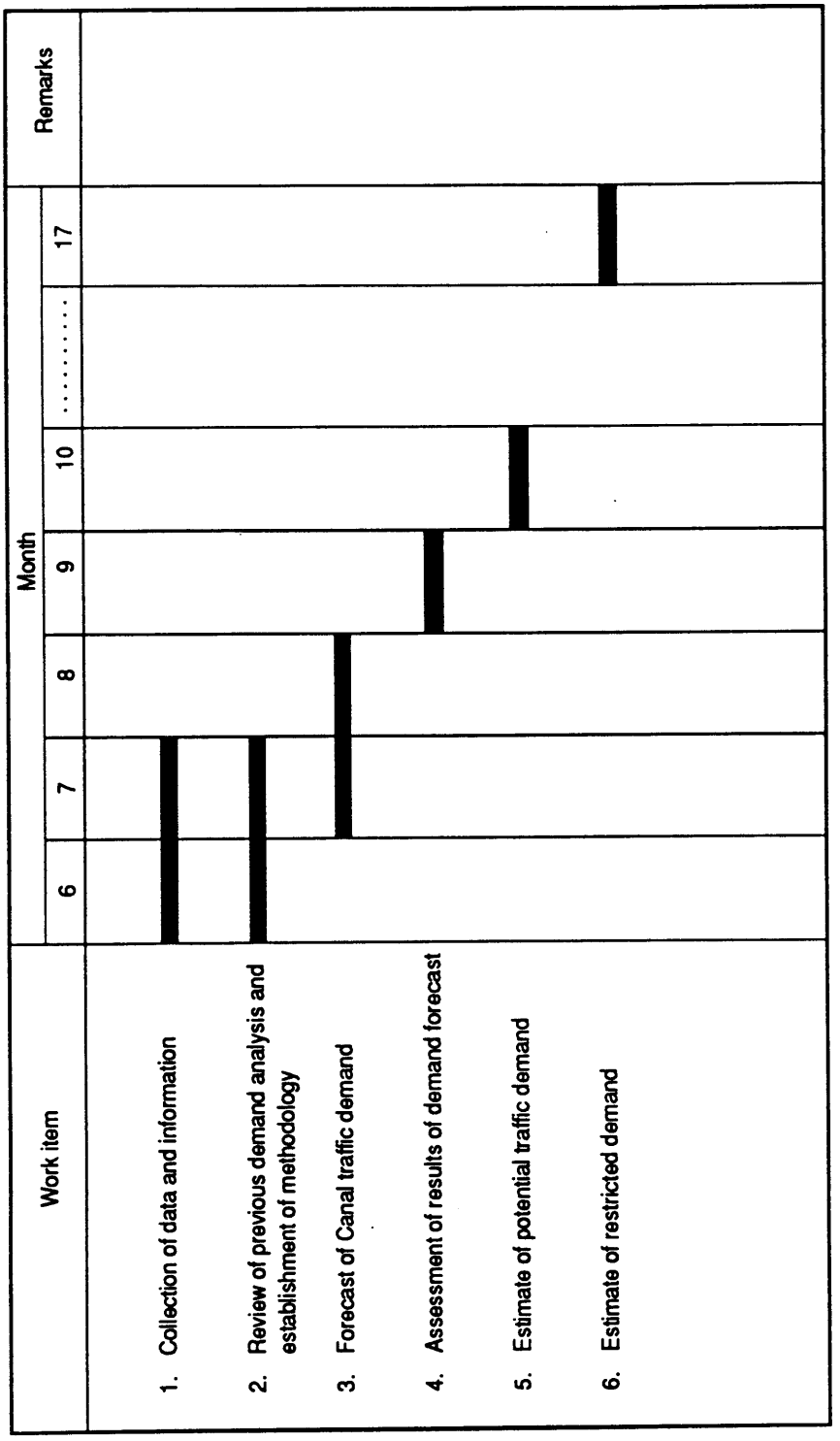


Figure 1 Work Schedule for Commodity and Traffic Projections

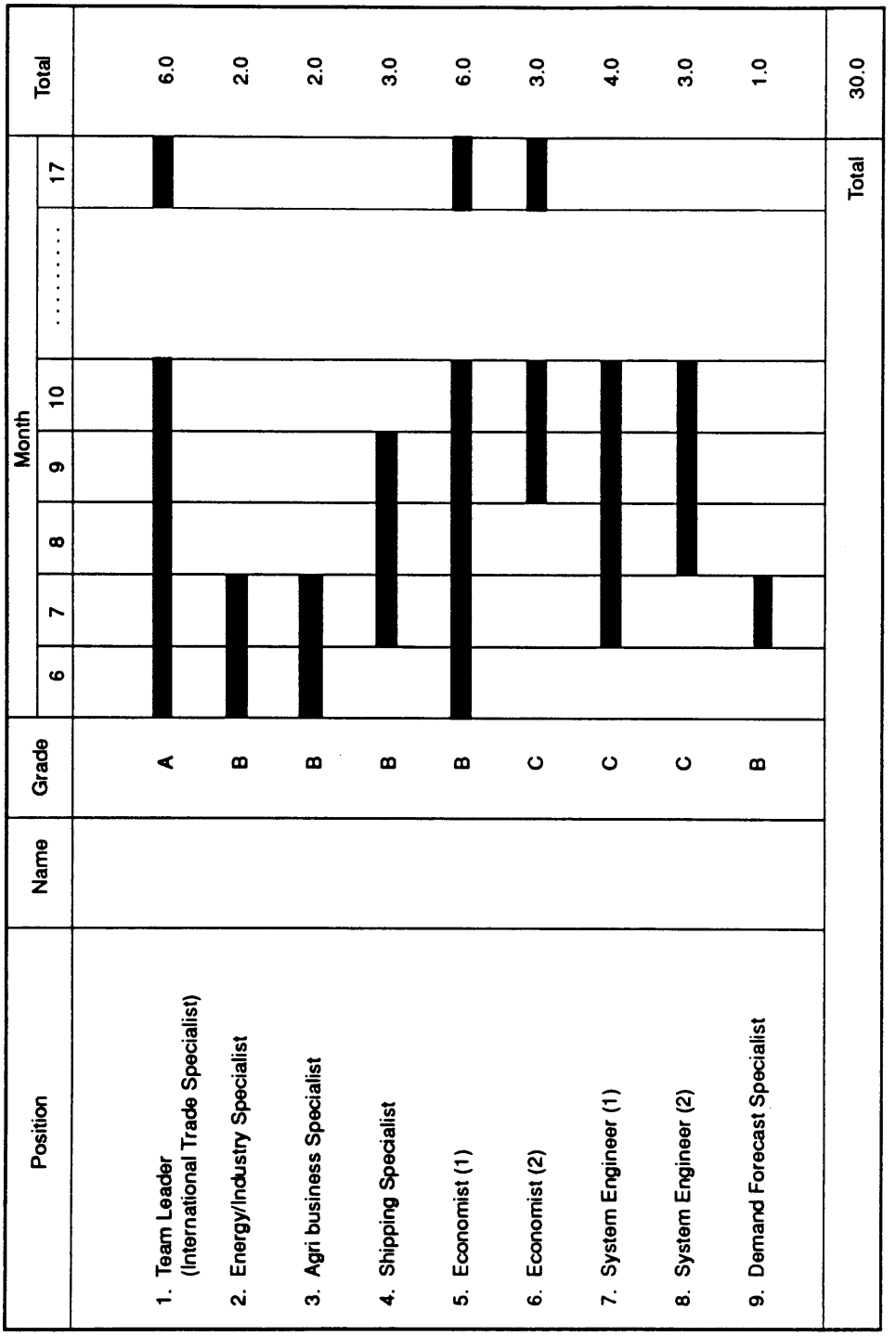


Figure 2 Manning Schedule for Commodity and Traffic Projections

Work item \ Position	1. Team leader	2. Energy/industry specialist	3. Agri-business specialist	4. Shipping specialist	5. Economist (1)	6. Economist (2)	7. System engineer (1)	8. System engineer (2)	9. Demand forecast specialist	Remarks
1. Data collection	P	S	S	S	S		S		S	P : Principal S : Supporting
2. Review of previous demand analysis and establishment of methodology	S	S	S	S	P		S			
3. Forecast of Canal traffic demand	S			S	P		S	S		
4. Assessment of demand forecast	S			S	P	S	S	S		
5. Estimate of potential demand	S				P	S	S			
6. Estimate of restricted demand	S				P	S				
7. Pertinent analysis	P			S	S	S				

Figure 3. Work Assignment for Commodity and Traffic Projections

- Results of future potential demand forecast under no constraints on passage.

5.3 Final Study Report

The component study contractor shall prepare sixteen (16) copies of a Final Study Report, and shall submit this to the Study Commission not later than thirteen (13) months after commencement of the Service. The Final Study Report shall cover and contain all the results of the studies and analyses required by this Terms of Reference. The report shall be submitted in a draft form, and shall be revised, where required, based on the comments of the Study Commission issued within thirty (30) days after receipt of the said report by the Commission. The Final Report shall consist of 1) executive summary 2) main body, and 3) conclusions & recommendations. The component study contractor selected to undertake the work will be provided with a topical outline to be used in preparing the Final Report. The Final Study Report shall contain, but not be limited to, the following:

(1) The same contents as in the Interim Report

(2) Results of future demand studies on cargo tonnage and number of transit vessels through the restricted canals, and

(3) Results of sensitivity analysis of future traffic demand through restricted canals affected by toll levels

5.4 Monthly Report

The component study contractor shall prepare ten (10) copies of Monthly Reports, and shall submit these to the Study Commission at monthly intervals.

The Monthly Report shall contain, but not be limited to, the following:

- The studies completed during the period and those to be performed during the following period.
- Major outputs of the studies, analyses, etc., completed.
- Major changes, problems, etc., during the period.
- Man-month input and study budget used during the period, and those accumulated up to the period.

The Monthly Report can be a brief letter report.

Comisión de Estudio
de las Alternativas
al Canal de Panamá
CENTRO DE INFORMACION

1 INTRODUCTION

These Terms of Reference describe the technical requirements for engineering and cost estimates of alternatives to the present Panama Canal. The work will be performed in two phases:

- Preliminary engineering and cost estimates to support prescreening of alternatives
- Engineering and cost estimates of approximately three of the alternatives that survive prescreening

Appendix 1 to these Terms of Reference describes a number of alternatives to the Panama Canal which have been proposed in the past. These alternatives are representative of, but may not be exactly the same as, those that the contractor will be requested to study.

2 OBJECTIVES

The purpose of this study is to provide a consistent level of preliminary engineering and cost estimates for each of the alternatives subject to prescreening, so that the alternatives can be compared equitably and so those alternatives having the greatest potential for further examination can be identified. For alternatives selected by the Commission for further study, the purpose is to prepare a preliminary design of each alternative and its appurtenant facilities.

3 SCOPE OF SERVICES

3.1 ENGINEERING

3.1.1 Engineering to Support Prescreening

The contractor shall prepare preliminary layouts of approximately 15 alternatives, and shall identify their major components, including approximate number, size, and location. The level of detail required for this study shall be sufficient for conducting a prescreening effort and which will allow the Commission to decide which alternatives are worthy of more rigorous examination.

At the start of this activity, the Commission will provide the Contractor with a general description and alignment corridor for each alternative and the engineering criteria listed in Table 1. The Commission will also provide the results of recent studies of the present situation in Panama and of the present status of the Panama Canal.

These studies provide data regarding the physical characteristics of the study region and describe the Panama Canal as it exists, as well as its physical and operational limitations. Additionally, the Commission will provide one copy of available topographic maps, bathymetric maps and air photos of the areas in which the alignment corridors are located.

Should the contractor require more detailed information, it shall be the contractor's responsibility to obtain the information. The Commission will assist the contractor in obtaining access to data available from agencies such as the Panama Canal Commission and the U.S. Army Corps of Engineers. Information available in the Commission's Information Center will be available for review by the contractor.

For some of the alternatives studied in the past, a significant amount of engineering has been performed, and detailed layouts and quantity estimates are available. The contractor shall review these layouts and estimates for applicability to the alignments selected for the study by the Commission, and shall modify them as necessary. Alternatives for which significant engineering has been completed include the Deep Draft Lock Canal Plan and Sea-Level Canal Routes 10 and 14S (Reference 1).

For other alternatives, additional engineering will be required to develop the concept sufficiently. This includes identifying the key components of the alternative, their approximate number, size, and location and the steps necessary to accomplish the alternative so that quantity estimates can be made for comparison during the prescreening process.

For lock canal alternatives which substantially increase the volume of water required for each passage through the locks, an analysis shall be performed to demonstrate that the concept will maintain Gatun Lake at the design level for the alternative, preferably without increasing the salinity of the lake.

In addition to development of quantities for cost comparisons, the preliminary layouts for each alternative shall be evaluated for constructibility, effects on the schedule, and effect on the operation of the existing Canal. Emphasis shall be focused on whether construction of each component is achievable, whether the construction operation will impose constraints on traffic passage through the existing Canal and the anticipated duration and such constraints. The extent of areas affected by each alternative shall be identified for analysis of relative environmental and socio-economic impacts.

3.1.2 Preliminary Engineering

The contractor shall prepare, for each alternative which has survived prescreening, the preliminary design for the alternative including appurtenant facilities. The coverage and accuracy required for this study must be sufficient for preliminary assessment and feasibility analysis of alternatives. The preliminary design shall include a general layout of the facilities and identify and quantify principal items of the work.

The component contractor shall review the technical literature to identify the latest proven developments in design of the key features included in each alternative, such as tidal gates, lock structures, lock gates, filling systems, and systems to minimize water consumption in lock canals. Latest trends in the design of complementary systems (railways, pipelines, highways) which have survived prescreening shall also be reviewed.

A water management strategy shall be prepared for each lock canal alternative. Since all of the lock improvement alternatives would increase the number of lockages (trips through the locks) and the volume of water available for lockages is finite, careful attention shall be given to lock designs that minimize water consumption. It may be necessary to consider other means to conserve water, such as reducing leakage through the spillway gates at Gatun Dam and replacing existing hydroelectric generation capacity within the Gatun Lake watershed with other forms of electric generation.

The preliminary design for each alternative shall be made based on engineering criteria furnished by the Commission and conditions along the proposed route. The designs shall be developed to the point where major items can be quantified and the effects of construction on present canal operations and on areas along the proposed alignments can be assessed. The volumes and types of material to be excavated will be estimated, and the methods and equipment used to excavate, transport and place excavated material shall be identified. Potential uses and locations for placement of excavated materials shall be recommended. Each design shall include a transportation safety system (e.g., ship navigation aids). The annual transit capacity shall be identified for each alternative, and factors such as the degree of technical difficulty and possibility of future expansion shall be assessed. The extent of areas affected by each alternative shall be identified for analysis of environmental, social, and economic impact. Real estate requirements for the alternative will be developed, along with an operation plan for each alternative.

3.2 COST ESTIMATES

3.2.1 Cost Estimates for Prescreening

A capital cost estimate for prescreening shall be prepared for each alternative at a level of detail sufficient for the Commision to decide which alternatives are worthy of more rigorous examination.

Readily available data for each alternative shall be reviewed to ascertain whether a cost estimate has been developed previously. Existing cost estimates that are applicable to the Commission-provided alternatives will be updated to reflect current year costs and consistent design parameters. Application of appropriate published indices for the various types of work (e.g., structural, mechanical, electrical, etc.) is acceptable for updating cost estimates.

For those alternatives without available cost estimates, quantities shall be estimated for the major cost items. Where certain activities are comparable from one alternative to the next (e.g., excavation and dredging), cost may be estimated by applying updated unit costs of the similar activities from alternatives for which cost estimates exist. For other activities which may vary from one alternative to the next, costs may be estimated by comparison to costs of similar types of projects (e.g., construction of hydraulic structures).

To the extent available, cost information for major items, such as land acquisition, construction of ports, highways, bridges, pipelines, and pumping facilities, shall be derived from local sources (e.g., Panama Canal Commission, Institute of Hydraulic Resources and Electrification, Trans-Isthmian Pipeline, etc.) through document searches and reviews of published studies, reports, and file records.

In selected cases, such as for large mechanical items (e.g., lock gates, pumps, valves, etc.) budget prices shall be solicited directly from vendors, if time permits.

Otherwise, cost information may be derived from the FA/FR Contractor's experience and from international sources through review of published documents on completed foreign installations similar to those proposed in the various alternatives.

A capital cost estimate shall be prepared for each alternative to be used in the preliminary screening.

3.2.2 Preliminary Cost Estimate

The contractor shall estimate the installed costs of each alternative that has survived prescreening. The cost estimate shall itemize: engineering, design, supervision, administration, land acquisition, direct and indirect construction costs, relocation and resettlement, management operating and maintenance costs, and other specifics that affect the cost of the alternative.

The cost estimates shall be order-of-magnitude estimates, sufficiently accurate for preliminary assessment and feasibility analyses for alternatives. Criteria for the cost estimates, such as the method of analysis, escalation rates, interest rates, treatment of taxes and duties, and required level of accuracy of the cost estimate, shall be established in cooperation with the Commission at the beginning of this task.

An overall project schedule shall be developed for each alternative, including permitting, engineering, design, land acquisition, relocation and resettlement of populations with the affected area, and construction of the alternative. The Commission will provide guidance regarding the permitting procedures which would be expected to govern the approval process for this Project, and the duration of the permit review process. The overall project schedule shall be used to develop a schedule of expenditures, so that costs of the various alternatives can be evaluated on a consistent basis (e.g., present worth).

A construction plan shall be prepared for each alternative. This plan shall identify how major construction activities will be sequenced to meet the milestone dates identified in the construction schedule. The route of the alternative shall be divided into sections, the type and quantity of work in each shall be identified, and a chart of equipment and personnel needs, by type and by year, shall be prepared. A list of construction facilities required for each alternative and their approximate location shall also be prepared. Recommendations for accomplishing major work items by contract or by force account shall be provided, along with the rationale for the recommendation.

A conceptual management and operation plan shall be developed, identifying the personnel required for administration of the alternative and its supporting facilities.

An estimate shall be made of operating and maintenance (O&M) costs, including the type, frequency and cost of major rehabilitations to be made during the project life. The estimate shall also address such items as navigation aids, auxiliary operational equipment, safety systems, and cost of tug fleet.

The contractor shall analyze the sensitivity of the cost estimate to changes in principal variables, such as rock type and slope angles required for stability of major excavations. Results of these analyses shall be used in selecting allowance for contingencies.

The estimates shall address the cost of the principal items of work as well as the cost of construction roads, bridges, offices and camps, construction facilities, plants and equipment, consumables, environmental mitigation, construction management, engineering and administration, land acquisition, compensation, and contingencies.

In all of the estimates, construction conditions in a tropical climate shall be properly taken into account. These will include health and sanitary requirements, and others as appropriate.

4 REPORTS

4.1 Progress Reports

The contractor will provide monthly progress reports. A letter report will be sufficient. This will document current project status, anticipated activities, problems and resolution, and status against budget.

4.2 Technical Reports

Separate technical reports shall be prepared for both the prescreening and the preliminary engineering and cost estimates.

4.2.1 Prescreening Reports

The engineering report shall present an evaluation of each alternative, summarizing the results of the prescreening study including layouts and rationale, quantities, impacts, and relative soundness of approach.

The report for cost estimates for the prescreening study shall contain, as a minimum, the following support documentation for each alternative studied:

- Summary table that compares cost of various alternatives. Cost breakdown should be provided to permit comparison of major cost items
- List of assumptions and/or references used to develop major cost items

- Where applicable, production rates used to prepare time schedules for major items of work
- Bar chart schedules showing sequence and duration of design and construction
- Tables showing quantities, unit prices and total cost of various items used to develop total cost for major items of work. This data may be provided in an Appendix.

4.2.2 Preliminary Engineering and Cost Reports

The report for engineering shall contain, as a minimum, the following support documentation for each alternative studied:

- General plan view and profile showing locations of and elevations of major structures and facilities
- Separate plan view and typical profiles of each new proposed facility/ structure (locks, canals, channels, terminals, bridges, operating facilities, roads, dams, cofferdams, diversions, pumping stations, dikes, breakwaters, etc)
- Tables listing design assumptions for major facilities/structures and/or references used
- General geologic maps and profiles. (Particularly important in areas of significant excavations, fills, spoil areas, and foundations of major structures.)
- Tables showing types and quantities of materials to be excavated
- Tables showing types, quantities, and source of fill materials
- Maps, graphs, tables, charts, etc, to graphically demonstrate water availability and management program

The report for cost estimates shall contain, as a minimum, the following support documentation for each alternative studied:

- Summary table that compares cost of various alternatives. Cost breakdown should be provided to permit comparison of major cost items
- List of assumptions and/or references used to develop major cost items
- Cross-reference list that identifies source of input used to develop quantities and unit prices

- Where applicable, production rates used to prepare time schedules for major items of work
- Table or graph showing annual cost from start to completion
- Table or graph showing annual professional, skilled and unskilled labor requirements
- Bar chart schedules showing sequence and duration of design and construction
- Tables and/or plots demonstrating typical daily shipping operation
- Tables showing quantities, unit prices and total cost of various items used to develop total cost for major items of work. This data may be provided in an Appendix

All reports must be written in comprehensible English. Units shall be expressed in the metric system. The pages of the text shall be 8-1/2" x 11" with pull-outs a maximum 11" x 17". Oversized drawings may be placed in a pouch within the text or assembled in a separate appendix.

5 SCHEDULE

It is planned to have this contract in place well in advance of the start of work date. The contractor shall perform the work in accordance with the schedule shown in Figure 1. Figures 2 and 3 show the manning schedule and position assignments for this TOR. Figure 4 shows the Engineering and Cost Estimate general flow chart.

6 STAFFING

The following personnel with the credentials described shall be employed full time on this project by the contractor.

Project Manager - Demonstrated experience in overall responsibility for design, construction, and operation of large scale civil projects in Central and/or South America. Experience in canal, lock, harbor, dredging, and cofferdam construction.

Engineer - Registered professional engineer. Demonstrated experience in design, construction, and operation of civil projects with emphasis on large scale cut and fill, blasting, and dredging operations and hydraulic/ marine projects.

Cost and Scheduling Engineer - Demonstrated experience in preparation of cost estimates, schedules, budgets and forecasts of expenditures for large civil projects in Central and/or South America.

It is anticipated that the Contractor will need to provide the following support personnel to complete the study:

Geologist	Railroad Engineer
Geotechnical Engineer	Pipeline Engineer
Civil/Hydraulic Engineer	Highway Engineer
Structural Engineer	Cost Engineer
Mechanical Engineer	Blasting Specialist
Electrical/Controls Engineer	Construction Specialist
Waterways Specialist	Design & Quantities Engineer
Transportation & Safety Operations Specialist	Real Estate Specialist
Ports & Harbor Engineer	Draftsman

The types and number of such personnel, and durations that they will be required to work cannot be accurately determined until the "short list" of alternatives has been established. The contractor shall have the capability to provide several of each of the above types of personnel/specialists for the periods necessary to support the schedule for this component study.

7 REFERENCES

1. The Atlantic-Pacific Interoceanic Canal Study Commission, Study of Engineering Feasibility, Appendices 1, 2, 4 through 10 and 17, 1970.

2. Bastian, D. F., The Transisthmian Alternatives for Increasing the Throughput Across Panama, 1989 Nation Forum and Annual Meeting Transportation Research Forum, October 1989.

3. The National Transportation Study

4. Centerport Study

5. Project costs, Tennessee-Tombigbee Waterway, U.S. Army Corps of Engineers, Mobile District

Table 1
Criteria to be provided to the Contractor for Engineering and Cost Estimates (From Prescreening, A.3)

Engineering Criteria

1. Design Vessels by Class – Vessel speed, displacement, length, beam, draft (TFW)
2. Canal and Approach Channel by Class – Bottom width and bottom elevation for straight sections and curves, water level elevation, excavation slopes in different materials
3. Lock – Dimensions (Width, length, depth of water over sill)
4. Highway – Design standards (curvatures, grades, shoulder widths, cut and fill slopes, bridge widths) and design capacity
5. Railway – Design standards, design capacity and cargo types
6. Pipeline – Design standards, commodity types, terminal locations, design capacity
7. Conveyor – Design standards, design capacity, commodity types, environmental requirements terminal locations
8. Slopes (Cut and Fill) – Design standards for various geologic materials
9. Placement of Excavated Materials – Locations for placement of excavated materials on land, marine areas and Gatun Lake, minimum water level after placement of excavated materials in Gatun Lake
10. Stream Diversion – Design flows
11. Terminals – Storage requirements, environmental requirements
12. Harbors/Ports – Design vessel, dimensions, capacity

Cost Estimate Criteria

1. Method
2. Escalation Rates
3. Interest Rates
4. Taxes and Duties

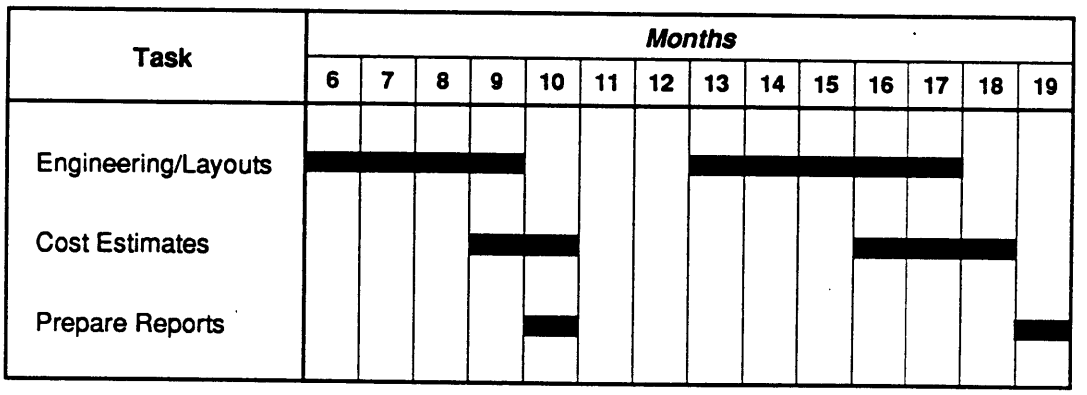


Figure 1 Work Schedule for Engineering and Cost Estimates

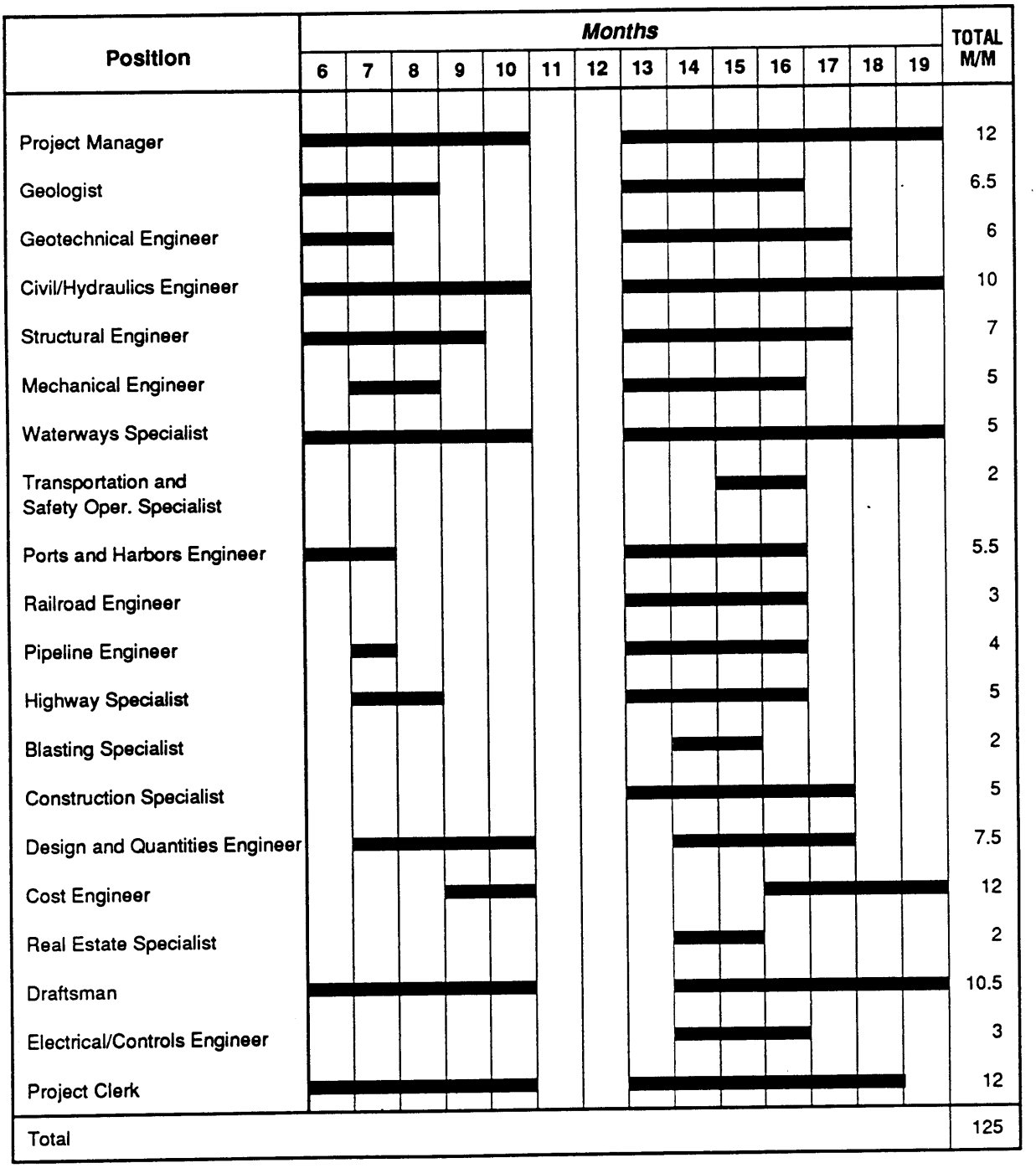


Figure 2 Manning Schedule for Engineering and Cost Estimates

Position	*Tasks*		
	Eng/Layouts	Cost Estimates	Reports
Project Manager	P	P	P
Geologist	S		
Geotechnical Engineer	S		
Civil/Hydraulics Engineer	P		P
Structural Engineer	S		
Mechanical Engineer	S		
Waterways Specialist	P		P
Transportation and Safety Oper. Specialist	S		
Ports and Harbors Engineer	S		
Railroad Engineer	S		
Pipeline Engineer	S		
Highway Engineer	S		
Blasting Specialist	S		
Construction Specialist	S		
Design and Quantities Engineer	S		
Cost Engineer		P	P
Real Estate Specialist			
Draftsman	S		S
Electrical/Controls Engineer	S		
Project Clerk	S		S

Legend:
P = Principal
S = Supporting

Figure 3 Major Work Assignment for Engineering and Cost Estimates

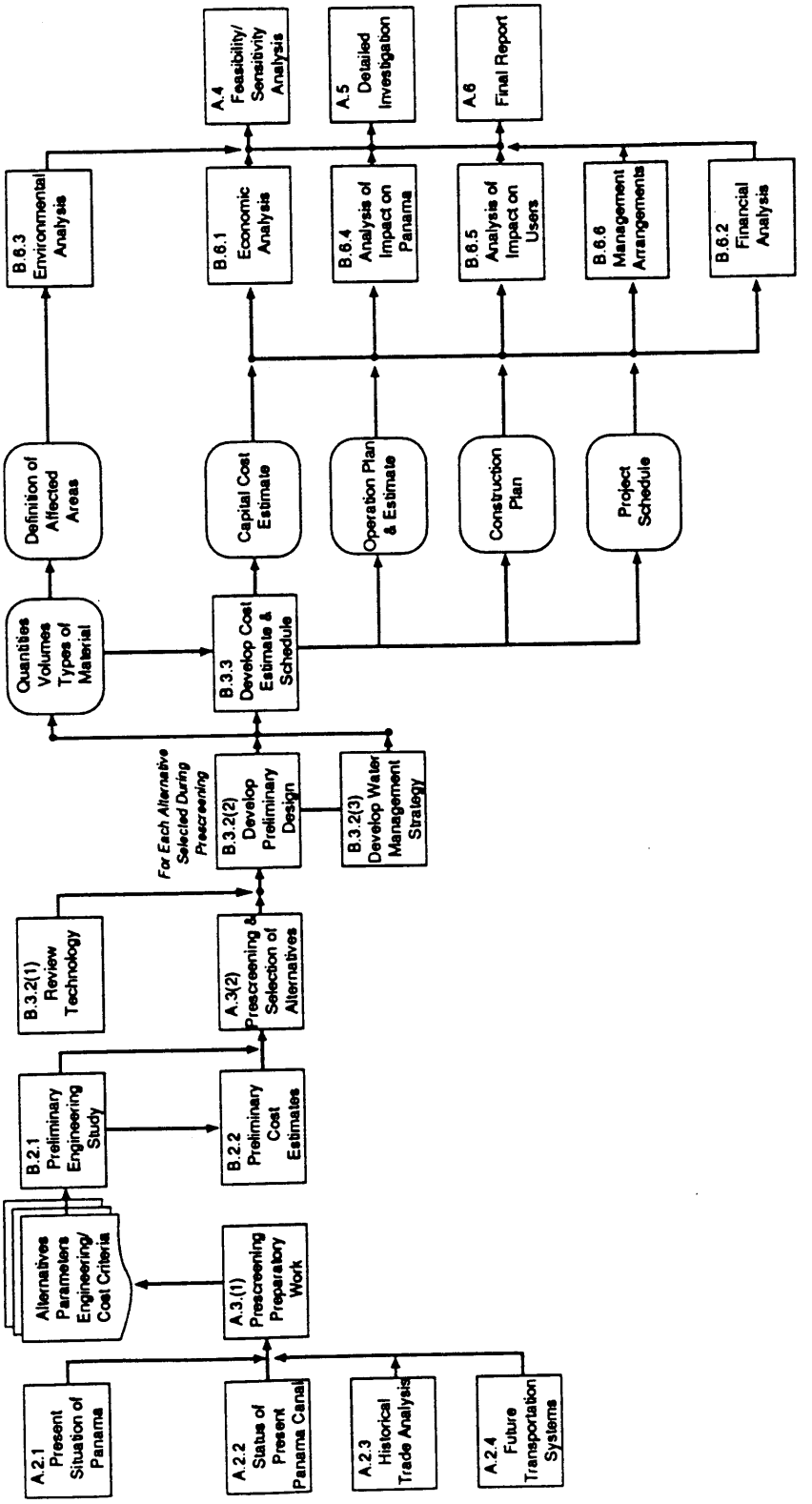


Figure 4 General Flow Chart for Engineering and Cost Estimates

Appendix A

Engineering and Cost Estimates

DESCRIPTION OF ALTERNATIVES

This section contains a list of the possible alternatives to be studied and analyzed. The possible alternatives may be broadly classified into three categories: improvements to the existing Canal, construction of a sea-level canal, and non-canal alternative transportation systems. These are listed below:

- Improvements to the Existing Canal
  - Status quo alternative
  - Non-lock improvements
  - Third Locks Plan
  - Terminal Lake Plan and Variations
  - Deep Draft Lock Canal Plan
  - Lopez-Moreno Plan
- Sea-Level Canal
  - 1970 Interoceanic Canal Studies, Route 10
  - 1970 Interoceanic Canal Studies, Route 14S
  - Vergara Plan
  - Nagano Plan
- Non-Canal Complementary Transportation Systems
  - Oil pipeline
  - Land bridge systems (railway and highway)
  - Centerport (upgrade existing railway and ports)

During the prescreening phase, some of the alternatives on this list will be eliminated. Technical, environmental, and economic factors will be used in the elimination process. Eventually, as the study proceeds, the preferred alternative will be selected and a detailed investigation of this alternative will be performed.

The alternatives are briefly described below. Figures illustrating selected alternatives (Reference 2) are presented at the end of this appendix.

2.1. STATUS QUO ALTERNATIVE (PRESENT PANAMA CANAL)

This will consider the Panama Canal as it presently exists. If the Panama Canal Commission's Gaillard Cut Widening Project proceeds, this improvement will be included in this base alternative. Similarly, other ongoing modifications such as navigational aids which will increase the capacity and/or efficiency of the present canal will be included in the status quo alternative.

2.2. NON-LOCK IMPROVEMENTS TO THE PRESENT PANAMA CANAL

These alternatives will include the proposed improvements discussed above if they are not yet approved and funded for construction and installation. Other improvements to the present canal (not including new locks and water level changes) will be addressed as part of this alternative. These possible improvements might include more efficient ship handling facilities which will result in faster transits; improved port facilities and marine support equipment; additional navigational aids to improve transit capabilities during bad weather and at night; additional widening and/or deepening of existing channels; removal of silts; additional or different water supply arrangements for lockage requirements; and improved water management systems.

2.3 LOCK IMPROVEMENTS TO THE PRESENT PANAMA CANAL

There are at least five lock improvement alternatives to be considered: the Third Locks Plan, the Terminal Lake Plan, Terminal Lake Plan Variations, the Deep Draft Lock Canal Plan, and the so-called Panamanian Alternative concept. Most of these previously published plans will have to be modified to provide for the maximum size and draft of ship selected for the planning of conceptual alternatives.

2.3.1 The Third Locks Plan

This plan was proposed in 1938 and major excavation was accomplished in 1940-1942. The plan was revised in 1947, and it is this version that will be studied. This plan calls for the construction of one additional lane of larger and deeper locks adjacent to the existing locks. Gatun Lake will remain at its present nominal 25.9 m MSL. Additional lockage water (fresh or possibly sea water) will have to be stored and possibly pumped.

2.3.2 The Terminal Lake Plan

This plan was initially proposed in 1943. It calls for abandoning the Pedro Miguel Locks, raising Miraflores Locks and constructing one lane of large locks at both Miraflores and Gatun. Gatun Lake will remain at its present level. A number of variations in the Terminal Lake Plan have been proposed. One of these variations replaces the locks at Gatun and Miraflores with two lanes of new large locks: Gatun Lake will be raised by about two meters. Additional lockage water (fresh or sea water) will probably be required.

2.3.3 The Deep Draft Lock Canal Plan

This plan was proposed in the Interoceanic Canal Studies 1970. It consists of adding a lane of new, large, triple-lift locks at Gatun and constructing a separate lane of triple-lift locks at Miraflores together with a bypass around the existing Pedro Miguel locks. Gatun Lake will remain at 25.9 m MSL. Again, additional lockage water will probably be required.

2.3.4 The Lopez-Moreno Plan

This concept is a more recent proposal. This plan will lower Gatun Lake from 25.9 m to 16.8 m. The upper lift of Gatun Locks and the entire Pedro Miguel Locks will be eliminated. The plan provides for using the remaining existing locks plus adding two new lanes of locks. One lane will accommodate 250,000 DWT ships with drafts of up to 20.4 m. The other new lane will provide locks which are relatively small. This system will permit more efficient use of lockage water. All existing channels will be widened and deepened. Additional lockage water storage will probably be needed.

2.4 SEA-LEVEL CANAL ALTERNATIVES

The Interoceanic Canal Studies 1970 (known as the Anderson Report) initially considered 11 sea-level canal alternatives in Panama (plus five in Panama and Colombia). Four of the Panamanian routes (and one of the Panama/Colombia routes) were studied in detail. The recommended sea-level canal alternatives were Routes 10 and 14S. The Report of the Preparatory Committee limits the sea-level canal options for the present study to these two routes.

The Route 10 sea-level canal lies about 16 km west of and generally parallel to the present Panama Canal. The Interoceanic Canal Studies 1970 proposed a design vessel of 150,000 DWT (a 250,000 DWT ship could transit during favorable currents).

The 1970 data may have to be revised and updated depending on what design vessel is selected for the present study. Tidal gates or checks will probably have to be installed to limit canal currents to a maximum of two knots. The Route 10 alignment will permit continued operation of the present Panama Canal.

Route 14S follows the general alignment of the present canal and consequently may have less impact on Panamanian infrastructure. The design vessel and tidal current criteria are the same as for Route 10. This routing results in a major lowering of the Gatun Lake, and it could interfere with the operation of the present canal during construction. The present canal would no longer be operable after completion of Route 14S.

The Vergara Plan is a variation on the sea-level canal plan recommended in the Anderson Report, and following Route 10 with some modifications including the adoption of tide control in the canal. The target size of vessels is 250,000 DWT, while the section of the canal is proposed to be 500 m in width and 25 m in depth. The plan also proposes the construction of berths protected by breakwaters at both entrances, instead of tidal gates to check the tidal current. As for excavation works, it recommends use of dredging rather than dry land excavation methods.

The Nagano Plan is another variation on the sea-level canal plan though the target size of vessels is increased to 300,000 DWT, and 500,000 DWT at high tide. The channel width will be 200 m and the depth, 33.0 m. Furthermore, in order to accommodate large vessels, an approach channel will be required at each end. The size of these channels will be 400 m in width, 35.8 m in depth, and 35 km in length at the Pacific end and 400 m, 33.4 m, and 5 km at the Atlantic end.

2.5 NON-CANAL ALTERNATIVE TRANSPORTATION SYSTEMS

The present Panama Canal could be complemented by several non-canal alternatives for moving commodities across the Isthmus. These alternatives include pipelines, conveyor systems, container transporters, railroad systems and highways plus their supporting facilities. The fundamental concept is to transport the cargoes from a ship on one side of the Isthmus to a ship on the other side in a manner that is more cost effective than expanding the present canal or other canal alternatives discussed above.

It is possible that these complementary systems can at least partially reduce the need for expansion of the present Canal or postpone the construction of costly new canal alternatives. Each of these complementary alternatives will require supporting

facilities consisting of moorings, port facilities, temporary product storage, processing and handling facilities, and related infrastructure.

A trans-Isthmus petroleum pipeline together with supporting facilities was constructed in 1982. This pipeline significantly reduced the number of daily canal transits. Pipeline alternatives which will augment the existing pipeline will be considered.

Long distance, large-scale conveyor systems for coal and other dry bulk products have been successfully used world-wide. An alternative will be formulated which utilizes this approach.

Many finished products are moved in standard sea containers or by similar means. An alternative which moves containers across the Isthmus by rail, highway, and/or a special container conveyor system will be considered.

A trans-Isthmus railroad presently connects the ports of Cristobal and Balboa. The Centerport feasibility study, currently contracted by the Republic of Panama, proposes improvements to the railroad and the two ports. The concept consists of improving the ports of Cristobal and Balboa and their connecting railroad. The ports would be used as major load centers for interlining and feeder service and the railroad would supplement the Canal's transhipment operations. The project calls for a 10-year period of phased improvements.

An alternative which involves a new or improved highway across Panama will also be considered.

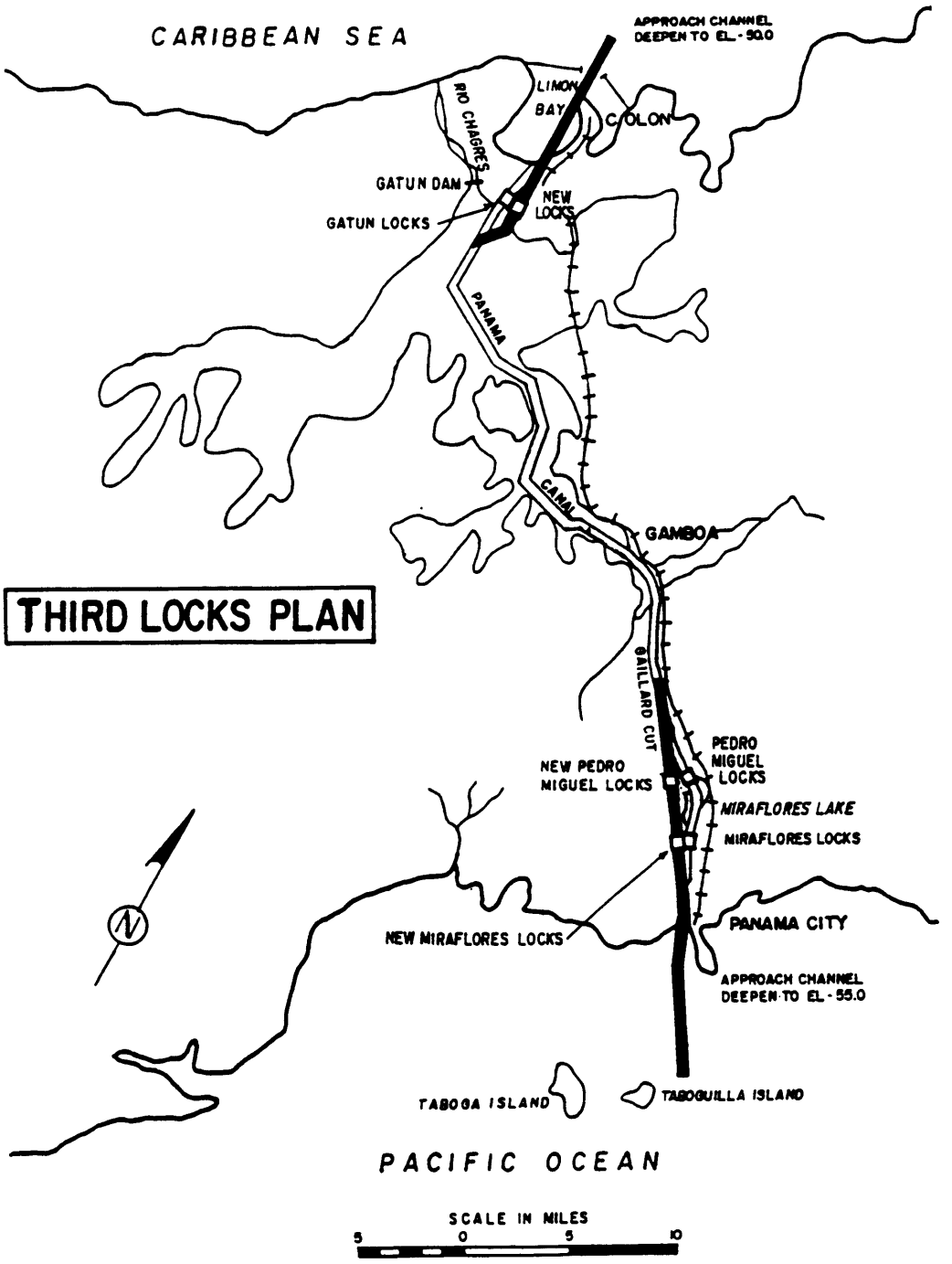
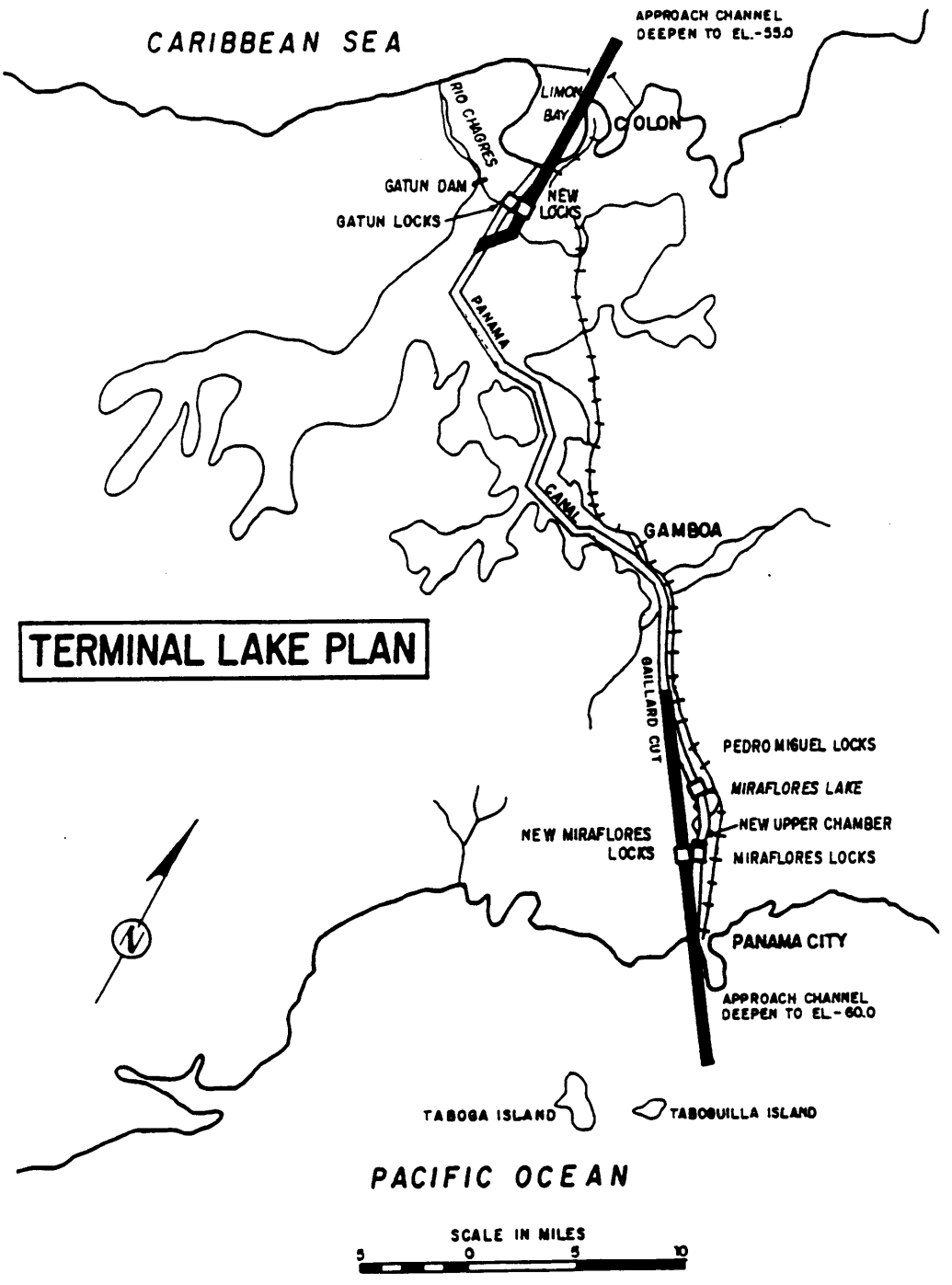
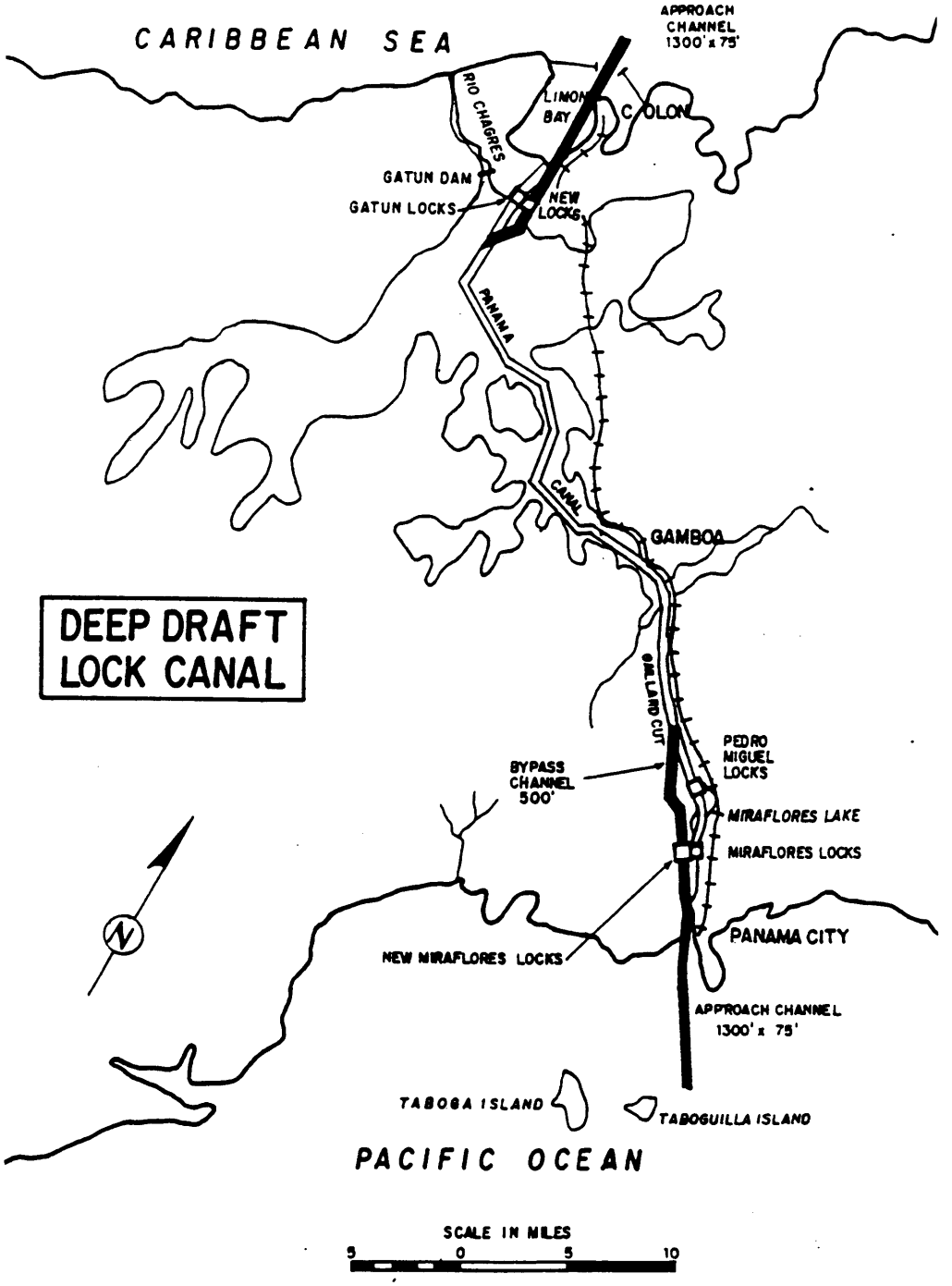


Figure A-1 Third Locks Plan



NOTE: New locks single lane 200' x 1500' x 50' @ min. Gatun Lake el 82'

Figure A-2 Terminal Lake Plan



NOTE: New locks single lane 160'x 1450'x 65' for 150,000 DWT design @ elev. Gatun Lake el 82'

Figure A-3 Deep Draft Lock Canal Plan

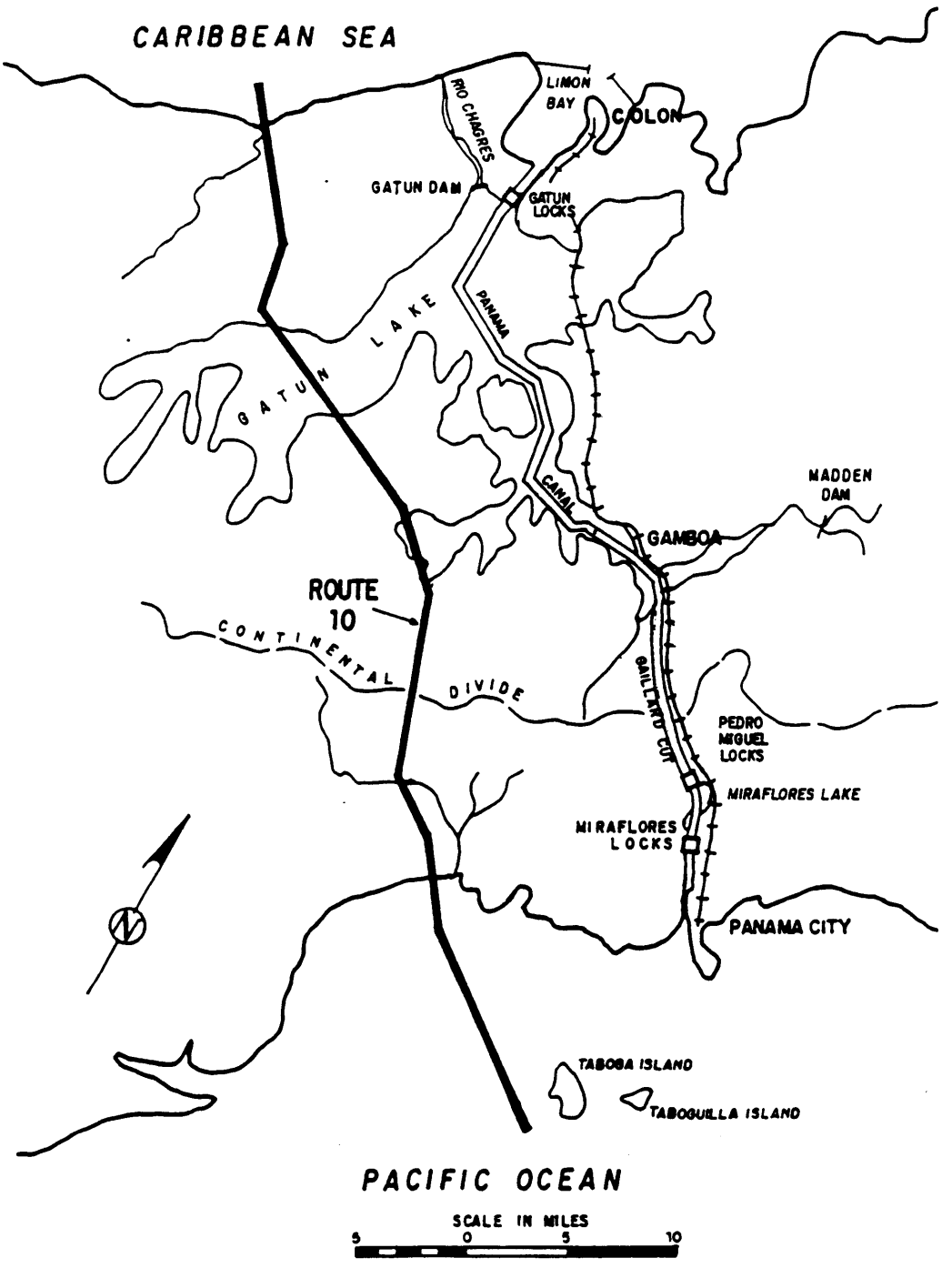


Figure A-4 Existing Canal and Proposed Route 10

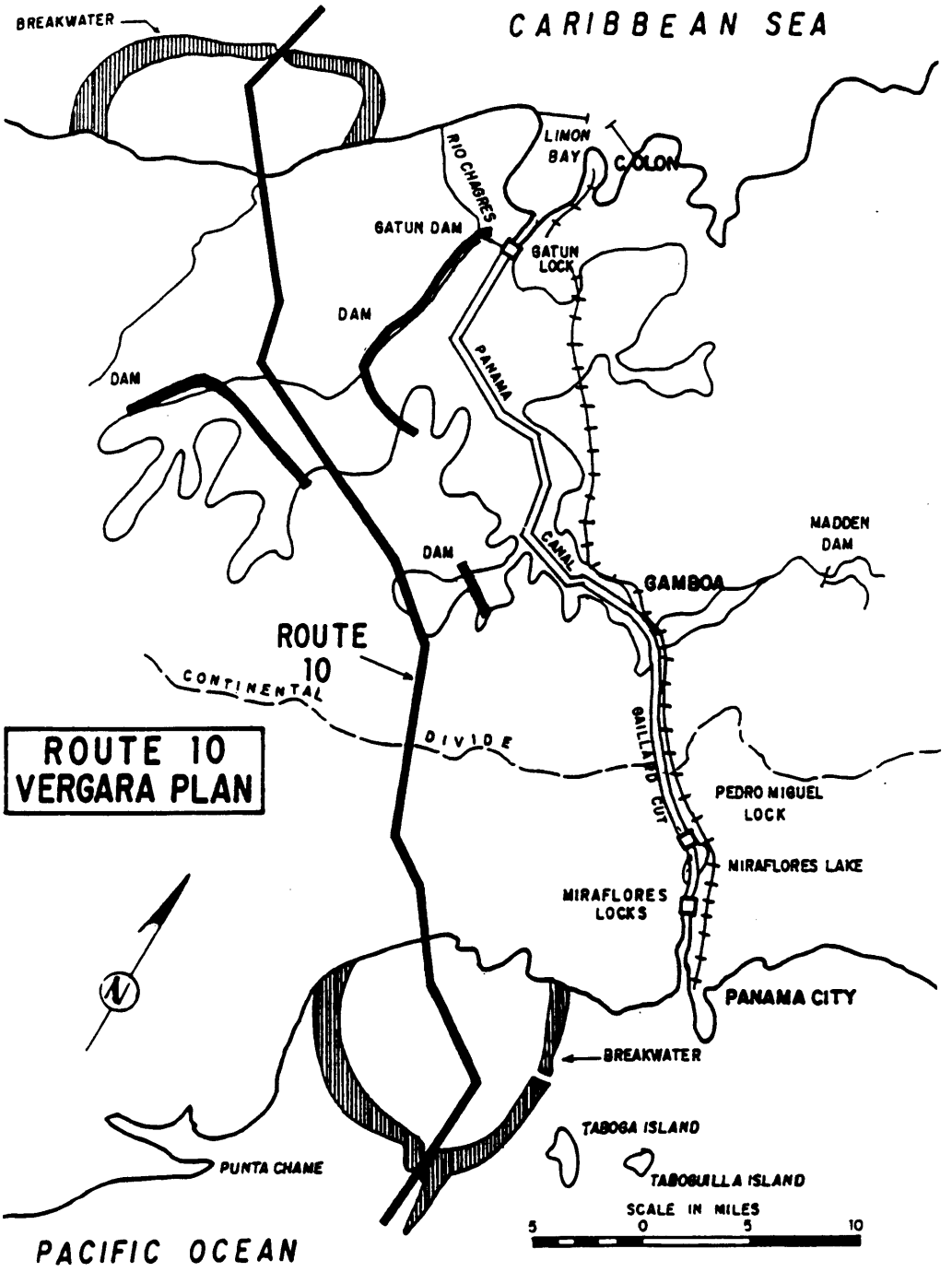


Figure A-5 Route 10 – Vergara Plan

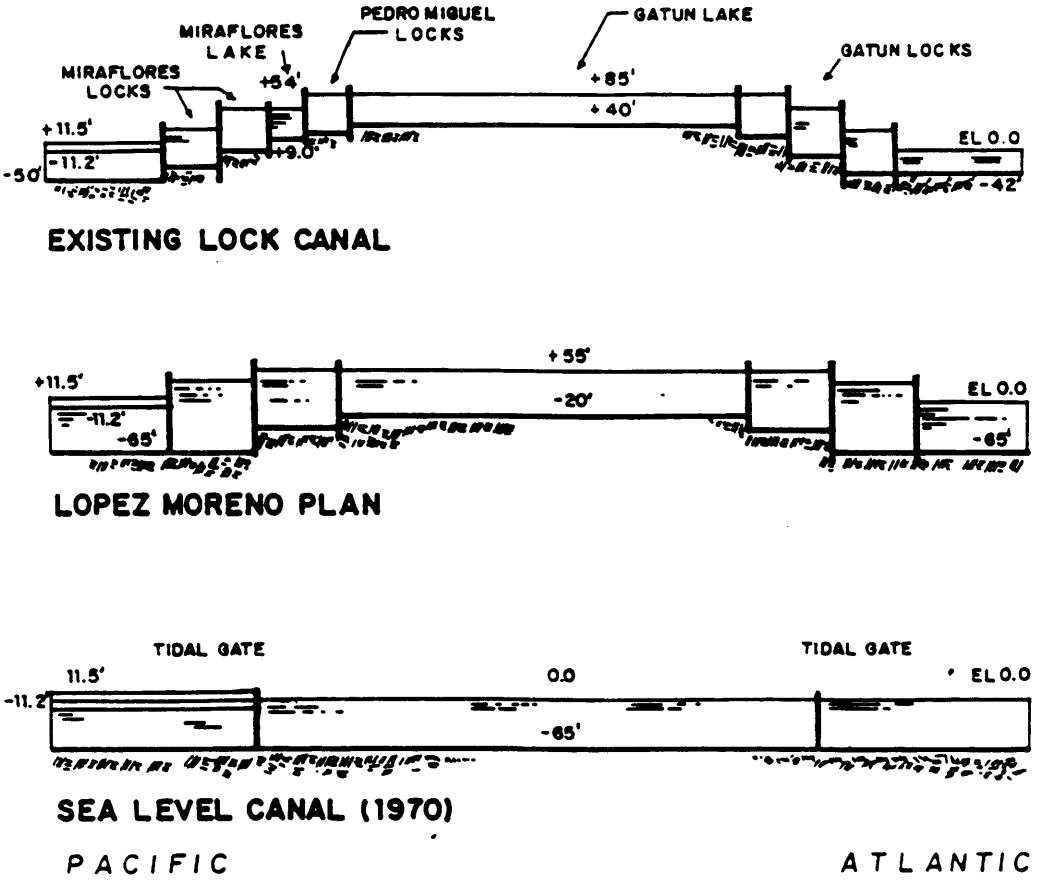


Figure A-6 Comparison of Canal Profiles

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Operating Characteristics and Capacity Evaluation

1 INTRODUCTION

This Component Study will be prepared in two stages. The first stage of the study will provide information to be used in the prescreening and selection of alternatives. The second stage will evaluate in detail the Operating Characteristics and Capacity evaluation of the selected alternatives. Both of these phases could involve the use of models. Existing models will be used to the extent possible. Development of new models will be done only after consultation with and approval of the Secretariat.

These two stages will be awarded to the same contractor. The terms of reference for both the Preliminary and Final Stages follow.

Preliminary Operating Characteristics and Capacity Evaluation Study

1 INTRODUCTION

This component study will provide a basis for prescreening of alternative plans by analyzing operating characteristics of each alternative and evaluating its transit capacity. Since more detailed studies of operating characteristics and capacity evaluation are set forth for the selected alternatives, after prescreening, in the later stage of the study, this component study is a preliminary one.

The alternatives to be taken up in this study shall include the following alternatives but will not be limited to these.

Improvements and enhancements to the existing canal

- Status quo alternative including Gaillard Cut widening plan
- Non-lock improvement
- Third Locks Plan
- Terminal Lake Plan and variations
- Deep Draft Lock Plan
- Lopez-Moreno Plan

Sea-level canal

- 1970 Interoceanic Canal Studies, Route 10
- 1970 Interoceanic Canal Studies, Route 14S
- Vergara Plan
- Nagano Plan

Non-canal alternative transport systems

- Oil Pipeline
- Land Bridge System (railway and highway)
- Related parts of the Centerport Concept will also be included in this category
- Others

Non-canal alternatives are considered as complementary transport systems which may be planned with one of the main alternative systems, most probably, with the alternative falling in the category of "improvements and enhancements to the existing canal".

This study will start by collecting and reviewing previous studies and data concerning all the alternatives listed above. Then, it will analyze and extract their operating characteristics, such as vessels' transit time, minimum interval of transit vessels, navigation safety and risk of accidents, systems flexibility for improvement, etc. In addition to these, fresh water consumption for lock canal alternatives and the effects of tidal changes for sea-level canal alternatives (with tidal gates and without tidal gates are the two distinct cases) shall be analyzed.

Based on the above analyses of operating characteristics, the transit capacity of the main alternatives which consist of alternatives falling in the categories of "improvements and enhancements to the existing canal" and "sea-level canal" shall be evaluated at the level of accuracy needed to meet the requirements of pre-screening*/.

For the non-canal alternative transport system, operating characteristics shall be analyzed for the proper range of capacities pre-determined**/ for each type of alternative, because the final selection of the capacity of the complementary transport system will be made after detailed investigations of traffic demands, and engineering/ cost aspects of the main alternatives pre-screened.

Needless to say, the analyses described above shall be made considering the possible ship mix associated with future transport demands. The basis of this analysis will be formulated from the results of preceding studies: "Historical Trade Analysis" and "Future Transport System". Differences in operating characteristics for the loaded/ballast conditions of different ship types shall also be analyzed to the extent necessary.

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*/ A brief description of pre-screening procedure will be attached to the Tender Documents of this component study. Materials for this can be easily abstracted from the DWP of pre-screening.

**/ The proper range of capacities for each non-canal alternative transport system will be decided based upon the results of the preceding studies, namely, "Status of Present Panama Canal", "Historical Trade Analysis" and "Future Transport System". The same conditions shall be given to the component contractor in charge of the "Preliminary Engineering Study" and "Preliminary Cost Estimates" by specifying it in TOR.

In carrying out this component study it should be kept in mind that the accuracy of the analyses may not be the same between the two categories of main alternatives namely, "improvements and enhancements to the existing canal" and "sea-level canal". The reason for this is the difference in available information for the component contractor of this study, because previous study on "Present Status of the Panama Canal" will provide detailed information and data for: i) status quo alternative, ii) non-lock improvements, and iii) Gaillard Cut Widening Plan; will be utilized for elaborating operating characteristics of a) Third Lock Plan, b) Terminal Lake Plan and variations, c) Deep Draft Lock Plan, and d) Lopez-Moreno Plan.

In order to carry out this component study efficiently, the use of computer simulation models is considered necessary. The size of the simulation models shall be suited for prevailing personal computer models, however, programming shall be made in such a manner that the models can be easily expanded for the use of main frame computers when it becomes necessary. Development of programs that will compile the PCC's data base into a proper form for the purposes of systems analysis and inputting data for the simulation is also advised.

Just for demonstration purpose, a brief example of how to simulate the existing Panama Canal system has been prepared, and appended as Attachment 1 for your reference.

2. OBJECTIVES

The principal objectives of this study are:

- To collect data and reports of previous studies concerning the various alternatives defined in the introduction of this TOR
- To review and analyze the above data and reports, then extract and define practicable indices for operating characteristics to evaluate alternatives
- To formulate simple computer simulation models which will be used for the pre-screening of the main alternatives by utilizing these operating characteristics studied above. In doing this, efforts shall be made to utilize existing models to the extent possible. In this relation CAS is rather of the view: a) "Modelling efforts should use existing models (i.e. LOCKCAP, LOCKCALC and/or later generations thereof) as opposed to developing new models, b) To the extent that the contractor believes that existing modelling is insufficient or requires modification, the contractor shall

consult with the Commission to obtain approval for revised or additional modelling."

- To validate these models against existing conditions, to the greatest extent possible, then complete capacity evaluation for each of the main alternatives.

- To set an appropriate range of capacity for the non-canal alternative transport systems, then analyze and evaluate their operating characteristics
- To evaluate operating characteristics other than those mentioned above, as required.

3 SCOPE OF SERVICES

The scope of services to be conducted by the component study contractor for attaining the objectives set out above is discussed hereunder.

3.1 Collection of Data and Information

All the necessary data and information for the study of the preliminary operation characteristics study and capacity evaluation shall be collected, especially:

- Statistics, data, and information obtainable from the Panama Canal Commission
- Reports and supporting documents for all the alternatives defined in the introduction of this TOR
- Statistics, data, and information relating to large-scale sea-level canals, e.g., the Suez Canal
- Information and data on the present state of the art of pipelines and rail/road land bridge
- Results of the preceding studies, such as "Historical Trade Analysis", "Future Transportation System", and "Present Status of the Panama Canal", which will be undertaken by the FA/FR study contractor
- Other necessary data and information, if any

All the necessary data and information will be given by CAS. If additional data collection is necessary, that will be authorized by CAS.

3.2 Review of Previous Studies

Previous studies relating to all the main alternatives and the results of preceding studies shall be reviewed constructively to understand the operating characteristics of each alternative. This review shall be made not only for the operating characteristics directly concerning capacity evaluation, but also for those not directly concerning capacity evaluation.

3.3 Defining Practicable Indices of Operating Characteristics

Based on the reviewing work described in 3.2 above, practicable indices of operating characteristics for capacity evaluation shall be defined. In carrying out this part of the service, due consideration shall be given to the accuracy and availability of data for the indices to be defined.

3.4 Establishing Approach for the Capacity Evaluation

Summarizing the works outlined in 3.2 and 3.3, the most appropriate approach for the capacity evaluation of main alternatives shall be established. In doing so, the approaches adopted in the previous studies shall be critically reviewed to reflect their merits regarding the approach to be proposed. The utmost effort shall be made to achieve conciseness and clarity of approach and avoid unnecessary details and complication.

3.5 Formulating Simulation Models

Based on the approach established in 3.4 and the indices defined in 3.3, two simulation models shall be prepared; one for the lock canal alternatives and the other for the sea-level alternatives. In preparing simulation models, utmost efforts shall be taken for the search and assessment of existing models available. / In this relation CAS is rather of the view: a) Modelling efforts should use existing models (i.e. LOCKCAP, LOCKCALC and/or later generations thereof) as opposed to developing new models, b) To the extent that the contractor believes that existing modelling is insufficient or requires modification, the contractor shall consult with the Commission to obtain approval for revised or additional modelling."

The simulation models shall be so designed as to evaluate the transit capacity of each alternative to the extent necessary to guarantee the reasonable pre-screening of the alternatives which fall under the same category.

3.6 Validating Simulation Model

The simulation models shall first be tested partially by using simplified parameters, then by validation against existing conditions. Data for input are expected to be extracted from the results obtained through the works defined in 3.1. However, additional field observations can be carried out when it becomes necessary.

3.7 Evaluating Capacity for Each of the Main Alternatives

After the validation of the model, the transit capacity of all the main alternatives shall be evaluated by the simulation models against the properly assumed traffic demand associated with certain ship mixes. Evaluating criteria shall be explicitly stated for all the cases. Use of different set of criteria shall be encouraged to provide a wider

choice for pre-screening. Evaluation shall be applied not only for the normal set of conditions but also for special cases such as adverse weather conditions, major maintenance periods, and reasonably assumed accidents. Evaluation for changes in operating rules is also encouraged.

3.8 Furnishing Secretariat with Simulation Models

Since the simulation models are expected to be fully utilized by the Secretariat and the FA/FR component contractor at a later stage of the study, the complete set of manuals, detailed flow charts, list of programmings and discs should be furnished to the Secretariat.

3.9 Evaluating Operating Characteristics not Directly Affect Capacity Evaluation

Evaluation of operating characteristics which are not directly relating to the transit capacity but have a significant effect on costs and or constraints shall also be carried out. Fresh-water consumption for lock canal alternatives is an example of this.

3.10 Setting the Range of Capacity for the Non-Canal Alternatives

The proper range of capacities shall be pre-determined for each type of non-canal alternative. For details, please refer to the explanation given in the introduction of this TOR.

3.11 Analysis and Evaluation of Operating Characteristics for the Non-Canal Alternatives

Analysis and evaluation of operating characteristics for each of non-canal alternatives shall be made covering the appropriate range of capacity determined in 3.10.

4 SCHEDULE

The overall schedule for completion of the whole study is 30 months and the time allocated for completion of this component study is five months in total. This study will start in the 6th month of the overall schedule of the study and will be completed by the end of the 10th month, as shown in Figure 1. The proposed manning schedule for this component study is shown in Figure 2. The major work assignments for this component study are shown in Figure 3.

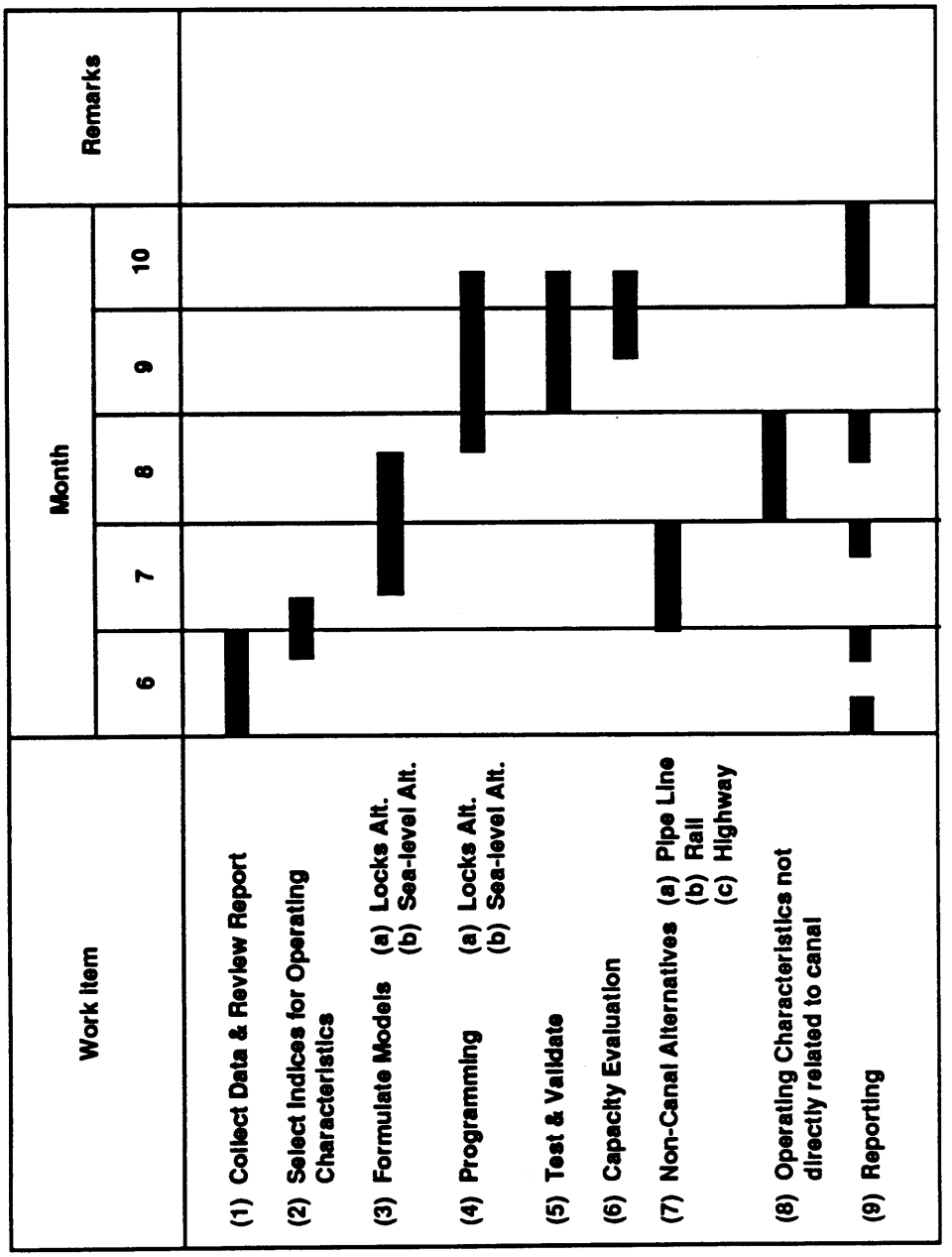


Figure 1. Work Time Schedule for Preliminary Operating Characteristics/Capacity Evaluation

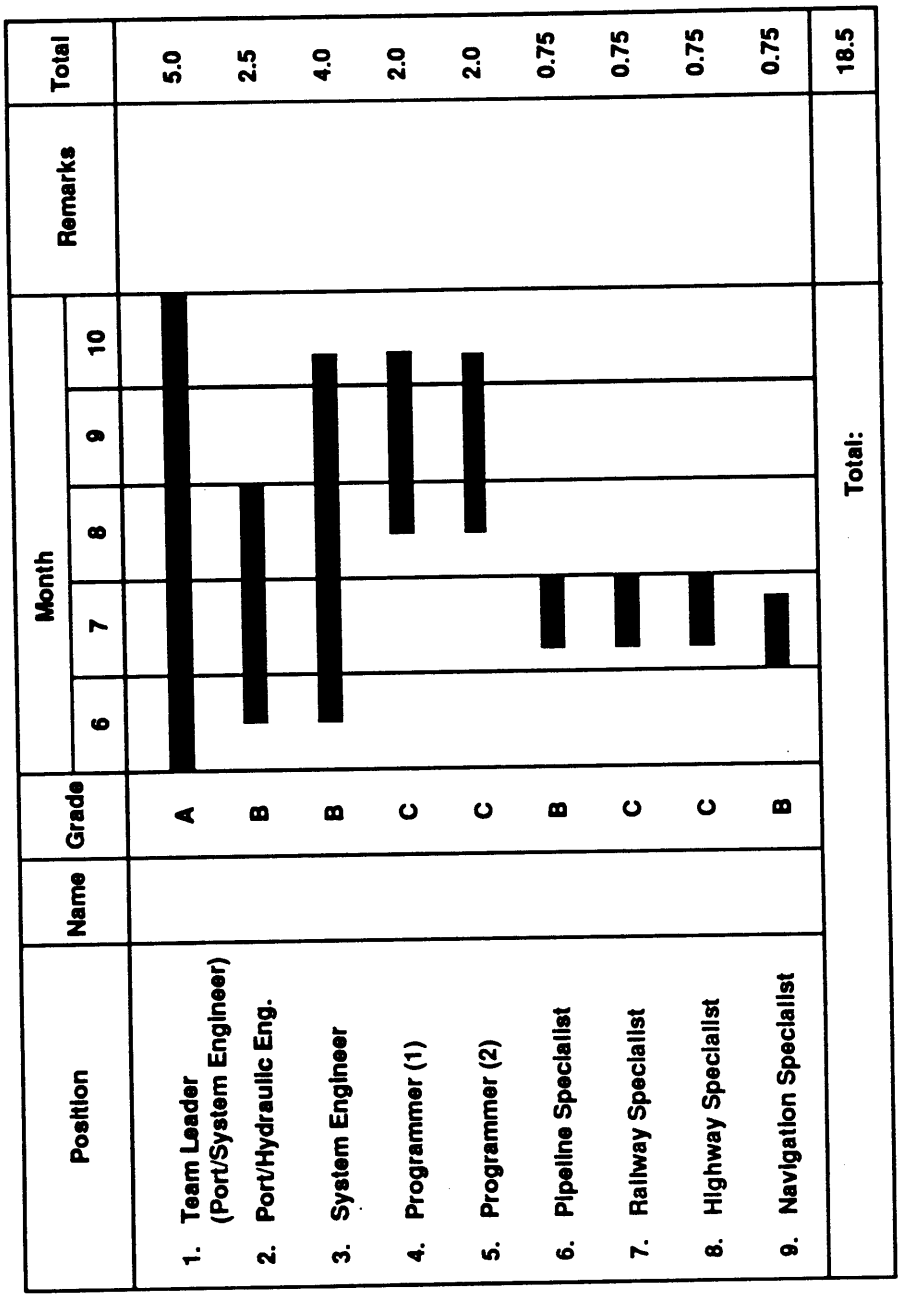
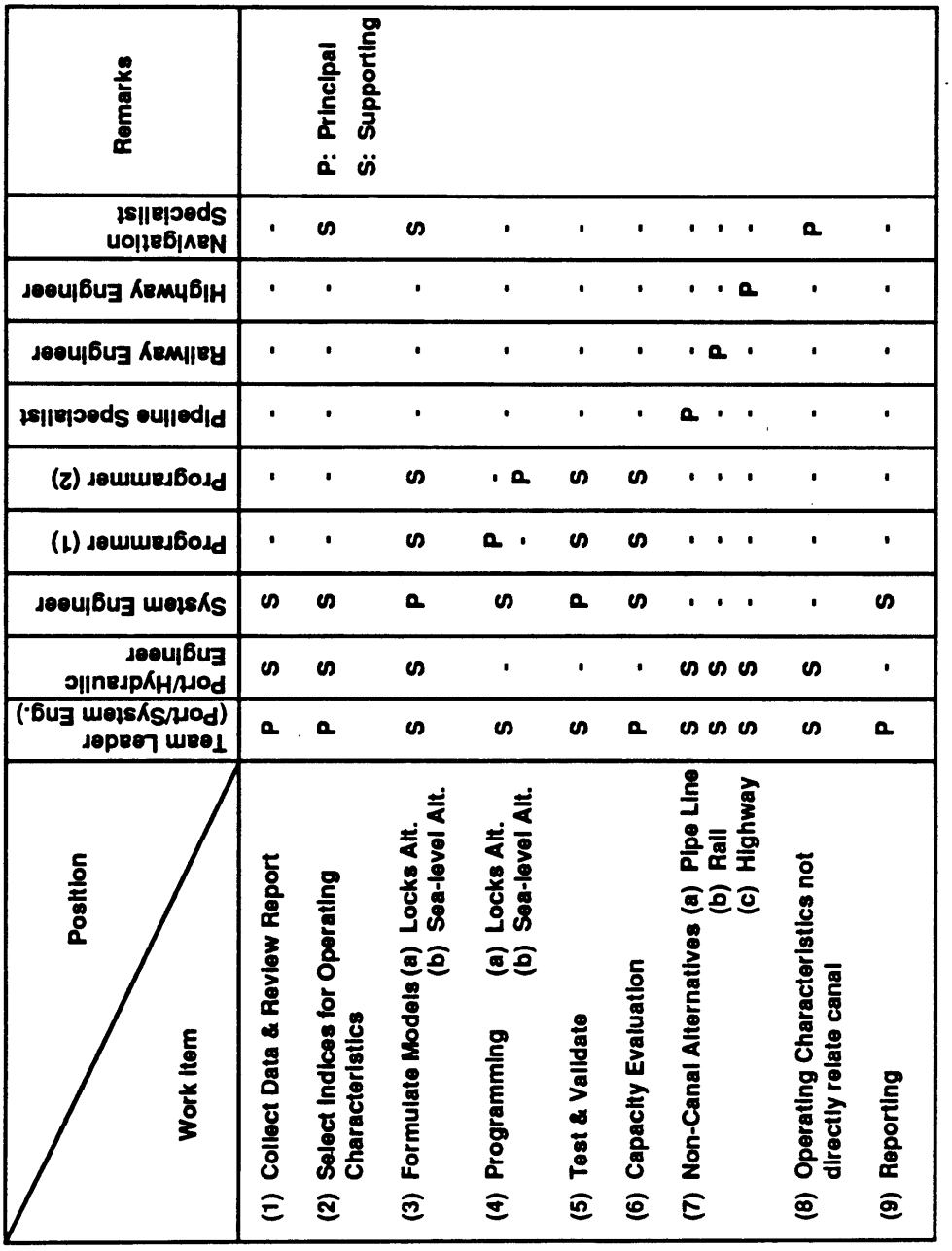


Figure 2. Manning Schedule for Preliminary Operating Characteristics/Capacity Evaluation



Work item \ Position	Team Leader (Port/System Eng.)	Port/Hydraulic Engineer	System Engineer	Programmer (1)	Programmer (2)	Pipeline Specialist	Railway Engineer	Highway Engineer	Navigation Specialist	Remarks
(1) Collect Data & Review Report	P	S	S	-	-	-	-	-	-	P: Principal
(2) Select Indices for Operating Characteristics	P	S	S	-	-	-	-	-	S	S: Supporting
(3) Formulate Models (a) Locks Alt. (b) Sea-level Alt.	S	S	P	S	S	-	-	-	S	
(4) Programming (a) Locks Alt. (b) Sea-level Alt.	S	-	S	P -	- P	-	-	-	-	
(5) Test & Validate	S	-	P	S	S	-	-	-	-	
(6) Capacity Evaluation	P	-	S	S	S	-	-	-	-	
(7) Non-Canal Alternatives (a) Pipe Line	S	S	-	-	-	P	-	-	-	
(b) Rail	S	S	-	-	-	-	P	-	-	
(c) Highway	S	S	-	-	-	-	-	P	-	
(8) Operating Characteristics not directly relate canal	S	S	-	-	-	-	-	-	P	
(9) Reporting	P	-	S	-	-	-	-	-	-	

Figure 3. Work Assignment for Preliminary Operating Characteristics/Capacity Evaluation

5 REPORTS

The Reports to be prepared by the component study contractor shall be:

- Inception Report
- Interim Report
- Final Study Report
- Monthly Report

All reports shall be written in comprehensible English. Units shall be expressed in the metric system. The pages of text shall be in principle 8-1/2" x 11" with pull-outs a maximum of 11" x 17". Oversized drawings may be placed in a pouch within the text or assembled in a separate appendix.

5.1 Inception Report

The component study contractor shall prepare sixteen (16) copies of an Inception Report for the component study, "Preliminary Operating Characteristics and Capacity Evaluation", and shall submit this to the Study Commission not later than fifteen (15) days after commencement of the Service. The Inception Report shall contain, but not be limited to, the following:

- Statistics, data, information, etc. to be collected by the component study contractor including those collected in the studies such as "Status of Present Panama Canal", "Historical Trade Analysis", and "Future Transportation System and Significance of the Panamanian Isthmus in World Trade" which will be obtainable from the Information Center,
- Approach to be adopted for various studies and analyses,
- Overview of the results of studies and analyses concerning establishment of the approach for the analysis of operating characteristics, and capacity evaluation, etc., and
- Work flow chart, study time schedule, man-month input and study budget plan.

5.2 Interim Report

The component study contractor shall prepare ten (10) copies of an Interim Report to be submitted to the Study Commission not later than three (3) months after the

commencement of the Service. The Interim Report shall contain, but not be limited to, the following:

- Items of study and analysis completed during the period and those to be conducted during the remaining study period,
- List of collected data, information, and reports with brief comments on them, and
- Major output of studies and analyses completed during the period such as:
  - Results of review and analyses of previous studies and reports
  - Results of selecting indices for operating characteristics of alternatives
  - Results of assessment of proposed approach for operating characteristics analysis and capacity evaluation
  - Results of modeling of simulation program for capacity evaluation
  - Results of range setting and operating characteristics analysis for the capacity of non-canal alternatives
  - Results of analysis of operating characteristics not directly relating to the capacity

5.3 Final Study Report

The component study contractor shall prepare sixteen (16) copies of a Final Study Report, and shall submit this to the Study Commission not later than five (5) months after commencement of the Service. The Final Study Report shall cover and contain all the results of the studies and analyses required by these Terms of Reference. The report shall be submitted in a draft form, and shall be revised, where required, based on the comments of the Study Commission issued within thirty (30) days after receipt of the said report by the Commission. The Final Report shall consist of 1) executive summary, 2) main body, 3) conclusions & recommendations, and 4) appendices including manuals, detailed flow charts, programming lists and discs for simulation models. The component study contractor selected to undertake the work will be provided with a topical outline to be used in preparing the Final Report. The Final Study Report shall contain, but not be limited to, the following:

- The same contents as in the Interim Report,
- Results of the partial test and the validation of simulation models, and

Results of operating characteristics analysis and capacity evaluation for all the main alternatives.

5.4 Monthly Report

The component study contractor shall prepare ten (10) copies of the Monthly Reports, and shall submit these to the Study Commission at monthly intervals.

The Monthly Report shall contain, but not be limited to, the following:

- The studies completed during the period and those to be performed during the following period.
- Major inputs of the studies, analyses, etc. completd.
- Major changes, problems, etc., during the period.
- Man-month input and study budget used during the period, and those accumulated up to the period.

The Monthly Report can be in the form of a brief letter report.

5.5 Reference

Lock and Waterways Capacity models (LOCKCAP, LOCKCALC) U.S. Army Corps of Engineers, WES, Lock performance monitoring system.

Attachment 1

Preliminary Operating Characteristics Study and Capacity Evaluation of Existing Panama Canal System

TASK DESCRIPTION

The purpose of this study is to carry out a preliminary operating characteristics study for the existing canal system and evaluate the approximate capacity of the existing canal system. The study shall be so designed that the evaluated capacity of the existing canal system, together with the results of preliminary demand and traffic forecast, will provide a sound basis for pre-screening of alternatives.

APPROACH

This study item is the combination of i) preliminary operating characteristics study for the present canal system, and ii) preliminary capacity evaluation of the present canal system. The first part will consist of defining and describing various operating characteristics of the present canal system in both i) operating characteristics of sub-systems, and ii) operating characteristics induced by the adoption of a specific set of operating rules and constraints of the system.

The sub-system will include, among others, the following:

- Anchorage and port area at the both ends,
- Approach channel at the both ends,
- Gatun Lake and Miraflores Lake,
- Three (3) locks namely, Gatun, Pedro Miguel, and Miraflores including their approaches,
- Restricted channel at Gaillard Cut, and
- Tie-up station on the west bank of Paraiso Reach.

Major sets of operating rules and constraints will include, among others, the following:

- Ship's arrival patterns to the canal system,
- Ship mix for canal transit,
- Day and night operation,
- Individual passage and convoy operation,
- Passage through the Gaillard Cut including foggy weather condition,

- Major lock maintenance works, and
- Cases of accidents.

The main source of input to this study item is the status of the present Panama Canal, and the following steps will be taken to carry out this part of study:

Step-1: Collect available data relating to canal operation

Step-2: Analyse and assess the above data

Step-3: Make interviews and confirmation with concerned staff of the PCC and users

Step-4: Plan and conduct additional field observation when necessary

In the second part, for the capacity estimation for pre-screening purposes, a simple computer program will be developed to simulate major operating characteristics and evaluate the capacity of the present canal system. To this end, the schematic expression shown in Figure A-1 as the functional representation of the present canal system is proposed:

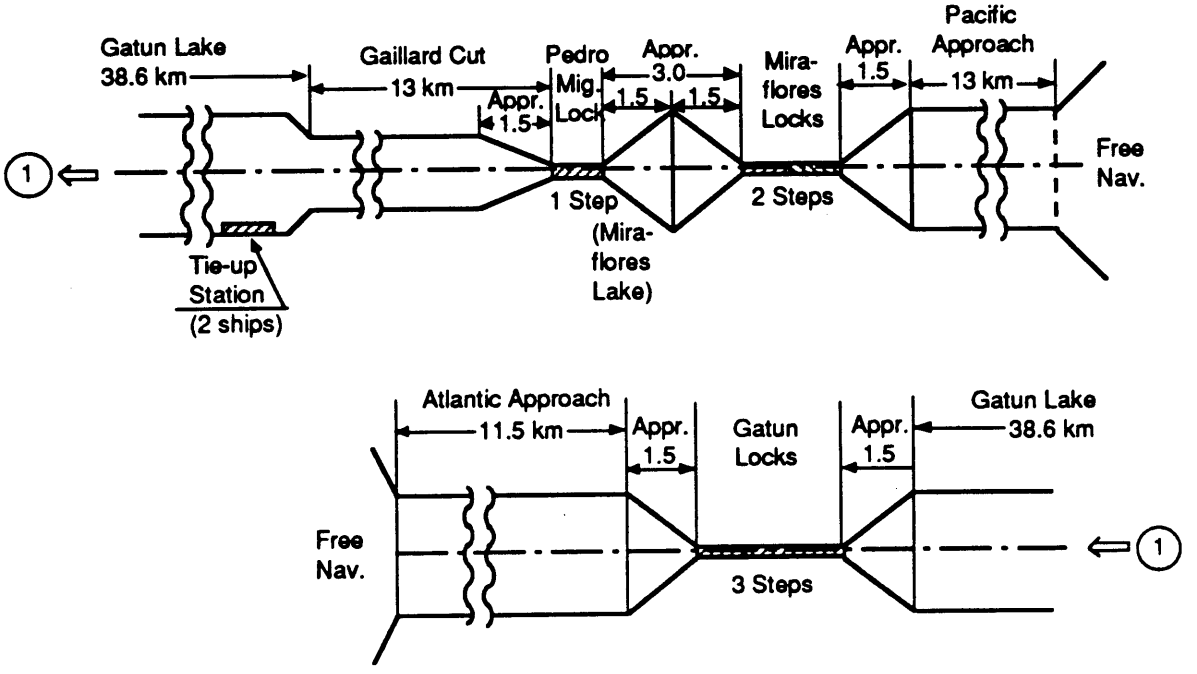


Figure A-1 Schematic Expression of Present Canal System

The main function of this system, from the navigation point of view, can be classified into the following five (5) categories:

1) Less restricted navigation area consisting of i) Pacific approach, ii) Gatun Lake, and iii) Atlantic approach,
2) Substantially restricted navigation area consisting of Gaillard Cut,
3) Locks (completely restricted navigation area) consisting of i) Miraflores (2 steps), ii) Pedro Miguel (1 step) and iii) Gatun (3 steps),
4) Approaches to the locks (strongly restricted navigation area) consisting of 6 sections (both sides of three (3) locks), and
5) Tie-up station stations on the west bank of Paraiso Reach.

Of the above five categories, the last one, the tie-up station, has a slightly different function from the other four. Firstly, a tie-up station is mainly required under convoy operation to make full use of the lock's idle time induced by one-way passage through the Gaillard Cut. Secondly, it will not relate directly, for the above reason, to the passage of individual ships, and therefore can be treated as a variation of canal operations.

Categories one to four, can be represented in the proposed simulation program as different sub-systems corresponding to the different nature of ships' passage through the respective sub-systems. To state it very simply, it can be said that these are the different sub-routines used to calculate ships' passage time through the respective sub-systems. However, the parameters to be adopted may differ from one particular sub-system to another even under the same category. For example, the logical sequence of programming for all the lock systems may be identical, but the parameter adopted may differ between Gatun, Pedro Miguel and Miraflores.

The greater part of the necessary parameters and some of the logical sequences will be decided upon the deliverables from the study item "Status of Present Panama Canal", but supplementary field observations, if necessary, will be carried out under the first half of this study item.

Once the core part of the simulation program is completed, it will be tested against the present situation of the canal under: i) normal condition and ii) various special conditions such as major lock maintenance operation period, foggy conditions in the Gaillard Cut, and various accidents.

Necessary improvements and adjustments shall be made to the program until such stage that satisfactory agreement between the real situation and simulated results can be obtained.

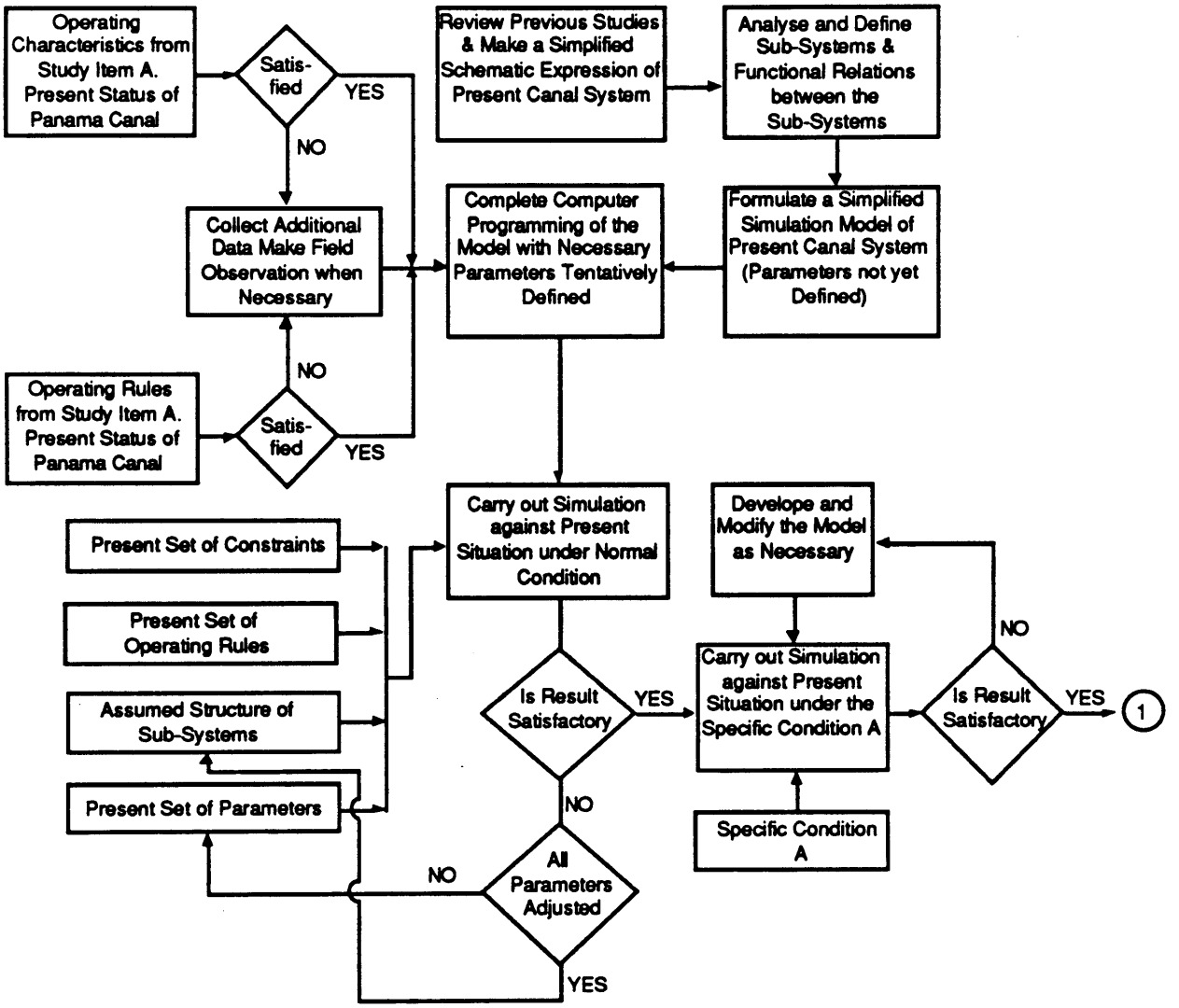
Then set the different levels of traffic demands with associated ship mixes and feed in the model to evaluate the capacity of the present canal system. If some improvement in the transit capacity of the present canal system is expected by changes in operating rules, this may be added to the capacity under present operating rules.

The proposed simulation model, therefore, can be used at a later stage as a tool for the evaluation of various improvement schemes for the existing canal system.

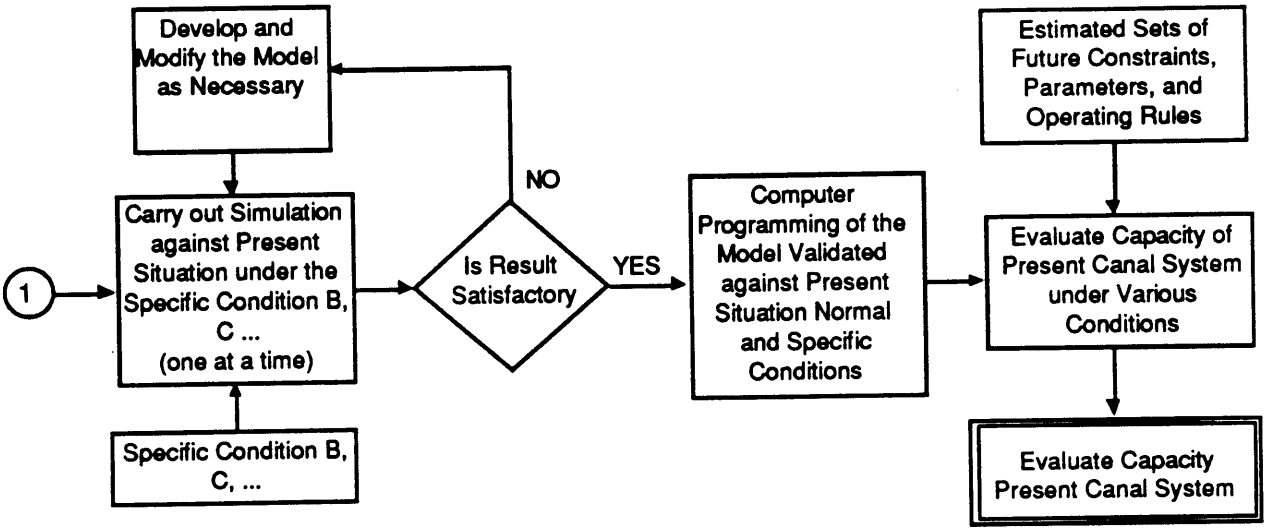
DELIVERABLES

The main deliverables from this study item will be; i) the evaluated capacity of the present canal system, ii) a simulation program with manual, disc and program list used for the capacity evaluation, and iii) a complete set of operating characteristics and constraints of the present canal system which were used for the capacity evaluation.

The proposed simulation model shall be capable of being utilized for more general purposes with minor modifications.



Flow Chart - Capacity Evaluation of Present Canal System (1)



Flow Chart - Capacity Evaluation of Present Canal System (2)

Operating Characteristics and Capacity Evaluation

1 INTRODUCTION

This is one of the important studies for carrying out the subsequent feasibility analysis. It will also be indispensable in determining the commodity and traffic projections under the constraints conditions on passages across the Isthmus. In these studies, all the principal factors influencing the transit vessels in case of canals alternatives or transport in case of other modes of transportation must be clearly identified and analyzed to understand the operating characteristics of each alternative, and to evaluate its capacity.

This component study shall be conducted in two phases; the operating characteristics of each of the prescreened alternatives shall be analyzed from several view points in terms of the transit time of vessels by type and size in the case of canal alternatives or transport time in the case of other modes of transportation, and then the capacity of each alternative shall be evaluated based on the results of analyses of the operating characteristics.

1.1 Operating Characteristics

Analysis of operating characteristics shall be made by evaluating performance of vessels transiting through each of the prescreened alternatives. Such performance shall be measured by transit time and the minimum interval between ships.

Operational characteristics will differ from one alternative to other in combination with type and size of vessels. Generally, transit time of vessels in the case of the lock canal alternative will be largely governed by lock operation and passages through restricted waterways, while in the case of the sea-level canal alternative it may be affected chiefly by tidal motion in the canal and the restricted speed of vessels due to hydraulic characteristics. Operational characteristics of each of the alternatives shall be analyzed from the following viewpoints:

- Physical and configurational aspects
- Hydrographic and hydraulic aspects
- Hydrological aspects
- Meteorological aspects
- Navigational performance of vessels
- Managerial and institutional aspects

Physical and configurational aspects which will limit passage (e.g., dimensions and alignment of the channel, configuration of the locks, etc.) shall be analyzed.

Hydrographic and hydraulic conditions will be a key factor for ship operations, especially in the case of the sea-level canal. Tidal motion in the canal shall be analyzed to determine critical velocity of tidal current for each size of vessel and to evaluate time requirements for sailing, anchoring, temporary tie-up, and other speed-reduction operations.

Hydrological conditions will be one of the key factors in the case of the lock-canal alternative. The number of transit vessels will depend directly on the balance of water between inflow from the catchment area, direct rainfall into the reservoir, and water use for lock operations. Controlling water level of the reservoir will also be indispensable in maintaining the water depth of the navigation channel for safe transit of vessels. In the sea-level canal, rushing flood flows into the channel from side rivers will be another problem which would hinder navigational operations of transit vessels. Hydrological characteristics of the alternatives shall then be analyzed from these viewpoints especially in regard to the reservoir operation plan and navigation channel plan. In the analysis, the hydrological regime shall also be taken into account to obtain affirmative results.

Meteorological conditions will provide further navigational characteristics of the alternatives. Since the alternatives will pass through a tropical, high humidity area, passages will occasionally be hindered by torrential rainfall, mist, or fog.

Navigational performance of vessels shall be thoroughly examined for each type and size of vessel with respect to sailing speed, ship-to-ship interval, stopping distance, maneuverability of vessel in the restricted channel, etc. It shall be analyzed in combination with other physical and navigational characteristics of the alternatives.

In addition to the technically-oriented characteristics above, non-technical characteristics in relation to managerial, institutional, and operational aspects shall be analyzed. These analyses will determine how efficient operation and safe and speedy transit could be attained through time-to-time management of passage, periodic maintenance, and safety control systems.

The safety control system shall be examined to secure safe transit in each alternative and provide countermeasures against particular operational problems which may be characteristic to a given alternative. They will also provide recovery procedures from accidents which may interrupt operation. The safety control systems shall also be studied to cover the objectives of day-to-day safety control system, long-term periodic safeguard system, and emergency safeguard system.

The operational characteristics of each alternative shall be analyzed by examining those factors influencing the transit of vessels in time and minimum ship-to-ship interval in case of canal alternatives as well as transport time in case of other modes of alternatives. It shall be analyzed by formulating a simulation model for each type and size of typical vessels for canal alternatives and for commodity groups for other modes of alternatives. The simulation model in the case of the lock canal, for instance, shall also be designed to analyze the transit time in each section of the canal such as entrance channels, locks, open waterway, restricted waterway, etc. Existing models will be used to the extent possible. Development of new models will be done only after consultation with and approval of the Secretariat.

The minimum ship-to-ship interval which will vary from section to section under different restricting conditions shall be analyzed in the model. In this case variables shall be grouped into two kinds: the ones with regular and periodic occurrence, and those that occur irregularly or randomly. The latter variables shall be re-evaluated in the subsequent study by generating random conditions. They will be occurrences of foggy or torrential rainy conditions, hydrological cycles, etc.

In the case of the sea-level canal the same analysis as above on the transit time and minimum ship-to-ship interval shall be made on the simulation model. In this case, however, they will be affected by tidal current produced in the waterway, and maneuverability of vessels will be the main concern in the analysis. If a tidal check gate is installed in the waterway to mitigate tidal current, operating time of the gate will be an important factor restricting the transit time.

In the case of other mode of transportation which function as complementary transport means, distribution of type and size of arriving and departing vessels, and sharing of cargoes with the canal transit, etc. shall be carefully taken into account to formulate a simulation model.

The results of this study will be the average time in the canal, and minimum ship-to-ship interval or the average transport time through other modes and shall be used for the subsequent study "Capacity Evaluation".

1.2 Capacity Evaluation

The purpose of this study is to estimate the transit capacity of each of the prescreened alternatives, to evaluate the maximum passable size of transit vessel, and to examine flexibility and possibility for the future expansion when demand increases. The study shall be started by using the results of the operating characteristics study for each

alternative as the principal elements. This will provide an estimate of the transit capacity, and will also provide the information required for establishment of the safety control and operation systems.

Evaluation of the transit capacity shall be made by formulating a simulation model consisting of two systems:

- For evaluating transit capacity
- For evaluating maximum passable size of vessel

The capacity for each alternative shall be estimated by analyzing arrival time of vessels, studying the optimum methods of transit such as random (first come, first served), convoy or semi-convoy method, and by evaluating passage time in the restricted and open waterways or in the locks under the conditions and assumptions anticipated in the former study, "Operating Characteristics," which included unexpected accidents, unfavorable weather conditions, limited water usage during dry season or year, etc., as the irregular and random occurrences.

The maximum passable size of vessel shall be evaluated by means of optimization study comparing the cost required for each scale of the alternative and the respective transit capacity that could be expressed by the number of transit vessels and transit cargo tonnage.

The results of the capacity evaluation shall be the estimated transit capacity for each alternative expressed in the maximum cargo tonnage and number of transit vessels for canal alternative and the maximum transportation capability for other modes which will provide a baseline for the feasibility studies of economic and financial aspects, management arrangements, etc. and feedback data for the demand forecast.

2 OBJECTIVES

The principal objectives of the component studies, "Operating Characteristics" and "Capacity Evaluation" are:

Operating Characteristics

- To collect and analyze the data and information concerning operating characteristics
- To identify and clarify factors influencing the performance of each of the alternatives

- To estimate the time required and minimum interval of ships for transit of vessels through the lock or sea level canal as well as the time required for transport commodity through other modes of transportation

Capacity Evaluation

- To collect and analyze the data and information concerning capacity evaluation for each alternative, and to review the results of operating characteristics study
- To examine uncontrollable conditions and bottlenecks on traffic
- To estimate transit capacity of each alternative in terms of number of transit vessels as well as maximum possible size of vessel for canal alternatives and transport capability for other modes of transportation
- To assess flexibility and possibility of future expansions and modifications of each alternative

3 SCOPE OF SERVICES

The scope of the services to be conducted by the component study contractor for attaining the objectives set out above is discussed below.

3.1 Operating Characteristics

3.1.1 Collection of Data and Information

All the necessary data and information as well as the results of the previous relevant studies for operating characteristics shall be collected, but not be limited to, as follows:

- Statistics (1960-1990) for time in canal water (TICW) (Panama Canal)
- Statistics for time in canal water (other large size canals)
- Statistics for time required for transporting oil through pipelines
- Statistics for time required to transiting through landbridge
- Various basic factors for operating canals, etc.
- Results of previous relevant studies, etc.
- Other necessary data and information, if any

All the necessary data and information will be given by CAS. If additional data collection is necessary, this will be authorized by CAS.

3.1.2 *Analysis on Time in Canal Water (TICW) for Lock and Sea Level Canals*

TICW for lock and sea-level canals shall be analyzed by each type and size of transit vessels by using statistics for the Panama Canal and other large-size canals in the world so as to provide the basic data for estimation of transit time required.

3.1.3 *Analysis on Time Required for Transiting through Other Modes of Transportation*

Time required for transiting through other modes of transportation such as oil pipeline, landbridge, etc., shall also be analyzed by each item of commodity groups to be transported.

3.1.4 *Identification and Analysis of Factors Influencing Transit*

All the principal factors influencing transit shall be identified and analyzed for lock and sea-level canals as well as for other modes of transportation such as oil pipeline, landbridge, etc., by classifying into the following:

- Physical and configurational aspects
- Hydrographic and hydraulic aspects
- Meteorological aspects
- Hydrological aspects
- Navigational aspect
- Managerial and institutional aspects
- Safety control system

3.1.5 *Estimation of Transit Time and Minimum Interval of Ship for Lock and Sea-Level Canals*

Transit time including time required for formalities, procedures for transit, etc. and minimum interval of ship shall be estimated both for lock and sea-level canals. Estimation may be made by introducing a simulation technique which is modelled based on the data of the presently operated large-scale canals such as Panama, Suez, etc. Operating characteristics for each type of canal shall be analyzed for typical types and sizes of vessel which will be determined taking into account the

distribution of types and sizes of world fleet. Transit time analysis and minimum interval of ship in conjunction with the operating characteristics of each alternative will provide basic data for "Capacity Evaluation".

3.1.6 Estimation of Transit Time for Other Modes of Transportation

Transit time including time required for formalities, procedures for transit, etc., shall be estimated for other modes of transportation such as oil pipeline, landbridge, etc. Estimation may be made by introducing a simulation technique which will be modelled based on the data of the presently operated pipelines, landbridges, etc. Operating characteristics shall be analyzed for each of the other modes of transportation.

3.2 Capacity Evaluation

3.2.1 Collection of Data and Information

All the necessary data and information required for capacity evaluation shall be collected. Most of the basic data will come from the component study "Operating Characteristics" that may be conducted either prior to this study or, in some cases, in parallel with it. The following statistics, records, etc., however, shall be collected to carry out the capacity evaluation for each alternative.

- Statistics for arrival of transit ships by type and size for Panama Canal
- Statistics for arrival of transit ships by type and size for other large-size canals
- Records of accidents of Panama Canal
- Records of unfavorable weather conditions for transit of Panama Canal
- Hydrological records for Panama Canal
- Records of reservoir operation and water use for lockage operation
- Rules and regulations for transiting the Panama Canal

All the necessary data and information will be given by CAS. If additional data collection is necessary, this will be authorized by CAS.

3.2.2 Analysis of Arrival Time Pattern of Transit Ships

In order to forecast the future pattern of arrival times for ships for each alternative, the past and recent records shall be analyzed in detail.

Then, the possible cases of fleet input to each of the canal alternatives shall be examined taking into account the priority vessels, formation of convoys, etc.

3.2.3 Analysis of Uncontrollable Conditions on Passage

Studying operational records of the Panama Canal, uncontrollable conditions on passage in conjunction with accidents, unfavorable weathers, etc. shall be identified. Various incidents that hindered the normal transit operation of the Panama Canal shall be clarified, and their causes and effects shall be analyzed in terms of occurrence frequency, duration and magnitude. All the results of the study here shall be input into the simulation analysis for transit capacity of each canal alternative.

3.2.4 Analysis of Water Uses and Reservoir Operation

In order to formulate the maximum water usage plan of potential water sources for the purpose of lockable operation, hydroelectric power generation, water supply, etc. hydrological records, water uses and reservoir operation results shall be analyzed in detail, and the reservoir operation study for each of the alternatives shall be made including the studies for new reservoir development and possible water saving methods. Through the study, maximum possible water use shall be estimated and distribution and severity of water shortage shall be clarified. All the results of the study here shall be used for the simulation analysis to estimate the transit capacity of each canal alternative.

3.2.5 Evaluation of Transit Capacity for Lock and Sea-Level Canals

The evaluation of transit capacity of the prescreened lock and sea-level canals shall be made by using simulation analysis, where operational conditions of ships shall be input into simulation model. Transit capacity may be evaluated through an interpretation of the transit service time that will be consumed on each section along the canal waterway. The simulation base concerning ship handling will come from the component study, "Operating Characteristics". In formulating the simulation model, the operational aspects which will impact on the transit service time of the ships crossing over the canal waterway shall be taken into account. The simulation analysis shall be based on time factors and all parameters used for the analysis such

as safe ship speed through the canal, minimum ship intervals, etc., shall be treated to maximize the transit capacity.

The transit capacity of the canal alternative may be evaluated in the form of total time requirement of the ships for transiting the canal. The minimum total time requirement of the ships will give the maximum transit capacity of the canal.

3.2.6 Evaluation of Transport Capacity of Other Modes of Transportation

The evaluation of transport capacity for other modes of transportation shall also use simulation analysis where operational conditions of the transportation facilities shall be input into the simulation model. Transit capacity may be evaluated through interpretation of transit service time that will be consumed for transhipping, marshalling, transmitting on the mainline, waiting, etc. along the transportation line.

As in the case of canal alternatives, transit capacity may be evaluated in a form of total time requirement through other modes of transportation such as pipelines, landbridge, etc. The minimum total time requirement for transport will also give the maximum capacity of the other modes of transportation.

3.2.7 Evaluation of Maximum Passable Size of Vessel

The evaluation of the maximum passable size of vessels through each of the canal alternatives shall be made by comparing the scales and capacities of the canal with respective costs required for construction and operation. The evaluation may be made by introducing the simulation analysis.

The maximum passable size of vessels through the canal will be finally determined based on the configuration of the canal that has the optimum scale. Then, the optimum capacity of the canal will be determined by calculating the maximum number of transit vessels through the canal.

4 SCHEDULE

The overall schedule to complete the whole study is 30 months and the time allocated to complete this component study is 5 months. This study will start at the 13th month of the overall schedule for the study and will end by the 17th month as shown in Figure 1. The proposed manning schedule for this component study is shown in Figure 2. The major work assignment for this component study is shown in Figure 3.

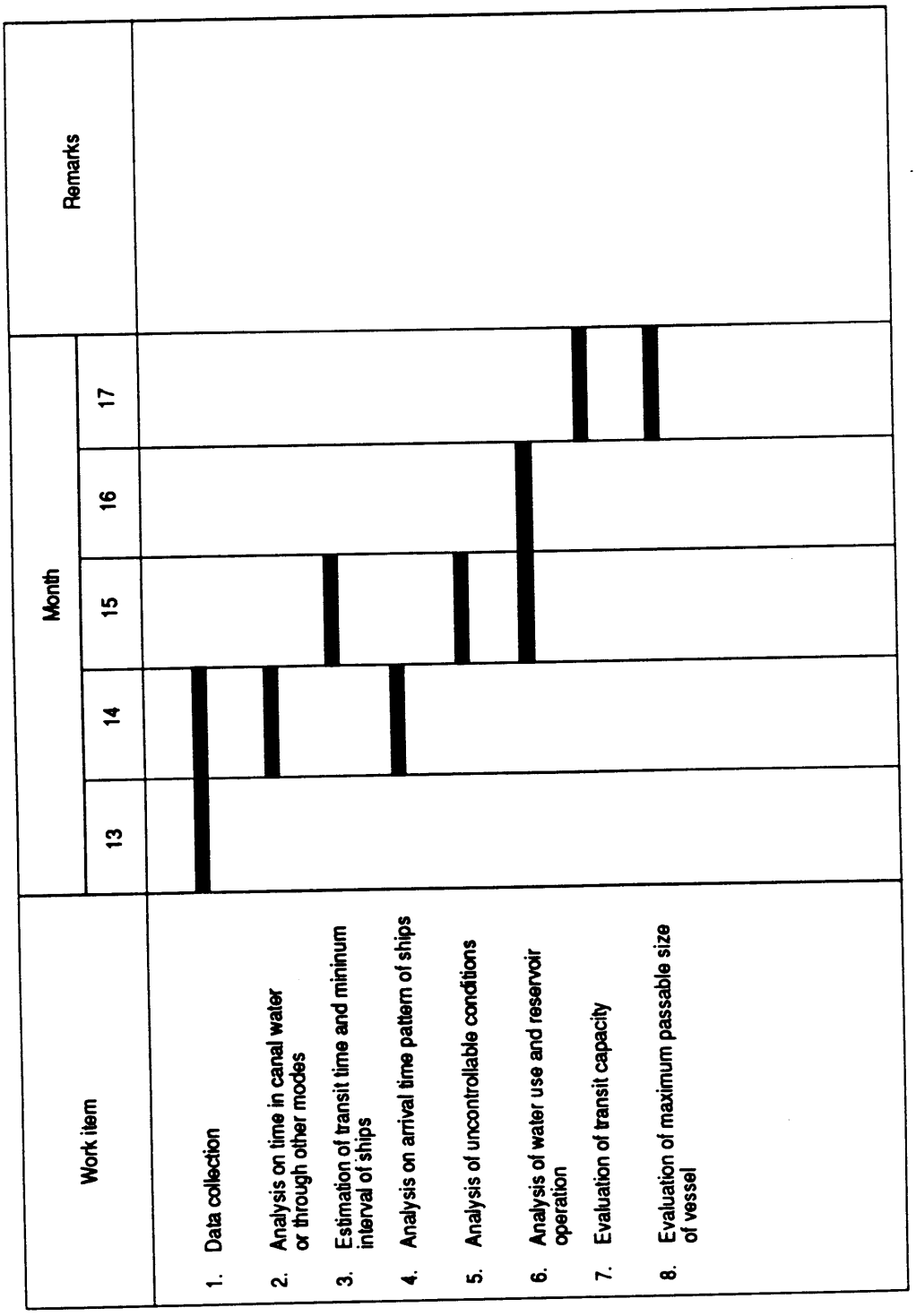


Figure 1. Work Time Schedule for Operating Characteristics and Capacity Evaluation

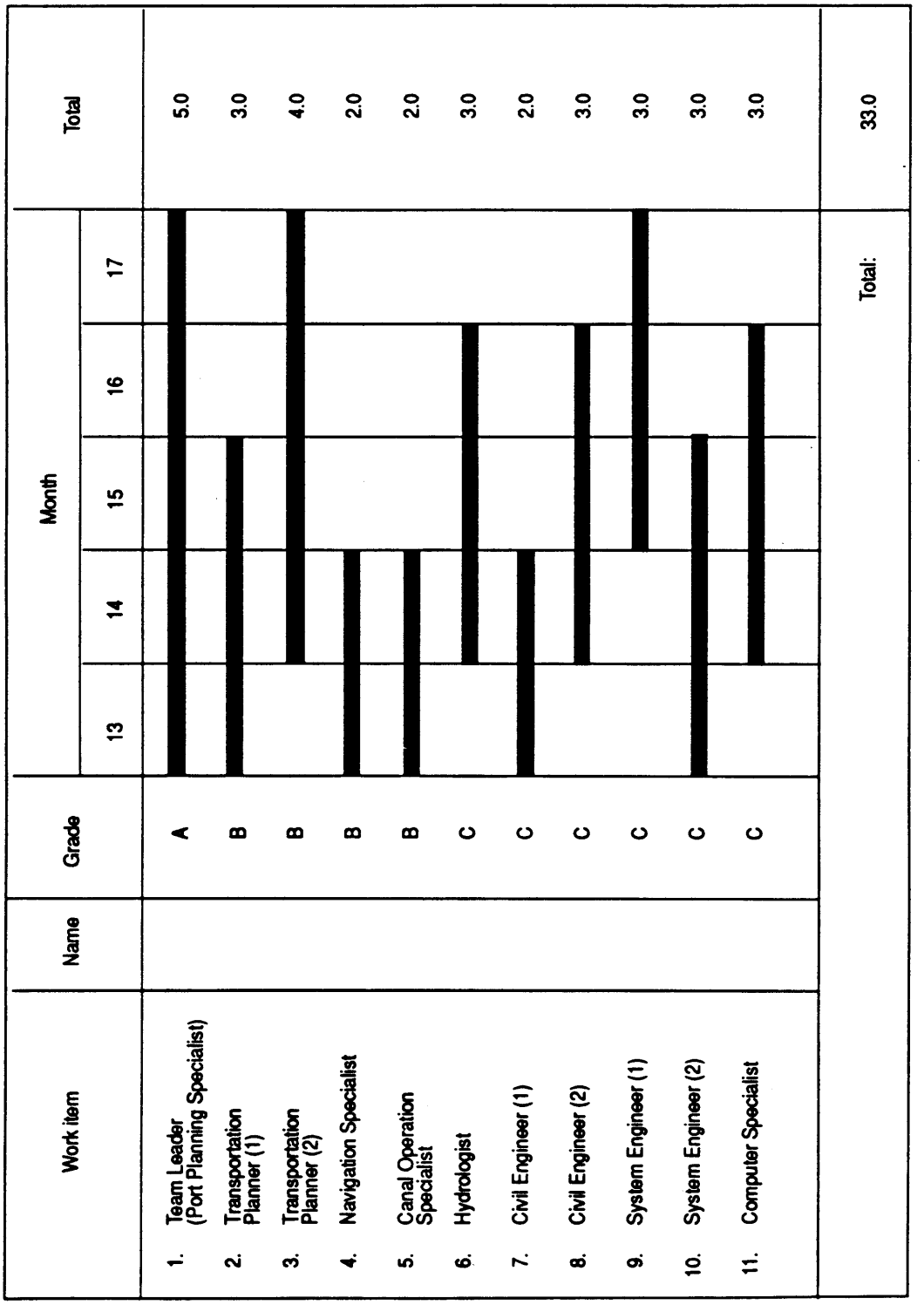


Figure 2. Manning Schedule for Operating Characteristics and Capacity Evaluation

Work item \ Position	1. Team leader	2. Transportation planner (1)	3. Transportation planner (2)	4. Navigation specialist	5. Canal operation specialist	6. Hydrologist	7. Civil engineer (1)	8. Civil engineer (2)	9. System engineer (1)	10. System engineer (2)	11. Computer specialist	Remarks
1. Data collection	P	S		S	S		S			S		P : Principal S : Supporting
2. Analysis on time in canal water or through other modes	S	P	S	S	S	S	S	S		S	S	
3. Estimation of transit time and minimum interval of ships	S	P	S					S		S	S	
4. Analysis on arrival time	S	S	P				S	S		S	S	
5. Analysis on uncontrollable conditions	S	S	S					S	S	S	S	
6. Analysis of water use and reservoir operation	S					P		S	S	S	S	
7. Evaluation of transit capacity	S		P						S			
8. Evaluation of maximum passable size of vessel	S		S						S			

Figure 3. Major Work Assignment for Operating Characteristics and Capacity Evaluation

5 REPORTS

The Reports to be prepared by the component study contractor shall be:

1) Inception Report
2) Interim Report
3) Final Study Report
4) Monthly Report

All reports must be written in comprehensible English. Units shall be expressed in the metric system. The pages of the text shall be principle 8-1/2" x 11" with pull-outs a maximum of 11" x 17". Oversized drawings may be placed in a pouch within the text or assembled in a separate appendix.

5.1 Inception Report

The component study contractor shall prepare sixteen (16) copies of an Inception Report for the Component study, "Operating Characteristics and Capacity Evaluation" and shall submit this to the Study Commission not later than fifteen (15) days after commencement of the Service. The Inception Report shall contain, but not be limited to, the following:

(1) Statistics, data, information, etc. to be collected by the component study contractor including those collected in the component study "Preliminary Operating Characteristics and Capacity Evaluation" which will be obtainable from the Information Center,

(2) Methodologies to be adopted for various analyses,

(3) Overview on the results of studies and analyses concerning transit time, ship-to-ship interval, uncontrollable conditions, water use, transit capacity, maximum passable size of vessel, etc., and

(4) Work flow chart, study time schedule, man-month input, and study budget plan.

5.2 Interim Report

The component study contractor shall prepare ten (10) copies of an Interim Report to be submitted to the Study Commission not later than three (3) months

5.2 Interim Report

The component study contractor shall prepare ten (10) copies of an Interim Report to be submitted to the Study Commission not later than three (3) months aftercommencement of the Service. The Interim Report shall contain, but not be limited to, the following:

(1) Items of studies and analyses completed during the period and those to be conducted during the subsequent period,

(2) List of collected data and information with brief comments, and

(3) Major outputs of studies and analyses completed during the period such as:

- Results of analysis on time in canal water or time through other modes of transportation
- Results of analysis of transit time and minimum interval of ships
- Results of analysis on arrival time pattern of ships
- Results of analysis of uncontrollable conditions

5.3 Final Study Report

The component study contractor shall prepare sixteen (16) copies of a Final Study Report, and shall submit this to the Study Commission not later than five (5) months after commencement of the Service. The Final Study Report shall cover and contain all the results of the studies and analyses required by this Terms of Reference. The report shall be submitted in a draft form, and shall be revised, where required, based on the comments of the Study Commission issued within thirty (30) days after receipt of the said report by the Commission. The Final Report shall consist of 1) executive summary 2) main body, and 3) conclusions & recommendations. The component study contractor selected to undertake the work will be provided with a topical outline to be used in preparing the Final Report. The Final Study Report shall contain, but not be limited to, the following:

(1) The same contents as in the Interim Report

(2) Results of analysis of water use and reservoir operation

(3) Results of evaluation of transit capacity and maximum passable size of vessel

5.4 Monthly Report

The component study contractor shall prepare ten (10) copies of Monthly Reports, and shall submit these to the Study Commission at monthly intervals.

The Monthly Report shall contain, but not be limited to, the following:

- The studies completed during the period and those to be performed during the following period.
- Major inputs of the studies, analyses, etc., completed.
- Major changes, problems, etc., during the period.
- Man-month input and study budget used during the period, and those accumulated up to the period.

The Monthly Report can be a brief letter report.

Background Biological Data and Biological Inventory

Comisión de Estudio de las Alternativas al Canal de Panamá
CENTRO DE INFORMACION

1 INTRODUCTION

One of the component studies to be conducted is a biological inventory, which is the subject of this term of reference. In parallel with the component studies, the Study Commission will be assisted by a contractor responsible for the Feasibility Analysis/Final Report (FA/FR). The FA/FR Contractor will assist the Commission in the identification of alternatives, prescreening of alternatives, and the recommendation of the best alternative. Information from the component studies is used as input to these tasks.

2 OBJECTIVES

The biological inventory is intended to be a systematic survey designed to document biota which exist in areas of Panama which would be affected by construction and operation of any of the canal alternatives. The information collected will be used to characterize biotic and related abiotic conditions. The inventory will serve two primary purposes:

- Establishment of a study baseline
- Input to the environmental analysis

Information from the inventory can also be of use in the feasibility assessment and the detailed investigation of the selected alternative.

Studies conducted in the 1960s to evaluate the concept of a sea-level canal identified numerous gaps in the knowledge of biology in the isthmian region. For the marine fauna, in particular, surveys found numerous new species and raised many questions concerning the taxonomic status of closely related Atlantic and Pacific forms. The studies were designed to consider routes from Colombia to Costa Rica on both coasts and did not address specific areas in detail or deal with seasonal, annual or longer-term variation. This type of information remains to be collected.

The interoceanic canal studies also resulted in the gathering of information on terrestrial and freshwater, habitats. These studies were designed primarily to provide information to address impacts of nuclear excavation and, therefore, focused on route selection and pathways of radionuclide transfer.

These limitations and the lack of biological data pertaining to important species found in Panama made it impossible to adequately predict biological changes which would potentially occur due to mixing of Pacific and Atlantic biota. In response, the National

Academy of Sciences - National Research Council designed additional studies to be conducted if a sea-level canal is to be constructed. The basic scope was summarized in Appendix 16 of Annex V of the 1970 report of the Atlantic-Pacific Interoceanic Canal Study Commission. The program that was designed involved both field collections and laboratory experimentation. It was complex, long-term, and expensive; the estimated cost was $20 million.

It is important to note that should a plan for a sea-level canal reach later planning stages, such studies are still warranted. The present study, however, has a different scope and context than those envisioned in the NAS-NRC plan, as well as a limited budget and schedule. In addition, the overall study goal is to recommend an alternative transportation system based on a feasibility analysis. These factors reduce the necessary level of detailed ecological data.

It is also not intended for the biological inventory to collect information already documented adequately from previous studies. To avoid such duplication of effort, the results of the literature survey to be conducted during the first two months will be used to modify the sampling program where appropriate. The human settlement information and impact analysis will be included in the Component Study on the "Economic and Impact Analysis: (Impact on Panama)."

3 SCOPE

3.1 Introduction

The contractor selected to perform the biological inventory will conduct a literature search and collect, analyze, and report data from marine, freshwater, and terrestrial habitats according to the plan described below. The plan has been designed to take into account other component studies and work to be performed by the FA/FR Contractor. As a result, the contractor is not expected to deviate from the plan without written authorization from the Commission.

At the same time, it is recognized that anticipated, as well as unanticipated, events could require revisions of the study scope. To maximize the return on available resources, the scope will be subject to revision as the project progresses. For example, at the conclusions of the prescreening activity, the scope will be revised as necessary to focus on the remaining alternatives.

3.2 Project Description

The biological inventory will involve the literature search, initial mobilization efforts, short-term reconnaissance surveys, the main data collection task, and data analysis

and reporting. The inventory will document the biota which potentially can be affected by construction and/or operation of any of the transportation alternatives. In addition the biotic collections, measurements of abiotic conditions such as temperature, salinity, soil/sediment characteristics, etc. will be made. Collections will be made in marine, freshwater, and terrestrial habitats.

Figure 1 shows the location of the Republic of Panama and identifies major geographic features. Figure 2 shows political boundaries and locates transportation-related features. Figure 3 focuses on major components of the Panama Canal and Figure 4 provides additional detail concerning the canal and adjacent areas. It is in this area that the biological inventory will take place.

3.2.1 Existing Canal

The existing Panama Canal extends about 80 km across the Isthmus of Panama from northwest to southeast. Vessels entering the Canal from the Atlantic Ocean reach the Gatun Locks through an 11 km waterway from Cristobal, and then pass through three-step locks to reach Gatun Lake. From there on, approximately 50 km of waterway leads to the Pedro Miguel Locks where the water elevation is lowered 9 m followed by a further 16 m descent at the Miraflores Locks to reach sea level. From there on, there is a further 6 km of waterway and a 7 km channel into the Pacific Ocean.

There are all together 12 locks in six sets and the maximum lift is 25-26m. The locks are 305 m in length, 33.5 m in width and 12.1 m in navigable depth. The normal maximum tonnage of vessels capable of passing through the canal is 65,000 DWT and the maximum annual capacity of the canal is believed to be about 200 million tons. A large quantity of water is needed for the lock operations, and the Chagres River, Gatun Lake, and abundant rainfall in the region provide the source. Mean annual rainfall ranges from 1,850 to 3,400 mm.

3.2.2 Study Area

The study area is intended to encompass areas affected by any transportation option under consideration and as a result may be altered from the currently defined area as the project proceeds. For the present, the study area is based on several assumptions:

- The area is based on modified lock alternatives. If one or more sea-level alternatives is selected by the prescreening, the scope of this study will be revised to cover the appropriate geography.

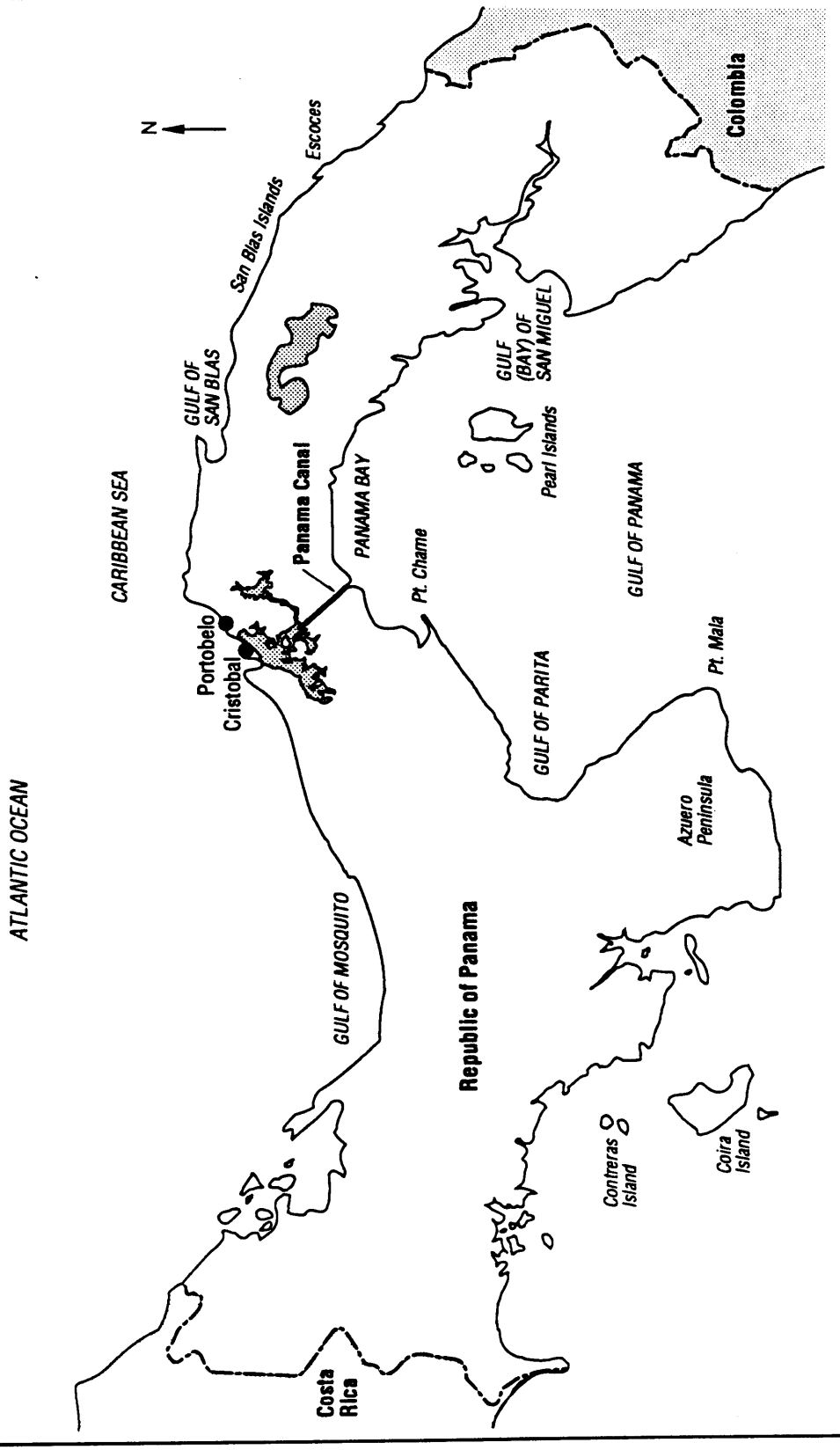


Figure 1 Republic of Panama Geographic Features

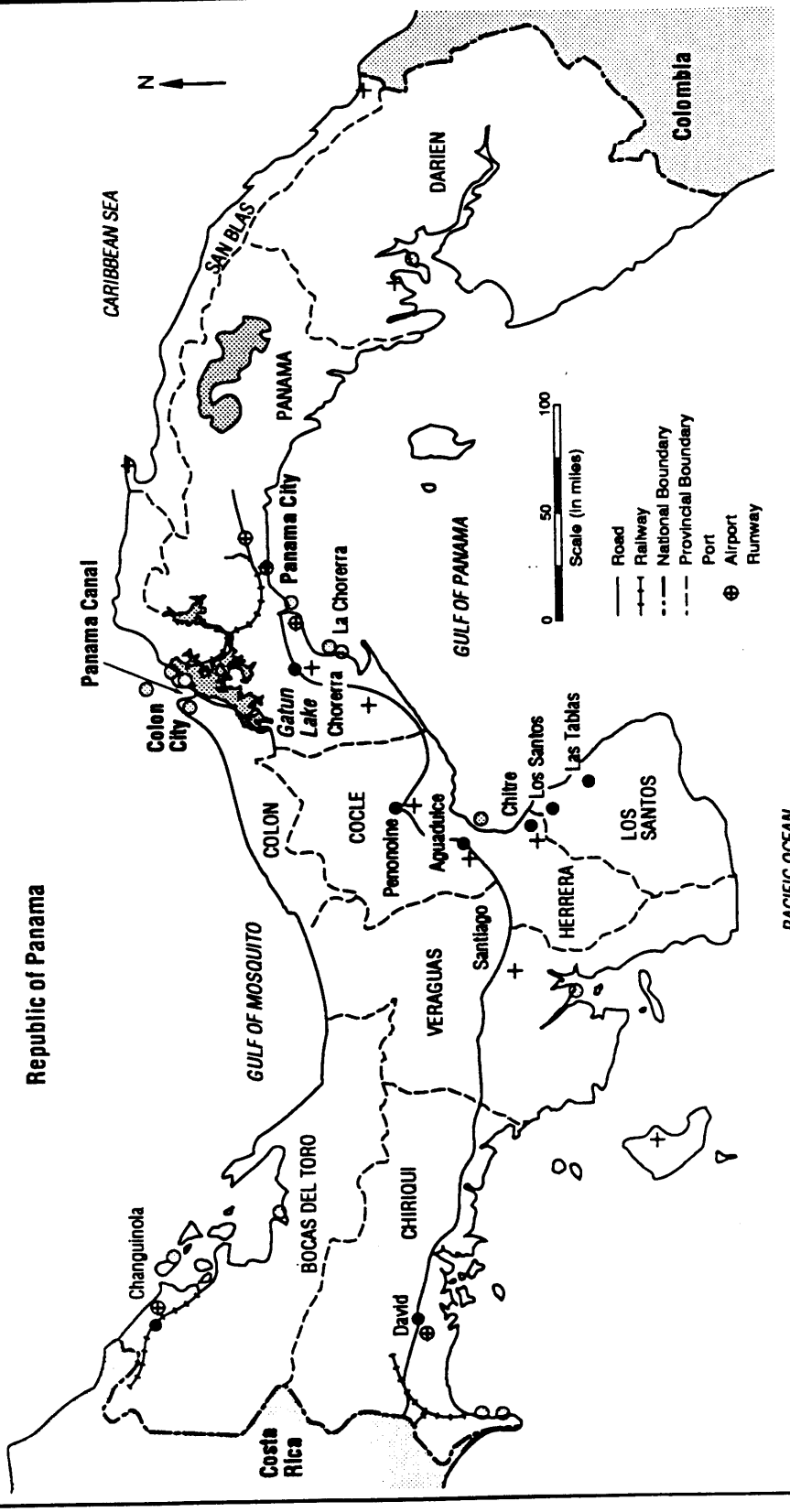


Figure 2 Panama Political Boundaries and Transportation Features

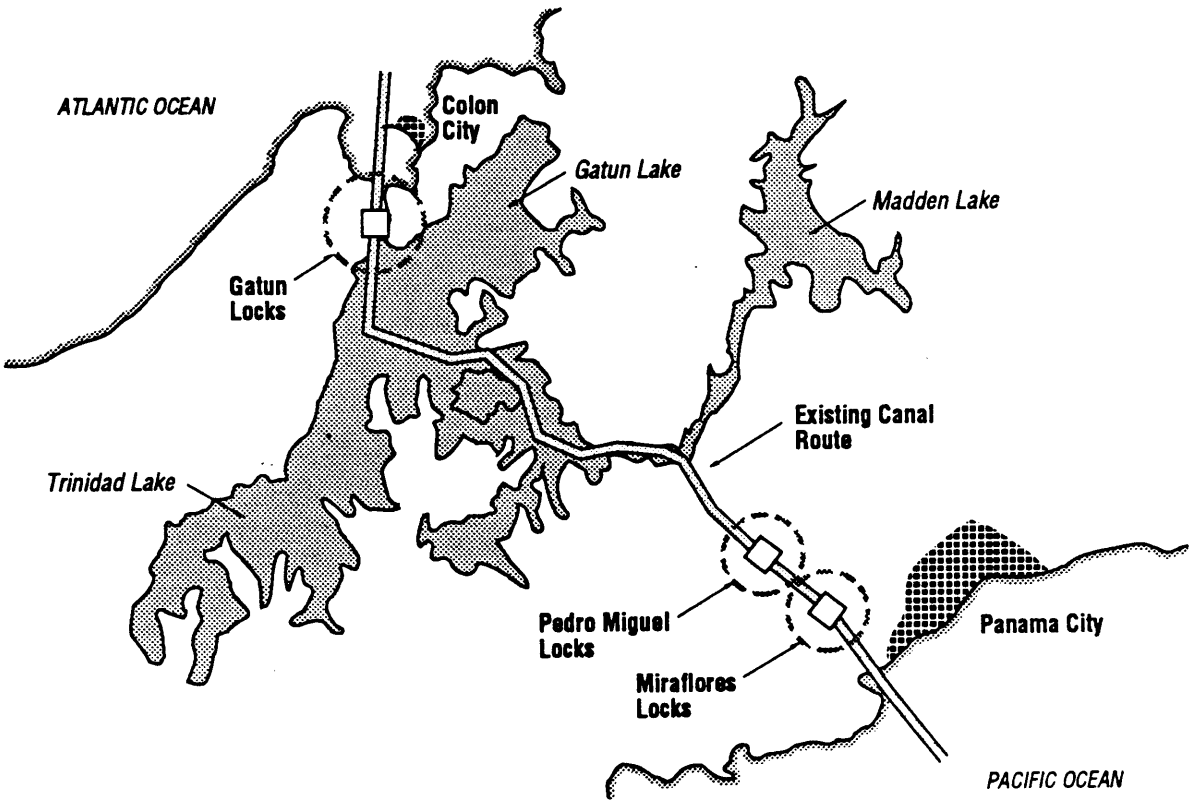


Figure 3 Major Components of the Panama Canal

Figure 4 Panama Canal and Adjacent Areas

- The water resources for the Panamanian alternative will be limited to the Gatun and Madden Lakes watershed. The original plan (see Figure 5) indicated an option to increase the water supply by rerouting the U and San Miguel rivers and creating Indio Lake. Since these are considered supplemental sources and represent impact to two undisturbed watersheds, the required changes are not considered as part of the current project plan.
- The land-based alternatives will be confined to a corridor between the east side of the Canal and Boyd-Roosevelt Highway (Rt3). This area includes the existing railroad and has access to necessary infrastructure. Any more remote location would include higher construction and operation costs and would impact less disturbed areas.
- Any upgrading or new port facilities on the Atlantic side will be confined within the breakwater. This includes channel deepening or widening, changes to the anchorage, changes to the port and creation of new terminal facilities for land-based transportation. Any other assumption requires significant development and environmental effects in a currently undeveloped area.
- Any upgrading or new port facility on the Pacific side will be confined to the area inshore of the existing dredged channel. The assumption appears reasonable unless spoil disposal beyond this area is necessary.
- As in previous studies and design efforts, spoil from the Canal will be disposed of in Gatun Lake, within one mile of the Canal, or adjacent to the entrance channels. It is necessary to study disposal areas for dredge and excavation spoil, but disposal sites have yet to be designated. However, given the cost of transporting the material, it is unlikely that sites selected in the future will be further away.
- Marine habitats adjacent to the canal entrances will be affected by increased traffic, spills, spoil disposal, etc. The precise extent cannot be defined presently but local hydrodynamics can be taken into account to extend the study area in the appropriate directions.

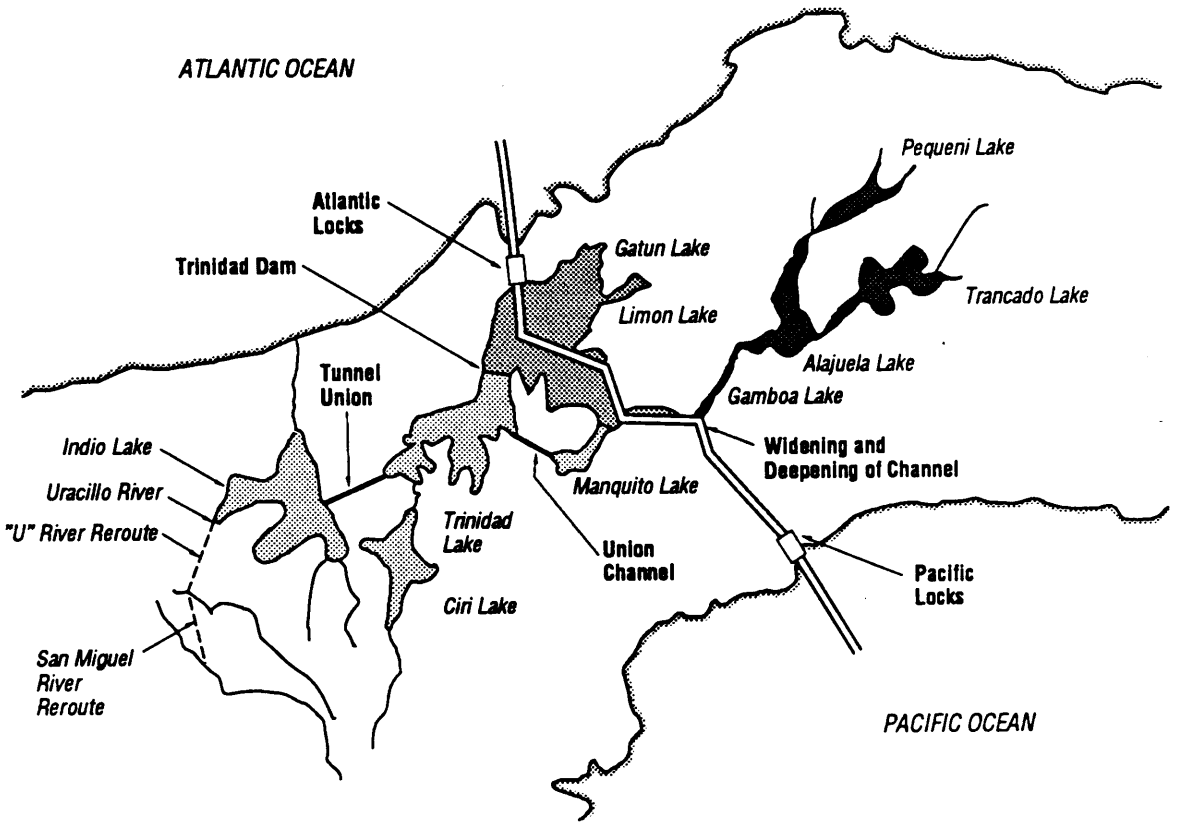


Figure 5 Panamanian Alternative Water Supply

The assumptions result in definition of the study area as shown in Figure 6. The geographic extent is determined primarily by the large scale watershed changes associated with the Panamanian alternative. Existing lakes as well as new reservoir sites are included. Upstream rivers such as Rio Trinidad, Rio Caimito and Rio Pescado are excluded since these habitats remain unchanged regardless of downstream modification. The existing canal and its approaches are included as is the existing railroad. In general, the inventory will consider affected areas only and not attempt to characterize the entire region. If the prescreening or other activities result in affected areas beyond the study area, the area will be modified accordingly.

Available information concerning the engineering design of each alternative will be provided to the contractor prior to reconnaissance surveys. This should be reviewed to ensure an adequate understanding of alternatives and their influence on sampling.

3.3 Project Area Characterization

The study area has been the subject of a large number of ecological studies. These have resulted from the presence of the Smithsonian Institution, the University of Panama, actions associated with the Canal itself and the ease of access by the world's scientists to the varied habitats in Panama.

The following, while not focused on the study area, provides useful information on the environmental setting in Panama. Much of the information is taken from the Environmental Report for widening of Gaillard Cut (Panama Canal Commission 1987).

3.3.1 Abiotic Conditions

The climate of Panama was categorized by Tosi (1971) as Tropical Moist Forest Life Zone. The mean annual rainfall is 1,850-3,400 mm and the mean annual temperature is about 26°C. In the canal area, the rainy season usually extends from mid-April to mid-December, and total precipitation diminishes with distance North to South following prevailing northeast winds.

Along Gaillard Cut, the topography is flattened due to the vast deposits of fill, although there are still numerous conical and irregularly-spaced hills in the region. Terrain is relatively resistant to erosion from stream flowing and weathering, and drainage prevails toward the Canal. Soils primarily are clayish in texture, acidic, and have a high mineral content. The topsoils typically are shallow and thus can be very fragile when exposed.

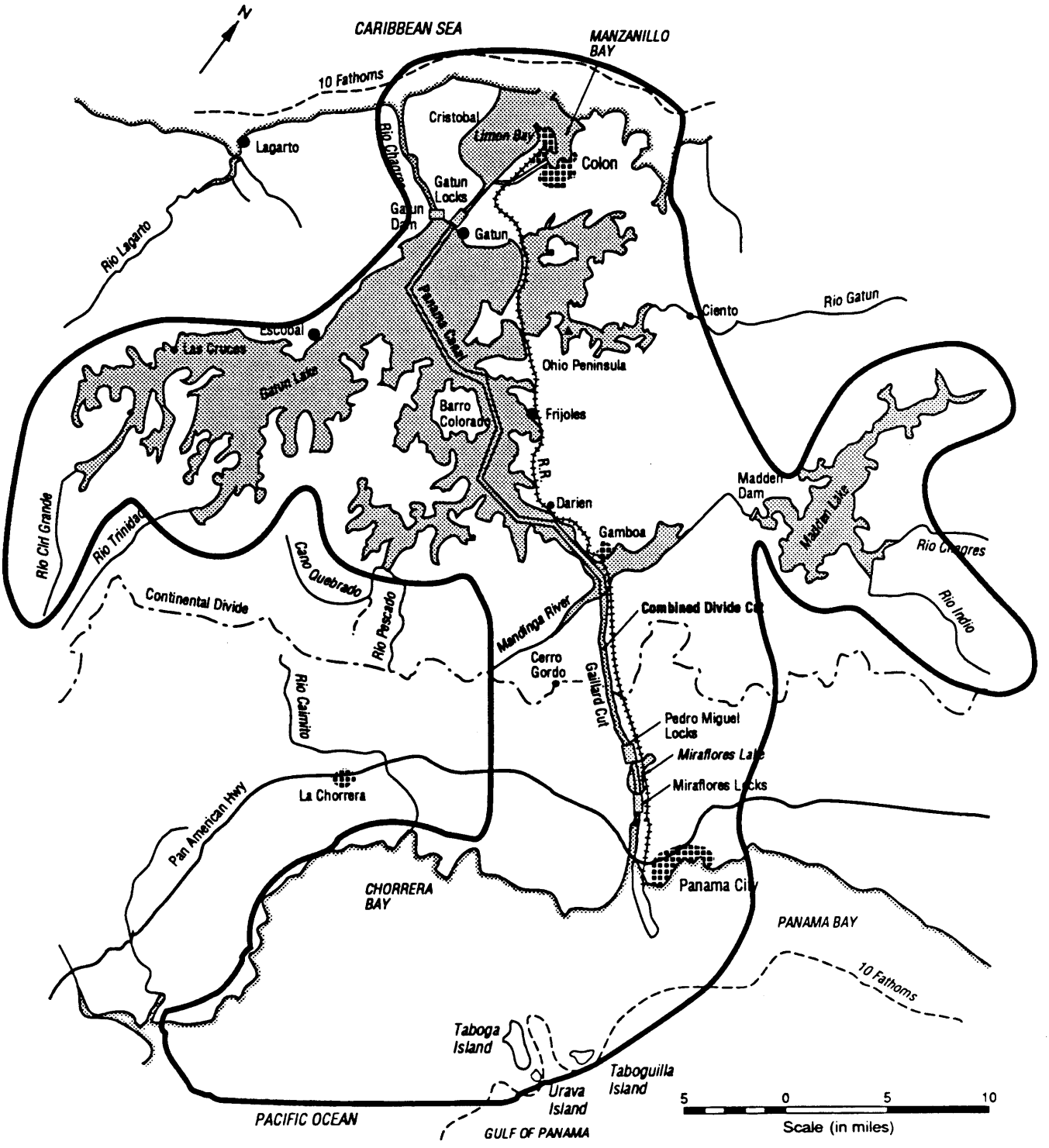


Figure 6 Study Area

Hilly terrain that lies within the protected limits of the former Canal Zone is the source of virtually all watercourses that flow across the east and west banks of Gaillard Cut. The drainage areas of these perennial and intermittent streams have remained substantially vegetated, and unaffected by urbanization and industry. They are characterized by shallow depths and slow velocities because of the primarily low topography, and ordinarily experience temporary increases in flow and turbidity during the rainy season. The net discharge contributed by the Cut's tributaries is very small in comparison to the influx of waters from the Gatun and Madden Reservoirs and their principal effluents.

The waters of Gaillard Cut flow southward and through the Pacific-side locks. Because of this seaward flushing process, the Cut is replenished almost constantly by fresh water. Significant turbidity increases occur during wet season, especially from the Chagres River. Detailed studies by the Canal organization have confirmed that water in the Cut is of good physical and chemical quality throughout the year (Gonzales et al, 1975). Canal water baseline data acquired in 1972, 1975, and 1979 are shown in Table 1.

A follow-on survey of water quality in Gaillard Cut and in Gatun Lake at proposed alternative open-water disposal sites was performed during 1984 and 1985. Data were obtained from a profile of the water column at each sampling station as summarized in Table 2. These findings, for a broad range of parameters (secchi disk depth, temperature, pH, dissolved oxygen or DO, biochemical oxygen demand or BOD, turbidity, suspended solids, nitrogen, and phosphorous), indicated that water quality in Gaillard Cut has remained comparable to the earlier surveys.

Gatun Lake, one of the largest man-made impoundments in the world, possesses many small bays and a total shoreline of more than 1,000 miles. Its deepest areas lie in the main body North of Barro Colorado Island, where some soundings are over 70 feet. The waters predominantly are of excellent quality, and have high transparency, low fecal coliform counts, almost neutral pH, and DO levels near saturation with less than 0.5 mg/1 difference between the top and bottom. Water temperatures range from 27.5° to 29.5°C all year, and there are no significant thermoclines because the difference from top to bottom usually is less than 0.4°C. The waters are soft, 35-45 mg/1 hardness, and low in alkalinity, less than 40 mg/1. Nutrient content also is low, but sufficient to support a large biomass of aquatic macrophytes. Gatun Lake is in a mesotrophic state of eutrophication and thus maintains a high rate of productivity in a well-balanced ecosystem. A detailed limnological review was published by Zaret in 1984.

Table 1
Water Quality Baseline Data (Panama Canal Area*)

Parameter	Gatun Lake**			Gaillard Cut		
	1972	1975	1979	1972	1975	1979
Temperature (°C)	28.0	28.1	28.1	28.2	28.2	28.2
pH (Unit)	7.3	7.2	7.1	7.0	7.0	7.2
Fecal Coli (Count/100 ml)	31	12	19	112	170	93
DO	6.0	6.2	5.8	5.1	5.8	5.9
BOD (5-Day)	0.64	0.67	0.69	0.55	0.55	0.58
Turbidity (NephelometricTurbidity Unit)	2.66	3.80	3.12	18.3	20.2	9.5
Alkalinity (mg/l CaCO3)	36	36	35	49	47	50
Fluoride	0.051	0.053	0.049	0.05	0.06	0.06
Ammonia	0.02	0.02	0.02	0.012	0.025	0.030
Kjeldahl Nitrogen	0.1	0.13	0.10	0.20	0.24	0.21
Nitrate-N	0.037	0.039	0.034	0.212	0.223	0.085
Total Phosphorus	0.024	0.026	0.015	0.019	0.023	0.026
Arsenic	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Barium	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Cadmium	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Chromium	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Copper	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Iron	124.6	131	138	341	431	450
Lead	<0.040	<0.040	<0.040	<0.040	<0.040	<0.005
Lithium	<0.100	<0.020	<0.020	<0.10	<0.10	<0.10
Manganese	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Mercury	<0.0004	<0.0004	<0.0004	<0.020	<0.020	<0.020
Nickel	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Potassium	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Selenium	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Silver	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Sodium	6.2	6.1	6.2	7.4	7.1	7.4
Zinc	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020

* Annual averages; "<" denotes level below detection limit of test methods; Concentrations expresses in mg/l except where indicated.

** Five representative stations.

Table 2

Water Quality at Proposed Excavation and Open-Water Disposal Sites*

	Secchi (Feet)	Temperature (°C)	pH (Units)	DO (mg/l)	BOD (mg/l)	Turbidity (NTU's)	Suspended Solids	Kjeldahl Nitrogen (mg/l)	Ammonia Nitrogen (mg/l)	Total Phosphorous (mg/l)
Gaillard Cut										
North Sector (north end of Cut)	3.50	27.65	7.38	4.65	.88	10.80	7.50	.10	.007	.024
Central Sector (near Gold Hill)	2.50	27.45	7.16	5.00	.24	12.28	6.67	.10	.011	.033
South Sector (Paraiso potable water intake)	4.00	27.70	6.96	4.84	.57	7.19	2.83	.10	.017	.027
Frijoles Bay										
Part A	7.54	28.75	7.42	6.04	.84	17.74	1.50	.10	.01	.03
Part B	6.67	28.80	7.53	5.93	1.31	16.99	.83	.10	.01	.02
Aojeta Bay										
West half	14.00	28.85	7.88	6.45	1.23	.63	1.76	.10	.010	.015
East half	17.00	28.90	7.72	5.83	1.51	.48	.68	.10	.010	.021
Pena Blanca Bay										
North half	12.75	28.75	7.77	6.00	.35	3.98	.52	.10	.01	.01
South half	13.00	29.10	7.78	5.94	.28	2.68	.52	.10	.011	.011
Adjacent Areas										
Dump 14	5.92	28.45	7.48	5.87	1.26	53.01	.28	.11	.04	.09
Barro Colorado Island (across from Frijoles Bay)	7.25	28.75	7.64	6.07	.33	18.26	1.67	.10	.04	.02

* Results are averages based on two testing cycles performed during 1984 and 1985 wet seasons at given locations; each cycle consisted of a sampling profile comprising top, mid and bottom water levels.

Gatun Lake provides the water necessary to operate the locks during each ship transit. The level of Gatun Lake varies between a maximum of 88 ft (spillway elevation) and minimum of 82 ft (acceptable ship's draft limit). As a result, available storage is about 570,000 acre-feet. Water to maintain the lake level comes from a series of tributaries supplemented by the creation of Madden (Alajuela) Lake on the Chagres River. The level of Alajuela Lake varies considerably, between 200 and 252 ft, and the lake storage capacity is about 460,000 acre-feet. The lake also provides drinking water and the discharge is harnessed for hydroelectric power generation.

The principal tributaries of the Gatun Lake Watershed are the Chagres, Trinidad, Ciri, and Gatun Rivers; numerous small streams additionally feed the system. Major turbidity increases can occur seasonally depending on the amount of rainfall and associated runoff. Turbidity increases associated with inflows from the Chagres River normally will extend North up the channel to Barro Colorado Island, Frijoles Bay, and to a lesser degree, Aojeta Bay. Beyond, there is little evidence of year-round fluctuation in turbidity. The follow-on water quality survey of lake stations was conducted during wet season, and the findings (shown in Table 2) did not indicate any significant changes from the region's average baseline for that time of year.

Water quality differences which appeared between the sampling localities, including readings for secchi disk, BOD, turbidity, and suspended solids, can be attributed to temporary and local impacts of heavy rainfall and close by dredging activities during sampling.

Minimal sediment has accumulated on the rocky and leveled floor of Gaillard Cut since deepening/maintenance was completed there in 1985. The flushing effect carries solid runoff material into and through this narrow channel towards the locks, so only a relatively thin layer normally is deposited at the bottom. Any sediment present in the Cut is disturbed frequently by ship traffic, causing temporary resuspension in the water column.

Limited testing of sediment composition in the Lake was reported by the agency's 1975 water study. It was stated then that there still is slow decomposing organic matter at lake bottom areas, which probably is related to remnants of the forest inundated when Gatun Lake was formed in 1912. Organic debris is continuously added from the vast weed populations at the shorelines and shallow areas, and is oxidized effectively as a result of the almost daily turnover of these waters. The bottom sediments are silty-clay in texture, olive gray in color, and reflect composition of runoff. A very recent, independent report on sediment quality (heavy metals, phosphorus, organic carbon, and total nitrogen) at 80 Gatun Lake localities has confirmed there is a distinctive distribution pattern for most metals along the path of

the old Chagres River bed; the concentrations found altogether are rather low, similar to those reported by the canal organization and can be attributed to geochemical characteristics of the drainage system rather than anthropogenic influences (Delvalle, 1986).

Sediment conditions in Frijoles Bay were analyzed and the findings are summarized in Table 3. Typically, the material contained approximately 70% montmorillonite (a soft clay mineral) and 30% bentonite, kaolinite, and other clay minerals. The chemistry findings did not reveal any unusual values in metals, volatile solids, nitrogen, oil and grease, or chemical oxygen demand (COD), and are within ranges found in earlier surveys.

3.3.2 Biotic Conditions

The country environmental profile prepared by the U.S. Agency for International Development offers a comprehensive report on the terrestrial vegetation of Panama, including the canal area (USAID, no date). An extraordinary diversity of plant species has been associated with the canal area (Leigh et al, 1982), and sections of forest extend up to five miles (the boundary of the former Canal Zone) on either side of the ship channel. In some areas, the distribution of vegetation reflects the influence of railroad and canal construction as well as the farming practices associated with those periods. Practically all of the most valuable timber that helped compose the original forest was removed long ago, and the many fruiting tree species planted since construction now are frequently seen. Canal operations and military training also have contributed to alteration of the natural vegetation processes.

Bank areas and most adjacent slopes already are regularly maintained for a number of activities related to the Canal for lighting, navigational aids, and slope stability. Vegetation close to the channel thus consists primarily of grasses, with some stands of secondary growth particularly along parts of the east side margins.

A vegetation survey was performed within 1 mile of the Canal. As shown on Table 4, more than 100 species were recorded in the survey, and all represent lowland secondary forest associations found over much of tropical American. Among the grasses were cana silvestre or Vietnam grass (Saccharum spontaneum), faragua (Hyarrhenia rufa) and introduced pasture species, Guinea grass (Panicum maximum), Napier grass (Pennisetum prupureum), and Rhode grass (Chloris gayana). Mixed age plant indicators often seen were guarumo, capulin, malagueto, mangabe, and laurel. The common later secondary tree associations of the region included

Table 3

Sediment Quality at Alternative Open-Water Disposal Sites*

	Volatile Solids	Kjeldahl Nitrogen	Oil and Grease	COD	Hg	Pb	Zn	Fe	Cu
Frijoles Bay									
Part A	11.9	347.5	1709.0	8,792.3	0.11	8.4	120.2	77,941	149.9
Part B	10.3	205.2	763.0	15,721.1	0.04	12.1	119.0	72,597	102.7
Aojeto Bay									
West	12.1	331.1	2065.7	47,653.4	0.09	6.0	100.3	73,069	119.2
East	11.3	253.7	984.4	51,125.8	0.06	12.0	105.5	74,639	114.4
Pena Blanca Bay									
North	14.4	556.1	1107.4	56,920.9	0.06	12.9	122.6	79,972	129.2
South	16.9	474.5	2367.1	79,586.8	0.07	14.4	118.9	89,428	149.9

* Concentrations are expressed in mg/kg except where indicated. Results are averages based on two testing cycles performed during 1984 and 1985 wet seasons at given locations. Samples were obtained using a 6"x6" Ekman Dredge.

Table 4

Vegetation Recorded Adjacent to Gaillard Cut

Family	Scientific Name	Common Names	Sampling Stations W-1	W-2	W-3	W-4	E-1	E-2	E-3
ANACARDIACEAE	Anacardium excelsium	Espavé	C	C	C		C	C	C
	Astronium graveolens	Zorro						O	
	Mangifera indica	Mango	O	C	O		C	C	C
	Spondias mombin	Jobo, Hog Plum	C	C	C		C	C	C
ANNONACEAE	Annona reticulata	Anón	C	C			C	C	C
	A. spraguey	Toeta	C	C			C		C
	Xylopia frutescens	Malagueto	C	C	C		C	C	C
	X. sp.	Malagueto	C	C			C	C	C
ARACEAE	Dieffenbachia longispatha	Otó de lagarto				*			
	Philodendron sp.	Philodendron	*						
ARALIACEAE	Didymopanax morototoni	Mangabe, Guarumo de pava	C	C	C	O	C	C	C
	Sciadodendron excelsum	Jobo, Corroncho de largarto						C	
BIGNONIACEAE	Jacardanda copaia	Jacaranda, Cigarrillo	C	C				C	C
	Bignonia sp.?	Liana, Bejuco	*	*					
	Probably Arrabidaea sp.	Bejuco	*	*				C	C
	Tabebuia guayacan	Guayacán	C	C				C	C
	T. rosea	Roble de sabana	O						
BOMBACACEAE	Ceiba pentandra	Ceiba, Bongo	*					*	
	Ochroma pyramidale	Balsa, Balso	C	C	C	C	C	C	C
	Pseudabombax septenatum	Barrigón, Ceibo barrigón	C	C			C	C	C
BORAGINACEAE	Cordia alliodora	Laurel	C	C		C	C	C	C
BUSERACEAE	Bursera simaruba	Carate, Indio desnudo, Almácigo	C	C	C	C	C	C	C
CAESALPINIOIDEAE	Cassia multijuga?	Cañafistulo de Montaña, Bronze shower					C	C	C
	C. sp.	Cassia							*
	C. reticulata	Laureño						*	
COCHLOSPERMACEAE	Cochlospermum vitifolium	Poro-poro, Brazilian rose	C	C	C	C	C	C	C
COMBRETACEAE	Terminalia amazonia	Amarillo real	C	C	C			C	C
CYATHEACEAE	Cyathea sp.	Helecho arbóreo, Tree ferm	O	*					*
CYCLANTHACEAE	Carludovica palmata	Portorrico, Jipa-japa	C	C	C			C	C
	Cyclanthese bipartitus	Lengua de buey	O	*	*			*	

Table 4 (Cont'd)

Family	Scientific Name	Common Names	Sampling Stations W-1	W-2	W-3	W-4	E-1	E-2	E-3
CYPERACEAE	Cyperus sp.	Junco	O	*	*				*
DILLENIACEAE	Curatella americana	Chumico				*		*	*
	Davilla nitida	Chumiquillo							*
ELAEOCARPACEAE	Muntingia calabura?	Periquito, Capulin							*
EUPHORBIACEAE	Croton billbergianus	Sangrillo					C	C	O
	Chamaesyce hirta	Hierba de pollo						*	
	Hevea brasiliensis	Caucho, Rubber tree						*	
	Sapium caudatum	Olivo, Wild fig		C				C	
FLACOURTIACEAE	Hasseltia floribunda	Parimontón, Raspa lengua							*
GESNERIACEAE	Kohleria tubiflora	Undetermined						*	
GRAMINEAE	Chusquea sp.	Carricillo	C	C			C	C	C
	Gynerium sagittatum	Caña blanca, Wild cane			C				C
	Hyperrhenia rufa	Faragua		C	C			C	C
	Panicum grande	Guinea	*						
	P. maximum	Guinea grass		C			C	C	C
	P. purpurascens	Pará grass				*			
	Paspalum sp.	Undetermined		*					
	P. virgatum	Cabezona						*	
	Pennisetum purpureum	Elefante, Napier grass						*	
	Saccharum spontaneum	Caña silvestre, Caña salvaje	O	C	A	A	C	C	VF
	Setaria sp.	Rabo de mono		*				*	*
GUTTIFERAE	Vismia baccifera	Achiotillo, Pintamozo	C	C			C	C	C
LAURACEAE	Ocotea sp.?	Aquacate	C	C				C	
	Persea americana	Sigua						*	
LECYTHIDACEAE	Gustavia sp.	Membrillo	C	C		C	C	C	C
MALPIGNIACEAE	Byrsonima crassifolia	Nance		C	C	C	C	C	C
MARANTHACEAE	Calathea sp.	Calatea	*	*					
MELASTOMATACEAE	Clidemia sp.	Undetermined							
	Miconia argentea	Papelillo	C	C			VF	C	C
	M. sp.?	Dos caras	C	C			C	C	C

Table 4 (Cont'd)

Family	Scientific Name	Common Names	Sampling Stations W-1	W-2	W-3	W-4	E-1	E-2	E-3
MELIACEAE	Cedrela odorata	Cedro, Spanish cedar			*		*	*	
	Trichilia sp.	Alfajia					C	C	
MIMOSOIDEAE	Acacia melanoceras	Cachito							*
	Enterolobium cyclocarpum	Corotú	C	C		C	C	C	C
	Mimosa sp.	Dormidera, Sensitive plant	*	*	*	*	*	*	*
	Inga sp.	Guavo	C	C		C	C	C	C
	Pithecellobium sp.	Pichinde							C
MORACEAE	Brosium alicastrum	Verbá, Berbá						O	O
	Castilla elastica	Hule, Caucho	C	C					
	Cecropia sp.	Guarumo, Trumpet tree	C	C	C	C	C	C	C
	Ficus sp.	Higuerón	C	C	C		C	C	C
	F. sp.	Undetermined	O						
MUSACEAE	Heliconia sp.	Bijao, Chichica	*	*	*	*	*	*	*
	Musa sp.?	Platanillo	*	*			*		
MYRTACEAE	Syzygium jambos	Pomarosa, Rose apple	*	*			*		
	Psidium guajava	Guayaba						*	
PALMAE	Acanthorrhiza warscewiczii	Palma de escoba							*
	Astrocaryum standleyanum	Chonta, Black palm					C	C	C
	Bactris sp.	Caña brava	C						C
	Desmoncus sp.	Matamba							C
	Elaeis oleifera	Corozo, Corocito	C	C			C	C	VF
	Oenocarpus panamanus	Maquenque, Trufa	C	C					
	Roystonea regia	Palmera real		O			C	C	
	Scheelea zonensis	Palma real, corozo	C	C			C	C	VF
PAPILIONDIDEAE	Andira inermis	Almendro de rio, Cabbage bark					C	C	
	Crotalaria retusa?	Crotalatia	*	*		*			*
	C. vitellina?	Crotalaria		*					
	Diphysa robinioides	Macano							*
	Erythrina fusca	Gallito, Palo santo	C			C	C	C	C
	Glyricidia sepium	Mata ratón, Balo						*	
	Mucuna pruriens?	Pica-pica		*		*			*
	Ormosia sp.	Peronil	*						
PIPERACEAE	Piper sp.	Cordoncillo	*	*			*	*	*
	P. sp.	Hinojo oloroso							
POLYGONACEAE	Coccoloba sp.	Uvero						*	
	Triplaris cumingiana	Vara santa	C	C		C	C	C	C

Table 4 (Cont'd)

Family	Scientific Name	Common Names	Sampling Stations W-1	W-2	W-3	W-4	E-1	E-2	E-3
RUBIACEAE	Cephaelis sp.	Undetermined	*	*					
	Genipa americana	Jagua	C				C	C	C
	Isertia sp.?	Undetermined							*
RUTACEAE	Zanthoxylum sp.	Arcabú, Prickly yello	C					C	C
SAPINDACEAE	Paulinia sp.?	Bejuco	*	*					
SAPOTACEAE	Chrysophyllum cainito	Caimito	C	C					C
SELLAGINELLACEAE	Selaginella sp.	Selaginela						*	*
SIMAROUBACEAE	Simeroube amara	Aceituno						*	
SOLANACEAE	Solenum asperum	Friega platos							*
	S. sp.?	Undetermined							
STERCULIACEAE	Guazuma ulmifolia	Guácimo, Bastard cedar	C	C	C	C	C	C	C
	Helicteres guazumaefolia	Majaguillo, Guácimo torcido		*					
	Sterculia apetala	Panamá, Panama tree		C		C	C	C	
TILIACEAE	Apeiba tibourbou	Cortezo, Monkey comb	C	C	C	C	C	C	C
	Luehea speciosa	Guácimo colorado	C	C	C		C	C	C
	L. sp.	Guácimo pacheco	C	C					C
ULMACEAE	Trema micrantha	Capulin, Jordancillo	C	C				C	C
VERBENACEAE	Lantana camara	Lantana							C
	Vitex gigantea	Cuajado blanco						O	O
VOCHYSIACEAE	Vochysia herruginea	Mayo, Yemeri mayo, Pegle					C	C	
ZINGIBERACEAE	Costus villosissimos	Caña agria	*	*					*

KEY: O=Occasional; C=Common; VF=Very Frequent; A=Abundant; *=Observed, but numbers not recorded

barrigon, cuajado blanco, verba, jacaranda, Panama tree, gallito, sagrillo, and many more. A number of hardwoods also were observed, such as guayacan (Tabebvia guayacan and T. rosea), prickly yellow (Zanthoxylum sp.), amarillo real (Terminalia amazonia), zorro (Astronium graveolens), and espave (Anacardium excelsium), but as expected very few were of commercially attractive size. Selective logging throughout the region long ago was further evidenced by the absence or near absence of fine wood trees like cedar (Cedrela odorata) and mahogany (Suwietenia macrophilla), and contrasted with an abundance of mango (Magnifera indica), rose apple (Syzygium jambos), caimito (Chrysophyllum cainito), and other cultivated fruit-bearing species.

Dry season fires often occur, just as throughout Panama's countryside, but revegetation soon takes place with the onset of the first rains of the wet season. Nearby secondary forests, mainly established on the hilly terrain, normally are not burned but may be subject to slash-and-burn agriculture.

Steep slopes at the channel margins, relatively deep water depths along the banks, the constant disturbance by transiting ships in the excavation areas do not permit development of aquatic vegetation except in a few small inlets. Small pieces of floating plant mats sometimes move from the contiguous river and lake waters into and out of the Gaillard Cut, southward with the current.

The phytoplankton and macrophyte communities of Gatun Lake have been carefully reviewed by the canal agency, in connection with an earlier sea-water pumping feasibility analysis (Weers, 1974; Pasco, 1974; Teas, 1974). Algal populations were shown to consist of nearly 180 species representing four groups: the Chlorophyta (green algae, including desmids), Bacillariophyta (including diatoms), Cyanophyta (blue-green algae), and Pyrrophyta (including dinoflagellates). Because Gatun Lake waters are thoroughly mixed and lack thermoclines, these phytoplankton are uniformly distributed in the water column. No single species dominates the community throughout the year, as desmids are most prevalent in the rainy season and diatoms and nannoplankton populations are highest at the end of that period and during dry season. Occasionally, blue-green algae also become locally abundant.

There are at least 28 species of macrophytes identified from Gatun Lake, consisting of submergent, emergent, free-floating, and marginal plants. The dominant species, Hydrilla verticellata, is indigenous to India, but apparently had been in the canal area for many years and began proliferating in Gatun Lake after year-round water level stabilization was achieved with completion of Madden Dam. Hydrilla maintains dense foliage from within approximately three feet of shore out to depths of 20 feet or slightly more, and its growth must be closely monitored by the Panama Canal

Commission. Other pest weeds of importance are water hyacinth (Eichornia crassipes) and water lettuce (Pistia stratiotes); when unchecked these species can form large free-floating mats at river banks and lake shorelines.

Panama's National Institute for Renewable Natural Resources (INRENARE, formerly RENARE) has developed a list of the wide variety of animals that may be found within the Panama Canal Watershed and adjacent areas. This is provided in Table 5. Additional discussions on the wildlife species characteristic of the former Canal Zone are presented in the Installation EIS prepared for the U.S. Army Garrison-Panama (formerly the 193d Infantry Brigade) (VTN Louisiana, Inc., 1977). Following is an overview of the major taxonomic groups.

Mammals-Handley (1966) and Mendez (1970) offer comprehensive descriptions of the mammalian fauna of Panama. Widespread hunting resulting in the near disappearance of certain large animals, including jaguars and other cats, tapirs, deer, capybaras and peccaries from the canal area and contiguous lands long ago. However, many of the smaller types have remained relatively abundant in the region's protected grass, scrub and forest habitats. The most commonly seen in the study area are coatimundis, opossums, armadillos, sloths, rabbits, bats, raccoons, tree squirrels, marmosets, nequis, agoutis, and other various rodents. INRENARE considers a number of small, terrestrial mammals to be endangered or threatened in Panama yet many of them (armadillos, marmosets, nequis, agoutis, etc.) may be locally common especially in the forests of the former Canal Zone. These populations remain protected since treaty implementation, largely due to the designation of national parks (Parque Nacional Soberania, Parque Natural Metropolitano, and Parque Nacional Chagres) and the Barro Colorado Island Nature Monument.

The long-tailed otter (Lutra annectens) is a rather uncommon aquatic mammal known to occur in Gatun Lake. The West Indian manatee (Trichechus manatee) is another rare aquatic species inhabiting Gatun Lake. This mammal apparently occurred in the Chagres River valley prior to the building of the Canal, but was eliminated later by rural subsistence hunters. Descendants from nine specimens that were stocked during 1964 for canal weed control are now distributed in various parts of the lake.

Reptiles and amphibians – Snakes are very numerous in Panama and most of the approximately 130 different kinds, including commonly encountered boas, are not poisonous. Venomous snakes that may occur in the study area comprise both corals and vipers; they are represented by bushmasters, fer-de-lances, hog-nosed and eyelash vipers. Also common are turtles, lizards, frogs, toads, and salamanders.

Table 5

List of Wildlife Recorded from Panama Canal Watershed Based on Data Compiled by National Bureau of Renewable Natural Resources, Panama, 1984

Class	Order	Scientific Name	Spanish Common Name
Mammalia	Lagomorpha	Sylvilagus brasiliensis	Conejo muleto
	Rodentia	Sciurus granatensis	Ardilla colorada
		S. variegatoides	Ardilla negra
		Coendou rothschild;	Puerco espin
		Hydrochaeris hydrochaeris*	Poncho, Capibara
		Agouti paca*	Conjeo pitado
		Dasyprocta punctata*	Neque, Machango
		Proechymis semispinosos	Mocangue
	Carnivora	Urocyon cinereoargenteus	Micho de cerro
		Procyon cancrivorus*	Gato manglatero
		P. lotor*	Gato manglatero
		Nasua nasua	Gato solo
		Lutra annectens (longicaudis?)	Nutria
		Potos flavus	Cosumbi
		Bassaricyon gabbii	Olingo
		Mustela frenata	Comadreja
		Eira barbara	Gato negro
		Galictis vittata	Lobo pollero
		Felis onca*	Tigre, Jaguar
		F. pardalis*	Manigordo
		F. wiedii*	Tigrillo congo
		F. jagouaroundi*	Tigrillo congo
		F. concolor	Puma
	Sirenia	Trichechus manatus*	Manati
	Perissodactyla	Tapirus bairdii*	Tapir, Macho de monte
	Artiodactyla	Tayassu pecari*	Puerco de monte
		T. tajacu*	Zaino
		Odocoileus virginianus	Venado de cola blanca
		Mazama americana	Venado colorado
			Mono aullador
			Mono arana colorado
			Mono titi
			Mono nocturno, Jujuna
			Mono cariblanco

Table 5 (Cont'd)

Class	Order	Scientific Name	Spanish Common Name
	Primates	Alouata palliata*	Mono aullador
		Ateles Geoffroyi*	Mono arana colorado
		Saguinus geoffroyi*	
		Aotus trivirgatus*	
		Cebus capucinus*	
	Marsupialia	Didelphis marsupialis	Zorra
		Caluromys derbianus	Zorra roja
	Chiroptera	Desmodus rotundus	Vampiro comun
		Noctilio leporinus	Murcielago pescador
		Diclidurus virgo	Murcielago blanco
		Vampyrum spectrum	Falso vampiro
		Diacmus youngii	Vampiro overo
	Edentata	Myrcecophaga tridactyla#	Oso caballo
		Tamandua tetradactyla	Oso hormiguero
		Cyclopes didactyles*	Tapacacara, Gato balsa
		Bradypus infuscatus	Perezoso de 2 dedos
		Cabassous centralis*	Armadillo rabo de puerco
		Dasypys novemcictus*	Armardillo
Amphibia	Anura	Bufo marinus	Sapo comun
		B. typhonius	Sapo
		Hyla phlebodes	Rana
		H. crepitans	Rana
		Agalychnis callidryas	Rana
		Dendrobates auratus	Rana
		Colestethus nubicola	Rana
		Leptodactylus pentadactylus	Rana
		L. bolivianus	Rana
		Rana warschewitschi	Rana
		Atelopus varius zeteki*	Rana dorada
Reptilia	Apoda	Oscaecilia ochrocephala	Cecilia
	Crocodilia	Crocodylus acutus*	Lagarto aguja
		Caiman crocodylus fuscus*	Babilla
	Squamata	Iguana iguana*	Iguana verde
		Anolis auratus	Lagartija
		A. biporcatus	Lagartija
		Corithophanes cristatus	Camaleon

Table 5 (Cont'd)

Class	Order	Scientific Name	Spanish Common Name
Reptilia	Squamata (cont.)	Basiliscus basiliscus	Meracho
		Thecadactylus rapicaudus	Salamenguesa
		Lepidoblepharis sanctaemartea	Salamenguesa
		Mabuya mabouya	Mata caballo
		Gonotodes albogularis	Limpiacasa
		Ameiva ameiva	Borriguero
		A. festiva	Borriguero
		Lachesis muta	Berrugosa
		Bothrops atrox	Berrugosa
		B. schlegelii	Taboba de pestana
		Micrurus mipartitus	Coral
		Boa constrictor	Boa
		Corallus annulatus	Boa
		Rhadinaea decorata	Culebra
		Rhinobothryum bovalli	Falsa coral
		Xenodon yabdocephalus	Culebra
		Clelia clelia	Culebra
Aves	Tinamiformes	Tinamus major*	Perdiz de arca
		Crypturellus soui	Perdiz de rastrojo
	Podicipediformes	Podiceps dominicus	Buzo
		Podilymbus podiceps	Buzo
	Pelecaniformes	Annhinga anhinga	Cuervo de aguja
		Pelecanus occidentalis	Pelicano
		Phalacrocorax olivaceus	Pati cuervo
		Fregata magnificens	Tijereta de mar
	Cicorniformes	Butorides virescens	Martinete
		Casmerodios albus	Garza real
		Tigrisoma lineatun	Garza tigre rayada
		Cochlearius cochlearius	Garzota cuchara
		Agami agami	Garza pechicastana
		Ixobrychus exilis	Garza enana

Table 5 (Cont'd)

Class	Order	Scientific Name	Spanish Common Name
	Anseriformes	Dendrocygna viduata	Jacamillo
		D. bicolor	Yaguoso colorado
		D. autumnalis*	Guichichi
		Cairina moschata*	Pato real
		Anas americana	Pato calvo
		A. platyrhynchos*	Ana de real
		A. cyanoptera	Cerceta colorado
		A. discors	Cerceta ala azul
		A. clypeata	Pato cuchara
		Aythya collaris*	Pato de collar
		A. a	Pato pechiblanco
		ffinis*	Pato tigre
		Oxyura dominica*	
Aves	Falconiformes	Sarcoramphus papa	Rey de gallinazo
		Cathartes aura	Noneca
		C. burrovianus	Guala
		Coragyps atratus	Gallote
		Elanus leucurus#	Milano
		Elanoides forficatus#	Gavilan tijereta
		Leptodon cayanensis#	Gavilen cabecigris
		Chondrohierax uncinatus#	Gavilan piquiganchudo
		Harpagus bidentatus#	Gavilan bidente
		Ictinia plumbea#	Gavilan plomizo
		Accipiter superciliosus#	Gavilancito enano
		Buteo magnirostris#	Cuiscui
		B. jamaicensis#	Guaranguao
		B. albonotatus#	Gavilan negro
		Buteogallus antharacinus#	Gavilan cangrejo
		Harpya harpyja#	Harpia
		Spizaetus tyrannus#	Aguila crestuda negra
		Herpetotheres cacinnas#	Vaquero
		Micrastur ruficollis#	Halcon de monte rayado
		M. semitorquatus#	Halcon del monte collarejo
		M. mirandollei#	Halcon gateador
		Daptrius americanus#	Caracara
		Milvago chimachima#	Chimango
		Falco peregrinus*	Halcon peregrino
	Galliformes	Crax rubra	Pavon, Pava rubia
		Penelope purpurascens	Pava cimba
		Ortalis cinereiceps	Paisana
		Odontophorus gujanensis	Gallito de monte
		Rhynchortyx cinctus	Gallito de monte menor
		Colinus cristatus	Codorniz
		Odontophorys erythrops	

Table 5 (Cont'd)

Class	Order	Scientific Name	Spanish Common Name
	Gruiformes	Aramus guarauna	Carrao
		Aramides cajanea	Cocaleca gris
		Gallinula chloropus	Gallineta de agua
		Porphyrula martinica	Polla sultana
		Fulica americana	Gallineta ceniciente
		Heliornis fulica	Patico de agua
Aves	Charadriiformes	Pluvialis dominica	Chorlito dorado
		Charadrius collaris	Turillo
		Caladris canutus	Playero gordo
		Jacana jacana	Gallito de agua barbudo
		Tringa solitaria	Playero solitario
		Actitis macularia	Playerito coleador
		Gallinago gallinago	Agachadiza
		Larus argentatus	Gaviota argentea
		L. pipixcan	Gaviota de franklin
		Chlidonias niger	Gaviotin negro
		Sterna hirundo	Gaviotin comun
	Columbiformes	Columba cayennensis*	Torcaza comun
		C. speciosa*	Paloma escamosa
		C. nigrirostris*	Tres pesos son
		C. talpacoti	Tortolita colorada
		Leptotila verreauxi	Paloma rabiblanca
		Geotrygon veraguensis	Paloma verdusca
	Psittaciformes	Brotogeris jugularis#	Perico piquiblanco
		Pionus menstruus#	Cazanga
		Amazona autumnalis#	Loro mona roja
		A. farinosa#	Loro verde o real
		Ara macao#	Guacamaya bandera
		A. chloroptera#	Guacamaya roja
		A. severa#	Guacuita
		Amazona ochrocephala#	Loro mona amarilla
	Cuculiformes	Piaya minuta	Pajaro ardilla enano
		Crotophaga major	Cocinera
		C. ani	Garrapatero comun
		Dromococcyx phasianellus	Pajaro gallo
		Neomorpus geoffroyi	Hormiguero montanes
		Coccyzus americanus	Cuclillo piqui-amarillo
	Strigiformes	Otus guatemalae#	Buhito jaspeado
		Lophostrix cristata#	Buho penachudo
		Pulsatrix perspicillata#	Buho de anteojos
		Ciccaba virgata#	Buho montanes
		C. nigrolineata#	Buho blanquinegro
		Tito alba#	Lechuza

Table 5 (Cont'd)

Class	Order	Scientific Name	Spanish Common Name
	Caprimulgiformes	Lurocalis semitorquatus	Tapacamino selvatico
		Chordeiles acutipennis	Tapacamino menor
		Nyctidromus albicollis	Capacho
		Caprimulgus rufus	Dormilon moreno
Aves	Apodiformes	Chaetura spinicauda	Vencejo de rabadilla blanquecina
		Glaucis hirsuta	Ermitano barbudo
		Threnetes ruckeri	Pico de hoz
		Colibri delphinae	Colibri de coronilla
		Amazilia amabilis	Colibri hermoso
		A. tzacatl	Colibri colicastana
		Chalybura urochrysia	Colibri colibronceado
		Damaphila julie	Colibri pechiviolaceo
		Thalurania colombica	Colibri de coronilla
		Klais guimeti	Colibri cabeciviolaceo
		Lophornis delattri	Coqueta corona leonada
	Trogoniformes	Trogon messena	Aurora
		T. melanurus	Aurora colilarga
		T. viridis	Tragon de cola blanca
		T. rufus	Tragon gracioso
		T. violaceus	Tragon violaceo
	Coraciformes	Ceryle torquata	Martin pescador grande
		C. alcyon	Martin pescador pasajero
		Chloroceryle americana	Martin pescador verde
		Electron platyrhynchum	Pajaro raqueta piquiancha
		Momotus momota	Pajaro raqueta de coronilla azulada
	Piciformes	Capito maculicoronatus	Capitan corona manchada
		Aulacorynchus prasinus	Currutaco
		Seleidera spectabilis	Pichilingo prieto
		Celeus loricatus	Capintero prieto
		Campehilus haematogaster	Carpintero acanelado
		Pteroglossus torquata	Pichilingo
		Ramphastos sulfuratus	Paleton
		Piculus callopteros	Carpintero de mejilla rayada
		Dryocopus lineatus	Carpintero real barbirayado

Table 5 (Cont'd)

Class	Order	Scientific Name	Spanish Common Name
Aves	Apodiformes	Chaetura spinicauda	Vencejo de rabadilla blanquecina
		Glaucis hirsuta	Ermitano barbudo
		Threnetes ruckeri	Pico de hoz
		Colibri delphinae	Colibri de coronilla
		Amazilia amabilis	Colibri hermoso
		A. tzacatl	Colibri colicastana
		Chalybura urochrysia	Colibri colibronceado
		Damophila julie	Colibri pechivioláceo
		Thalurania colombica	Colibri de coronilla
		Klais guimeti	Colibri cabeciviolaceo
		Lochornis delattri	Coqueta corona leonada
	Trogoniformes	Trogon massena	Aurora
		T. melanurus	Aurora colilarga
		T. viridis	Tregon de cola blanca
		T. rufus	Tregon gracioso
		T. violaceus	Tregon violaceo
	Coraciformes	Cervle torquata	Martin pescador grande
		C. alcyon	Martin pescador pasajero
		Chloroceryle americana	Martin pescador verde
		Electron platyrhynchum	Pajaro raqueta piquiancha
		Momotus momota	Pajaro raqueta de coronilla azulada
	Piciformes	Capito maculicoronatus	Capitan corona manchada
		Aulacorynchus prasinus	Currutaco
		Selenidera spectabilis	Pichilingo prieto
		Celeus loricatus	Capintero prieto
		Campephilus haematogaster	Carpintero acanelado
		Pteroglossus torquatus	Pichilingo
		Ramphastos sulfuratus	Paleton
		Piculus callopteros	Carpintero de mejilla rayada
		Dryocopus lineatus	Carpintero real barbirayado

Table 5 (Cont'd)

Class	Order	Scientific Name	Spanish Common Name
	Passeriformes	Dendrocincla fuliginosa	Trepedor pardo
		Decohychura longicaudata	Trepador cola de una
		Dendrocolaptes certhia	Trepador barreteado
		Xiphorphynchus lachrymosus	Trepador listado
		Lepidocolaptes souleyetii	Trepador cabecirayado
		Sclerurus guatemalensis	Raspa hoja
		Thamnophilus punctatus	Pavita hormiguera ceniza
		Thamnistes anabatinus	Hormiguero bermejon
		Dysithamnus punticeps	Hormiguero coronipunteado
		Myrmotherula fulviventris	Hormiguero leonado
		Pittasoma michleri	Merendero
		Chiroxiphia lanceolata	Toledo
		Shiffornis turdinos	Saltarin paralauta
		Sapayoa aenigma	Verdon de montana
		Cotinga nattererii	Cotinga azul mayor
		Sirystes sibilator	Papamosca copeton
		Platyrinchus mystaceus	Piquichato gargantiblanco
		Tolmomyias assimilis	Moscareta amarilleja
		Elaenia chiriquensis	Mononcita
		Ramphocelus dimidiatus	Sangretoro
		Myopagis gaimardii	Monona montaraz
		Leptopogon amaurocephalus	Moscareta cabeciparda
		Ornithion brunneicapillu	
		Trachycineta bicolor	Golondrina
		Neochelidon tibialis	Golondrina
		Thryothorus rufalbus	Ruisenor
		Henicornina leucosticta	Ruisenor
		Mycrobates cinereiventris	Ruisenor
		Vireo altiloquus	Ruisenor
		V. flavoviridis	Ruisenor
		Hylophilus aurantiifrons	Ruisenor
		Cyanerper lucidus	Ruisenor
		Dendroica pensylvanica	Canario
		Wilsonia canadensis	Canario
		Gymnostinops montezuma	Canario
		Cacicus cela	Calandria
		Icterus mesomelas	Calandria
		I. galbual	Calandria
		Euphonia anneae	Calandria
		E. minuta	Calandria
		Tangara florida	Calandria
		T. gyrola	Calandria
		Piranga flava	Calandria
		Habia rubic	Calandria
		Tachyphonus delatrii	Calandria
		Heterospingus rubrifons	
		Chrysothlypis chrysomelas	
		Saltator maximus	
		S. atriceps	
		Tiaris olivacea	
		Atlapetes brunneinucha	
		Emberizoides herbicola	

The green iguana (Iguana iguana), protected in Panama because of intense hunting pressure, is abundant in the canal area. Iguanas often are attracted to bare ground for nesting along the banks of rivers and islands, and the shores of Gatun Lake; soft, exposed material at recent excavation and disposal sites also has been sought for egg-laying. The American crocodile (Crocodylus acutus), which is considered endangered throughout Central and South America, is found in limited numbers in the lake and Gaillard Cut, as are populations of the aguja caiman (Caiman crocodylus fuscus).

Birds – There is a great diversity of bird life throughout the Isthmus. According to Ridgely (1976), almost 900 species of birds have been sighted in Panama (more than occur in the entire United States and Canada) and approximately 700 breed locally. During the northern autumn and spring periods, migrant passerines and ducks become conspicuous elements of the avifauna. In December, during the annual Christmas count performed by the Panama Audubon Society, more than 200 kinds of birds usually are recorded from the Pacific Canal localities. As with mammals, hunting pressures before controls were instituted years ago reduced a segment of the native population, and there now are few resident wild turkeys, quail, eagles, ducks and many other game and nongame birds in the study area. Terns, herons, egrets, kingfishers, teals and other waterfowl, which formerly preyed on phytophagous fish species, also have been disappearing from Gatun Lake over the past 20 years. Among birds normally encountered in the study area are buzzards, grackles, hummingbirds, kingbirds, robins, wrens, finches, flycatchers, and tanagers.

The types of aquatic life found in Gatun Lake and its contiguous water, are extensively described in several contributing papers to the sea-water pumping feasibility analysis (Greenberg, 1974;Abele, 1974; Hurlbert, 1974; Zaret, 1974; Hogue, 1974; Bozeman and Dean, 1974) and in the Canal agency's EIS prepared for introduction of the white amur (Ctenopharyngodon idella) into Gatun Lake during 1977 (Panama Canal Co., 1977). The studies have included population dynamics and relationships to plant ecosystems for the lake's zooplankton, fishes, molluscs, crustaceans, insects and related organisms. An up-to-date compilation of works by Zaret (1984) also provides a detailed account of this most intensively examined of Central American lakes. Following is a summary of the principal nonmammal groups that occur in Gatun Lake.

Zooplankton – The zooplankton community is dominated by crustaceans and rotifers. The crustaceans are principally represented by cladocerans and copepods, with a brief appearance of decapod shrimp larvae in the plankton early each year. In addition to these limnetic (open water) animals, there is a variety of small benthic crustaceans dominated by paeleomonid shrimps.

Fishes – The most common freshwater fishes recorded from Gatun Lake represent the families Atherinidae, Characidae, Cichlidae, Gobidae, Eleotridae, Pimelodellidae, and Poeciliidae; there are also several marine forms that enter via the locks. The species historically found in the lake proper, the locks and adjacent drainage are listed in Table 6, although probably many are no longer present or are very rare because of the impact of the accidental introduction of a predatory South American cichlid in 1967.

Benthos – Fresh-water bottom-dwelling organisms are principally comprised of populations of molluscs, annelids, and arthropods. At the relatively turbulent and sediment-free bottom of Gaillard Cut, establishment of such communities is difficult and limited. In contrast, the conditions of depth, water quality and accumulated sediment in Gatun Lake often favor benthos development. A special study conducted to determine biological impacts of channel deepening, showed that in areas sampled near Barro Colorado Island the molluscs contributed by far the greatest biomass (Zaret, 1974). As many as 51 bivalves and 70 snails per square meter were recorded, and populations showed remarkable consistency between the sampling stations.

Open-water disposal sites proposed in Frijoles, Aojeta, and Pena Blanca bays were surveyed for benthos throughout the approximated boundaries during the March-April period in 1985. A summary of findings is presented in Table 7. Similar to the earlier observations, most collections at the three bays yielded a prevalent clam (Corbicula sp.) and as many as 50 or more specimens were counted in some samples. Two types of snails (Melanoides tuberculata and Pyrogophours coronatus) and an oligochaete worm (Branchiura sowerbyi) were sporadically observed, but were far less common. Again, there was a relatively uniform distribution of the dominant organisms. Other organisms seen rarely in the samples were waterbugs, caddisflies, midges, isopods and leeches.

The literature concerning the marine environment is diverse and fairly extensive. It will not be repeated here. Instead the reader is encouraged to read the summary information in Appendix 16 to Volume 5 of the report of the Atlantic-Pacific Interoceanic Canal Study Commission (1970).

3.4 Background Biological Data

A comprehensive literature survey will be conducted to provide background information on the terrestrial, marine, and freshwater flora and fauna in the vicinity of the study area. The purpose of this task is to acquire, from available information, data

Table 6

Fish Species of Gatun Lake, Canal Locks, and Adjacent Drainages*

Family	Scientific Name
Primary Consumers	
Astroblepidae	Astroblepus longifilis
Callichthyidae	Hoplosternum thoracatum
Characinidae	Astyanax fasciatus
	A. ruberrimus
	Brycon argenteus
	B. chagrensis
	B. petrosus
	B. striatulus
	Bryconamericus cascajalensis
	B. emperador
	Characidium sp.
	Cheirodon affinis
	Compsura gorgonae
	Ctenolucius hujeta
	Curimata magdalenae
	Gasteropelecus maculatus
	Gephyrocharax atricaudata
	Hoplias microlepis
	Hyphessobrycon panamensis
	Piabucina panamensis
	Roeboides guatemalensis
	R. occidentalis
	Saccoderma sp.
Doradidae	Trachycorystes amblops
Hypopomidae	Hypopomus occidentalis
Loricariidae	Ancistrus chagresi
	Chaetostoma fischeri
	Leptoancistrus canensis
Pimelodidae	Imparales sp
	Pimelodella chagresi
	Rhamdia wagneri
Steropygidae	Eigenmannia virescens
Trichomycteridae	Trichomycterus striatus
Secondary Consumers	
Anguillidae	Anguilla rostrata
Cichlidae	Aequidens coeruleopunctatus
	Cichla ocellaris**
	Cichlasoma maculicauda
	Geophagus crassilabris
	Neotroplus panamensis

Table 6 (Cont'd)

Family	Scientific Name	Family	Scientific Name
Cyprinodontidae	Rivulus brunneus	Atherinidae	Melaniris chagresi
	R. chucunaque	Belonidae	Strongylura marina
	R. montium	Bothidae	Citharichtyhs gilberti
Poeciliidae	Brachyrhaphis cascajalensis	Carangidae	Caranx hippos
	B. episcopi		Oligoplites saurus
	B. sp.	Centroponidae	Centropomus armatus
	Gambusia nicaraguensis		C. ensiferus
	Heoheternadria tridentiger		C. nigrescens
	Phallichthys amates		C. parallelus
	Poecilia mexicana		C. pectinatus
	Poeciliopsis elongata		C. robalito
	Priapichthys darienensis		C. undecimalis
Synbranchidae	Synbranchus marmoratus		C. unionensis
		Clupeidae	Ilisha fuerthii
Peripheral Consumers			Sardinella stolifera
Ariidae	Arius multiradiatus	Elopidae	Elops saurus
	Felichthys pinnimaculatus		Megalops atlanticus
	Galeichthys jordani	Eleotridae	Dormitator latifrons
	G. seemani		D. maculatus
	Netuma oscula		Eleotris amblyopsis
	N. planiceps		E. picta
	Selenapsis dowi		E. pisonis

Table 6 (Cont'd)

Family	Scientific Name	Family	Scientific Name
	Euleptoeleotris clarki		Gobionellus microdon
	E. shropshirei		Microgobius miraflorensis
	Gobiomorus dormitor		Sicydium antillarum
	G. maculatus		S. salvini
	Guavina guavina	Lutjanidae	Lutjanus argentiventris
	Hemieleotris latifasciatus		L. aya
	Leptophilypnus fluviatilis		L. colorado
	L. panamensis		L. novemfasciatus
Engraulidae	Anchoa panamensis	Mugilidae	Agonostomus macracanthus
	A. spinifer		A. monticola
	Anchovielle curta		Chaenomugil proboscideus
	A. elongata		Joturus pichardi
	A. lucida		Mugil curema
Gerridae	Diapterus peruvianus	Pomadasyidae	Pomadasys bayanus
	Eucinostomus argenteus		P. crocro
	Gerres cinereus	Pristidae	Pristis microdon
Gobiesocidae	Gobiesox nudus	Sciaenidae	Bairdiella ronchus
Gobiidae	Awaous tajasica		Cynoscion albus
	A. transandeanus		Micropogonia altipinnis
	Bathygobius soporator	Soleidae	Achirus fluviatilis
	Garmannia hildebrandi		A. mazatlanus
	G. homochroma	Syngnathidae	Oosthethus lineatus

Table 6 (Cont'd)

Family	Scientific Name	Family	Scientific Name
	Pseudophallus mindii		
	Syngnathus elcapitanense		
Tetraodontidae	Sphoeroides annulatus		
	S. testudineus		

* Tabulated in connection with the 1974 Gatun Lake sea water pumping feasibility study; list does not inlclude the Chinese carp (Ctenopharyngodon idella) introduced in 1977 as a weed control agent, and two species of chichlids (Tilapia nilotica and T. rendalli) that apparently accidentally reached Gatun Lake in 1983 from pond aquaculture facilities.

** Accidentally introduced in 1967.

Table 7

Dominant Macrobenthos at Alternative Open-Water Disposal Sites in Gatun Lake March-April 1985*

	Frijoles Bay (25 Samples)**	Aojeta Bay (11 Samples)	Pena Blanca Bay (12 Samples)
MOLLUSCS			
Pelecypods (clams)			
Corbicula sp.			
- Mean number per sample	28.6	15.7	30.8
- Percent of total macrobenthos per site	84.4	79.4	87.5
Gastropods (snails)			
Melanoides tuberculata			
- Mean number per sample	2.2	2.4	1.8
- Percent of total macrobenthos per site	6.4	6.9	5.0
Pyrgophours coronatus			
- Mean number per sample	1.9	1.6	1.2
- Percent of total macrobenthos per sample	5.5	7.8	3.3
ANNELIDS			
Oligochaetes (worms)			
Branchiura sowerbyi			
- Mean number per sample	1.5	0.5	1.3
- Percent of total macrobenthos per site	2.5	2.3	3.8

* Based on identificaitons of 48 representative samples, each a four-grab composite using a 6"x6" Ekman Dredge and sieved through standard (No. 50) mesh; 51 additional survey composites examined on-site were consistent with these summarized findings.

** Data combined from 13 samples at Part A and 12 samples at Part B.

on Panamanian flora and fauna in order to provide input to the prescreening of alternatives, guide the subsequent field work and supplement field data in the preparation of descriptions of existing conditions. The information will also be of use in the feasibility analysis, environmental analysis, and in the detailed evaluation of the selected alternative. The information will be identified, obtained, and reviewed and pertinent information summarized. Copies of relevant documents will be provided for inclusion in the Information Center.

Sources of data include various studies and reports directly related to the Panama Canal as well as other projects performed by government and private organizations. Groups of scientists or individuals have performed relevant research and have publications and unpublished data which would be of use. Various individuals and organizations should be consulted to obtain any pertinent information in their possession. Possible sources of information include:

- ANCON Society
- Audubon Society
- Panama Canal Commission (PCC)
- Commission for the Study of Alternatives to the Panama Canal
- Smithsonian Institution (SI)
- Smithsonian Tropical Research Institute (STRI)
- U.S. Army Corps of Engineers
- Universities (Panama, Miami)
- Battelle Memorial Institute
- Libraries
- Databases

Initially, material should be sought from those sources known to have larger amounts of useful data, e.g., PCC, STRI, Battelle, ANCON. As the subject and extent of material becomes clearer, other sources can be approached and a computer database search can be designed to effectively identify publishes references using pertinent key words.

The ecological and water quality information to be collected must be relevant to:

- Defining existing conditions
- Evaluating alternatives

- Providing a basis for impact evaluation

The information to be obtained should include material on species occurrence, population dynamics, habitat requirements, interspecific relationships, trophic level interactions, life histories, and documented responses of Panamanian species to environmental changes.

The publications and data obtained will be reviewed by biologists with experience in impact assessment. It will be evaluated to assess the general validity and specific applicability to the project. Judgments will be based in part on factors such as the currency of the data, its completeness, coverage of the area of concern, and reliability. Any gaps in the data are to be clearly identified.

A report will be prepared to summarize the relevant available information and document further data requirements. The discussion of species-environmental relationships should include descriptions of species occurrence and abundance, normal population fluctuations, habitat requirements, area usage, life history, identification of food chains, and other interspecies relationships. The report should avoid extensive text by focusing on dominant or important species occurring in the study area.

The report on available literature will be used in related study efforts and suitable for inclusion in the final report of the project. At the conclusion of the biological inventory, the material collected will be provided to the Information Center for cataloging and filing. Documentation of contacts with researchers will also be submitted.

3.5 Sampling Design

The objectives of the biological inventory can be met with a variety of sampling designs. The field program which follows was influenced by many considerations including the following:

Duration. The biological inventory is one of many studies being conducted during the Study of Alternatives to the Panama Canal. It has been scheduled based on interrelationships with other study components. Optimally, the inventory should begin after the prescreening of alternatives and development of sufficient design information and end prior to initiation of the environmental analysis. However, based on comments seeking more extended sampling, the literature review and mobilization for the field work have been scheduled to start after prequalification and tendering. It is recognized that there is an associated risk that early sampling may not coincide with

the study area defined after prescreening, although care will be taken to focus early sampling in areas most likely to be involved in the post prescreening process.

The end of the inventory has been extended to 14 months. Further extension would have unacceptable effects on the Commission's overall project schedule. As it is, sampling from the first 3-4 quarters will serve as input to the environmental analysis, and feasibility analysis. Sampling from the last quarter will provide input only to the detailed investigation.

Frequency of Sampling. The current 14-month schedule offers the possibility of some year-to-year comparisons not previously feasible. On a schedule of less than one year, seasonal sampling was selected to provide reasonable representative sampling and maximize cost-effectiveness. With the 14-month schedule, quarterly sampling is planned to take advantage of both the annual characterization and the indication of year-to-year variation. This will also provide more information on migratory species and the increased number of times in the field may increase observations of rare or unique species. Sampling more frequently than quarterly is not warranted for a feasibility study and would significantly reduce the sampling which could be accomplished in each sampling period, potentially decreasing the cost-effectiveness.

Sampling Equipment and Techniques. Final selection of sampling gear and techniques will be made after mobilization and reconnaissance surveys. These activities will include use of proposed gear under field conditions to ensure proper equipment selection and analysis of preliminary samples of certain types to determine techniques to be used consistently throughout the inventory. For example, species-area curves can be obtained from available data or developed from benthic sampling to determine replication requirements. Cost estimates during tendering should be based on sampling described in Sections 3.6-3.8. Initial efforts will also be directed toward determination of precision and accuracy of the selected sampling and analytical techniques.

Sampling Locations. Locations for sampling shown in the following sections have been selected based on current understanding of the design of alternatives and the need for samples which are representative of various habitats. Precise sampling locations will be selected during reconnaissance surveys based on factors such as accessibility, effective use of sampling gear, preexisting stress, and habitat consistency. Locations will vary somewhat with the type of sampling (i.e., benthos, fish, water quality) to permit effective inventorying rather than focusing on a precise location.

It is recognized that treaty, military, and other restrictions on access will exist in some areas. The contractor will be expected to obtain necessary clearances when possible. If sampling is precluded in certain areas, the scope will be modified accordingly.

3.6 Terrestrial Sampling

The contractor will be responsible for providing necessary services to collect, analyze and report data on the terrestrial ecology of the study area. Sampling will take place in the following areas:

- The sites of Pequen, Trancado, and Ciri Lakes
- Areas adjacent to canal sections subject to widening.
- Dredge and excavation spoil disposal areas on upland sites (within 1 mile of the Canal)
- The right-of-way(s) for land-based alternatives.

Mobilization should include obtaining recent aerial photography of the study area and quantitative delineation of major vegetative cover types. Aerial photography of the canal watershed is available from the PCC and of the military land from the U.S. Army Corps of Engineers. Reconnaissance surveys will be conducted subsequently in each cover type for ground-truthing and to select suitable sampling locations. These surveys will aid in defining habitat diversity and identify options for adequately sampling the area to meet project objectives. Any necessary permits for collecting will be the responsibility of the contractor.

After the surveys, the scope will be refined as necessary, discussed with representatives of the FA/FR Contractor and approved by the Commission. Field work will be initiated soon thereafter. The precise timing should be such that five quarterly samplings take place during the available time period.

Each sampling effort is intended to inventory terrestrial fauna and flora and note effects of seasonal variation. Longer term variation can not be resolved in a program of this duration but should be noted as appropriate where it can be inferred from earlier studies. The sampling will encompass the following areas: vegetation, soils, mammals, birds, selected insects, and reptiles and amphibians. Particular care should be taken to confirm the presence of species which are endangered or threatened.

Based on aerial photo interpretation and reconnaissance surveys, vegetative cover types will be defined for all affected areas. In each cover type, transects will be established using appropriate sampling techniques to obtain data on density, dominance, frequency, and importance value for each cover type. The work should permit an evaluation of community succession and relationships between plant distribution and general soil conditions. Voucher specimens should be retained and later placed in the Information Center.

In addition to sampling in other areas, agricultural land should be mapped with regard to the kinds and extent of crops grown. Information should also be collected on annual crop yields and value.

Faunal investigations will be habitat-based and will determine distribution, relative abundance, and plant-wildlife relationships. Bird populations will be surveyed along established routes in each defined habitat in affected areas. Sightings made while traversing the route will be used to estimate relative abundance and habitat utilization. Migrant and resident species of raptors, passerines, and waterfowl will be noted and use of the area (nesting, breeding, feeding, and wintering) would be determined. Hunting statistics should be obtained.

A nondestructive sampling program will be conducted for small-to-medium sized mammals within each representative cover type. Live traps, e.g., Sherman or Haverhart, will be set to obtain data on relative abundance/habital utilization. The size of the trapline or grid will be determined by the size of the area being sampled. A minimum of three trap nights per habitat will be used. For game and non-game species of large mammals, several observations should be made including track and scat surveys in each representative cover type.

For herpetofauna (reptiles and amphibians), nondestructive sampling should be performed in each major cover type using drift nets and pitfall traps. In addition, general searches of appropriate habitats (rotting logs, pools, etc.) should take place. Species composition, relative abundance, and habitat utilization should be recorded. Special surveys should be performed to evaluate the presence of endangered or threatened species. Habitats known to be occupied by these species should be surveyed to maximize the chance of observing the plant or animal sought.

Insects which represent disease vectors or a nuisance to the local population are of concern. Affected areas near residential locations should be surveyed to identify the presence of such species, their local distribution, and relative abundance.

Any areas which have been set aside as habitats or wildlife preserves but which will be affected by any alternative will be surveyed. The techniques described above will be used. In addition, any signs of environmental stresses in the study area such as fire, drought, farming, logging, insect infestation will be documented to develop an overall picture of the quality of the existing environment.

3.7 Freshwater Sampling

The contractor will be responsible for providing necessary services to collect, analyze, and report data on the freshwater ecology of the study area. Sampling will take place in freshwater sections of the Canal, Gatun and Madden Lakes, the Chagras River downstream of Gatun and Madden Dams, and tributaries that will be damned to create new reservoirs.

After mobilization, reconnaissance surveys will be conducted in each of these areas. These surveys will focus on defining habitat diversity and the options for adequately sampling the areas to meet project objectives. After the surveys, the scope will be refined as necessary, discussed with representatives of the FA/FR Contractor and approved by the Commission. Field work will be initiated soon thereafter. The precise timing should be such that representative quarterly sampling takes place during the available time period.

Each sampling is intended to inventory freshwater flora and fauna and note effects of variation over time. Longer term variation can not be resolved in a program of this duration but should be noted as appropriate where it can be inferred from earlier studies. The sampling will include water quality, sediment analysis, aquatic mammals, fish, benthos, and aquatic macrophytes.

Water quality sampling will take place at the locations shown on Figure 7. There are a total of 13 stations. Water samples or readings are to be taken at surface and bottom. The following parameters are to be obtained: temperature, dissolved oxygen, biological oxygen demand, ammonia, Kjeldahl-N, nitrate-N, total phosphorus, total suspended solids, chlorophyl a, secchi depth, conductivity, coliform bacteria, alkalinity, and turbidity. Bottom samples will also be analyzed for iron, zinc, copper, lead, and mercury. Replicate analyses (2) are to be conducted on samples and replicate readings (3) are required for in-situ measurements. Ten percent of field samples should be repeated as a QA check. All stations should be sampled within no more than one week. Station records during sampling should include time of day and selected meteorological parameters such as air temperature, cloud cover, and wind velocity.

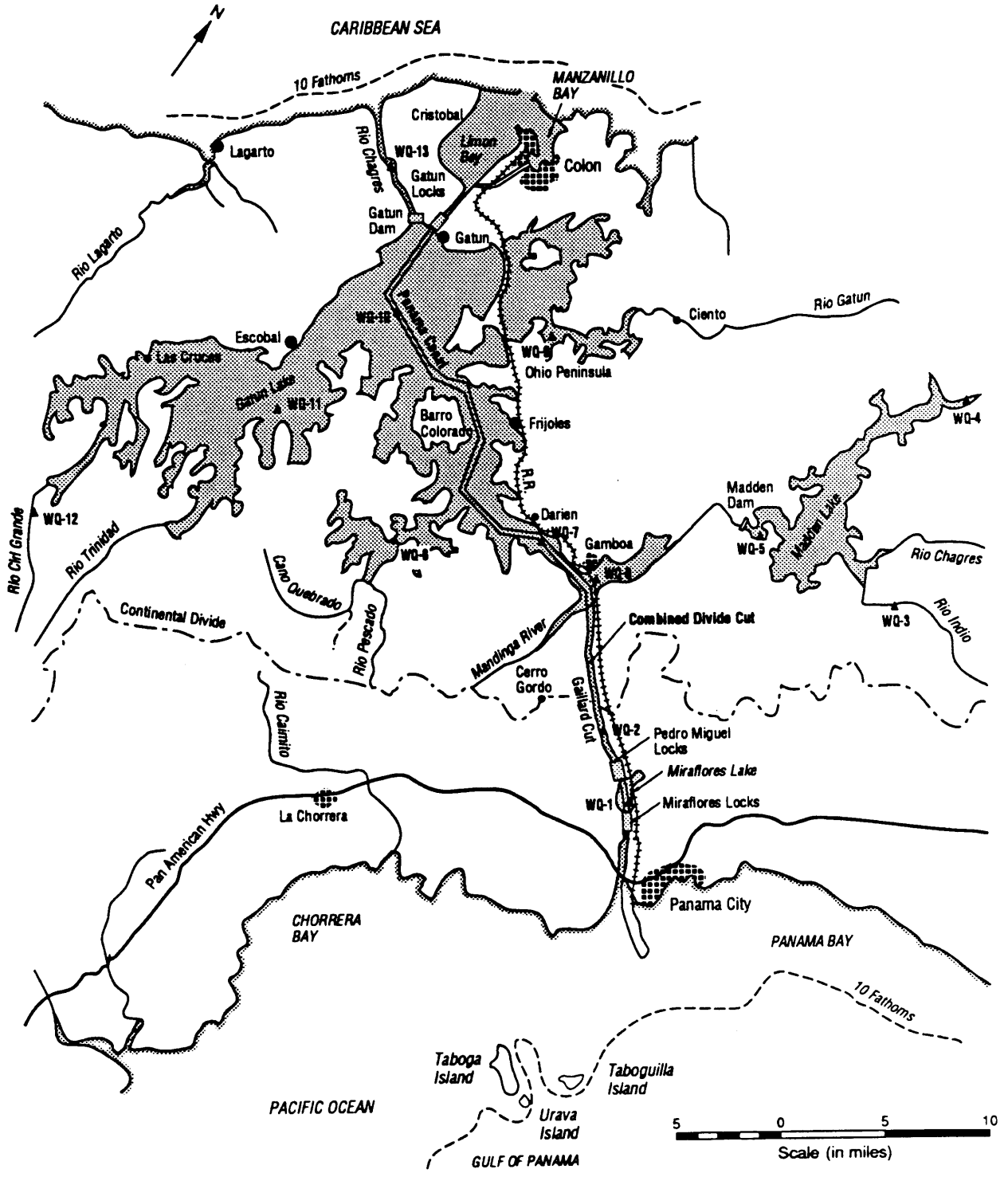


Figure 7 Water Quality Sampling Stations – Freshwater

Fish sampling will take place at the stations shown in Figure 8. Fish populations will be sampled using seines, electroshocking, trap nets, and gill nets where possible. Small trawls can be considered for deeper water. Gill nets should be multiple panel of varying mesh size. Samples should be standardized (area swept, transect length for shocking, length of set) from station to station. Seining and trawling will be replicated (2). All fish captured should be identified to species, weighed and measured for total length. Voucher specimens should be retained.

Data will also be collected on any sport or commercial fishing in the study area. Annual catch and value by species should be recorded. Value by area of Gatun Lake is of particular interest.

Benthos samples will be collected at stations shown in Figure 9. Triplicate samples should be taken at each station using quantitative sampling gear. Several types of grabs, e.g., Ponar, Peterson, will be tested during reconnaissance surveys and the most appropriate grab selected. Samples will be sieved through 1.0 mm mesh and preserved in formalin with rose benzol. The organisms retained are to be identified and counted. Voucher specimens will be retained.

At each benthos station, two sediment samples will be collected. One sample will be analyzed using standard sieves to determine grain size. The second sample will be analyzed for total carbon, total nitrogen, iron, zinc, copper, lead, and mercury.

Aquatic macrophyte and aquatic mammal distribution is to be recorded. For macrophytes, aerial photography should be used to map locations of attached and floating plants throughout Gatun Lake. Ground-truthing should be used as necessary to confirm identifications. Aerial overflights should be used to locate and count manatees. Other species should be recorded as observed during any sampling.

3.8 Marine Sampling

The contractor will be responsible for providing necessary services to collect, analyze and report data on marine ecology in the study area. Sampling will take place in the Atlantic and Pacific entrances to the Canal and upstream as far as Gatun and Miraflores Locks.

After mobilization, reconnaissance surveys will be conducted in each of these areas. These surveys will focus on defining habitat diversity and the options for adequately sampling the areas to meet project objectives. After the surveys, the scope will be refined as necessary, discussed with representatives of the FA/FR Contractor and

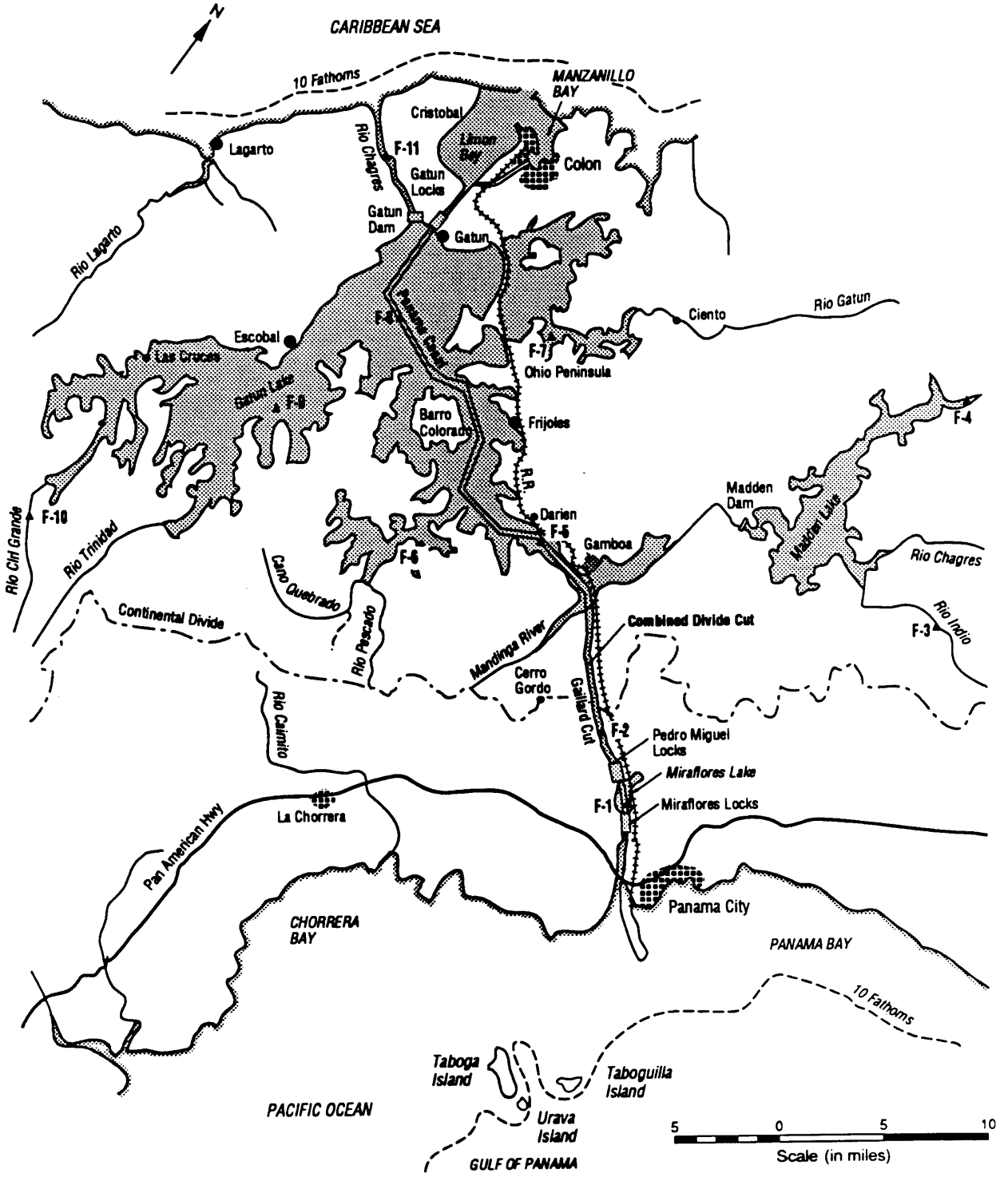


Figure 8 Fish Sampling – Freshwater

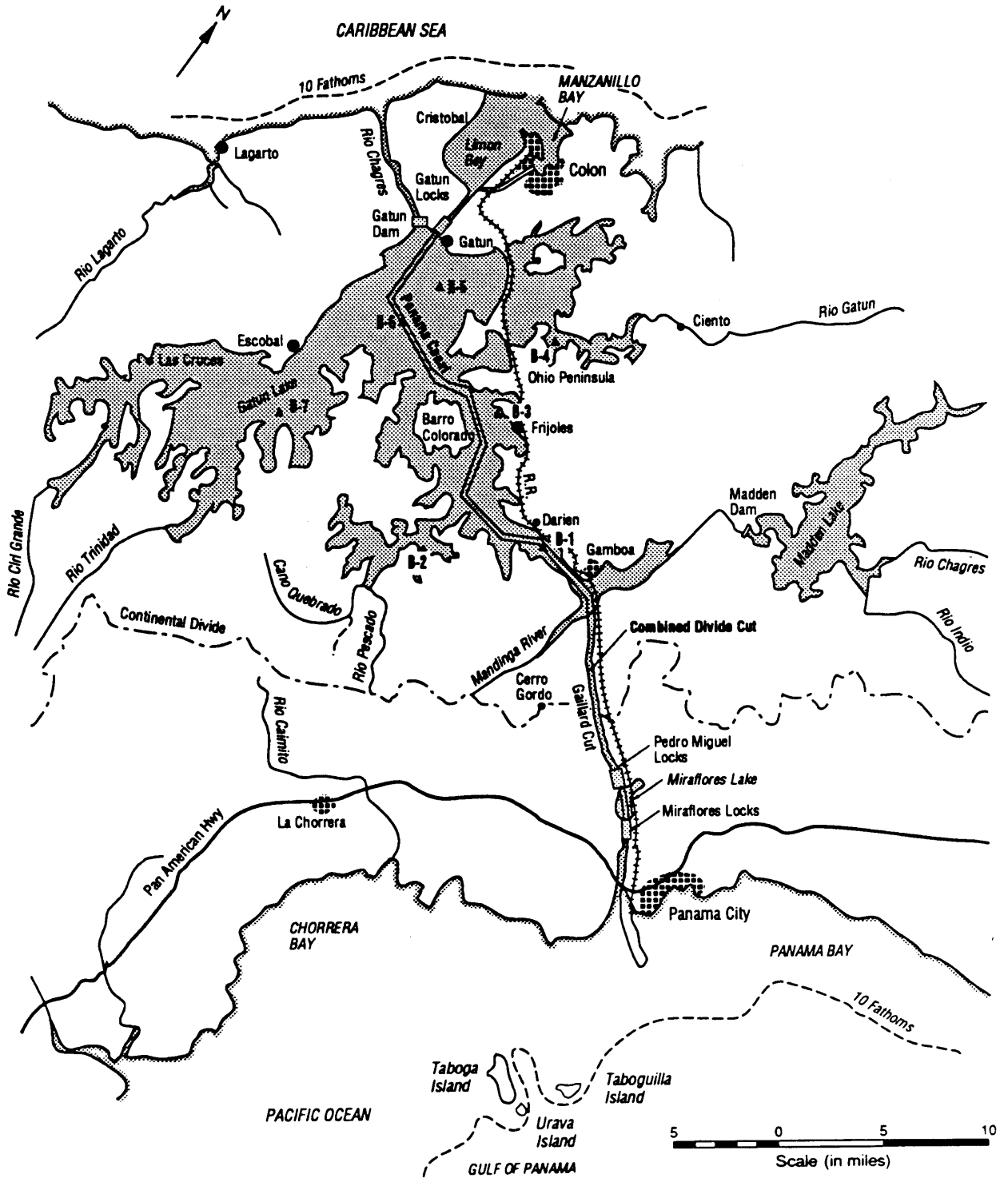


Figure 9 Benthos Sampling – Freshwater

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approved by the Commission. Field work will be initiated soon thereafter. The precise timing should be such that representative wet and dry season sampling takes place during the available time period.

Each sampling is intended to inventory marine fauna and note effects of variation over time. Longer term variation can not be resolved in a program of this duration but should be noted as appropriate where it can be inferred from earlier studies. The sampling will include water quality, sediment analysis, benthos, fish, and meroplankton.

Water quality sampling will take place at the locations shown on Figure 10. Samples or readings will be taken at the surface and bottom, on high tide. Stations 1-10 (or 11-16) are to be sampled within 3 hours centered on slack high tide. Sampling will include the following: temperature, dissolved oxygen, biological oxygen demand, salinity, turbidity, suspended solids, secchi depth, chlorophyl a, ammonia, Kjeldahl-N, nitrate-N, total phosphorus, coliform bacteria, iron, manganese, copper, zinc, and volatile organics. Replicate (2) analyses are to be conducted on samples and replicate readings (3) are required for measurements. Ten percent of samples taken will be repeated for QA checks. Station records during sampling should include time of day and selected meteorological parameters.

Fish sampling will take place at the stations shown in Figure 11. Shallow inshore stations (MFS) are intended to be sampled during high tide using seines or cast nets. Deep offshore stations (MFD)will be sampled by trawl or experimental gill nets. Samples should be standardized (area swept, transect length for trawling, length of set) from station to station. Seining, cast netting, and trawling will be replicated (2). All fish and invertebrates captured should be identified and counted and fish should be weighed and measured for total length. Voucher specimens should be retained.

Data will also be collected on local sport and commercial fisheries. Annual catch and value by species in Panama should be recorded. Any fishery specific to the study area is of particular interest.

Benthos samples will be collected at stations shown in Figure 12. There are a total of 14 stations. Each station will be sampled by grab. Several grabs, e.g., Van Veen, Smith-McIntyre, will be tested during reconnaissance surveys and the most appropriate grab selected. Replicate (3) samples will be taken by standardized grabs and the samples washed through a 0.5 mm sieve and preserved in a formalin rose benzol mixture. Organisms retained will be identified and counted. Voucher specimens will be retained.

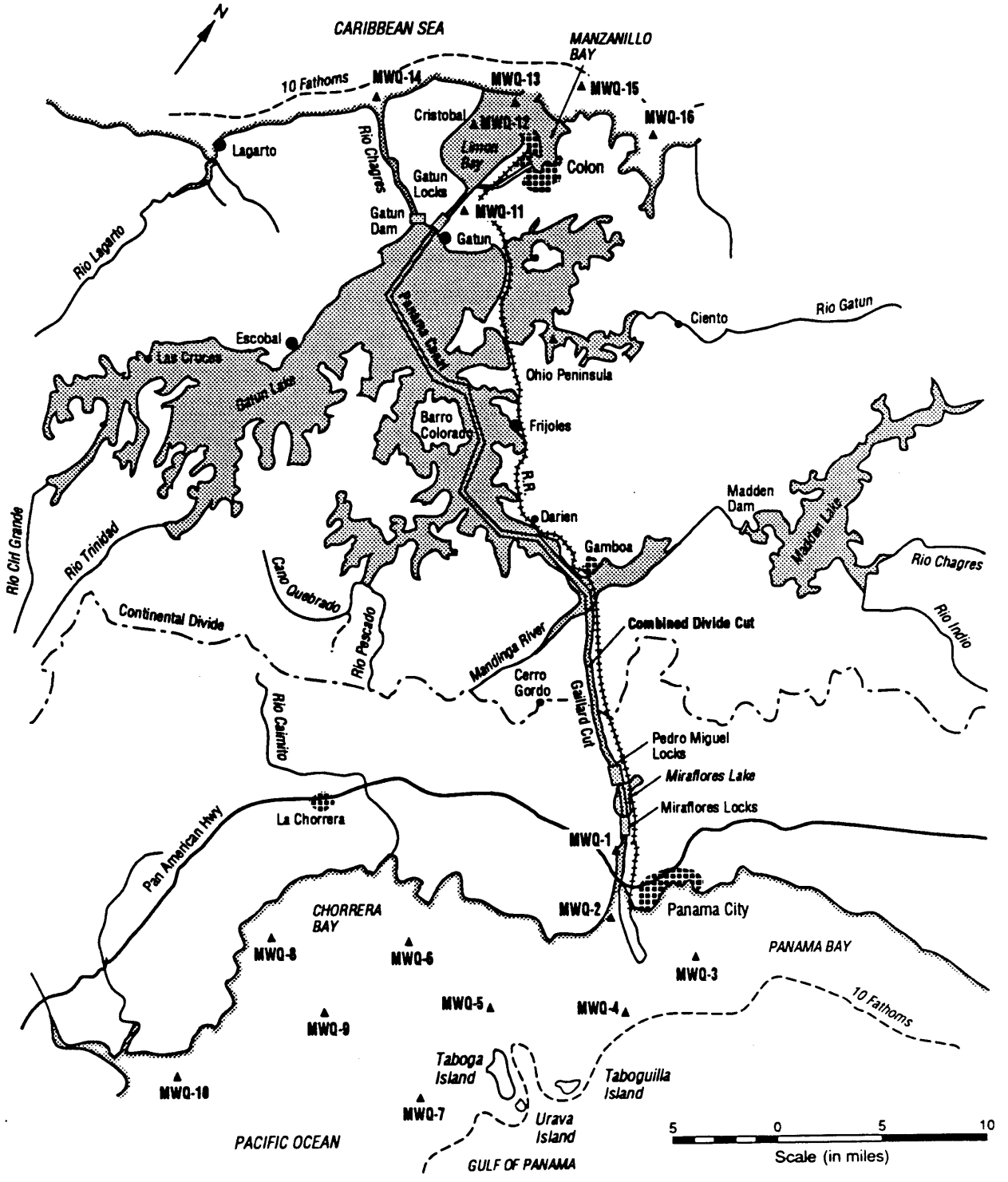

Figure 10 Water Quality Sampling Stations - Marine

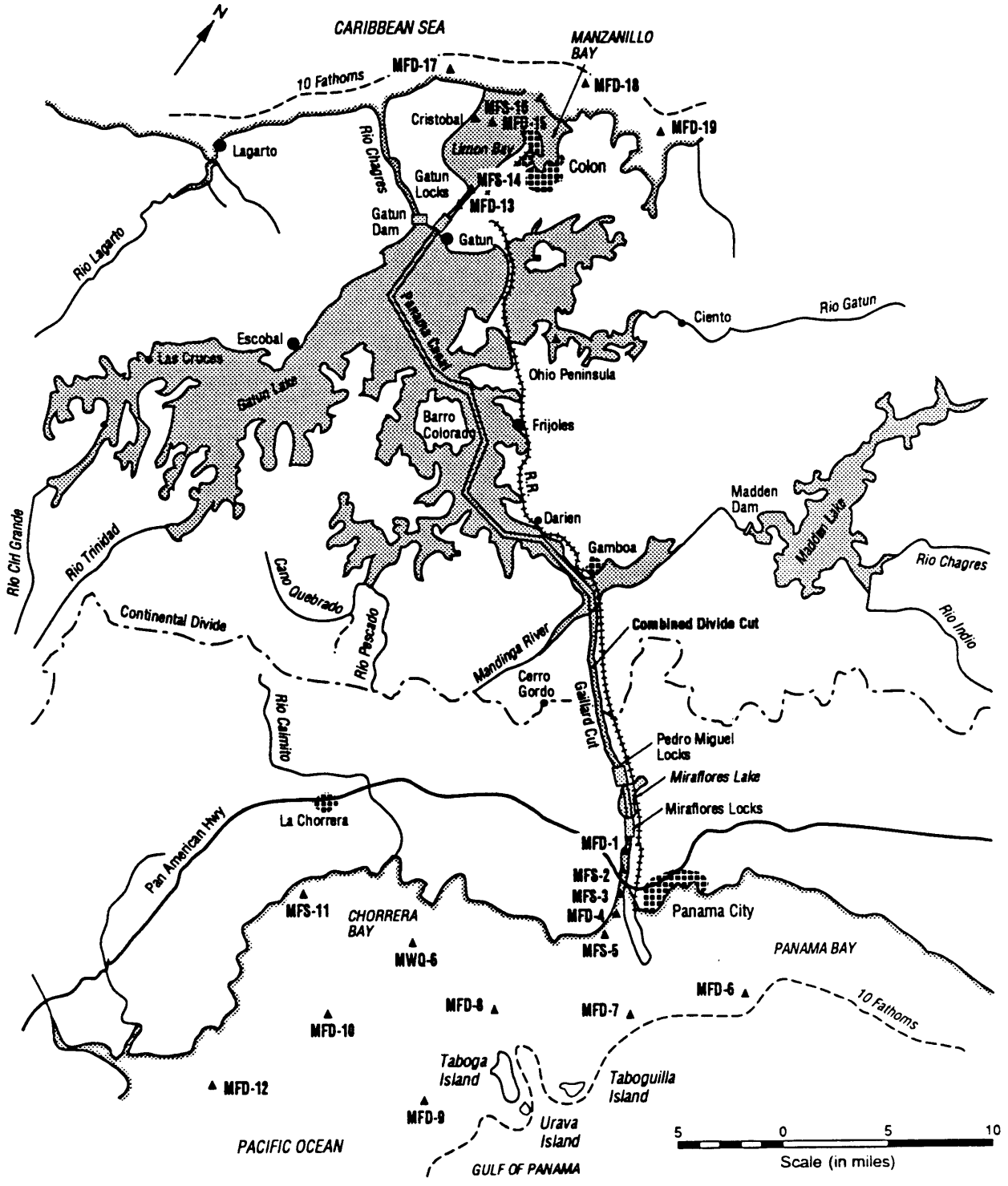

Figure 11 Fish Sampling Stations - Marine

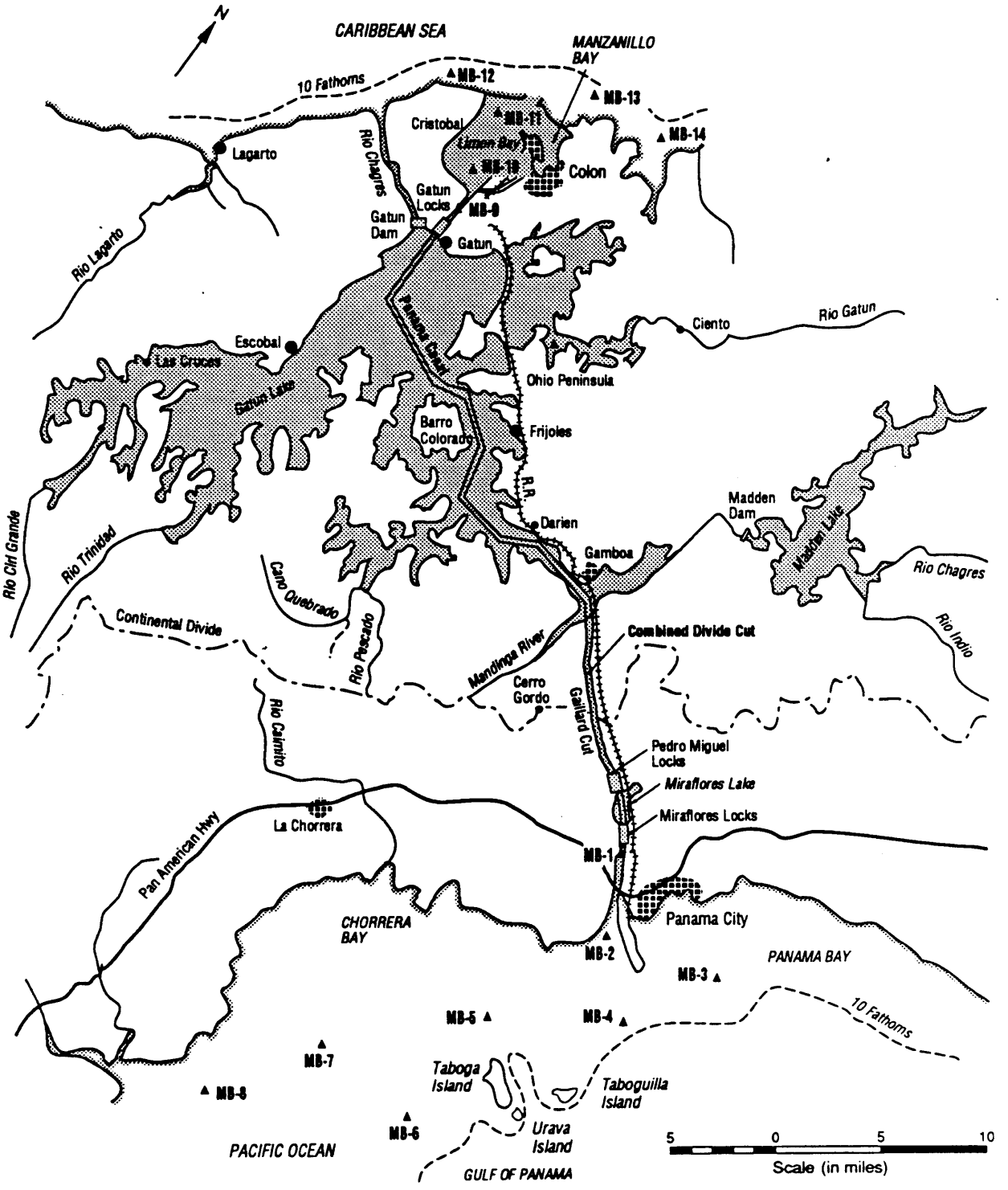

Figure 12 Benthos Sampling Stations - Marine

At each benthos station, two sediment samples will be collected. One sample will be analyzed using standard sieves to determine grain sizes. The second sample will be analyzed for total carbon, total nitrogen, iron manganese, copper, and zinc.

Coral formations and mangrove communities are limited in the study area. Coral reefs are found along the Atlantic coast and around Taboga, Uraba, and Taboquilla Islands. Mangroves similarly occur along the Atlantic coast, e.g., Bahia Las Minas, and around Chorrera Bay in the Pacific. These features should be located and mapped.

Meroplankton sampling will be conducted to document spawning activity in the study area. Samples will be taken at stations shown in Figure 13. Samples will be taken at high tide as an oblique tow using a 1-meter plankton net equipped with flow meter. Replicate tows (3) will be made at each station. Samples will be sorted using subsampling if necessary to identify fish eggs and larvae and invertebrate larvae and enumerate them. Holoplankton need not be analyzed. Voucher specimens will be retained.

4 REPORTS AND DOCUMENTS

The contractor shall provide the following:

4.1 Data Summaries

For each quarterly sampling, the contractor will provide a data summary report which includes the results of sampling and laboratory analysis. This will be accompanied by a brief narrative describing the sampling that took place and analytical techniques, where appropriate. Data will be reported by sample or replicate mean with a minimal amount of synthesis.

4.2 Progress Reports

The contractor will provide information as necessary for input to monthly progress reports. A letter report will be sufficient. This will document current project status, anticipated activities, problems and resolution, and status against budget.

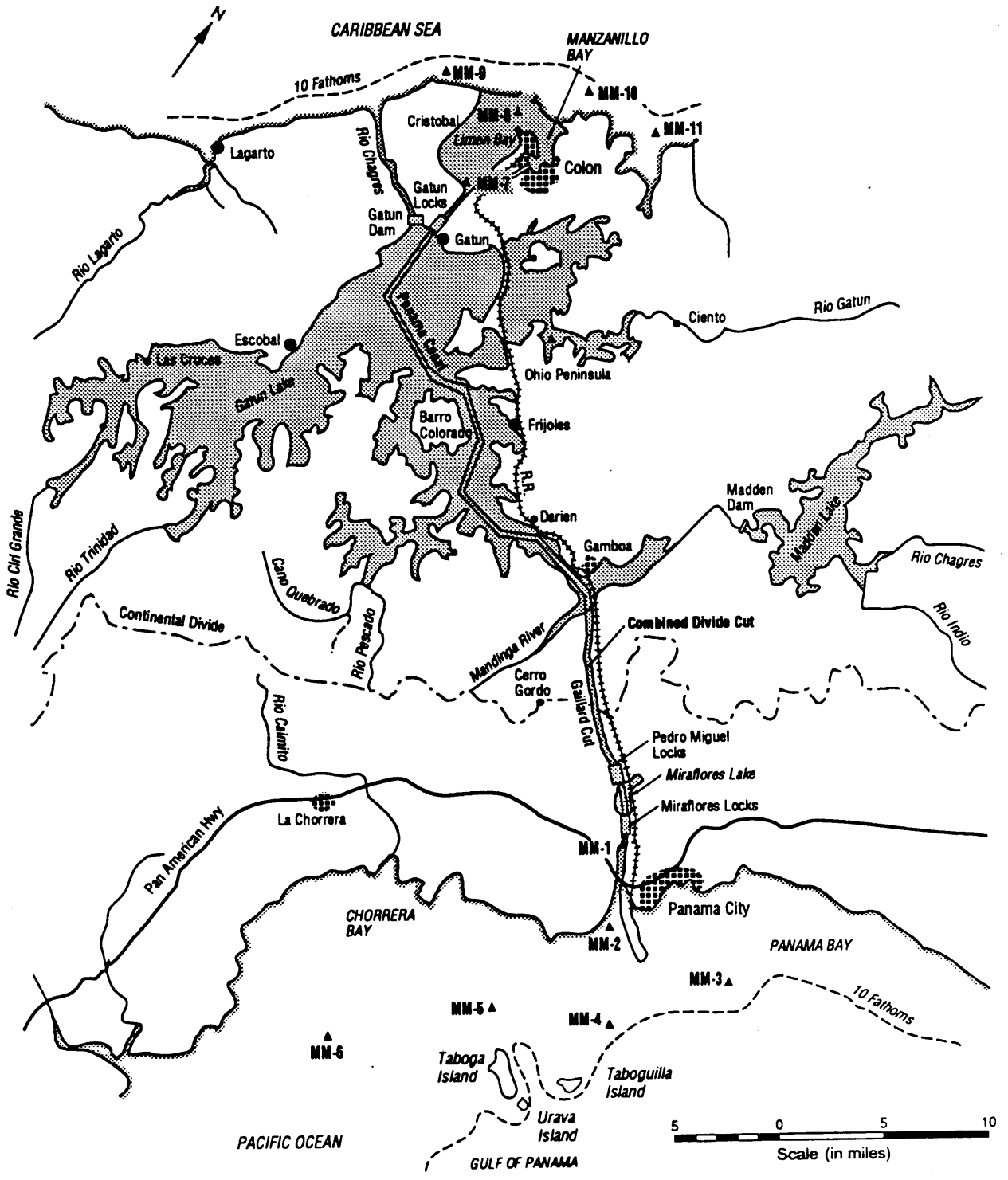

Figure 13 Meroplankton Sampling Stations - Marine

4.3 Literature Summary

The contractor will provide a draft report 60 days after project initiation which summarizes results of the literature survey. Literature which is obtained subsequent to this report will be provided to the Information Center and used as input to the description of existing conditions in the Draft Final Report.

4.4 Interim Reports

The contractor will provide a brief (less than 50 pages) description of the results of the samplings. Information presented will be in summary form, focusing on important species and significant findings. The reports will also include any recommended changes to be implemented during subsequent sampling. This report will be subject to review by the Commission and the contractor will be required to revise the report as necessary in response to comments.

4.5 Draft Final Report

The contractor will prepare a Draft Final Report which describes the findings of the sampling and synthesizes this information and other available data to provide a characterization of the existing terrestrial, marine, and freshwater communities within the study area. Rare and endangered species (based on ANCON Society's CDC database) or unique communities and their habitats will be discussed. The text should be accompanied by summary tables and figures rather than extensive data tables. The report will be prepared based on a minimum of three quarters of data to provide input to the environmental analysis. It will subsequently be updated with remaining sampling data and should then include consideration of year-to-year variation as seen in the surveys. The report will be subject to review and will require revision in response to comments.

4.6 Quality Assurance Documents

The contractor is expected to have and use for the project a set of standard operating and quality assurance procedures. These must be available to all project personnel and provide for necessary documentation of sampling, sample handling, and analysis. Necessary documentation is to be maintained by the Contractor but is subject to audit by the Commission

5 TIME SCHEDULE

The schedule for the biological inventory is only one item in an overall project schedule. As a result, start and end dates are dependent on other activities. To maximize data utility and minimize cost, the inventory would start after selection of alternatives during the prescreening tasks. However, schedule constraints then limit the sampling period to about nine months. The desirability of collecting data over a longer period resulted in scheduling the start of sampling prior to completion of the prescreening. It is recognized that the study area then must be defined based on the Commission's best judgment, and revision of the scope should be anticipated.

Initiation of the inventory is now scheduled for month 6 of the overall schedule, immediately after prequalification and tendering. The literature review will take place over the first two months. Mobilization and reconnaissance sampling will also begin at this time with scoped field work to begin in the third month of the inventory schedule. Specific dates will be assigned when the project begins but durations have been defined. Representatives of the Commission will participate in the surveys and work with the contractor to analyze findings. The scope will be refined as necessary, subject to approval of the Commission.

Five quarterly sampling efforts will take place in the next 14-month period. The precise timing will depend on actual conditions (date, weather, etc.). Given the short duration, the first sampling should take place as early as possible. The final sampling should take place early enough so that the Draft Final Report can be submitted by the end of the 16th month after authorization.

Figures 14, 15, and 16 contain the work schedule, manning schedule, and position assignments for this TOR.

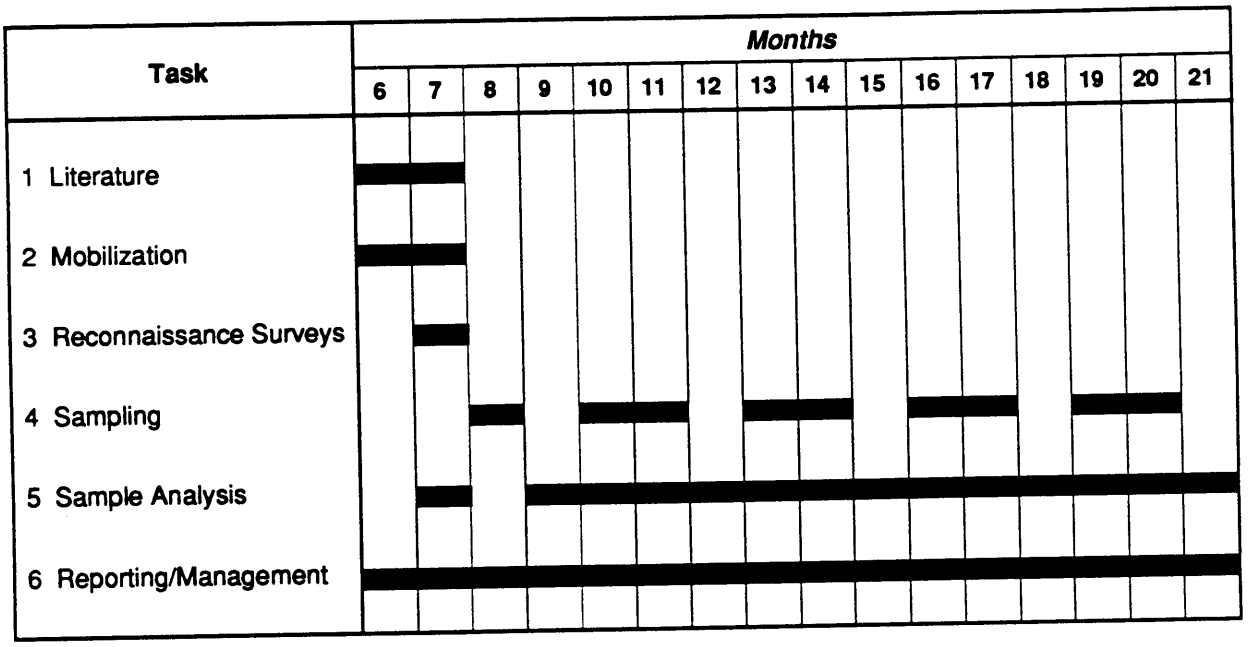

Figure 14 Work Schedule for Background Biological Data and Biological Inventory

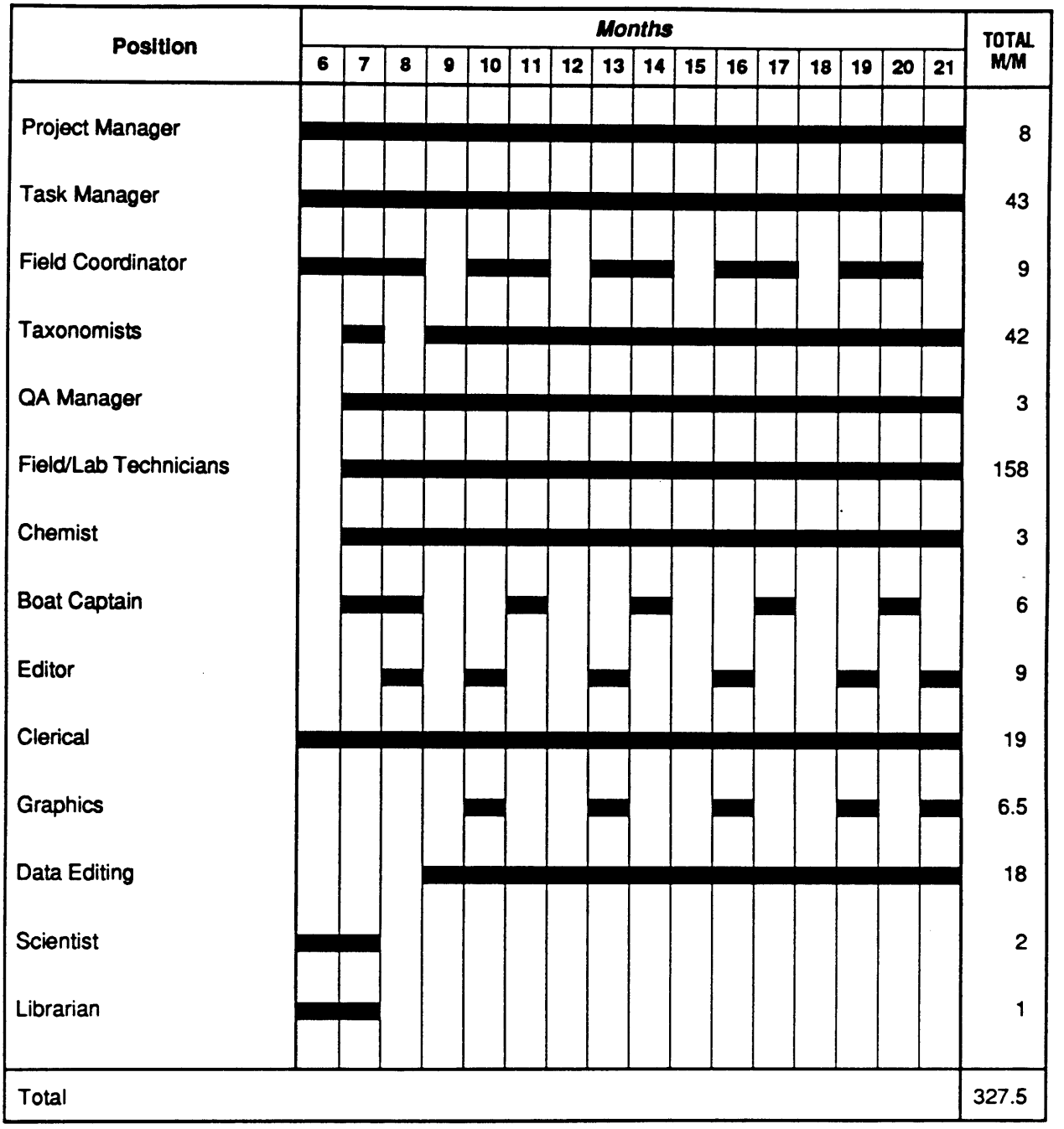

Figure 15 Manning Schedule for Background Biological Data and Biological Inventory

Position	Tasks (Figure 1)					
	1	2	3	4	5	6
Project Manager	P	P	P	P	P	P
Task Manager	P	P	P	P	P	P
Field Coordinator		S	S	S		
Taxonomists		S	S	S	S	S
QA Manager		S	S	S	S	S
Field/Lab Technicians (US)		S	S	S	S	
Field/Lab Technicians (Pan)		S	S	S	S	
Chemist		S	S	S	S	S
Boat Captain		S	S	S		
Editor						S
Clerical		S				S
Graphics						S
Data Editing						S
Scientist	P					P
Librarian	S					

Legend:
P = Principal
S = Supporting

Figure 16 Position Assignments for Background Biological Data and Biological Inventory

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Financing Scheme and Financial Analysis

This component study includes the following tasks:

- Financing Scheme
- Financial Analysis

Comisión de Estudio
de las Alternativas
al Canal de Panamá
CENTRO DE INFORMACION

1 FINANCING SCHEME

1.1 Introduction

This component study will be prepared for use in the Financial Analysis component study. Because the financial projections in Financial Analysis must be as accurate as possible, the most feasible schemes for each alternative must be formulated based on correctly collected cost data and detailed studies of various financing sources.

Sources of funds are different in their lending limits, interest rates, lending periods, securities, etc. Depending on the size of each alternative project, the allowable amount of each source may be far below the estimated total costs of each alternative. Therefore, combining several financing sources to reach estimated costs will be inevitable. When combining sources, the differences of each source in terms of conditions must to be taken into account. Funding sources should be properly combined for each alternative's needs. Sufficient funds should be available at all times during project implementation, start-up, and the early years of operation.

As there are very few examples of this kind of transportation-related project in terms of size and project life, the most appropriate terms and conditions which fit each project will be newly determined by optimization.

The results of this study will be the most optimum funding, together with terms and conditions for each of the prescreened alternatives, and will be used to carry out the Financial Analysis.

1.2 Objectives

The principal objectives of this study are as follows:

- To collect and analyze data and information on various financing sources which will be applied to each alternative
- To design the most appropriate funding scheme for the prescreened alternatives
- To provide basic data and information for the Financial Analysis

1.3 Scope of Services

The scope of services to be conducted by the component study contractor for attaining the above objectives is described below.

1.3.1 Collection of Data and Information

All the necessary data and information on the formation of the finance scheme, as well as cost information from the results of the Cost Estimates and Management Arrangements component studies will be collected. More specifically:

- Data and information concerning the capital costs and operation and management costs on each alternative
- Data and information concerning financing schemes of various macro-projects

After reviewing, rearranging, and analyzing the above data, information, and other financial aspects, possible financial sources including terms and conditions will be stated.

Possible financing sources may include:

- Government agencies
- International financing agencies
- Commercial banks

1.3.2 Identification of Various Kinds of Financing Sources

The possible financing sources stated above will be analyzed to measure their applicability in terms of the size of each alternative, etc.

Along with the above analysis, terms and conditions of each possible source and other financial aspects which may affect funding activities such as forecast of interest rates, etc., will also be analyzed to measure the possibility of each funding.

The analyzed items in terms and conditions will include interest rates, lending terms, security, grace period, repayment period, etc. Besides analyses of financing sources and their terms and conditions, analysis on other aspects of financing such as trend of interest rate, world economy, etc., will be useful.

1.3.3 *Study of the Types of Potential Financing*

Based on the foregoing analyses on possible funding sources, further studies to determine the type of financing will be conducted.

The prescreened alternatives will have various scales of funding requirements. In the case of sea-level canal alternatives, some 10 billion U.S. dollars may be required. For the case of lock improvement alternatives and non-canal complementary alternatives, several billion U.S. dollars may be required. When financing a macro-scale project, such as the sea-level canal, with a huge funding requirement, size of total funds requirement as well as the annual cash flow requirements (especially during the construction period) will be the main concern of lenders. Generally, such large funding requirements will be met by co-financing, both to cover the funds requirement, and to mitigate financing risks to each lender.

The potential types to be considered include:

- Sole financing
- Co-financing

1.3.4 *Clarification of Respective Components of Financial Scheme*

All the required items for the financial scheme of each alternative which is to be used for financial projection will be itemized and clarified.

1.3.5 *Optimization Study of Financial Schemes for Each Alternative*

Based on the cost information, and the findings on possible sources and types, a study will be conducted to determine the most optimum financing scheme for each alternative.

The point of optimization is to find the best combination of different sources with different terms and conditions that will meet the funding needs of each alternative.

In the case of co-financing, the optimum financing scheme for each alternative will be pursued to find the best combination of terms and conditions, i.e., interest rate, lending term, grace period, repayment period, etc., for each of the lenders (international, government funds, and commercial).

2 FINANCIAL ANALYSIS

2.1 Introduction

This study will be carried out to measure the financial feasibility of each alternative project. The results of this component study will be one of the most crucial elements in judging which alternative is financially feasible and to be executed.

To measure an alternative project's viability and feasibility, a financial projection during the project life is essential. The input data on costs and revenue for the financial projection will affect the results of this component study. The more detailed the cost and revenue data are, the more accurate the results of the study will be.

The component contractors preparing the Cost Estimate, Management Arrangements, Financing Scheme, Operating Characteristics, and Commodity and Traffic Projections component studies will provide data to the component study contractor preparing the Financial Analysis component study.

The major revenue sources will be toll revenue and it will be analyzed in detail by the component study contractor preparing the Financial Analysis. An analysis on the toll operation of the present Panama Canal and the past studies of the toll system by PCC will be useful in preparing the analysis.

To make projections, several assumptions must be made. Along with input costs and revenue data, assumptions which may be subjective could affect the results of the analysis. Therefore, assumptions should be made carefully.

The conventional ratios such as financial internal rate of return will be used for the final judgement on each alternative from the financial viewpoint.

2.2 Objectives

The principal objectives of this study are:

- To collect and analyze the data and information on tolls, the revenue of which is the major source of the whole operating revenue
- To collect the data and information which will be used for the financial projection, i.e., the projection of balance sheet, profit and loss statement, and cashflow statement

- To analyze the pro forma financial statements and evaluate each alternative and recommend the best alternative.

2.3 Scope of Services

The scope of services to be conducted by the component study contractor for attaining the objectives set out above are discussed below.

2.3.1 Collection of Data and Information on Toll Revenues

All necessary data and information including toll system information from other component studies such as Future Transportation Systems and Commodity and Traffic Projection will be collected. A review of the "Report of the Atlantic-Pacific Interoceanic Canal Study Commission" and "Panama Canal Commission's Report on Development and Evaluation of Toll Policies and Alternative System" may be helpful.

2.3.2 Examination of Basic Policies for Setting Toll System

The details of present toll systems for the Panama Canal and other transportation revenues will be obtained from the other component studies including the traffic demand forecast in Commodity and Traffic Projections, operating management cost in Management Arrangement, costs of competitive modes of transportation in Future Transportation System, etc.

The objectives of toll policy will be identified and each objective for setting toll policy will be examined. One of the criteria for setting a policy is how much the toll revenue from the proposed toll system can cover the expenses. Toll policies shall be studied in various cases including the following:

- Costs, excluding depreciation, which cannot be covered
- Costs, excluding depreciation, which can be covered
- Cost, including depreciation, which can be covered
- Costs and interests paid, which can be covered

2.3.3 Study and Analysis of Toll System

Studies and analyses on the details of the Panama Canal toll systems and other transportation systems will be conducted. In this activity, the rate schedule of existing toll systems and other important items will be analyzed.

2.3.4 Establishment of Toll System

Based on the analyses on toll systems used for various transportation systems including the present Panama Canal and the traffic projections for each alternative, toll systems of each alternative will be established, including policy, rate schedule, future projected increase, and so on. Considering the length of financial projection, expected increase, if any, will be inevitable. Recommended changes in the toll charges, to achieve sound financial results deemed justifiable, may be made.

2.3.5 Estimate of Other Revenues

Based on the studies and analyses such as those on existing toll systems, expected revenue sources other than toll for each alternative will be listed and those amounts will be estimated. In addition, if new revenue sources can be identified, they will also be listed and their amount estimated.

2.3.6 Identification of Cost Items and Other Information

In accordance with the attached example of financial statements, cost items will be identified. Items may be different in each alternative. New items may be added and unneeded items may be deleted if necessary. Then each identified item will be quantified to estimate costs. The following items shall be prepared:

- Capital expense plan
- Funding plan
- Tax
- Depreciation method

For the capital expense plan – which includes civil engineering works; capital dredging (i.e., other than routine maintenance); mechanical and electrical equipment; professional and other fees and overheads; and any other costs – collected data and information should be on the same basis as those collected for the Economic Analysis component study.

2.3.7 Estimation of Financial Cost of Each Alternative

Based on the financing scheme and the results of the study "Cost Estimates", financial costs will be calculated.

2.3.8 Financial Analysis

Toll revenues and other revenues and estimated costs will be used to form the financial projection of Income Statement, Balance Sheet, and Flow of Funds Statement (Exhibits 1, 2 and 3 at the end of this section).

To conduct the projection for the financial statements, the following assumptions will be made:

- The range covered by the project will be defined,
- Sponsor will be identified,
- Capital costs and operating costs will be defined,
- The project life will be determined,
- **Cost of Capital.** The cost of capital that will be used for the financial projection will be defined by the choice of the most cost saving financial source or the appropriate mixture of various financial sources out of those defined in "Financing Scheme."

The financial analysis for each alternative will be performed by using the same methodology as used in the analysis of the financial viability of large-scale development projects, and the following will be studied and analyzed.

- Financial viability: The financial viability for each alternative will be analyzed based on the financial statements including cash flow. In order to evaluate the results of financial analysis, the appropriate financial ratios such as coverage ratio will be used.
- Profitability of each alternative: To evaluate the profitability of each alternative, financial internal rate of return (FIRR) will be used.
- Financial planning: Financial planning, such as funding sources, their terms and conditions, etc., will be further analyzed. Financial planning in this study will include further review and take into account characteristics of each alternative which will be analyzed as they relate to other studies. For instance, the following factors will be studied:

  – Funding sources and terms and conditions which will be affected by the scale of total funding amount, will be examined for each alternative, especially in the case of co-financing.

- Terms and conditions of funding to be affected by various kinds of risks will be examined.

The base of the financial analysis will be determined to be the year 1990, and the costs and revenues will be expressed in constant 1990 prices.

3. SCHEDULE

The overall schedule for completion of the whole study is 30 months and the time allocated for completion of these component studies is three months for the Financing Scheme and four months for the Financial Analysis. These studies will start in the 17th month of the overall schedule of the study and the Financing Scheme will be completed by the end of the 19th month and the Financial Analysis will be completed by the end of the 20th month, as shown in Figure 1. The proposed manning schedule for these component studies is shown in Figure 2. The major work assignments for these component studies are shown in Figure 3.

4. REPORTS

The Reports to be prepared by the component study contractor shall be:

1) Inception Report
2) Interim Report
3) Final Study Report
4) Monthly Report

All reports shall be written in comprehensible English. Units shall be expressed in the metric system. The pages of the text shall be in principle 8-1/2" x 11" with pull-outs a maximum of 11 x 17". Oversized drawings may be placed in a pouch within the text or assembled in a separate appendix.

4.1 Inception Report

The component study contractor shall prepare sixteen (16) copies of an Inception Report for the component study, "Financing Scheme and Financial Analysis," and shall submit this to the Study Commission not later than fifteen (15) days after commencement of the Service. The Inception Report shall contain, but shall not be limited to, the following:

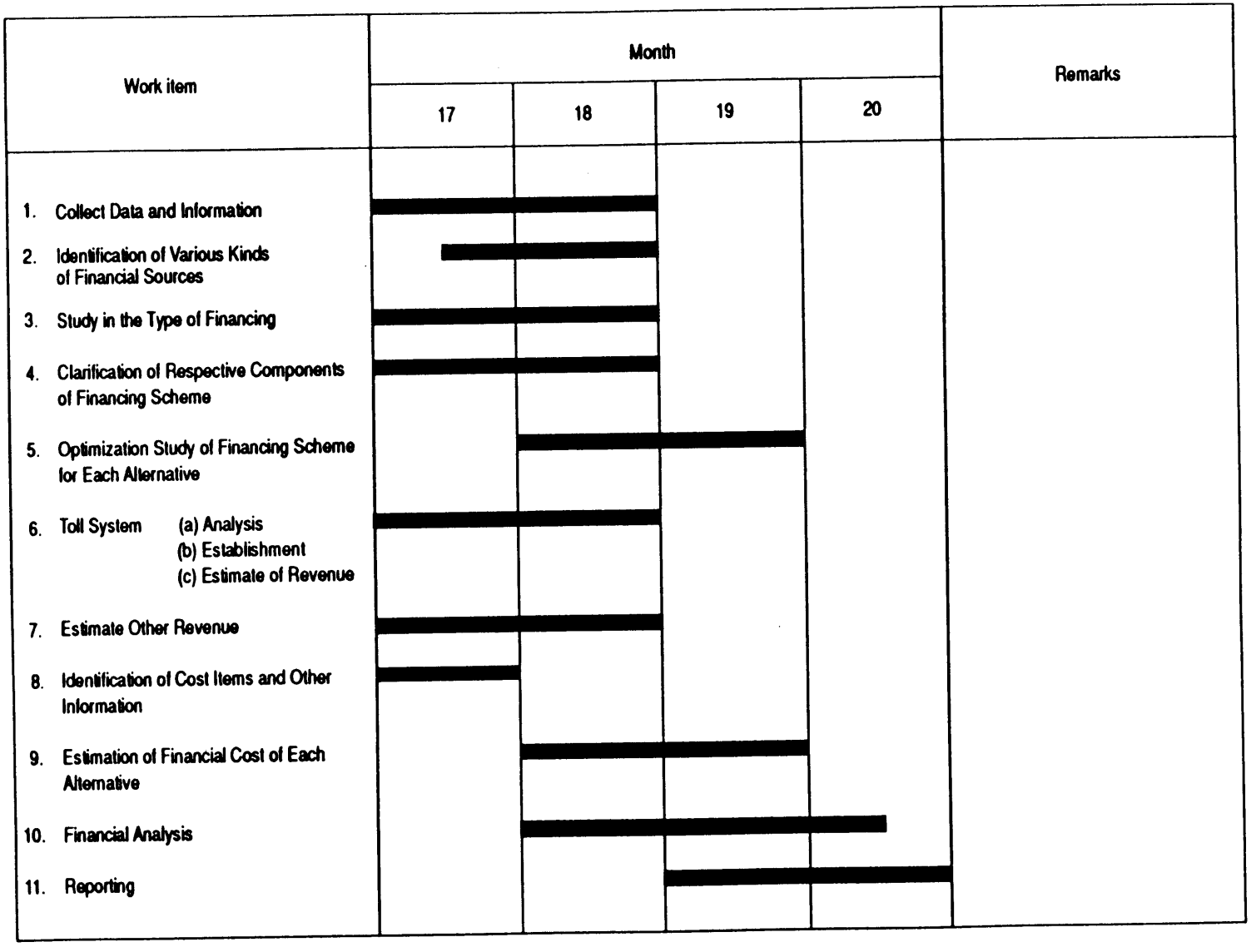

Figure 1. Work Time Schedule for Financing Scheme and Analysis

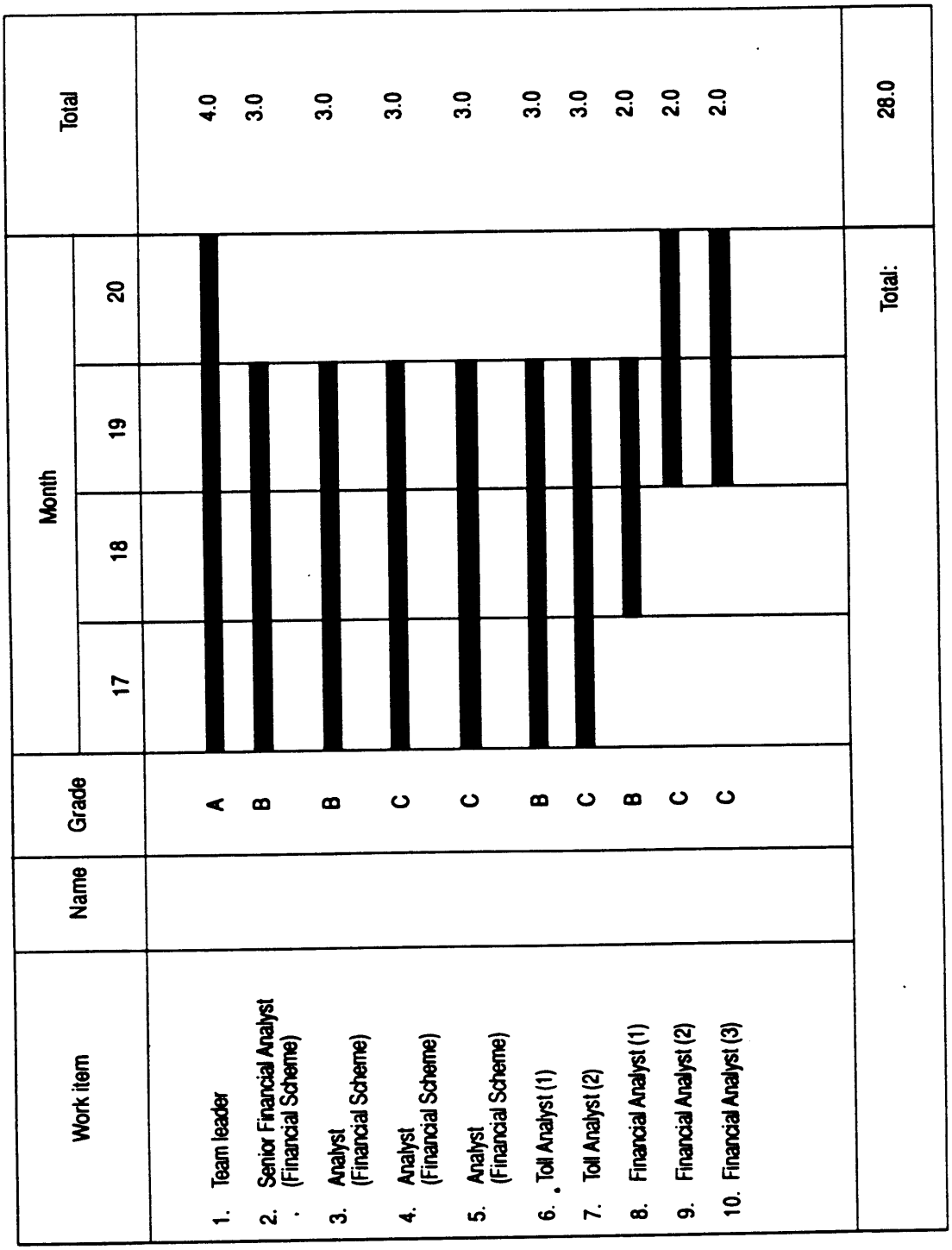

Figure 2. Manning Schedule for Financing Scheme and Financial Analysis

Task \ Position	1. Team Leader	2. Sr. Financial Analyst	3. Analyst (Fin. Scheme)	4. Analyst (Fin. Scheme)	5. Analyst (Fin. Scheme)	6. Toll Analyst	7. Toll Analyst	8. Fin. Analyst	9. Fin. Analyst	10. Fin. Analyst
1. Collect Data and Information	P	S	S	S	S	S	S	S		
2. Identification of Various Kinds of Financial Sources	S	P	S							S
3. Study in the Type of Financing	S	P	S	S	S			S		
4. Clarification of Respective Components of Financial Scheme	S	P	S	S	S			S	P: Principal S: Supporting	
5. Optimization Study of Financial Scheme for Each Alternative	P	S	S	S	S			S		
6. Toll System (a) Analysis	S					P	S	S		
(b) Establishment	S					P	S	S		
(c) Estimate Revenue	S					P	S	S		
7. Estimate Other Revenue	S	P						S	S	S
8. Identification of Cost Items and Other Information	S	P						S	S	S
9. Estimation of Financial Cost of Each Alternative	S	P						S	S	S
10. Financial Analysis	S	P						S	S	S
11. Reporting	P	S				S		S	S	

Figure 3. Position Assignment for Financing Scheme and Financial Analysis

(1) Statistics, data, information, etc. to be collected by the component study contractor including those collected in the related studies.

(2) Methodologies to be adopted for various studies and analyses,

(3) Overview on the results of studies and analyses

(4) Work flow chart, study time schedule, man-month input, and study budget plan.

4.2 Interim Report

The component study contractor shall prepare ten (10) copies of an Interim Report to be submitted to the Study Commission not later than three (3) months after commencement of the Service. The Interim Report shall contain, but not be limited to, the following:

(1) Items of studies and analyses completed during the period and those to be conducted during the subsequent period,

(2) List of collected data and information with brief comments, and

(3) Any major outputs of studies and analyses completed during the period such as:

- Identification of various kinds of financing sources and study on type of financing
- Optimization study of financing scheme for each alternative
- Study on toll system and other revenues
- Identification of cost items
- Estimation of financial cost for each alternative

4.3 Final Study Report

The component study contractor shall prepare sixteen (16) copies of a Final Study Report, and shall submit this to the Study Commission not later than four (4) months after commencement of the Service. The Final Study Report shall cover and contain all the results of the studies and analyses required by this Terms of Reference. The report shall be submitted in a draft form, and shall be revised, where required, based on the comments of the Study Commission issued within thirty (30) days after receipt of the said report by the Commission. The Final Report shall consist of 1) executive summary 2) main body, and 3) conclusions & recommendations. The component study contractor selected to undertake the work will be provided with a topical outline

to be used in preparing the Final Report. The Final Study Report shall contain, but not be limited to, the following:

(1) The same contents as in the Interim Report

(2) Results of financial analysis

4.4 Monthly Report

The component study contractor shall prepare ten (10) copies of Monthly Reports, and shall submit these to the Study Commission at monthly intervals.

The Monthly Report shall contain, but not be limited to, the following:

- The studies completed during the period and those to be performed during the following period.
- Major inputs of the studies, analyses, etc., completed.
- Major changes, problems, etc., during the period.
- Man-month input and study budget used during the period, and those accumulated up to the period.

The Monthly Report can be a brief letter report.

Exhibit 1

Income Statement

Operating Revenue		
Toll Revenue		
Other Revenues		
Operating Expenses		
Personnel Expense		
Administrative Expense		
Maintenance and Repair		
Depreciation Expenses		
Amortization of Deferred Assets		
Net Operating Income (NOI)		
NOI before depreciation		
Other Income and Expenses		
Fund Management Income		
Interest on Loans		
Net Income		
Tax		
Net Income after Tax		

Exhibit 2

Balance Sheet

Assets		
	Current Assets	
	Cash and Deposit	
	Cash Minimum	
	Cash Excess	
	Other Current Assets	
	Fixed Assets	
	Depreciable Assets less Accumulated Depreciation	
	Net Depreciable Assets	
	Other Assets	
	Deferred Assets	
	Total Assets	
Liabilities		
	Current Liabilities	
	Account Payable	
	Short Term Loan	
	Accrued Liabilities	
	Fixed Liabilities	
	Long term Loan	
	Other Liabilities	
Net Worth		
	Government Funds	
	Retained Earning	
	Net Income	
Total Liabilities and Net worth		

Exhibit 3

Source and Uses of Funds

Cash Inflow			
	Cash received		
	Tolls		
	Other Collections		
	Increase in Receivables		
	Total Cash Received		
Cash Disbursed			
	Operating Expenditures		
	Increase in Inventory		
	Increase in Liabilities		
	Total Cash Disbursed		
	Other Adjustments		
	Cashflow from Extraordinary Activities		
	Cashflow from Capital Activities		
	Net Increase (Decrease) in Cash		
	Cash, beginning of year		
	Cash, end of year		

Economic and Impact Analyses

Comisión de Estudio
de las Alternativas
al Canal de Panamá
CENTRO DE INFORMACION

This study includes the following:

- Economic Analysis
- Analysis of Impact upon Panama
- Analysis of Impact upon Users

1. ECONOMIC ANALYSIS

1.1 Introduction

The component study "Economic Analysis" is one of the key issues in the evaluation of the prescreened alternatives. The economic analysis of these alternatives shall compare all economic benefits and costs over the life of the project. This project will consider the Panamanian economy as well as the economies of the Panama Canal users and other related countries.

The analysis of the economic benefits will include analyses of both the primary and secondary benefits. The primary economic benefits will be identified in this study, and the secondary benefits in the component studies "Analyses of Impacts upon Panama and Users" will be carried out in a parallel study. The economic costs shall be estimated based on the results of the foregoing component study "Cost Estimate." This study converts the financial costs into economic costs by utilizing factors which evaluate shadow prices for Panamanian goods and services and eliminates transfer payments such as taxes, duties, subsidies and the like.

As with other transportation projects, the primary economic benefits attributable to each of the alternatives, will be measured as savings in time and cost of transportation. In order to quantify the tangible elements, the least costly alternative method, which could be considered under without-condition of the alternative to the Panama Canal, might be applicable. One of the least costly alternatives will presumably be the second best lock or sea-level canal which would have nearly the same capacity as the alternative to the Panama Canal. Another alternative might be a combination of ocean trade routes competitive with the Isthmian route such as those via the Cape of Good Hope, Cape Horn, and the Suez Canal with oil pipelines and land-bridge through the Panamanian Isthmus as well as land-bridges in the continental U.S. In such a case, this combination should have nearly the same capacity as the alternative to the Panama Canal. Intangible primary benefits of each of the alternatives could be safer navigation through the Isthmian route, reduction in transportation risk, etc. Both primary benefits, tangible and intangible, will implicitly express the users' capacity to pay. Should there be an additional method to measure

the users' capacity-to-pay, the same method would also be used to estimate the primary economic benefits. Should it also be necessary to estimate the primary economic benefits attributable to the country of Panama and other user countries, it might be possible to separate the Panamanian attribution from others based on the share of the Panamanian conventional flag ships and Panamanian owned ships versus that of others.

The secondary economic benefits shall be identified in the analyses of the impacts on Panama and other users during both the construction period and the operation stage. The benefits will then be measured as the secondary economic benefits irrespective of tangible or intangible benefits. The secondary benefits will be measured from the extensive area not only in Panama, but in user countries and other countries related to the Isthmian trade route. The secondary economic benefits shall be quantified to the extent possible and shall be converted into monetary value. In this case, however, care shall be taken to avoid double counting the benefits. In measuring the secondary economic benefits non-economic items shall be excluded.

The economic evaluation of each alternative shall be made by comparing the economic costs and the tangible economic benefits which are the sum of the primary and secondary benefits, and shall be calculated taking into account annual increase in transit cargo tonnage through the Panamanian Isthmus. The overall economic evaluation of each alternative shall then be made by comparing the intangible economic benefits (consisting mostly of the secondary benefits) or the influential effects of each alternative to Panama, users, and other related countries. The base year for the economic analysis shall be 1990 and all measurements of monetary terms shall be based on constant 1990 prices. Measurement of the economic benefits shall coincide with the economic life of each alternative determined separately in the foregoing study "Historical Trade Analysis." (This study will be released in due course by the Secretariat.) The time span to measure the economic benefit may be 50 years for most of the alternatives, and the target year for the economic evaluation will presumably be 2060 for the sea level canal case which will require the longest construction period, about 10 years. In this study, the evaluation of the alternative shall be made primarily from an economic viewpoint, and various indicators for the economic evaluation such as economic rate of return, net benefit, benefit-cost ratio, etc. shall be used.

1.2 Objectives

The principal objectives of this study which shall be undertaken by the component study contractor are as follows:

- To identify and estimate economic benefits and costs of each alternative
- To conduct cost-benefit comparisons and to calculate the economic rate of return and other indicators
- To conduct an overall evaluation of each alternative

1.3 Scope of Services

1.3.1 Collection of Data and Information

All the necessary data and information concerning the economic analysis as well as the results of the studies such as "Commodity and Traffic Projections", "Cost Estimates", "Financial Analysis", "Analysis of Impact upon Panama", "Analysis of Impact upon Users", and "Management Arrangements" shall be collected. All collected data and information will then be reviewed and analyzed for the economic analysis.

1.3.2 Identification of Economic Benefits

All the economic benefits, primary and secondary, tangible and intangible, shall be identified for each of the prescreened alternatives. The secondary benefits will be identified in the impact analyses. Then the results of identification of the impacts shall be collected in due course by the Secretariat.

1.3.3 Estimation of Economic Benefits

All the economic benefits, identified in 1.3.2 above, shall be quantified to the fullest possible extent, and tangible benefits shall be measured in monetary value for each of the prescreened alternatives. The primary economic benefit may be expressed by savings in time and in cost of transportation, and the least costly alternative method will be a helpful way to measure this primary economic benefit. Although most of the secondary economic benefits will be identified and analyzed in the impact analysis as influences to Panama and Canal users, in this study, they shall be converted into monetary value. Analysis and conversion of these secondary benefits will be carried out, taking into account the relationship of economic activities in Panama.

1.3.4 Identification of Economic Costs

All the economic costs shall be identified based on the results of the studies "Cost Estimate" and "Financial Analysis", and shall be classified into two cost items: those

which will be converted into economic costs (domestic costs such as Panamanian goods and services), and those which will not be necessarily converted (international cost items such as imported goods and services).

1.3.5 Analysis of Conversion Factors

The data and information concerning the conversion factors shall be collected and analyzed to transfer the identified cost items of Panamanian goods and services into international costs (economic costs). If there will not be any applicable conversion factors available, they shall be prepared.

1.3.6 Estimation of Economic Costs

All the economic costs, identified in 1.3.4, shall be measured in monetary value for each of the prescreened alternatives. In this case, Panamanian goods and services shall be converted into economic costs by using the conversion factors and by excluding transfer payments.

1.3.7 Comparison of Economic Costs and Benefits

All the economic costs and tangible economic benefits shall be compared for each of the prescreened alternatives, and various indicators such as economic internal rate of return, net benefit, benefit-cost ratio, etc. shall be calculated for evaluating each alternative.

1.3.8 Overall Economic Evaluation of Each Alternative

Taking into account all the tangible and intangible benefits, an overall economic evaluation of each of the prescreened alternatives shall be conducted. Evaluation shall be made by comparing the degree of effects especially to the country of Panama, Panamanian economy and the Canal users.

2 ANALYSIS OF IMPACT UPON PANAMA

2.1 Introduction

This study requires very extensive analyses on various aspects of effects: economic, socio-cultural, geographic, political, environmental, financial and so on. The study also requires analysis on human settlements in relation to the project implementation. Therefore, the component study contractor has to carefully review all the data sources including other studies by PCC and so on.

This study will be an inseparable part of the economic analysis in measuring secondary benefits of the project. Thus, the coverage and depth of study will be limited to the extent and size of effects and impacts; their monetary evaluation will be treated in the Economic Analysis.

2.2 Objectives

The principal objectives of the Analysis of Impact upon Panama are to identify probable secondary effects of and impacts on each alternative project on Panama and project region as well as to provide appropriate data and information for the subsequent Feasibility Analysis and Selection of the Best Alternative.

2.3 Scope of Services

The component study contractor will use the following scope of services in order to attain the objectives:

2.3.1 Collection of Data and Information

All the necessary data and information as well as the results of the foregoing studies, Present Situation of Panama, Biological Inventory, Financial Scheme, Economic Analysis, Financial Analysis, Environmental Analysis, and Analysis of Impact upon Users, shall be collected.

Out of these data and information upon impacts on Panama and the project region during both construction and operation will be reviewed and analyzed.

2.3.2 Identification of Impacts upon Panama during Construction

The data and information collected in regards to impacts during construction, will be categorized into direct/indirect impacts upon the project region and direct/indirect input upon Panama during construction.

Impacts during operation will be categorized into direct/indirect impacts upon the project region and direct/indirect impacts upon Panama during operation.

Therefore the following eight categories are identified:

- Direct impacts on project region during construction
- Indirect impacts on project region during construction

- Direct impacts on country of Panama during construction
- Indirect impacts on country of Panama during construction
- Direct impacts on project region during operation
- Indirect impacts on project region during operation
- Direct impacts on country of Panama during operation
- Indirect impacts on country of Panama during operation

Direct effects will be quantitatively analyzed as far as the available data allows. Care must be taken, however, to avoid the double counting of effects, particularly when distinguishing national and regional benefits.

Indirect effects will be no less important than direct effects, especially for such a major infrastructure project that will have large and long-lasting influences. In particular, regional development, if successfully induced, with increased economic activity and enhanced land and property value, may make the project successful not only economically but also financially. These indirect effects, therefore, should be carefully spelled out, although they are generally difficult to quantify.

2.3.3 Impact Analysis

In accordance with the above classification, each of eight categories will be analyzed.

3 ANALYSIS OF IMPACT UPON USERS

3.1 Introduction

The Analysis of Impact upon Users component study is closely related to the Economic Analysis and supplies important information to Feasibility Analysis and Recommendation of Best Alternative.

This study, similar to the Analysis of Impact upon Panama study, will measure the extent and size of effects and impacts.

All assumptions and conditions used in this study are compatible with those set up in other those during construction) and long-term (those during operational period) categories.

3.2 Objective

The principal objective of the Analysis of Impact upon Users is to identify and to analyze the secondary effects and impacts of each alternative. As in the Analysis of Impact upon Panama, the extent and size of the impacts which cannot be quantified will be measured; impacts measured in monetary terms will be further analyzed in Economic Analysis.

Direct impacts will be the main subject of the study, but some significant indirect impacts will also be identified and analyzed. These impacts will be quantified to the fullest extent possible.

3.3. Scope of Services

The component study contractor will use the following scope of services in order to attain the objectives:

3.3.1 Collection of Data and Information

As in Analysis of Impact upon Panama, the data and information sources for this component study are the results of foregoing crucial component studies such as Status of Present Panama Canal, Historical Trade Analysis, Future Transportation System, Commodity and Traffic Projections, Economic Analysis, and Analysis of Impact upon Panama. Besides these, impact studies conducted by PCC are good reference.

The collected data and information are reviewed and analyzed. Impacts will be classified into short-term impacts (during construction period) and long-term impacts (during operation period).

3.3.2 Identification Short-term and Long-term Impacts Upon Users

From the data and information collected above, impacts which were classified into short-term impacts and long-term impacts will be identified.

Short-term impacts will be then classified into direct short-term impacts and indirect short-term impacts.

Long-term impacts will also classified into direct long-term impacts and indirect long-term impacts.

3.3.3 Analysis of Impacts Upon Users

The analysis will be conducted in the categories described below.

Short-Term Impacts

Short-term impacts will be, but not be limited to, the following:

Direct Impacts:

- During construction of an alternative, demand for construction machinery and materials will increase in the developed industrial countries, Central and South American countries, and other developing countries. Demand for labor will be increased in Panama and surrounding countries. As a result, the economies will be stimulated mostly due to an increase of income.
- During construction some alternatives will limit the traffic in the existing canal and the use of relevant facilities. In some other cases, the existing canal will be temporarily closed. The effects on users and user countries will be significant.

Indirect Impacts:

- Construction activity will bring an increase of income to many countries, especially the adjacent countries.

Long-term Impacts

Direct Impacts:

- If ships currently too large for the Panama Canal are able to use the alternative, some vessels now using the Suez or Cape of Good Hope routes because of their size will change their route to Panama, even though the total volume of trade or their origin/destination will remain unchanged.
- In the same case as above, some commodities currently using the most cost-effective modes of transportation will be able to make use of the Isthmian route on oceangoing vessels. For example, petroleum could be shifted from the Trans-Panamanian Oil Pipeline to larger oil tankers which would be able to pass through the new canal.

Indirect Impacts:

- The increased size of vessels passing through the Panama Canal will induce some decrease in commodity prices in the world market by lowering transportation costs. This will activate new exports of commodities by supplier countries and promote development of resources. It will also stimulate the shipbuilding business and will encourage extension and enlargement of the major seaports of the world.

4 SCHEDULE

The overall schedule for completion of the entire study is 30 months and the time allocated for completion of these component studies is four months in total. These studies will start in the 17th month of the overall schedule and will be completed by the end of the 20th month, as shown in Figure 1. The proposed manning schedule for these component studies is shown in Figure 2. The major work assignments for these component studies are shown in Figure 3.

5. REPORTS

The Reports to be prepared by the component study contractor shall be:

1) Inception Report
2) Interim Report
3) Final Study Report
4) Monthly Report

All reports shall be written in comprehensible English. Units shall be expressed in the metric system. The pages of the text shall be in principle 8-1/2" x 11" with pull-outs a maximum of 11" x 17". Oversized drawings may be placed in a pouch within the text or assembled in a separate appendix.

5.1 Inception Report

The component study contractor shall prepare sixteen (16) copies of an Inception Report for the component study, "Economic and Impact Analyses" and shall submit this to the Study Commission not later than fifteen (15) days after commencement of the Service. The Inception Report shall contain, but not be limited to, the following:

Figure 1. Work Time Schedule for Economic and Impact Analyses

Work item	Name	Grade	Month				Total
			17	18	19	20	
1. Team leader		A					4.0
2. Senior Economist (1)		B					4.0
3. Senior Economist (2)		B					3.0
4. Economist (1)		C					3.0
5. Economist (2)		C					3.0
6. Senior Impact Analyst (1)		B					4.0
7. Senior Impact Analyst (2)		B					4.0
8. Impact Analyst (1)		C					4.0
9. Impact Analyst (2)		C					3.0
10. Impact Analyst (3)		C					3.0
						Total:	35.0

Figure 2. Manning Schedule for Economic and Input Analysis

Task \ Position	1. Team Leader	2. Senior Economist (1)	3. Senior Economist (2)	4. Economist (1)	5. Economist (2)	6. Senior Impact Analyst (1)	7. Senior Impact Analyst (2)	8. Impact Analyst (1)	9. Impact Analyst (2)	10. Impact Analyst (3)
1. Collect Data and Information	P	S	S	S	S	S	S	S		
2. Identification of Economic Benefits	S	P	S	S	S					
3. Estimation of Economic Benefits	S	P	S	S	S					
4. Identification of Economic Costs	S	P	S	S	S					
5. Analysis of Conversion Factors	S	P	S	S	S					
6. Estimation of Economic Costs	S	P	S	S	S					
7. Comparison of Economic Costs and Benefits	S	P	S	S	S					
8. Overall Economic Evaluation of Each Alternative	S	P	S	S	S					
9. Identification of Impact upon Panama during Construction	S					P	S	S	S	S
10. Analysis of Impact Upon Panama	S					P	S	S	S	S
11. Identification of Impact upon Users	S					P	S	S	S	S
12. Analysis of Impact upon Users	S					P	S	S	S	S
13. Reporting	P	S	S	S	S	S	S	S	S	S

P: Principal
S: Supporting

Figure 3. Position Assignment for Economic and Impact Analyses

(1) Statistics, data, information, etc. to be collected by the component study contractor including those collected in the related studies.

(2) Methodologies to be adopted for various studies and analyses,

(3) Overview of the results of studies and analyses

(4) Work flow chart, study time schedule, man-month input, and study budget plan.

5.2 Interim Report

The component study contractor shall prepare ten (10) copies of an Interim Report to be submitted to the Study Commission not later than three (3) months after commencement of the Service. The Interim Report shall contain, but not be limited to, the following:

(1) Studies and analyses completed during the period and those to be conducted during the subsequent period,

(2) List of collected data and information with brief comments, and

(3) Any major outputs of studies and analyses completed during the period such as:

- Identification and estimation of economic benefits
- Identification and estimation of economic costs
- Identification and analysis of impacts upon Panama and Canal users

5.3 Final Study Report

The component study contractor shall prepare sixteen (16) copies of a Final Study Report, and shall submit this to the Study Commission not later than four (4) months after commencement of the Service. The Final Study Report shall cover and contain all the results of the studies and analyses required by the Terms of Reference. The report shall be submitted in draft form, and shall be revised, where required, based on the comments of the Study Commission issued within thirty (30) days after receipt of the said report by the Commission. The Final Report shall consist of 1) executive summary, 2) main body, and 3) conclusions & recommendations. The component study contractor selected to undertake the work will be provided with a topical outline to be used in preparing the Final Report. The Final Study Report shall contain, but not be limited to, the following:

(1) The same contents as in the Interim Report

(2) Comparison of economic costs and benefits

(3) Overall economic evaluations of each alternative

5.4 Monthly Report

The component study contractor shall prepare ten (10) copies of Monthly Reports, and shall submit these to the Study Commission at monthly intervals.

The Monthly Report shall contain, but shall not be limited to, the following:

- The studies completed during the period and those to be performed during the following period
- Major inputs of the studies, analyses, etc., completed
- Major changes, problems, etc., during the period
- Man-month input and study budget used during the period, and those accumulated up to the period

The Monthly Report can be a brief letter report.

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Environmental Analysis

1 INTRODUCTION

One of the component studies to be conducted is an environmental analysis. This analysis is the subject of this terms of reference. In parallel with the component studies, the Study Commission will be assisted by a contractor responsible for the Feasibility Analysis/Final Report (FA/FR). The FA/FR Contractor's effort includes identification of alternatives, prescreening of alternatives, selection of a recommended alternative, and a detailed investigation of the selected alternative. Information from the component studies is used as input to these tasks.

2 OBJECTIVES

The Environmental Analysis Component Study will consider construction, operation, and maintenance of each alternative and address anticipated effects on the environment. The objective will be to identify impacts and the areas affected, characterize these potential effects to the extent possible and determine their significance.

The environmental analysis is restricted to an ecological assessment with the remaining environmental elements being considered under the Analysis of Impact upon Panama Component Study. The ecological analysis will be based on consideration of plans and designs for various canal alternatives in the context of the local marine, freshwater, and terrestrial ecosystems. Baseline information on species present will be provided by the Biological Inventory Component Study and other available sources of data. The assessment should conform to appropriate international guidelines and professional standards.

The effects of each alternative will be identified and characterized to the extent possible. This shall be accomplished by identifying concerns; reviewing plans for construction, operation and maintenance; identifying facility-biological interfaces; listing potential effects of each alternative on biotic groups, and defining the extent and magnitude of these effects. A descriptive report will be prepared to report the ecological effects for each alternative. The evaluation will focus on important species, e.g., representative, sensitive, economically valuable, and endangered. Where adverse effects are identified, consideration will be given to modifying plans and designs to eliminate or reduce effects. This effort will be done in consultation with engineering personnel.

At present it can be anticipated that issues to be considered will include, but not be limited to, the following:

- Physical, chemical, and biological changes in lakes and rivers
- Clearing of forests and loss of agricultural land
- Changes in water quality and effects on biota
- Direct and indirect effects of dredging and other construction activities
- Sedimentation or spoil placement effects on benthos
- Effects on protected and unique habitats
- Changes in fisheries
- Bio-contamination due to discharges, spills, etc.

These items have previously been identified by the Commission as issues of interest.

After designs incorporating means to reduce environmental effects have been developed, unavoidable effects will be defined and methods sought to mitigate these effects. Plans will be developed as warranted for unavoidable effects associated with each alternative. Given enhanced designs and mitigation plans for each alternative, a methodology will be developed and used to rank alternatives.

3 SCOPE OF SERVICES

3.1 Introduction

The contractor selected to perform the environmental analysis will use data from marine, freshwater and terrestrial habitats to perform analyses according to the plan described below. The plan has been designed to take into account other component studies and work to be performed by the FA/FR Contractor. As a result, the contractor is not expected to deviate from the plan without written authorization from the Commission.

At the same time, it is recognized that anticipated, as well as unanticipated, events could require revision of the study scope. To maximize the return on available resources, the scope will be subject to revision as the project progresses.

3.2 Project Description

An environmental analysis will be performed using information on existing ecology in Panama and on construction and operation of transportation alternatives. A biological inventory and engineering designs will be developed by contractors as part of other component studies.

Figure 1 locates the Republic of Panama and identifies major geographic features. Figure 2 shows political boundaries and locates transportation-related features. Figure 3 focuses on major components of the Panama Canal and Figure 4 provides additional detail concerning the Canal and adjacent areas.

3.2.1 Existing Canal

The existing Panama Canal extends 80 km across the Isthmus of Panama from northwest to southeast. Vessels entering the Canal from the Atlantic Ocean reach the Gatun Locks through an 11 km waterway from Cristobal, and then pass through three-step locks to reach Gatun Lake. From there on, approximately 50 km of waterway leads to the Pedro Miguel Locks where the water elevation is lowered 9 m followed by a further 16 m descent at the Miraflores Locks to reach sea level. From there on, there is a further 6 km of waterway and a 7 km channel into the Pacific Ocean.

There are all together 12 locks in six sets and the maximum lift is 25-26 m. The locks are 305 m in length, 33.5 m in width and 12.1 m in navigable depth. The normal maximum tonnage of vessel capable of passing through the canal is 65,000 DWT and the maximum annual capacity of the canal is believed to be about 200 million tons. An enormous quantity of water is needed for the lock operations, and the Chagres River, Gatun Lake and abundant rainfall in the region are fully utilized. Mean annual rainfall ranges from 1850-3400 mm.

3.2.2 Study Area

The study area is intended to encompass areas affected by any transportation option under consideration and as a result may be altered from the currently defined area as the project proceeds. For the present, the study area is based on several assumptions:

- The area is based on modified lock alternatives. If one or more sea-level alternatives is selected by the prescreening, the scope of this study will be revised to cover the appropriate geography.
- The water sources for the Panamanian alternative will be limited to the Gatun and Madden Lakes watershed - The original plan (see Figure 5) indicated an option to increase the water supply by rerouting the U and

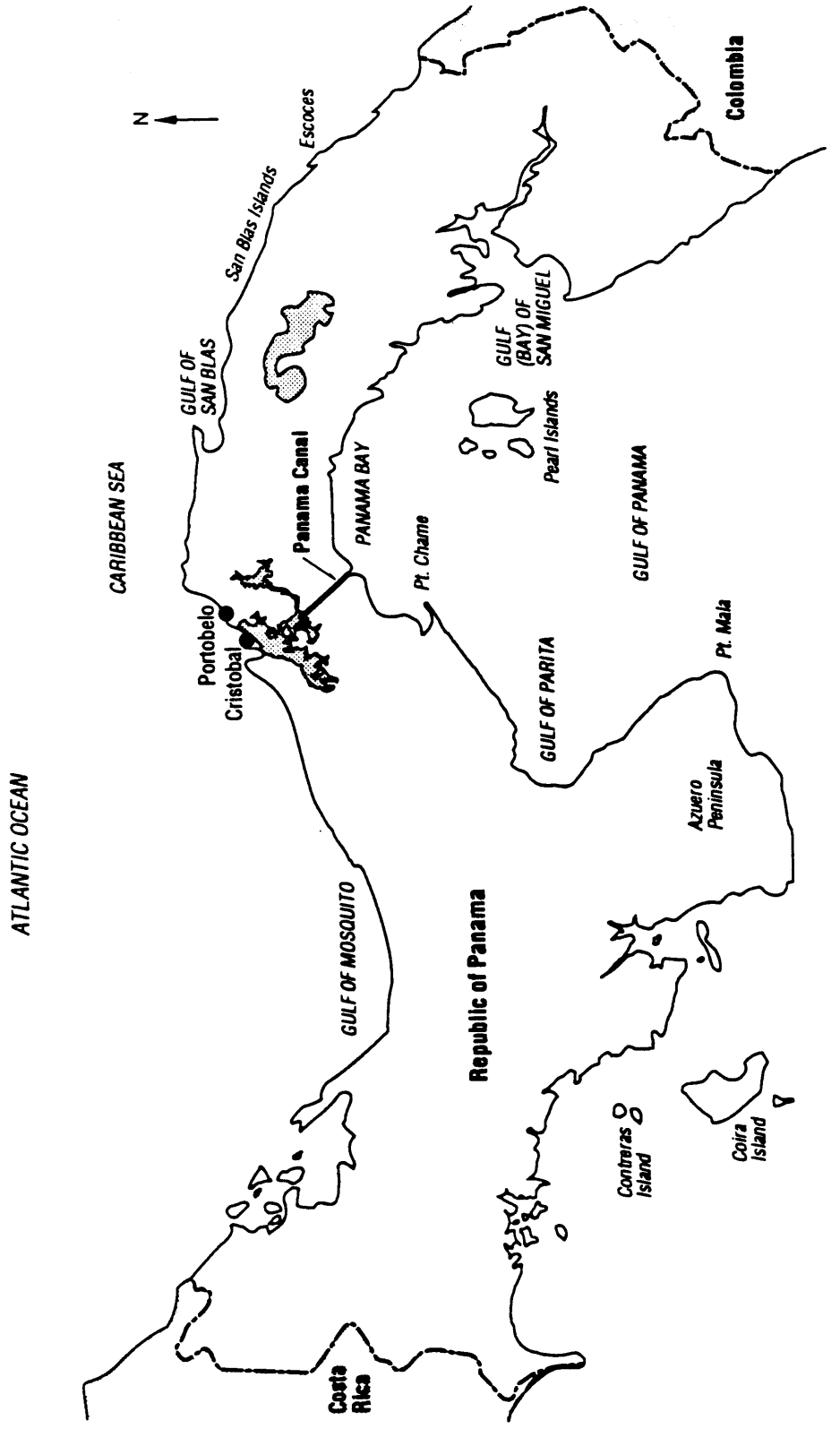

Figure 1 Republic of Panama Geographic Features

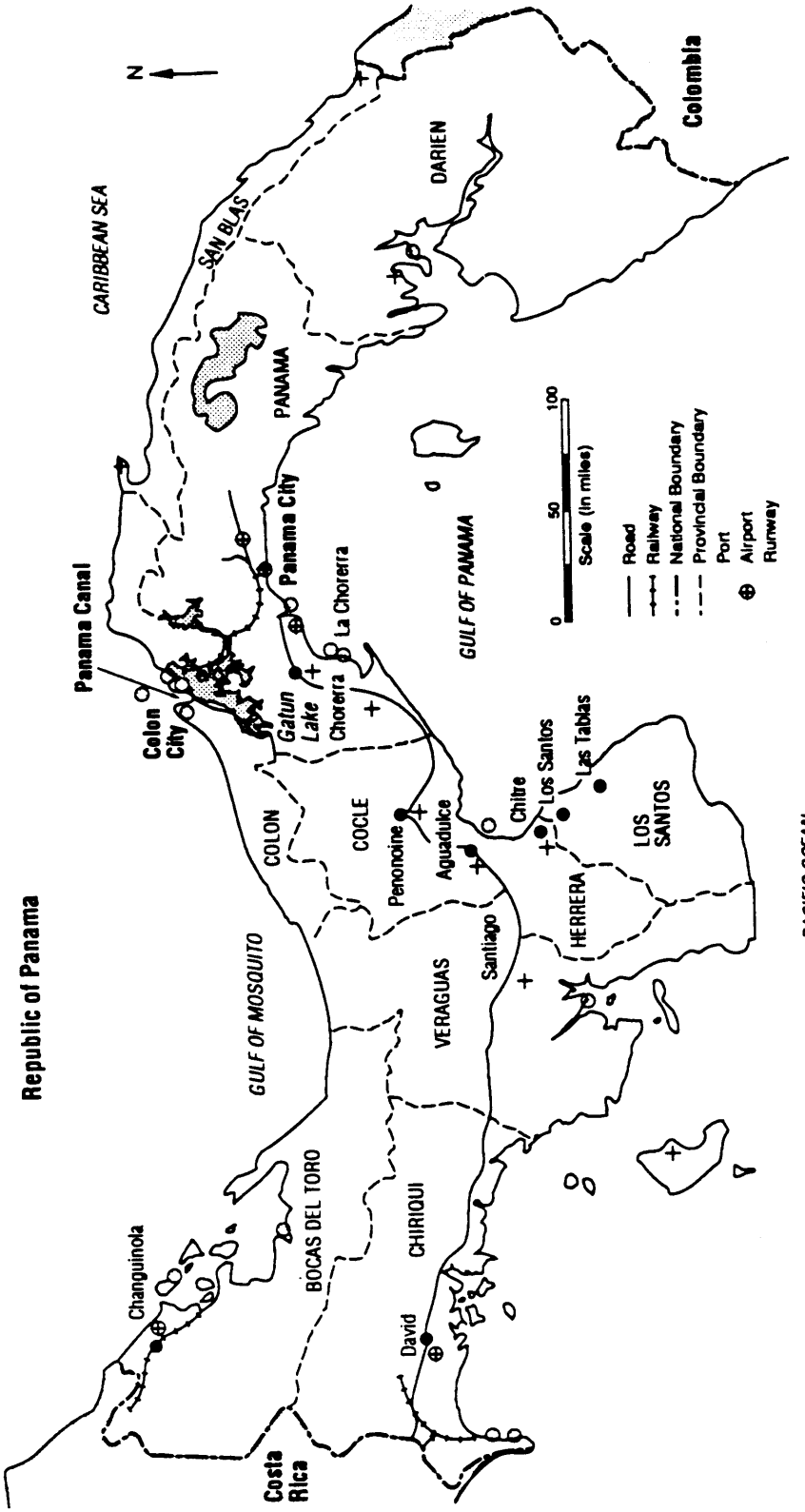

Figure 2 Panama Political Boundaries and Transportation Features

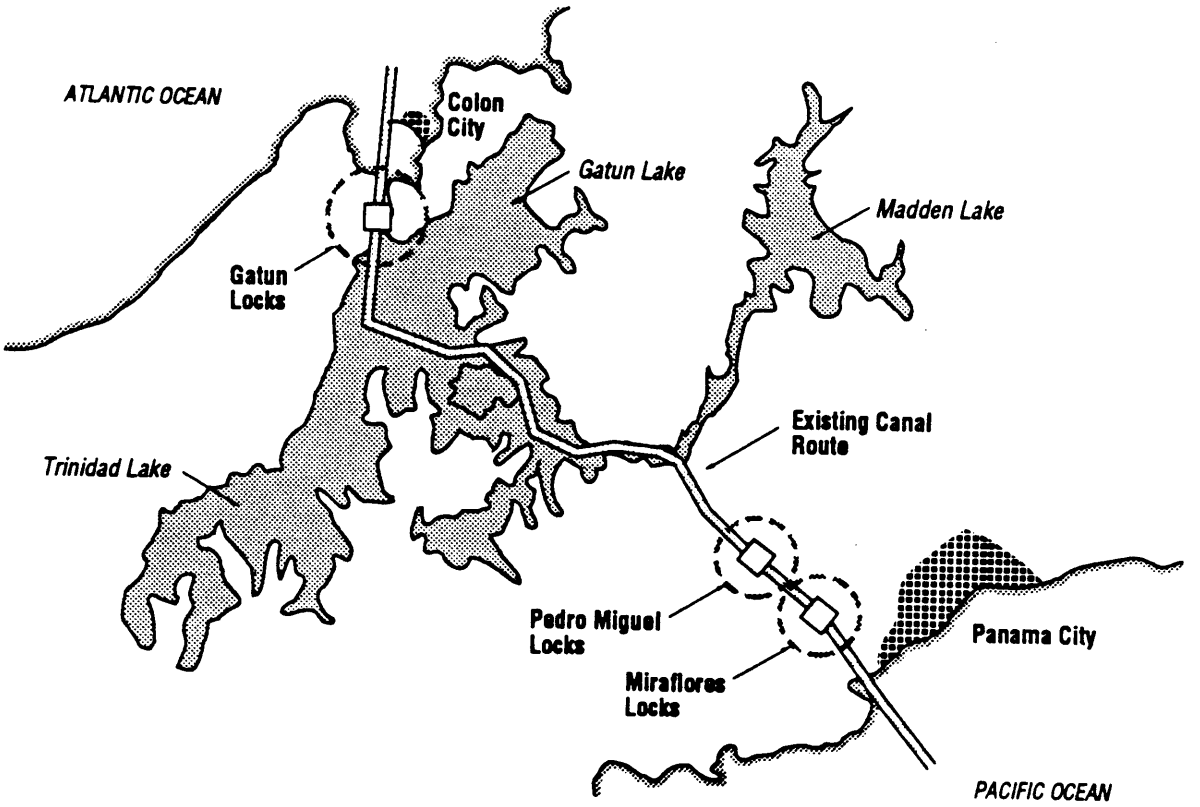

Figure 3 Major Components of the Panama Canal

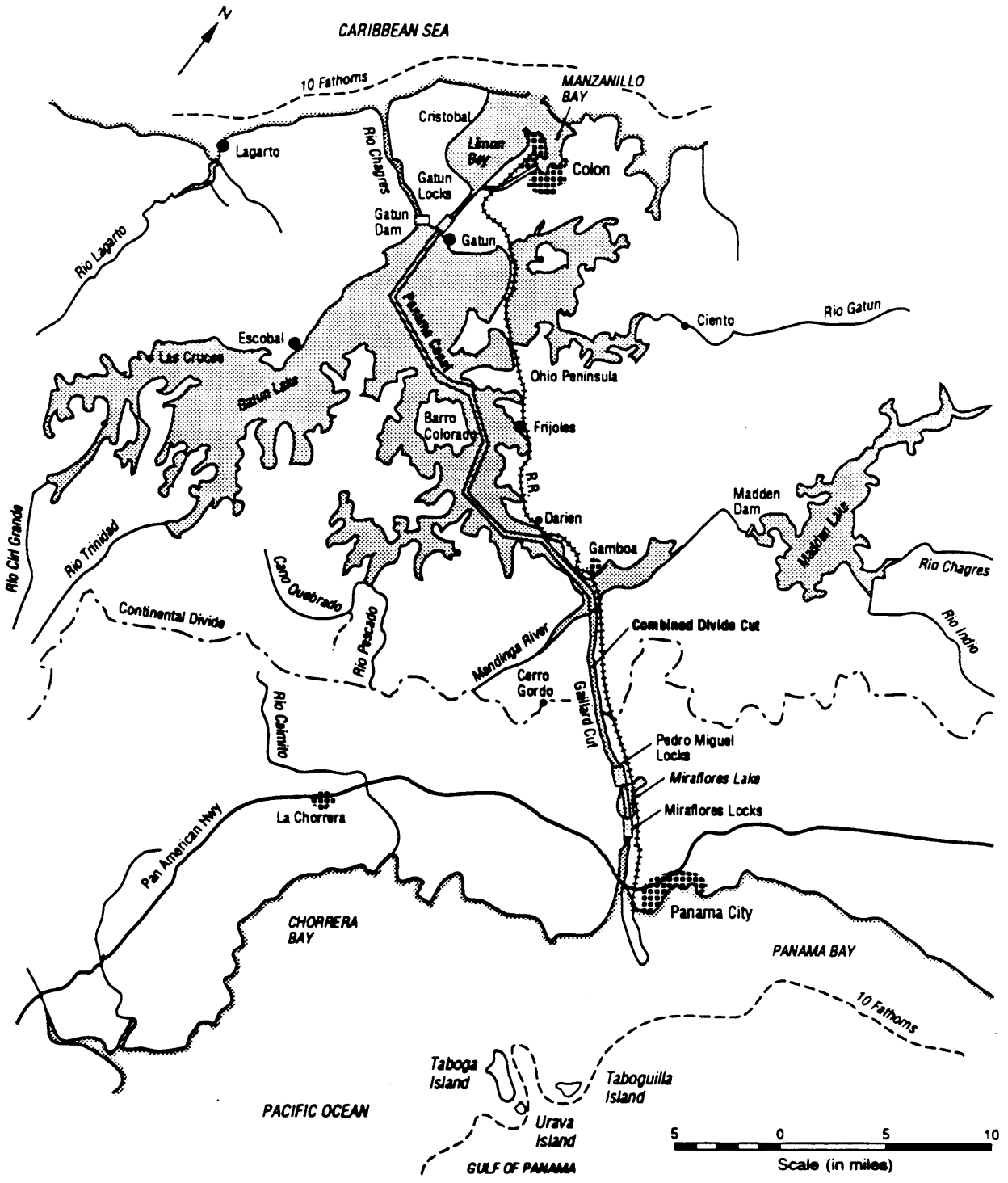

Figure 4 Panama Canal and Adjacent Areas

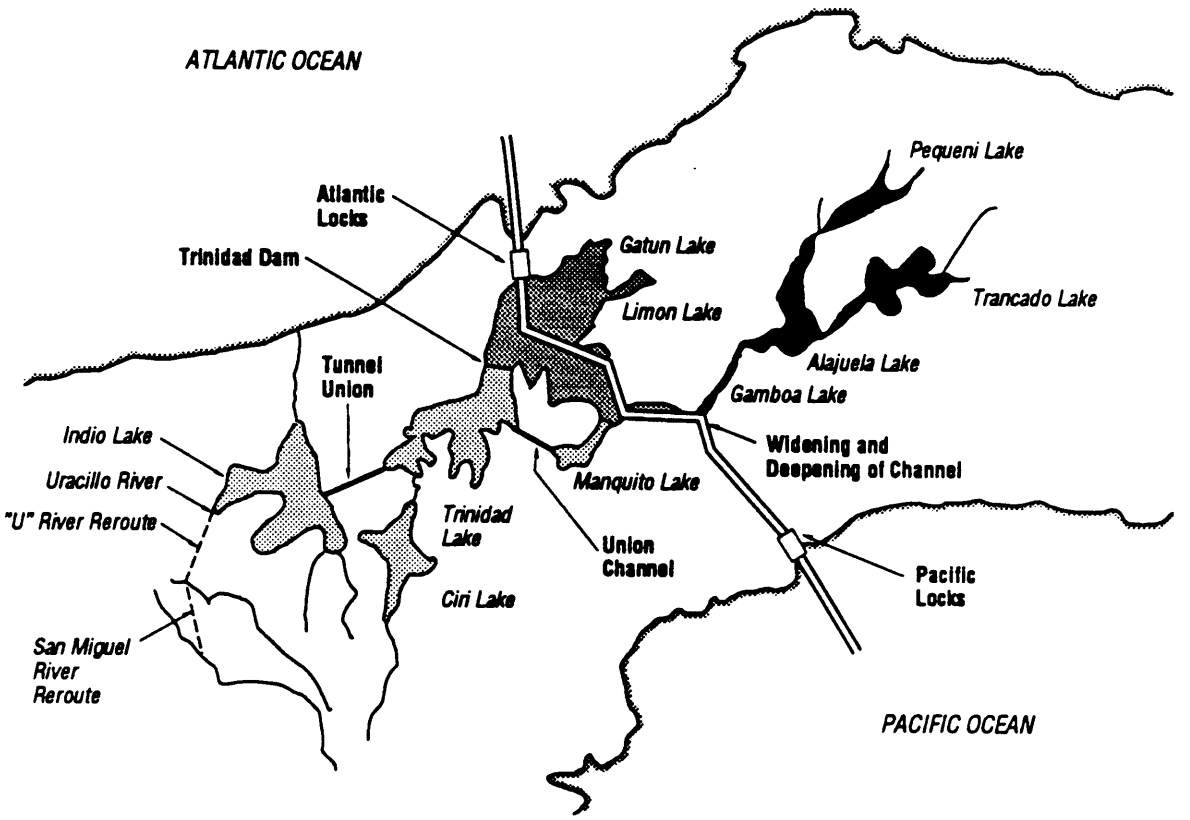

Figure 5 Panamanian Alternative Water Supply

San Miguel Rivers and creating Indio Lake. Since these are considered supplemental sources and represent impacts to two undisturbed watersheds, the required changes are not considered as part of the current project plan.

- The land-based alternatives will be confined to a corridor between the east side of the Canal and Boyd-Roosevelt Highway (Rt 3). This area includes the existing railroad and has access to necessary infrastructure. Any more remote location would incur higher construction and operation costs and would impact less disturbed areas.
- Any upgrading or new port facilities on the Atlantic side will be confined within the breakwaters. This includes channel deepening or widening, changes to the anchorage, changes to the port and creation of new terminal facilities for land-based transportation. Any other assumption requires significant development and environmental effects in a currently undeveloped area.
- Any upgrading or new port facility on the Pacific side will be confined to the area inshore of the existing dredged channel - This assumption appears reasonable unless spoil disposal beyond this area is necessary.
- As in previous studies and design efforts, spoil from the Canal will be disposed of in Lake Gatun, within one mile of the Canal, or adjacent to the entrance channels - It is necessary to study disposal areas for dredge and excavation spoil, but disposal sites have yet to be designated. However, given the cost of transporting the material, it is unlikely that sites selected in the future will be further away.

The assumptions result in definition of the study area as shown in Figure 6. The geographic extent is determined primarily by the large scale watershed changes associated with the Panamanian alternative. Existing lakes as well as new reservoir sites are included. Upstream rivers such as Rio Trinidad, Rio Caimito, and Rio Pescado are excluded since these habitats remain unchanged regardless of downstream modfication. The existing Canal and its approaches are included as is the existing railroad.

3.3 Environmental Analysis

The contractor will be provided with the results of the biological inventory, a summary of available biological literature and information on construction and operation of transportation alternatives under consideration after the prescreening. The contractor

Figure 6 Study Area

will review this material, reanalyze data as appropriate, obtain references pertaining to impact assessment, evaluate impacts, recommend design changes to reduce impacts, develop a mitigation plan, rank alternatives and prepare a summary report.

Earlier descriptions of the environmental analysis have included field or laboratory studies to deal with uncertainties concerning effects of mixing Atlantic and Pacific biota via a sea-level canal. Since this TOR is based on modified lock alternatives, it is assumed that no field or laboratory studies will be required. It is expected that taxonomic questions may arise; however, few, if any, can be resolved in the time available. It will be the responsibility of the contractor conducting the biological inventory to document these questions and provide temporary resolutions.

For each alternative, the Contractor will identify issues or concerns pertaining to the biological communities in terrestrial, freshwater and marine habitats. Issues could include: changes in commercial populations, loss of species, effects on endangered species, changes in species used by man, increases in nuisance species or disease. Valid issues for each specific alternative should be pursued.

After reviewing construction, operation, and maintenance plans for each alternative, the Contractor will focus attention on facility - biological interfaces. Examples include: dredging, underwater construction, spoil disposal, effluent discharges, accidental spills, reservoir creation, stream loss, air emissions, and noise. Both direct and indirect and temporary and long-term interfaces should be considered.

Consideration should also be given to external (not part of any alternative) activities which are also ongoing. Examples include continuing land slides, agricultural development or maintenance dredging along the Canal. The effects of these activities should be considered in predicting future conditions without the alternative being investigated.

Given the characterization of local floral and fauna in the study area and the information developed from the task described above, the contractor will develop a list of the potential effects of each alternative on local biota/ecology. This effort should be comprehensive in that it should cover all significant positive and negative impacts but can be tempered by focusing on issues of concern for the present project. Impacts should emphasize consideration of important species.

Having identified the types of effects anticipated, the contractor will define the extent and magnitude of effects, to the degree possible. Recognizing that data or literature on cause-and-effect in the Panamanian ecosystem may be lacking, information from other pertinent areas should be used as a supplement.

Adverse ecological impacts which have been identified and evaluated will be considered further, based on the facility-biology interfaces. Information provided by the engineering contractor on items such as location, construction technique and schedule, operating characteristics and maintenance procedures and schedule will be assessed to identify changes to plans and designs with the potential to reduce or eliminate ecological effects. Consultation with the engineering contractor or FA/FR contractor will be conducted to determine the feasibility of changes (including cost). Mutually agreed upon changes will be incorporated into the designs and the contractor will reassess the ecological impacts.

The assessment of revised designs will identify some impacts which are both unavailable and warrant mitigation. Criteria should be developed to determine the need for mitigation. Options for mitigation will be developed and evaluated for feasibility, effectiveness and cost in consultation with project engineers. Acceptable plans will be characterized fully and reassessed as part of the alternative's design. A final ecological impact assessment will be prepared for each transportation alternative.

Using the results of the final assessment, transportation alternatives will be ranked based on ecological impact to identify preferred alternatives. A methodology for the ranking will be developed and discussed with the Commission's representatives prior to application. The ranking will be used by the FA/FR Contractor in the overall feasibility analysis. In this task, a multidisciplinary ranking will take place and a preferred alternative selected.

The contractor will prepare a Draft Final Report describing methods and results for each step in the study. The report will be subject to review by the Commission. The Contractor will resolve comments and submit a final report.

4 REPORTS AND DOCUMENTS

Progress Reports

The contractor will provide monthly progress reports. A letter report will be sufficient. This will document current project status, anticipated activities, problems and resolution, and status against budget.

Interim Reports

The contractor will provide brief interim reports. These letter reports will summarize the following:

- Issues which have been identified
- Potential ecological effects of each alternative
- Suggested changes to design
- Options for mitigation
- Ranking methodology

These reports are intended to be short but informative, to keep the Commission appraised of progress and permit periodic review of the study direction.

Draft Final Report

The Contractor will prepare a Draft Final Report which summarizes the methodology and results of each step in the study. Discussions will include characterizations of the impacts of each alternative and documentation of design changes on which the assessments are based. The report will be subject to review and will require revision in response to comments.

Quality Assurance Documents

The contractor is expected to have and use for the project a set of standard operating and quality assurance procedures. These must be available to all project personnel and provide for necessary documentation of any analyses performed. Necessary documentation is to be maintained by the contractor but is subject to audit by the Commission.

5 SCHEDULE

The schedule for the environmental analysis is only one item in an overall project schedule. As a result, start and end dates are particularly important. Specific dates will be assigned when the project begins but durations have been defined. Upon authorization to proceed, the contractor will have four months to complete the study. The effort takes place in the 17th through 20th months of the overall program. Necessary input data will be provided during the initial week of the study and supplemented as the report of the Biological Inventory becomes available.

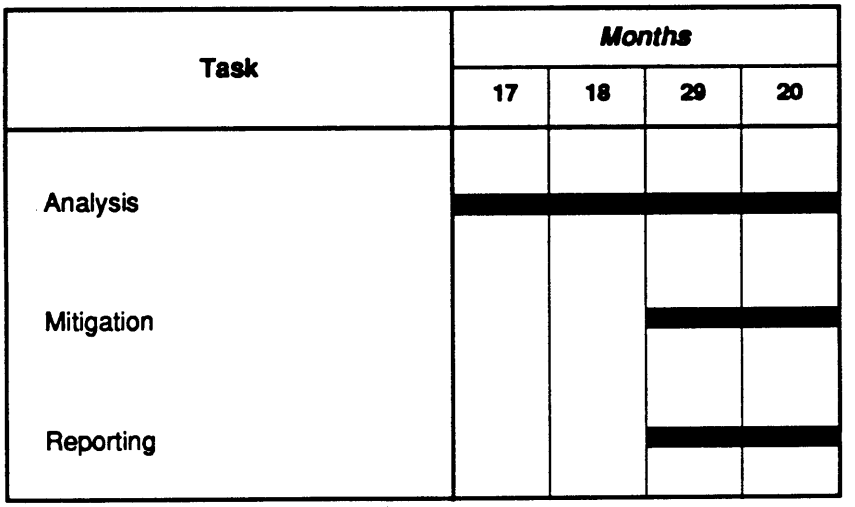

Figure 7 Work Schedule for Environmental Analysis

Task	Months				TOTAL M/M
	17	18	19	20	
Project Manager	■	■	■	■	3
Senior Scientist	■	■	■	■	9
Scientist	■	■	■	■	5
Editor			■	■	2
Graphics			■	■	1.5
Clerical	■	■	■	■	2
Total					22.5

Figure 8 Manning Schedule for Environmental Analysis

Position	*Tasks*		
	Analysis	**Mitigation**	**Report**
Project Manager	P	P	P
Senior Scientist	P	P	P
Scientist	P	P	P
Editor			S
Graphics			S
Clerical	S	S	S

Legend:
P = Principal
S = Supporting

Figure 9 Position Assignments for Environmental Analysis

Development of Additional Data

Upon completion of the Component Studies and the detailed feasibility analysis, the best alternative will be recommended. A detailed investigation of this alternative will then be undertaken. As part of this detailed investigation, additional data and information will be needed.

Thus, this Component Study will consist of developing needed additional data. The exact nature of the data that will be needed will be determined after the Component Studies and feasibility analysis are completed and the best alternative selected.

The additional data will be used mostly for refining the design, cost estimates, and time schedule of the best alternative. Other data may be required to refine the results of the demand analysis, capacity evaluation, and economic and financial analysis.

The scope of work for these studies will be developed on a cooperative basis between the Commission, the FA/FR contractor, and the appropriate Component Study contractors.

Management Arrangements

1 INTRODUCTION

It will be essential to establish well-planned, efficient management arrangement for each alternative scheme for transiting the vessels across the Panamanian Isthmus. To carry out the feasibility analysis for the management arrangements, therefore, the component study contractor shall formulate the optimum management arrangement plan for each of the prescreened alternatives. The management arrangements shall include, among others, the management organization structure, supplemented by supporting management facilities.

The Panama Canal is currently operated under a bi-national, U.S.A. and Panama, commission. Under present laws, this commission is precluded from issuing debt. In the year 2000, the operation of the Canal will be turned over to the Government of Panama.

This component study must take these factors into consideration in recommending management arrangements for the various alternatives.

A new organization, in addition to continuing to efficiently operate the canal, must arrange for the implementation of the capital expenditures programs associated with each of the alternatives to be studied. This could require not only overseeing major construction projects, but also arranging for the financing of these projects.

Thus, a sophisticated financial capability may be required that will be able to negotiate with major governments and international financial institutions, both public and private. Debt guarantees, for example, may have to be negotiated that will insure repayment of borrowed funds for capital improvement projects. Such potential needs must be taken into consideration in analyzing and recommending management arrangements for each alternative included in the study.

Feasibility analysis for the management arrangements may be carried out by the following steps:

1. Data necessary for formulating an optimum management arrangement will be collected for the existing Panama Canal and for other operating organizations similar in character and scale.
2. Operational and managerial characteristics relevant to each of the alternatives will be identified and assessed in terms of operational, financial, and managerial requirements.

3. The conceptual alternative management system for each alternative will be formulated and will be evaluated in various aspects ranging from scale of manpower requirements, possibility of automatic operation, privatization, response to anticipated risks, flexibility and balance of workload, etc.
4. Through the evaluation process, the optimum management system for each alternative will be chosen, and an outline of the scope of the respective management organization structure attached.
5. All the required supporting facilities for each alternative management system will be defined to provide the cost needed for the economic and financial studies with cost data.

The results of the study for the management arrangements for each alternative shall provide basic data for assessing the prescreened alternatives and selecting the best alternative in the subsequent study.

2 OBJECTIVES

The principal objectives of the component study, Management Arrangements which shall be undertaken by the component study contractor, are as follows.

1. To examine and review the operations, financial, and management systems of the present Panama Canal and other similar type of organizations.
2. To formulate and establish the optimum management arrangement for each alternative
3. To provide the basic data for assessing the prescreened alternatives and selecting the best alternative to the Panama Canal

3 SCOPE OF SERVICES

The scope of the services to be conducted by the component study contractor for attaining the objectives set out above are discussed below.

3.1 Collection of Data and Information

Basic data and information required for formulating the optimum management system for each alternative shall be collected through detailed surveys on the operation of the present Panama Canal as well as other similar types of organizations now in operation or under planning. In collecting the data and information consideration

shall be given to modern management techniques and skill including the following information processing tools:

- Management information system (MIS)
- Office automation (OA)
- Computerized data processing system
- Others

3.2 Examination of Operational and Managerial Services

The operational and managerial services of the present Panama Canal and other similar projects shall be examined and analyzed in detail to form the basis for the optimum management system to be established for each alternative. Examination and analysis shall cover such essential items, but not be limited to, the following:

- Legal structures
- Organization structure
- Management discipline
- Staffing
- Training
- Financial status and capabilities
- Information system
- Data bank
- Research and Development

3.3 Identification of the Requirements for Operational and Managerial Services

Through the studies on the operational procedures required for each alternative, all the requirements for operational, financial, and managerial services for each alternative shall be clearly identified and assessed. In the requirements shall be included operational and managerial problems which will likely occur in the course of operating the canal including maintaining of security and implementing capital improvement projects and the necessary countermeasures for them in terms of operational and managerial requirements such as task force, facilities, and equipment inputs, etc. This will also include an assessment of the potential need to arrange funding for capital improvement projects.

3.4 Formulation and Optimization of Management System

In due consideration of the characteristics of each alternative both in operational and managerial aspects, the management system shall first be developed for each alternative, and then to formulate the best suited management system for each alternative. In the management system all the key organization components such as board, administration, financial, maritime, technical, general, emergency, etc., shall be functionally positioned. The management system shall be formulated to suit to the normal periods, emergency conditions, and anticipated risks.

The management system for the complementary mode of transportation will also be formulated. It shall be considered as a supplementary element to support the management system which shall be developed for two different categories of alternative - lock canal and sea-level canal.

All the conceivable management systems shall be assessed and optimized to formulate the best suited management system by introducing the assessment criteria, for instance, proposed below:

- Scale of manpower requirement
- Possibility of automated operation and its expansion
- Built-in flexibility and compatibility of the system
- Balance of workload
- Adaptability to development
- Response to anticipated risks
- Relationship to the present Panama Canal
- Complexity in organization formation
- Needs to finance capital improvement programs

3.5 Establishment of Optimum Management System

The most optimum management system shall be established for each alternative through the assessment of the optimized management system. In the management system, the scope of assignments to be executed by each organizational component shall be defined in detail. Among others, these shall be for main structural body and supporting operational body such as logistics services, community services, canal security and protection, employee services, etc.

3.6 Establishment of Supporting Facilities for Management System

All the facilities and equipment which will be required to support the operational and managerial services, shall be identified for each alternative, and their specifications shall be defined with sufficient explanation of their function how those will play in the management operation of the system for each alternative.

3.7 Estimation of Management Costs

Based on the established management system with its supporting facilities, operation and maintenance costs of the management system shall be estimated for each alternative. The estimate of costs shall be made in reference to the unit prices estimated in the Cost Estimate component study. All the costs and expenses shall be estimated based on the constant 1990 price.

4 SCHEDULE

The overall time schedule to complete the whole study shall be 30 months, and the time schedule allocated to complete this component study shall be 4 months which shall start from the 17th month of the overall time schedule of the study and shall end by the 20th month.

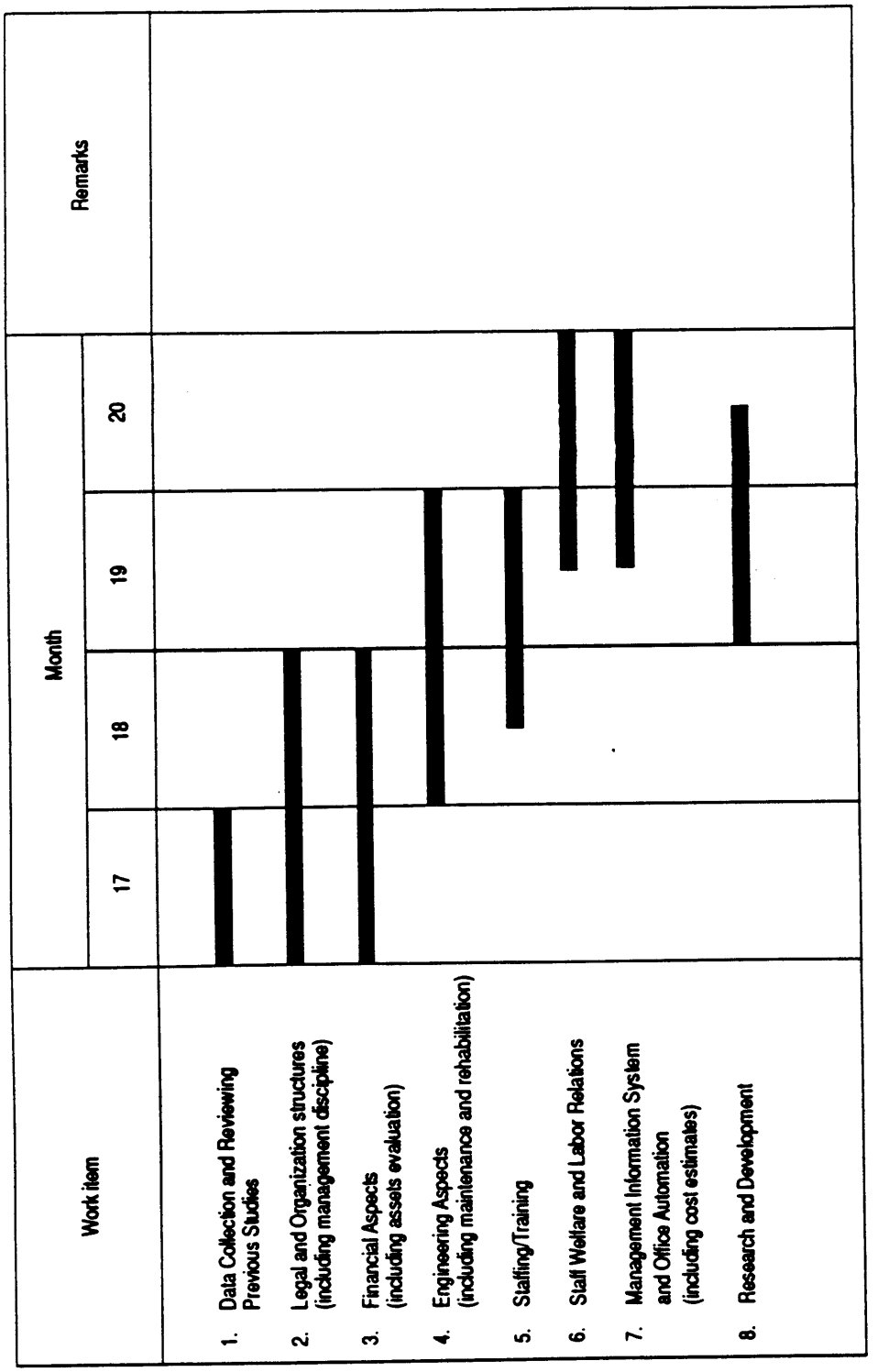

Figure 1. Work Time Schedule for Management Arrangements

Work item	Name	Grade	Month 17	Month 18	Month 19	Month 20	Total
1. Team leader (Management/Organization Specialist)		A	■	■	■	■	4.0
2. Senior Financial Analyst		B	■	■			2.0
3. Senior Civil Engineer		B		■	■		2.0
4. Senior Mechanical Engineer		B		■			1.0
5. System Engineer		C			■		1.0
6. Information/Computer Specialist		C				■	1.0
7. Labor Relation/Training Specialist		B			■	■	2.0
						Total:	13.0

Figure 2. Manning Schedule for Management Arrangements

Task \ Position	1. Team Leader	2. Senior Financial Analyst	3. Senior Civil Engineer	4. Senior Mechanical Engineer	5. System Engineer	6. Information/Computer Specialist	7. Labor Relation/Training Specialist	Remarks
1. Data Collection and Reviewing Previous Studies	P	S						P: Principal S: Supporting
2. Legal and Organization structures (including management discipline)	P							
3. Financial Aspects (including assets evaluation)	S	P	S	S				
4. Engineering Aspects (including maintenance and rehabilitation)	S		P	S				
5. Staffing/Training	S						P	
6. Staff Welfare and Labor Relations	S						P	
7. Management Information System and Office Automation (including cost estimates)	S				P	S		
8. Research and Development	P		S		S			

Figure 3. Position Assignment for Management Arrangements

5. REPORTS

The Reports to be prepared by the component study contractor shall be:

1) Inception Report
2) Interim Report
3) Final Study Report
4) Monthly Report

All reports shall be written in comprehensible English. Units shall be expressed in the metric system. The pages of the text shall be in principle 8-1/2" x 11" with pull-outs a maximum of 11" x 17". Oversized drawings may be placed in a pouch within the text or assembled in a separate appendix.

5.1 Inception Report

The component study contractor shall prepare sixteen (16) copies of an Inception Report for the component study, "Management Arrangements," and shall submit this to the Study Commission not later than fifteen (15) days after commencement of the Service. The Inception Report contain, but not be limited to, the following:

(1) Statistics, data, information, etc. to be collected by the component study contractor including those collected in the studies of "Status of Present Panama Canal" which will be obtainable from the Information Center,

(2) Approach to be adopted for various studies and analyses,

(3) Overview on the results of studies and analyses concerning establishment of the approach for the analysis of management arrangements, and

(4) Work flow chart, study time schedule, man-month input, and study budget plan.

5.2 Interim Report

The component study contractor shall prepare ten (10) copies of an Interim Report to be submitted to the Study Commission not later than three (3) months after commencement of the Service. The Interim Report shall contain, but not be limited to, the following:

(1) Items of studies and analyses completed during the period and those to be conducted during the subsequent period,

(2) List of collected data, information, and reports with brief comments on them, and

(3) Major output of studies and analyses completed during the period such as:

- Results of review of analyses of previous studies and reports
- Results of assessment of proposed approach for management arrangements
- Results of examination for legal and organizational structures
- Results of examination for financial aspects
- Results of examination for engineering aspects
- Results of examination for staffing, training, and staff welfare
- Results of examination for research and development
- Preliminary results of examination for staff welfare and labor relations, management information system, and office automation

5.3 Final Study Report

The component study contractor shall prepare sixteen (16) copies of a Final Study Report, and shall submit this to the Study Commission not later than four (4) months after commencement of the Service. The Final Study Report shall cover and contain all the results of the studies and analyses required by this Terms of Reference. The report shall be submitted in a draft form, and shall be revised, where required, based on the comments of the Study Commission issued within thirty (30) days after receipt of the said report by the Commission. The Final Report shall consist of 1) executive summary 2) main body, and 3) conclusions & recommendations and (4) appendices. The component study contractor selected to undertake the work will be provided with a topical outline to be used in preparing the Final Report. The Final Study Report shall contain, but not be limited to, the following:

(1) The same contents as in the Interim Report,

(2) Results of examiniation for management information system and office automation, and

(3) Results of examination for staff welfare and labor relations.

5.4 Monthly Report

The component study contractor shall prepare ten (10) copies of Monthly Reports, and shall submit these to the Study Commission at monthly intervals.

The Monthly Report shall contain, but not be limited to, the following:

- The studies completed during the period and those to be performed during the following period.
- Major inputs of the studies, analyses, etc., completed.
- Major changes, problems, etc., during the period.
- Man-month input and study budget used during the period, and those accumulated up to the period.

The Monthly Report can be a brief letter report.

Appendix 1

Budget Estimates for Components Studies

Appendix 1, Budget Estimates for Component Studies, is bound separately.

Comisión de Estudio
de las Alternativas
al Canal de Panamá
CENTRO DE INFORMACION

Appendix 2

WORK PLAN FLOWS AND DETAILED INPUT/OUTPUT RELATIONSHIPS

Comisión de Estudio
de las Alternativas
al Canal de Panamá
CENTRO DE INFORMACION

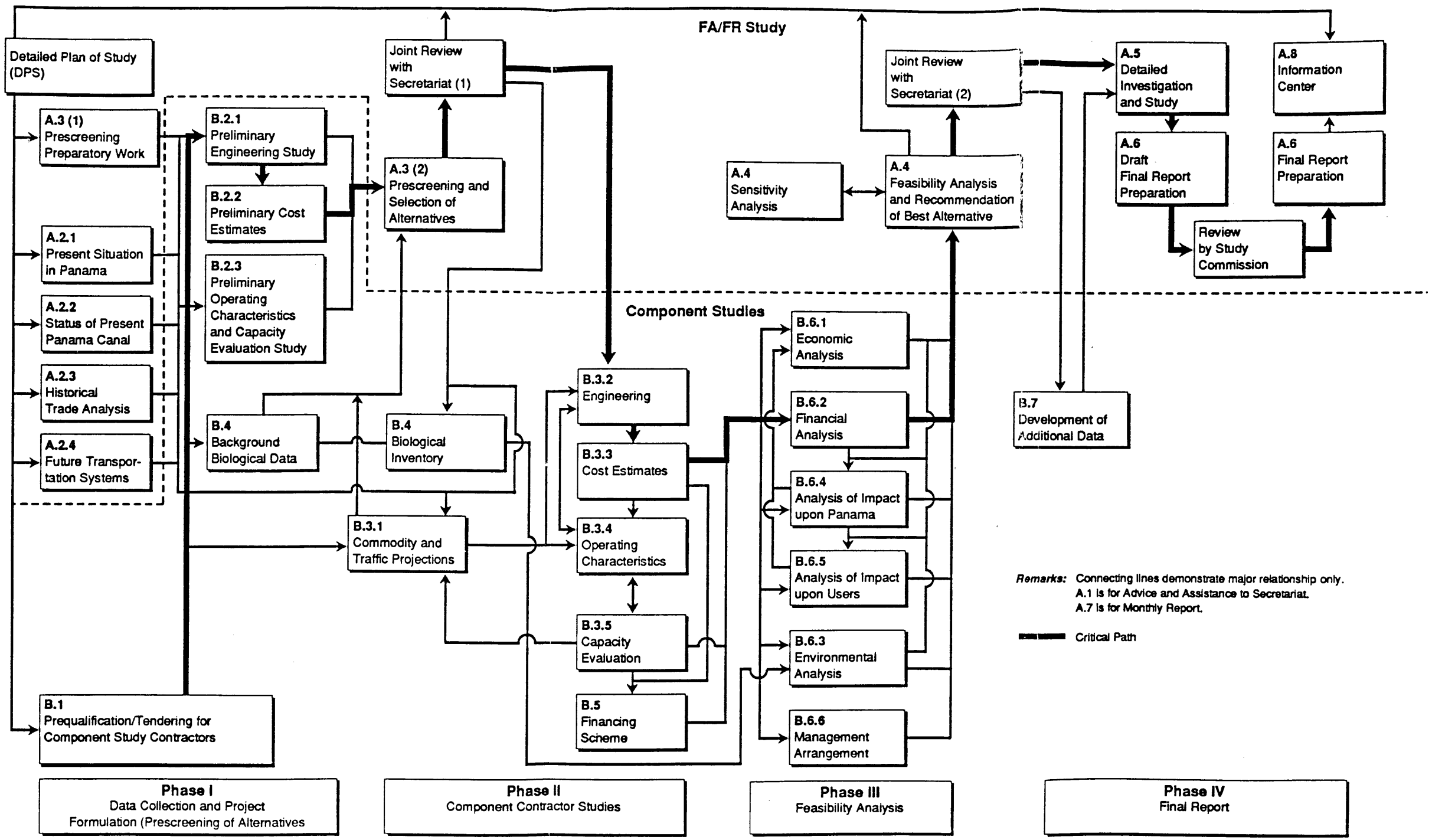

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Figure 1-1
Overall Work Plan Flow

Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
A. FA/FR STUDY	DURATIONS IN MONTHS																													
1. ADVICE AND ASSISTANCE																														
2. DATA COLLECTION AND ANALYSIS																														
1. PRESENT SITUATION IN PANAMA																														
2. STATUS OF PRESENT PANAMA CANAL																														
3. HISTORICAL TRADE ANALYSIS																														
4. FUTURE TRANSPORTATION SYSTEMS																														
3. PRESCREENING/SELECTION OF ALTERNATIVES																														
4. FEASIBILITY ANALYSIS/SELECTION OF ALTERNATIVE																														
5. DETAILED INVESTIGATION																														
6. PREPARE FINAL REPORT																														
7. MONTHLY REPORTS																														
8. PROVIDE INFORMATION CENTER WITH DATA																														
B. COMPONENT STUDIES																														
1. PREQUALIFICATION OF CONTRACTORS/TENDERING																														
2. PRELIMINARY STUDY FOR PRESCREENING																														
1. PRELIMINARY ENGINEERING STUDY																														
2. PRELIMINARY COST ESTIMATES																														
3. PRELIMINARY OPERATING CHARACTERISTICS																														
3. DEMAND ANALYSIS AND ENGINEERING																														
1. COMMODITY AND TRAFFIC PROTECTION																														
2. ENGINEERING																														
3. COST ESTIMATES																														
4. OPERATING CHARACTERISTICS STUDY																														
5. CAPACITY EVALUATION																														
4. BACKGROUND DATA/BIOLOGICAL INVENTORY																														
5. FINANCING SCHEME																														
6. FEASIBILITY ANALYSIS																														
1. ECONOMIC ANALYSIS																														
2. FINANCIAL ANALYSIS																														
3. ENVIRONMENTAL ANALYSIS																														
4. ANALYSIS OF IMPACT ON PANAMA																														
5. ANALYSIS OF IMPACT ON USERS																														
6. MANAGEMENT ARRANGEMENT																														
7. DEVELOPMENT OF ADDITIONAL DATA																														
JOINT REVIEWS																														

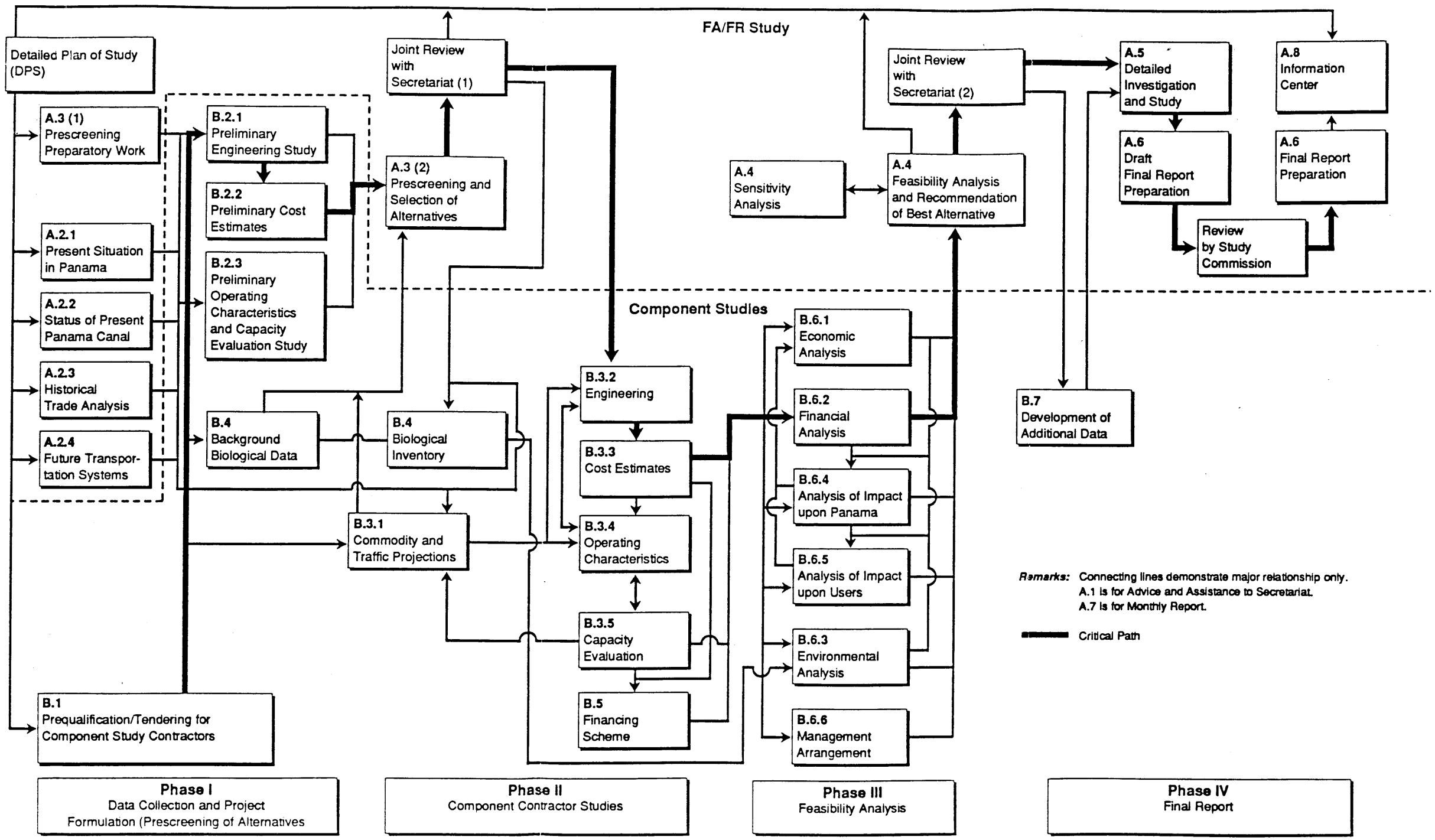
LEGEND

- ACTIVITY BAR
- CRITICAL PATH BAR
- REDUCED ACTIVITY

SINBOL

PANAMA CANAL ALTERNATIVES STUDY

Figure 1-2
Study Summary Schedule



Remarks: Connecting lines demonstrate major relationship only.
A.1 is for Advice and Assistance to Secretariat.
A.7 is for Monthly Report.

Critical Path

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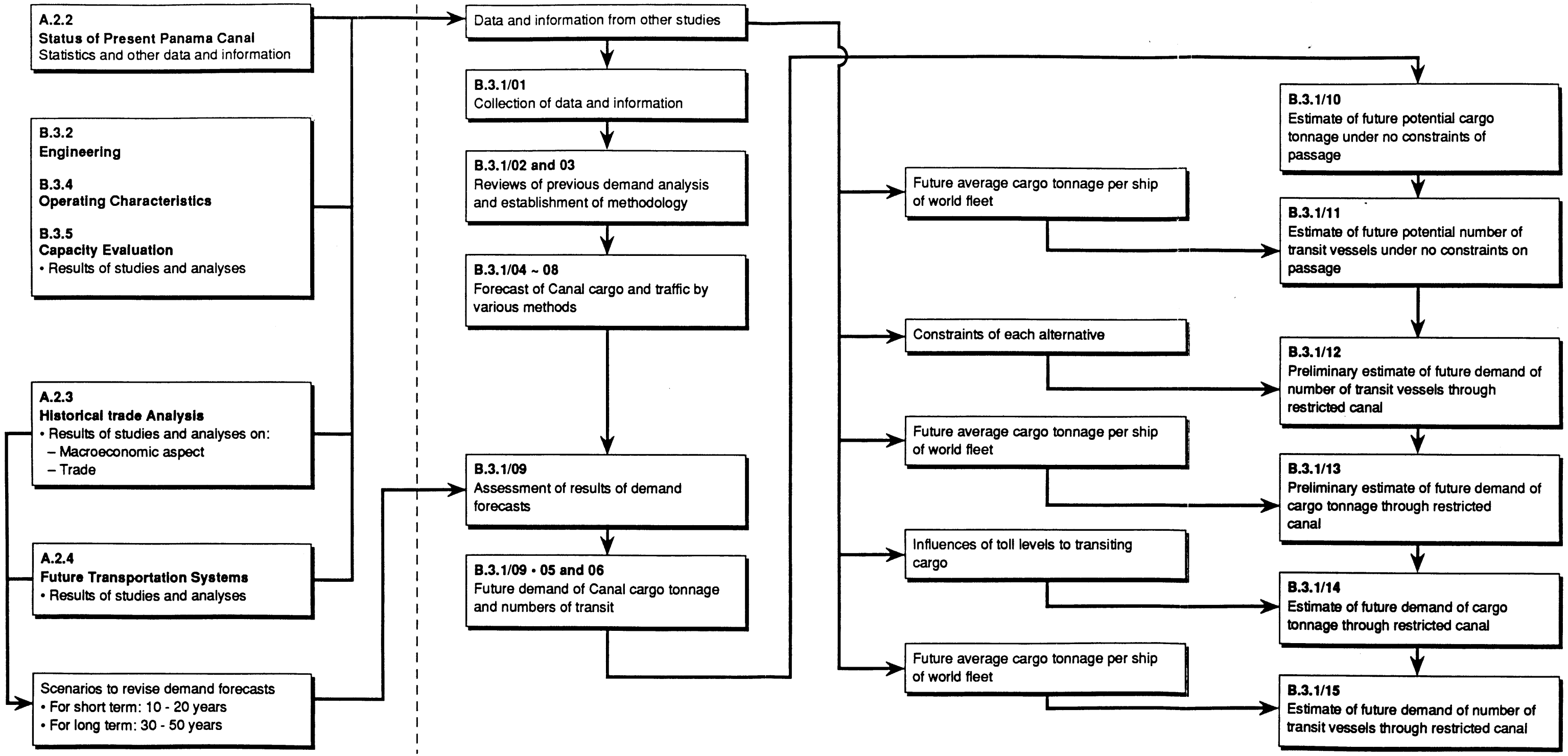
Overall Work Plan Flow



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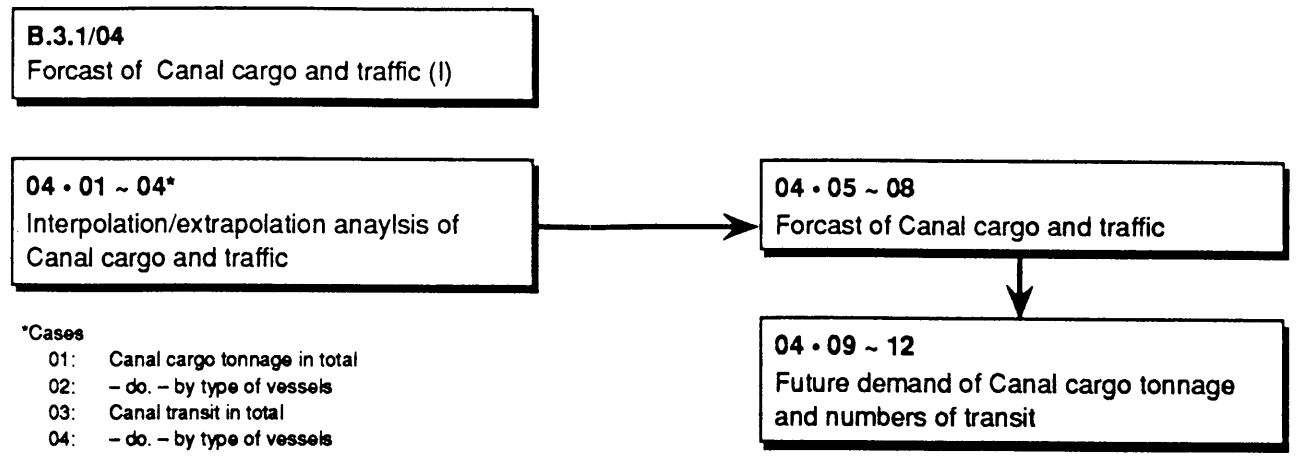
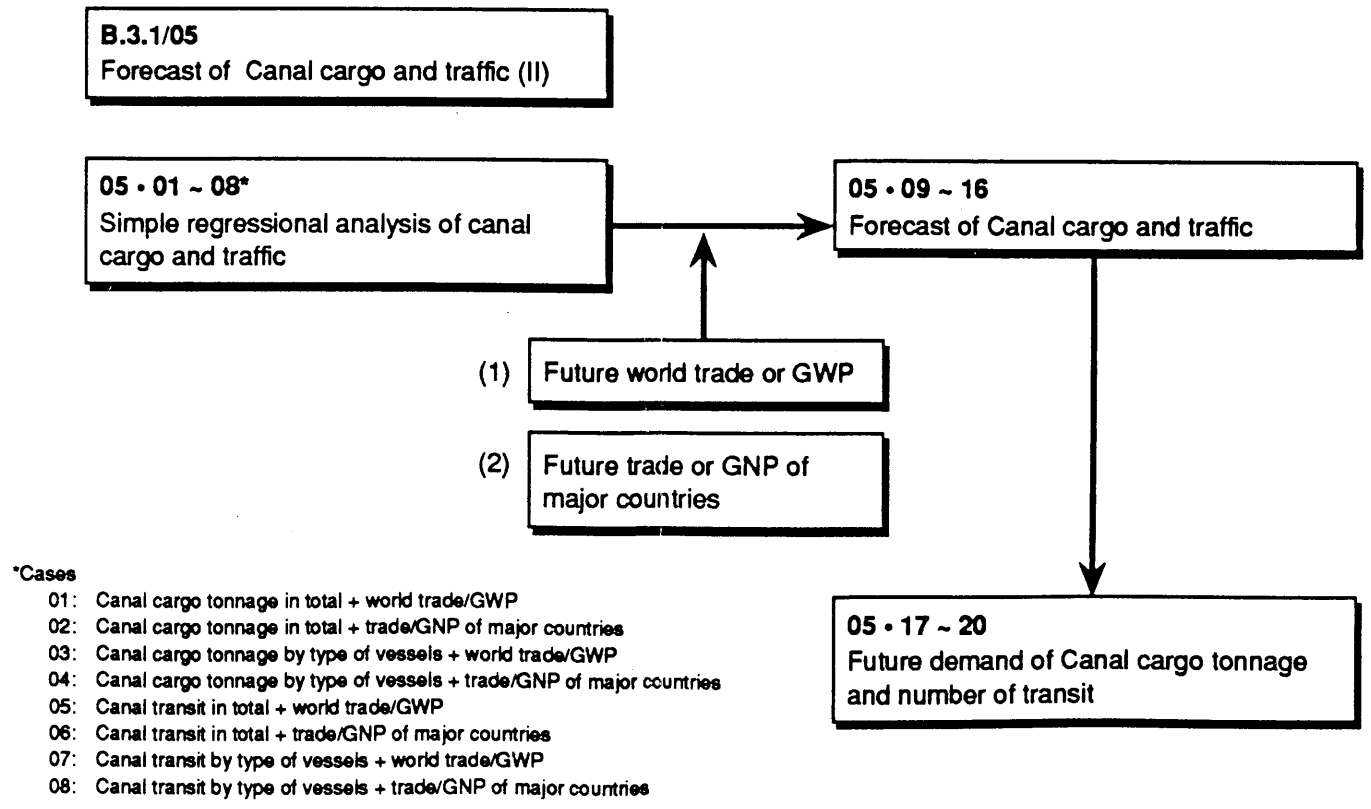
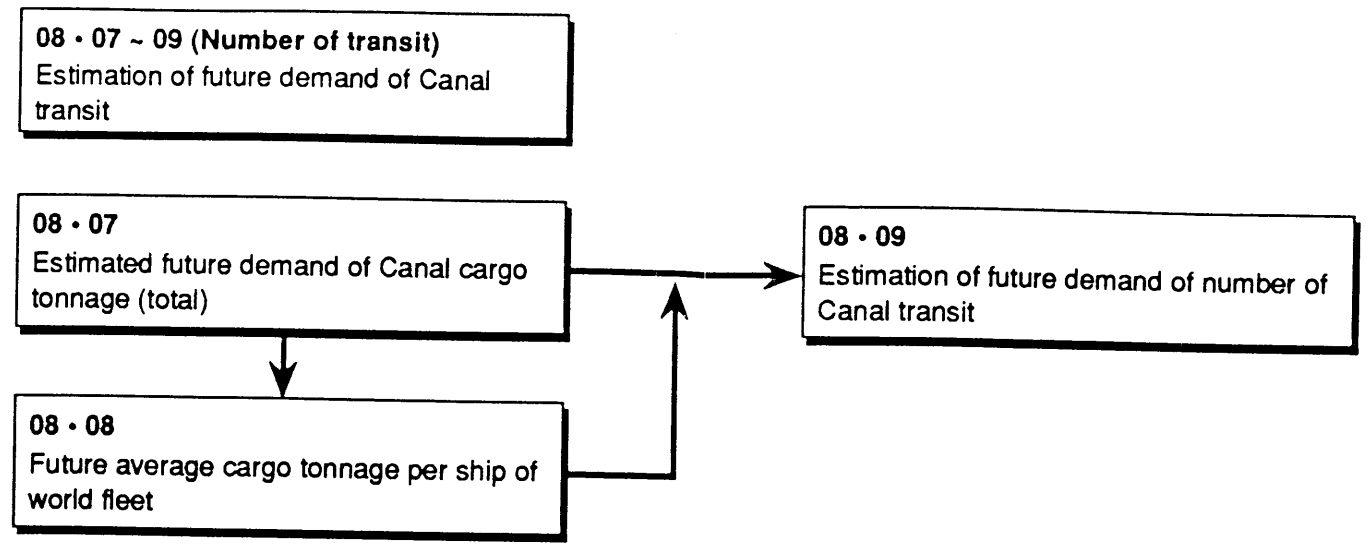
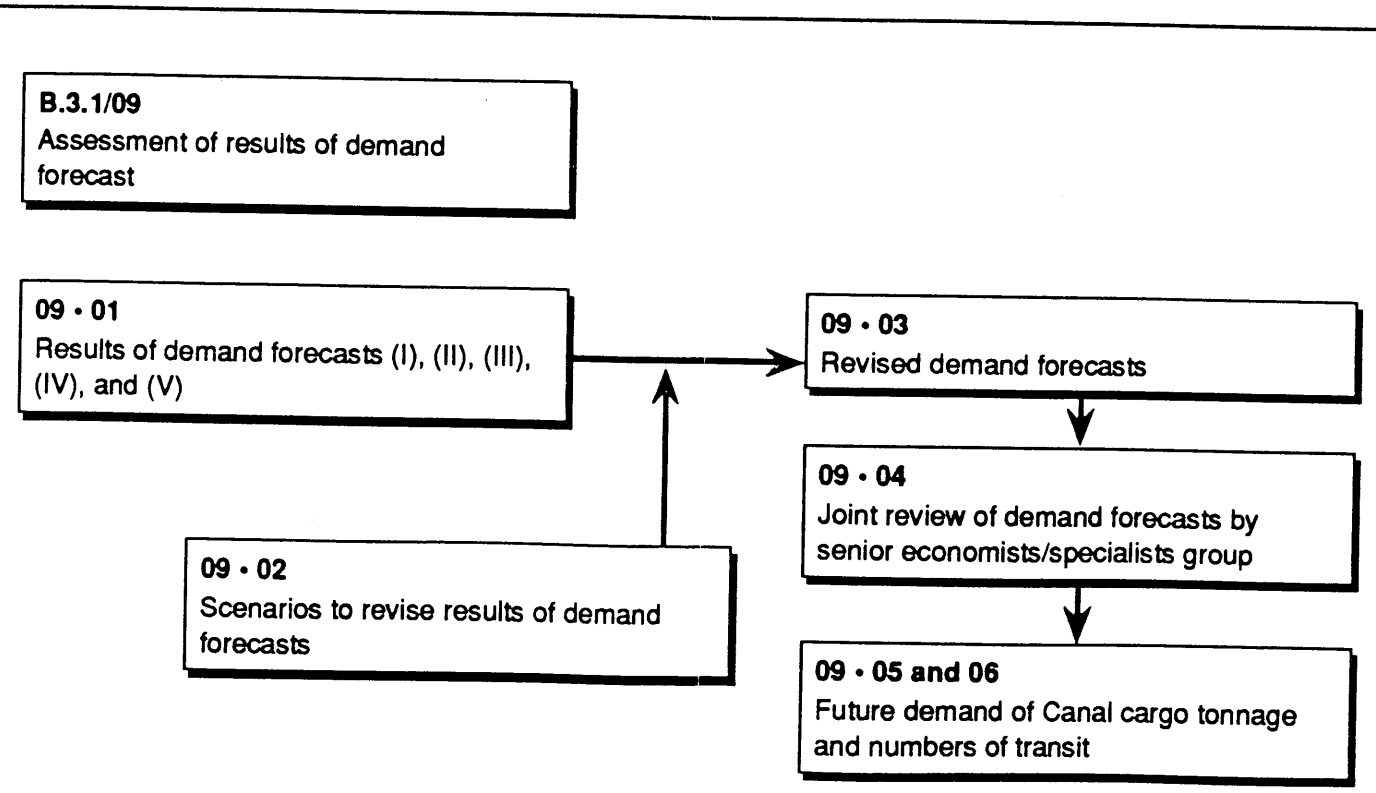
B.3.1
Commodity and Traffic Projections

Input		General Work Flow	Output	
•	Data and information of previous demand analysis	**B.3.1/01** Collection of data and information **01 • 01** Collection of statistics, reports, data, information, etc. → **01 • 02 and 03** Rearrangement, analysis, tabulation, illustration, etc.	B.3.1 01•02 01•03	Results of previous demand projections Methodology for previous demand projections
B.3.1 01•02 01•03	Results of previous demand projections Methodology for previous demand projections	**B.3.1/02 and 03** Review of previous demand analysis and establishment of methodology **02 • 01** Review of previous demand projections → **03 • 01** Assessment of methodology for previous demand projections **02 • 02** Clarification of factors influencing to demand projections **03 • 02** Establishment of methodology for demand analysis	B.3.1 03•02	Establishment of methodology for demand analysis

Input		General Work Flow	Output	
A.2.2 A.2.2 A.2.2 A.2.2	Statistics of Canal cargo tonnage in total Statistics of Canal cargo tonnage in total by type of vessels Statistics of Canal transit in total Statistics of Canal transit by type of vessels		B.3.1 04•09 04•10 04•11 04•12	 Future demand of Canal cargo tonnage (total) (I) Future demand of Canal cargo tonnage (by type of vessels) (I) Future demand of number of Canal transit (total) (I) Future demand of number of Canal transit (by type of vessels) (I)
A.2.2 A.2.2 A.2.2 A.2.2 A.2.3 A.2.3 A.2.3 A.2.3	Statistics of Canal cargo tonnage in total Statistics of Canal cargo tonnage by type of vessels Statistics of Canal transit in total Statistics of Canal cargo tonnage by type of vessels World trade, historical/future Gross world product (GWP), historical future Trade of major countries, historical future Gross national product (GNP) of major countries, historical future		B.3.1 05•17 05•18 05•19 05•20	 Future demand of Canal cargo tonnage (total) (II) Future demand of Canal cargo tonnage (by type of vessels) (II) Future demand of number of Canal transit (total) (II) Future demand of number of Canal transit (by type of vessels) (II)

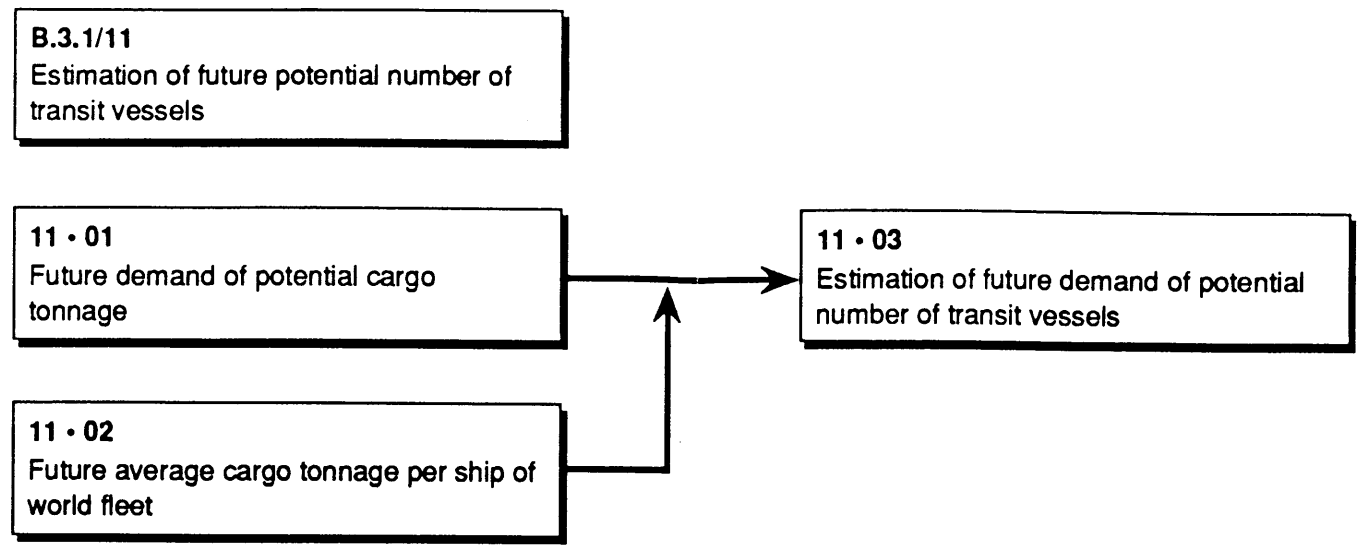
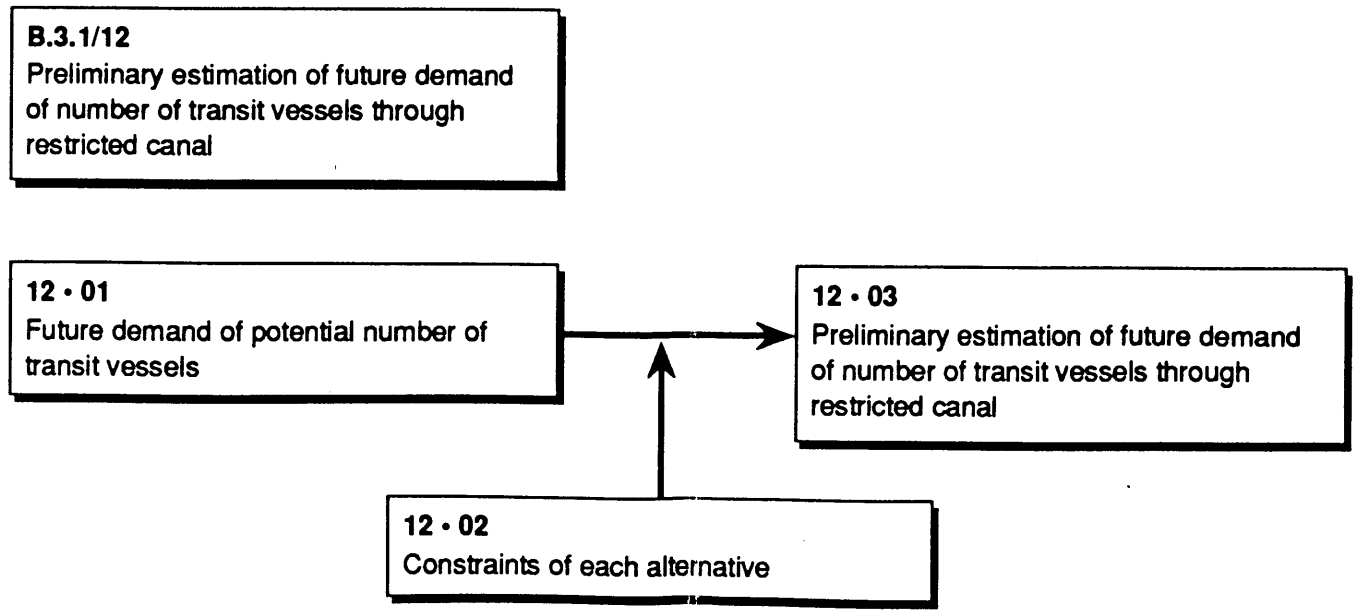
Input		General Work Flow	Output	
A.2.2 A.2.2 A.2.2 A.2.2 A.2.3 A.2.3 A.2.3	Statistics of Canal cargo tonnage in total Statistics of Canal cargo tonnage by type of vessels Statistics of Canal transit in total Statistics of Canal transit by type of vessels World population, historical/future Per capita GWP, historical/future World trade, historical/future	**B.3.1/06** Forecast of Canal cargo and traffic (III) **06 • 01 ~ 04**** Multiple regressional analysis of Canal cargo and traffic **06 • 05 ~ 08** Forecast of Canal cargo and traffic • Future world population • Future per capita GWP • Future world trade, etc. **06 • 09 ~ 12** Future demand of Canal cargo tonnage and number of transit *Cases 01: Canal cargo tonnage in total + macroeconomic indicators 02: Canal cargo tonnage by type of vessels + macroeconomic indicators 03: Canal transit in total + macroeconomic indicators 04: Canal transit iby type of vessels + macroeconomic indicators	B.3.1 06•09 06•10 06•11 06•12	Future demand of Canal cargo tonnage (total) (III) Future demand of Canal cargo tonnage (by type of vessels) (III) Future demand of number of Canal transit (total) (III) Future demand of number of Canal transit (by type of vessels) (III)
A.2.2 A.2.2 A.2.2 A.2.2 A.2.3 A.2.4	Statistics of Canal cargo tonnage in total Statistics of Canal cargo tonnage by type of vessels Statistics of Canal transit in total Statistics of Canal transit by type of vessels World trade, historical/future Average cargo tonnage per ship of world fleet, historical/future	**B.3.1/07** Forecast of Canal cargo and traffic (IV) **06 • 01 ~ 04**** Ratio analysis of Canal cargo and traffic **06 • 05 ~ 08** Forecast of Canal cargo and traffic Future world trade or future total movement of world fleet* **06 • 09 ~ 12** Future demand of Canal cargo tonnage and number of transit * (Total movement of world fleet) / (World trade in cargo tonnage) = (World trade in cargo tonnage) / (Average cargo tonnage per ship of world fleet) **Cases 01: Canal cargo tonnage in total + world trade/total movement of world fleet 02: Canal cargo tonnage by type of vessels + world trade/total movement of world fleet 03: Canal transit in total + world trade/total movement of world fleet 04: Canal transit by type of vessels + world trade/total movement of world fleet	B.3.1 07•09 07•10 07•11 07•12	Future demand of Canal cargo tonnage (total) (IV) Future demand of Canal cargo tonnage (by type of vessels) (IV) Future demand of number of Canal transit (total) (IV) Future demand of number of Canal transit (by type of vessels) (IV)

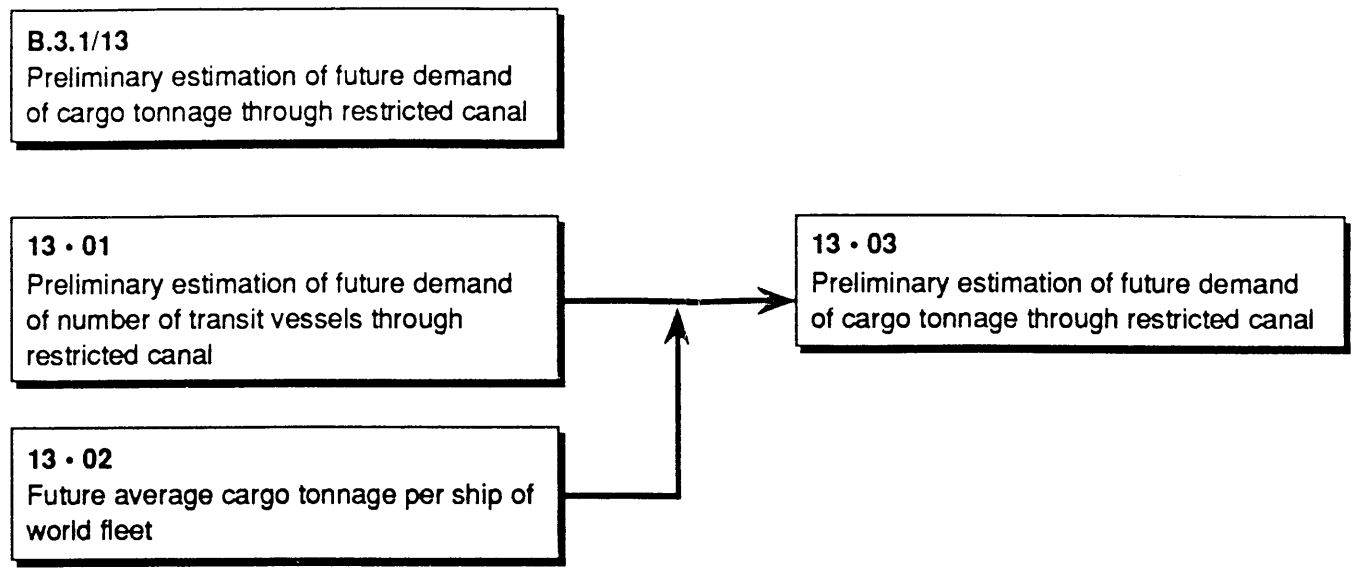
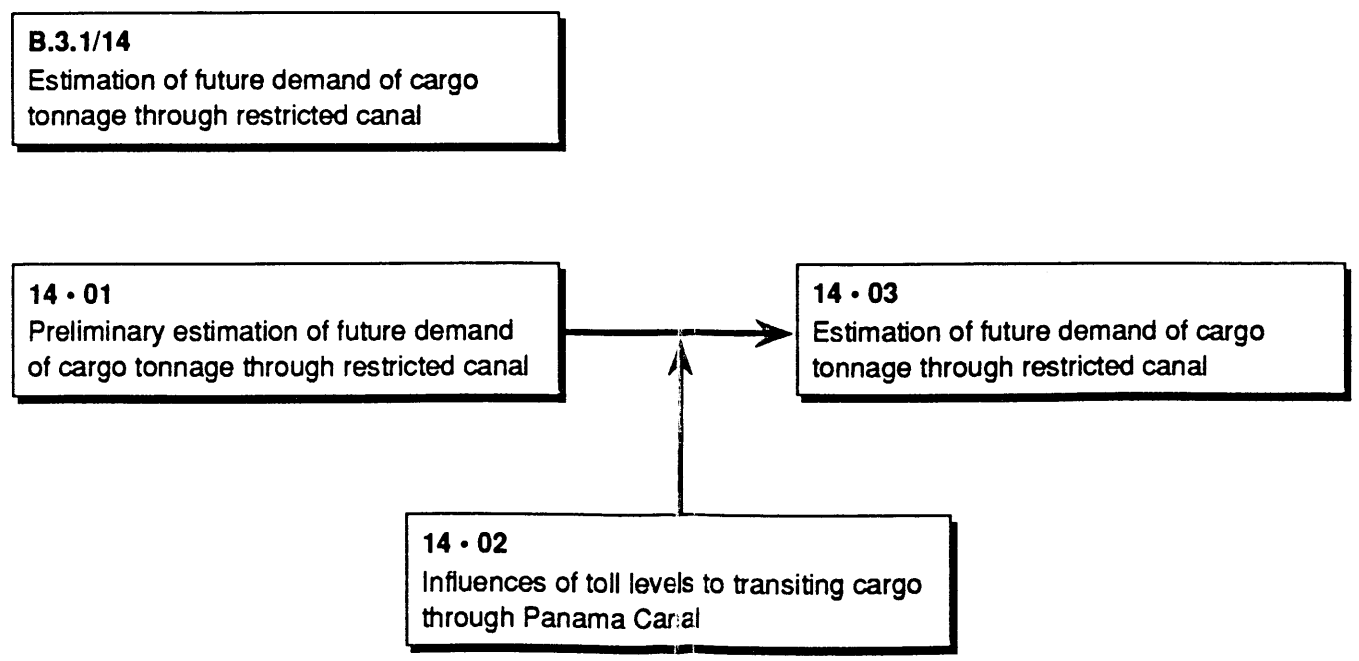
Input		General Work Flow	Output	
A.2.2	Statistics of Canal cargo tonnage in all commodity items by major import countries/regions	**B.3.1/08** Forecast of Canal cargo and traffic (V)	B.3.1 08-05	Future demand of Canal cargo tonnage (total) (V)
A.2.2	Statistics of Canal cargo tonnage by major commodity groups by major import countries/regions	**08 • 01 ~ 06 (Cargo tonnage)** Simulation analysis based on movement of major commodity groups summed up for each of major import countries/regions	08-06	Future demand of Canal cargo tonnage (by major commodity groups) (V)
A.2.3	Shifted cargo tonnage in all commodity items by major import countries/regions	**08 • 01** Formulation/review of simulation model for forecast of Canal cargo and traffic (V)		
A.2.3	Shifted cargo tonnage by major commodity groups by major import countries/regions	**08 • 02** Determination of variables: • Canal cargo tonnage • Shifted cargo tonnage • Other cargo tonnage • CIF for Canal cargo • CIF for shifted cargo • CIF for other cargo		
A.2.3	Other cargo tonnage in all commodity items by major import countries/regions	**08 • 03 and 04** Simulation analysis for Canal cargo tonnage in total and by each of major commodity groups by minimizing total import CIF value for each of major import countries/regions		
A.2.3	Other cargo tonnage by major commodity groups by major import countries/regions	**08 • 05 and 06** Estimation of future demand of Canal cargo tonnage in total and by each of major commodity groups by summing up those for major import countries/regions		
A.2.3	CIF for Canal cargo in all commodity items			
A.2.3	CIF for Canal cargo by each of major commodity groups			
A.2.3	CIF for shifted cargo in all commodity items			
A.2.3	CIF for shifted cargo by each of major commodity groups			

Input		General Work Flow	Output	
A.2.3	CIF for other cargo in all commodity items		B.3.1 08•09	Future demand of number of Canal transit (V)
A.2.3	CIF for other cargo by each of major commodity groups			
A.2.3	Total CIF of import commodity of all items by major import countries/regions			
A.2.3	Total CIF of major import commodity groups by major import countries/regions			
A.2.4	Average cargo tonnage per ship of world fleet			
B.3.1 04•09	Future demand of Canal cargo tonnage (total) (I)		B.3.1 09•05	Future demand of Canal cargo tonnage (High-Medium-Low estimate)
04•10	Future demand of Canal cargo tonnage (by type of vessels) (I)		09•06	Future demand of number of Canal transit (High-Medium-Low estimate)
04•11	Future demand of number of Canal transit (total) (I)			
04•12	Future demand of number of Canal transit (by type of vessels) (I)			
05•17	Future demand of Canal cargo tonnage (total) (II)			
05•18	Future demand of Canal cargo tonnage (by type of vessels) (II)			
05•19	Future demand of number of Canal transit (total) (II)			
05•20	Future demand of number of Canal transit (by type of vessels) (II)			
06•09	Future demand of Canal cargo tonnage (total) (III)			

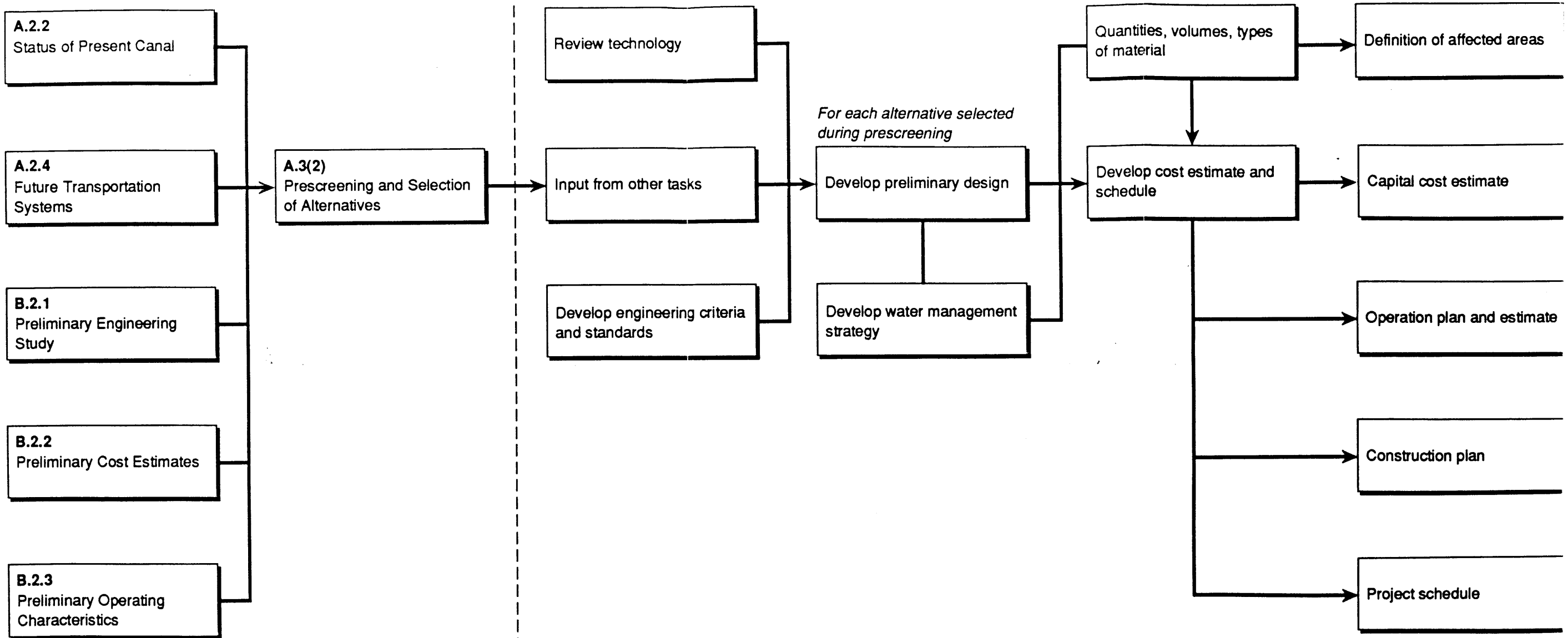
Input		General Work Flow	Output	
06•10	Future demand of Canal cargo tonnage (by type of vessels) (III)			
06•11	Future demand of number of Canal transit (total) (III)			
06•12	Future demand of number of Canal transit (by type of vessels) (III)			
07•09	Future demand of Canal cargo tonnage (total) (IV)			
07•10	Future demand of Canal cargo tonnage (by type of vessels) (IV)			
07•11	Future demand of number of Canal transit (total) (IV)			
07•12	Future demand of number of Canal transit (by type of vessels) (IV)			
08•05	Future demand of Canal cargo tonnage (total) (V)			
08•06	Future demand of Canal cargo tonnage (by major commodity groups) (V)			
08•09	Future demand of number of Canal transit (V)			
A.2.3	Scenarios based on "Historical Trade Analysis"			
A.2.4	Scenarios based on "Future Transportation Systems and Significance of Panamanian Isthmus in International Trade"			
B.3.1 09•05	Future demand of Canal cargo tonnage	**B.3.1/10** Estimation of future potential cargo tonnage	B.3.1 10•04	Future demand of potemtial cargo tonnage through Isthmian route (under no constraints on passage)
A.2.3	Cargo tonnage carried through other trade routes	**10 • 01** Proportional estimation by ship mix* → **10 • 04** Estimation of future demand of potential cargo tonnage		
A.2.4	Over-Panamax ship mix			
A.2.4	World fleet ship mix			
A.2.4	Cargo tonnage carried by other modes of transportation	**10 • 02** Future cargo tonnage thru Trans-Panamanian oil pipeline, land- and mini bridges, etc. → **10 • 04**		
		10 • 03 Future cargo tonnage thru other trade routes (except shifted cargo due to size of vessels) → **10 • 04**		

• Potential cargo tonnage = Canal cargo tonnage (1 + Over-Panamax ship mix/World fleet ship mix, except 10 • 02 and 10 • 03)

Input		General Work Flow	Output	
B.3.1 10 • 04 A.2.4	Future demand of potential cargo tonnage Average cargo tonnage per ship of world fleet		B.3.1 11 • 03	Future demand of potential number of transit vessels through Isthmian route (under no constraints on passage)
B.3.1 11 • 03	Future demand of potential number of transit vessels through Isthmian route • Factors influencing number of transit vessels		B.3.1 12 • 03	Preliminary estimation of future demand of number of transit vessels through restricted canal (for each alternative)

Input		General Work Flow	Output	
B.3.1 12-03	Preliminary estimation of future demand of number of transit vessels through restricted canal		B.3.1 13-03	Preliminary estimation of future demand of cargo tonnage through restricted canal *(for each alternative)*
A.2.4	Average cargo tonnage per ship of world fleet			
B.3.1 13-03	Preliminary estimation of future demand of cargo tonnage through restricted canal		B.3.1 14-03	Future demand of cargo tonnage through restricted canal *(for each alternative)*
A.2.2	Influences of toll levels to transiting cargo through Panama Canal			

Input		General Work Flow	Output	
B.3.1 14•03	Future demand of cargo tonnage through restricted canal	**B.3.1/15** Estimation of future demand of number of transit vessels through restricted canal	B.3.1 15•03	Future demand of number of transit vessels through restricted canal *(for each alternative)*
A.2.4	Average cargo tonnage per ship of world fleet	**15 • 01** Future demand of cargo tonnage through restricted canal → **15 • 03** Estimation of future demand of number of transit vessels through restricted canal		
		15 • 02 Future average cargo tonnage per ship of world fleet → **15 • 03**		



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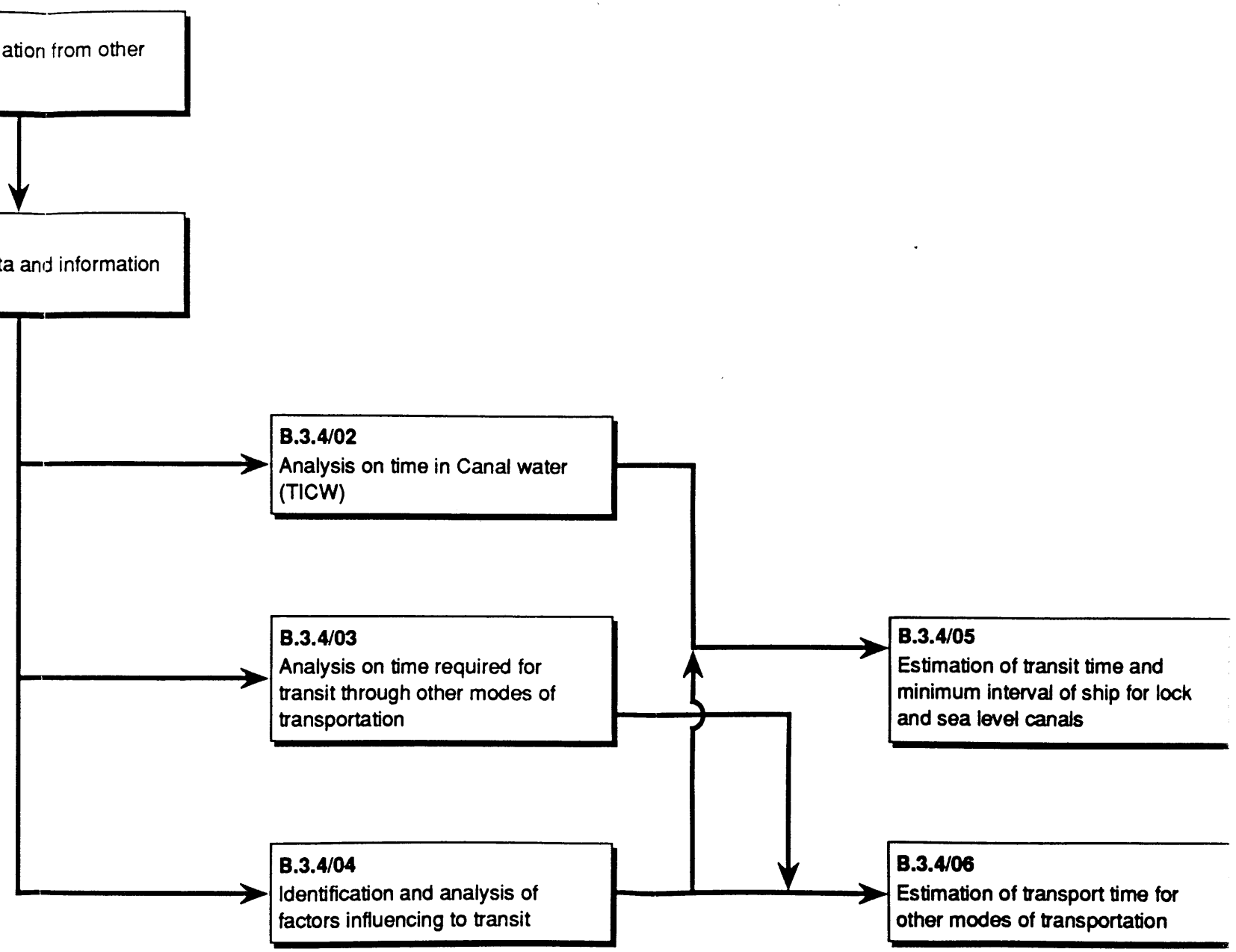
B.3.2 and B.3.
Engineering and Cost Estimate


Data and information from other studies
B.3.4/
Collection of data and information
B.3.4/02
Analysis on time in Canal water (TICW)
B.3.4/03
Analysis on time required for transit through other modes of transportation
B.3.4/04
Identification and analysis of factors influencing to transit
B.3.4/05
Estimation of transit time and minimum interval of ship for lock and sea level canals
B.3.4/06
Estimation of transport time for other modes of transportation

Input		General Work Flow	Output	
•	Statistics, reports, data, and information	**B.3.4/01** Collection of data and information **01 • 01** Collection of statistics, reports, data, information, etc. → **01 • 02 ~ 07** Rearrangement, analysis, tabulation, illustration, etc.	B.3.4 01•02 01•03 01•04 01•05 01•06 01•07	Statistics for time in canal water (TICW) (Panama Canal) Statistics for time in canal water (TICW) (Other large size canals) Statistics for time required for transporting oil through pipelines Statistics for time required for transiting through mini- and land-bridges Various basic factors for operating canals, etc. Results of previous studies, etc.
B.3.4 01•02 01•03 01•07	Statistics for TICW (Panama Canal) Statistics for TICW (Other large size canals) Results of previous studies, etc.	**B.3.4/02** Analysis of time in Canal water (TICW) **02 • 01** Analysis of TICW by type and size of vessels for lock and sea level canals → **05 • 02 ~ 03** TICW by type and size of vessels for each section of waterway for lock and sea level canals: • Anchorage area • Approach channel • Lock (for lock canal only) • Open waterway • Restricted waterway • Bypass waterway	B.3.4 02•02 02•03	TICW by type and size of vessels for lock canal TICW by type and size of vessels for sea level canal

Input		General Work Flow	Output	
B.3.4 01-04 01-05 01-07	Statistics for time required for transmitting oil through pipelines Statistics for time required for transmitting oil through pipelines for transiting landbridge Results of previous studies, etc.	**B.3.4/03** Analysis of time required for transiting through other modes of transportation **03 • 01** Analysis of time required for transiting through other modes of transportation → **03 • 02 ~ 04** Time required for transiting through other modes of transportation for each section of: • Main line • Transshipping/marshalling • Waiting, etc.	B.3.4 03-02 03-03 03-04	Time required for transiting through oil pipeline Time required for transiting through mini- and land-bridges Time required for transiting through other means of transportation
B.3.4 01-06 01-07	Various factors for operating canals, etc. Results of previous studies, etc.	**B.3.4/04** Identification and analysis of factors influencing transit **04 • 01** Identification and analysis of factors influencing transit for whole or each section → **04 • 02 ~ 03** Factors influencing transit for respective aspect of: • Physical and configurational • Hydrographic and hydraulic • Hydrological • Meteorological • Navigational • Managerial and institutional • Safety control	B.3.4 04-02 04-03	Factors influencing transit of vessels by type and size through lock and sea level canals Factors influencing transit through other modes of transportation

Input

A.2.4	Distribution of type and size of vessels of world fleet
B.3.4 02•02	TICW by type and size of vessels through lock canal
02•03	TICW by type and size of vessels through sea level canal
04•02	Factors influencing transit of vessels by type and size through lock and sea level canals

General Work Flow

B.3.4/05
Estimation of transit time and minimum interval of ship for lock and sea level canals

05 • 01 ~ 07
Simulation analysis based on average TICW with limitations inherent to each alternative

05 • 01
Formulation and review of simulation model for operating characteristics of lock and sea level canals

05 • 02
Determination of variables:
- Distribution of type and size of vessels
- Sailing speed
- Lockage operation
- Waiting time for transit
- Tie-up
- Ship to ship interval
- Others

05 • 03
Determination of safety control system

05 • 04
Determination of typical vessel for each type and size

05 • 05
Setting up of time frame for:
- Formalities and procedures for transit
- Passage through open waterway
- Passage through restricted waterway
- Lockage operation or tidal gate operation
- Tie-up

05 • 06
Simulation analysis on transit time of vessels through canal

05 • 07 and 08
Estimation of transit time and minimum interval of ship by type and size of vessels through lock and sea level canals

Output

B.3.4 05•07	Transit time and minimum interval of ship by type and size of vessels through lock canal
05•08	Transit time and minimum interval of ship by type and size of vessels through sea level canal

Input

A.2.4	Items and quantities of commodity groups to be transported
B.3.4 03-02	Time required for transiting through oil pipeline
03-03	Time required for transiting through mini- and land-bridges
04-03	Factors influencing transit through other modes of transportation

General Work Flow

B.3.4/06
Estimation of transit time for other modes of transportation

06 • 01 ~ 07
Simulation analysis based on average transit time with limitations inherent to each alternative

06 • 01
Formulation and review of simulation model for operating characteristics of other modes of transportation

06 • 02
Determination of variables:
- Items and quantities of commodity groups to be transported
- Transport speed
- Transshipment operation
- Marshalling for transport
- Others

06 • 03
Determination of safety control system

06 • 04
Determination of typical unit size of commodity groups to be transported

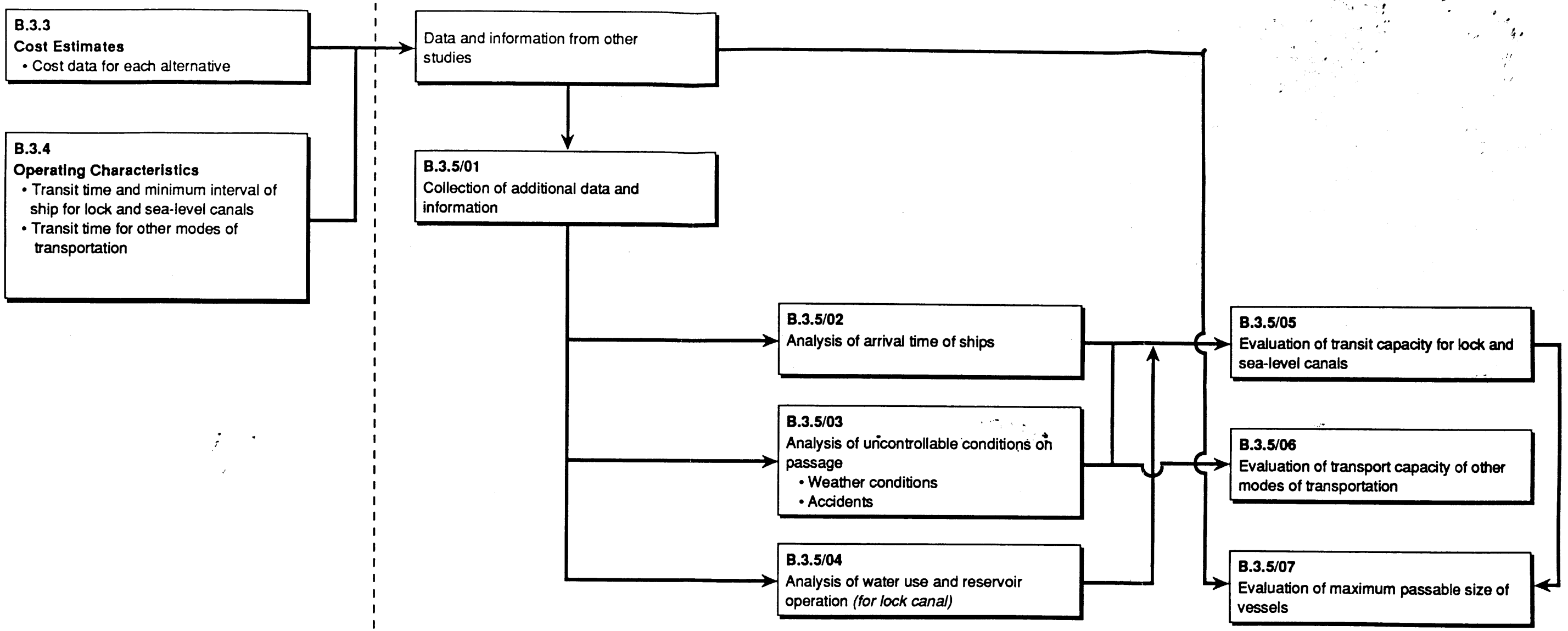
06 • 05
Setting up of timeframe for:
- Formalities and procedures for transport
- Transporting
- Transshipment operation
- Marshalling
- Waiting time

06 • 06
Simulation analysis on transit time

06 • 07
Estimation of transport time by other modes of transportation

Output

B.3.4 06-07	Tranport time through other modes of transportation



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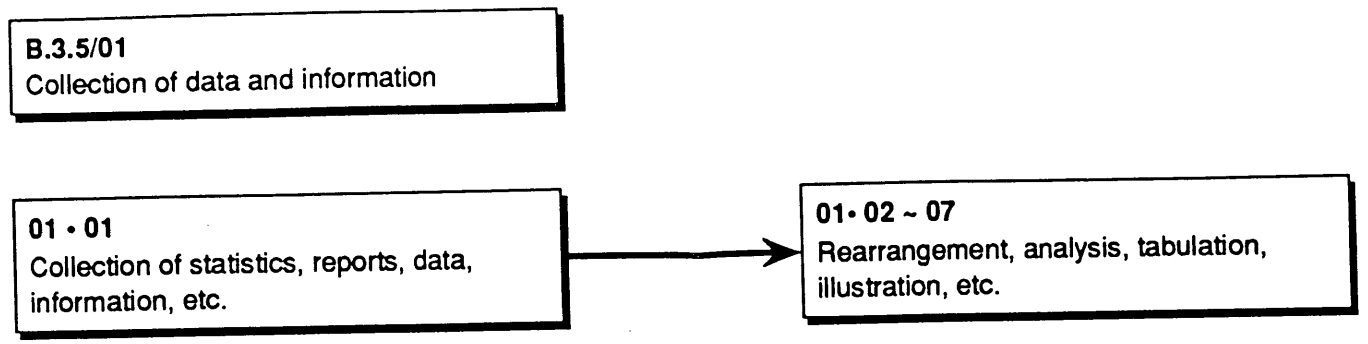
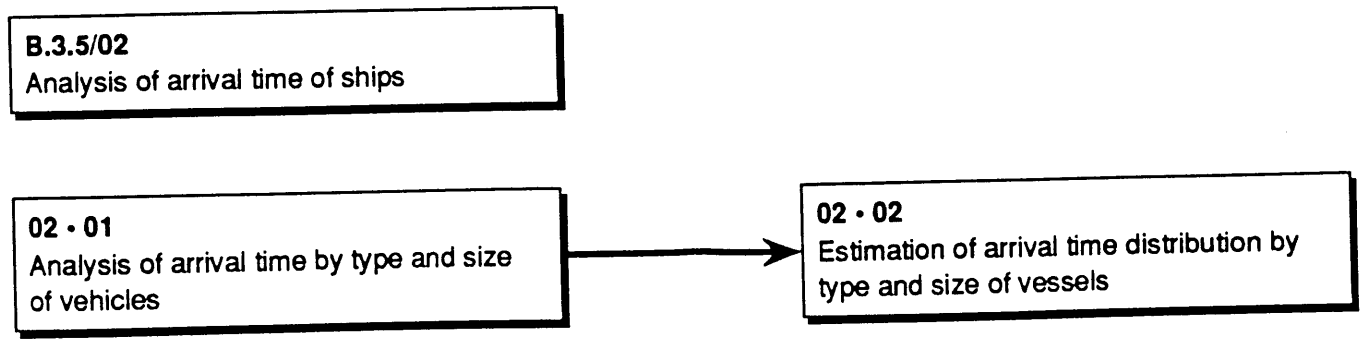
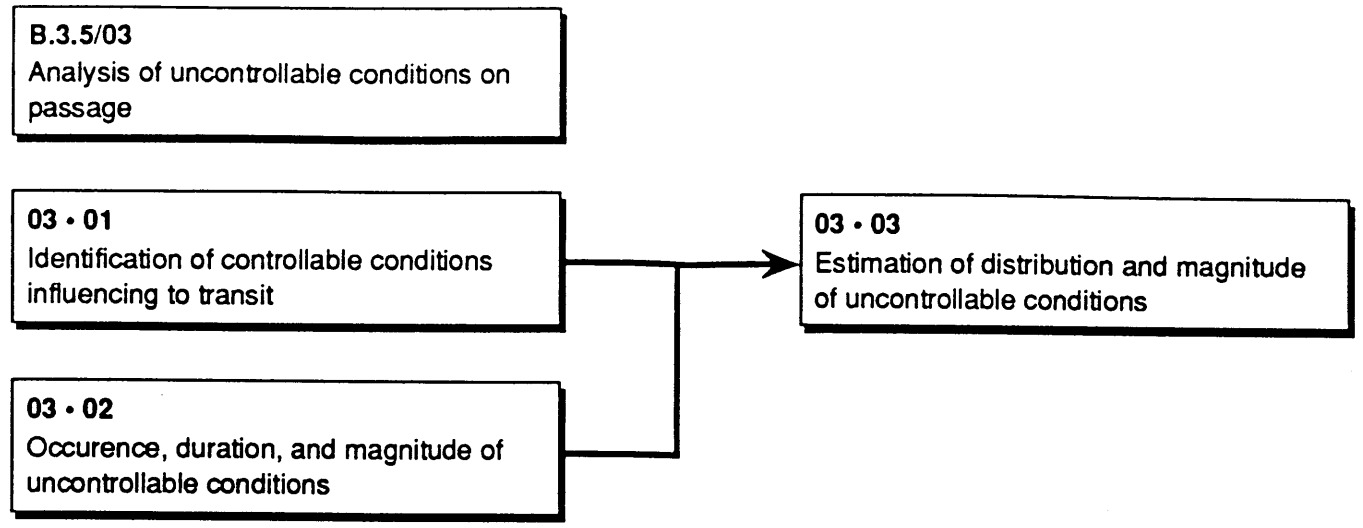
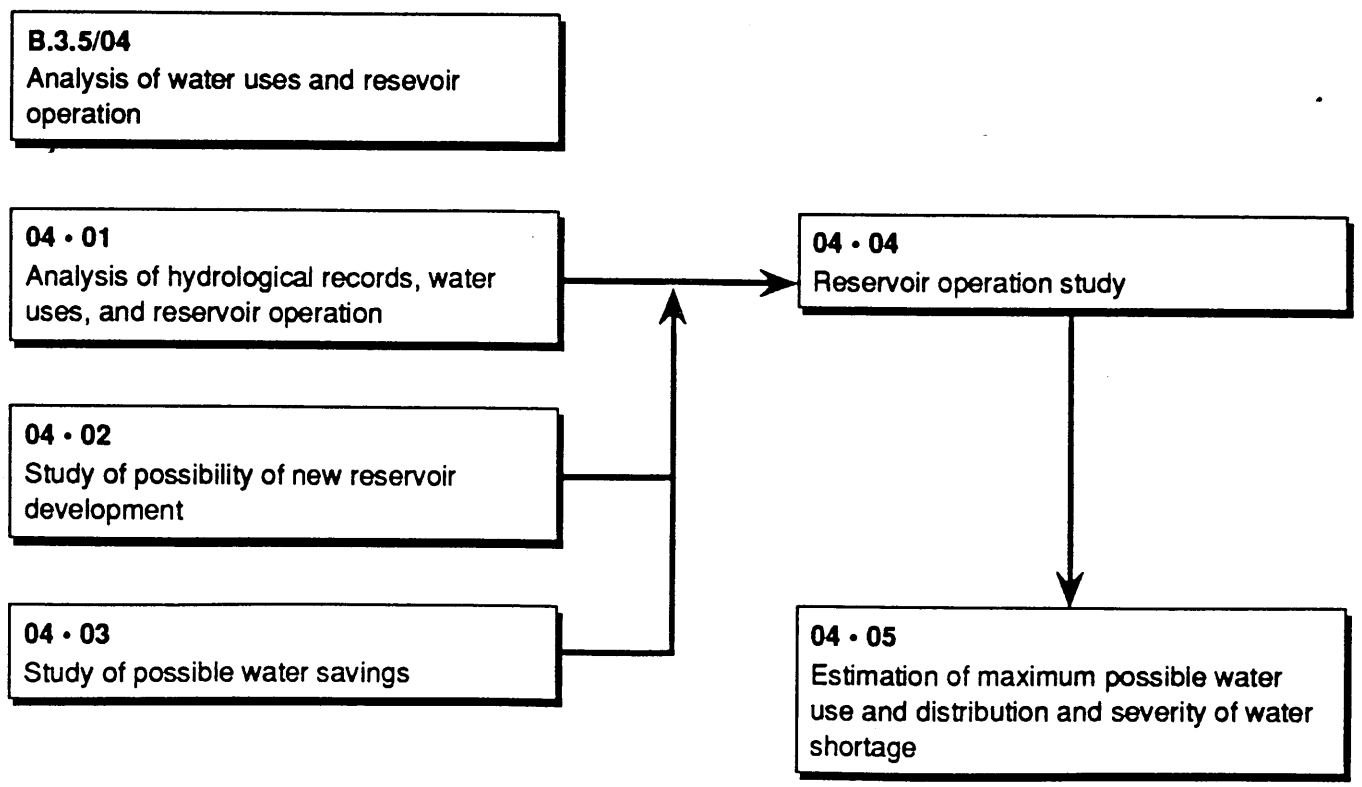
B.3.5
Capacity Evaluation

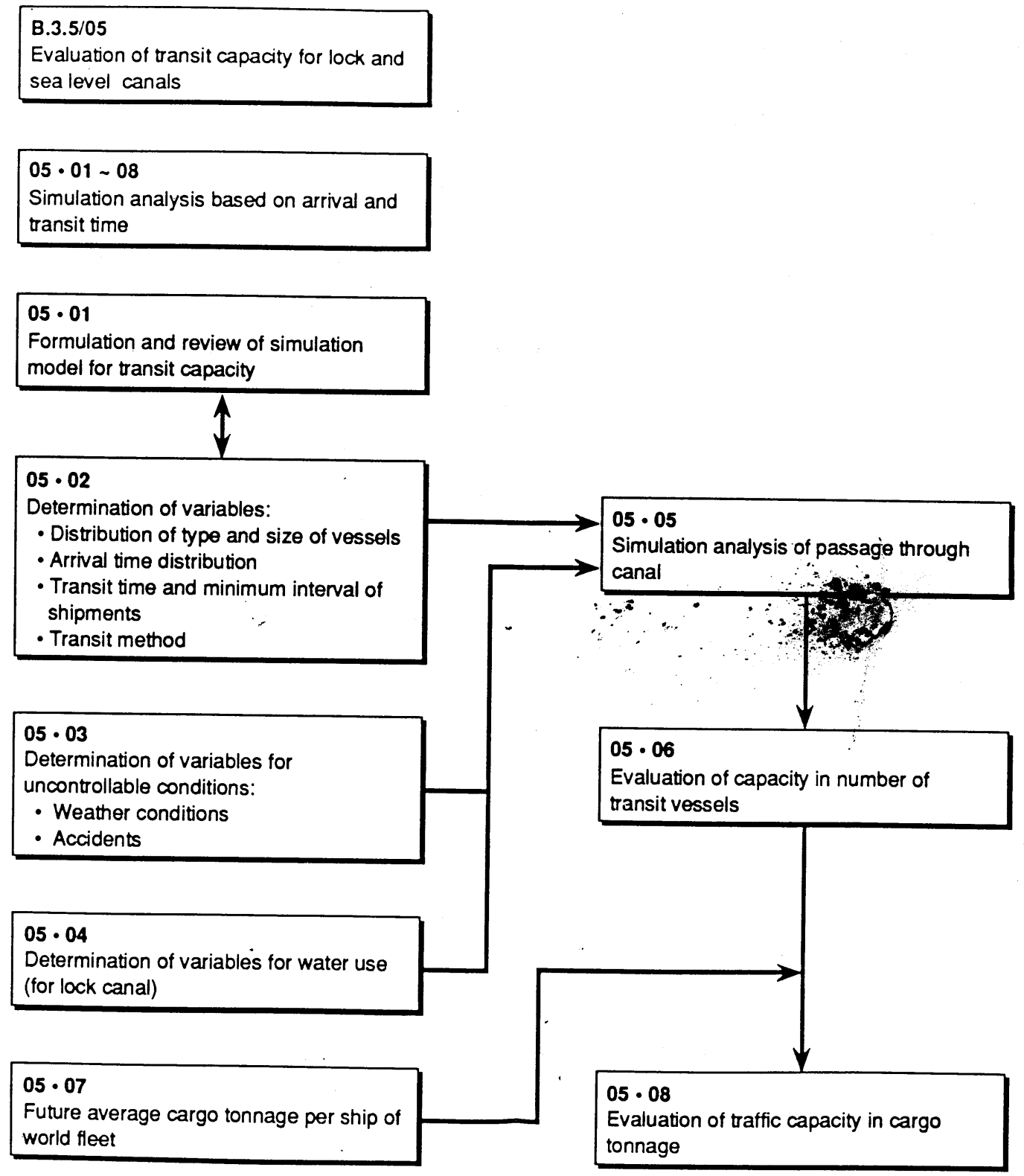
Input		General Work Flow	Output	
•	Statistics, reports, data, and information		B.3.5 01•01 01•03 01•04 01•05 01•06 01•07	Statistics for arrival of ships by type and size (Panama Canal) Statistics for arrival of ships by type and size (Other large size canals) Record of accidents (P.C.) Record of unfavorable weather for transit (P.C.) Hydrological records (P.C.) Records of reservoir operation and water use for lockage operation (P.C.)
B.3.5 01•02 01•03	Statistics for arrival of ships by type and size (Panama Canal) –do.– (Other large size canals)		B.3.5 02•02	Arrival time distribution by type and size of vessels

Input		General Work Flow	Output	
B.3.4 04-02 B.3.5 01-04 01-05	Factors influencing transit of vessels by type and size through lock and sea canals Record of accidents Record of unfavorable weather for transit		B.3.5 03-03	Occurence, duration, and magnitude of uncontrollable conditions
B.3.4 04-02 B.3.5 01-06 01-07	Factors influencing transit for vessels by type and size through lock and sea level canals Hydrological records Records of reservoir operation and water use for lockage operation		B.3.5 04-05	Maximum possible water use and distribution and severity of water shortage

Input

B.3.4 05-07	Transit time and minimum interval of ship by type and size of vessels through lock canal
05-08	Transit time and minimum interval of ship by type and size of vessels through sea level canal
B.3.5 02-02	Arrival time distribution by type and size of vessels
B.3.5 03-03	Occurrence, duration and magnitude of uncontrollable conditions
B.3.5 04-05	Maximum possible water use and distribution and severity of water shortage
A.2.4	Future average cargo tonnage per ship of world fleet

General Work Flow



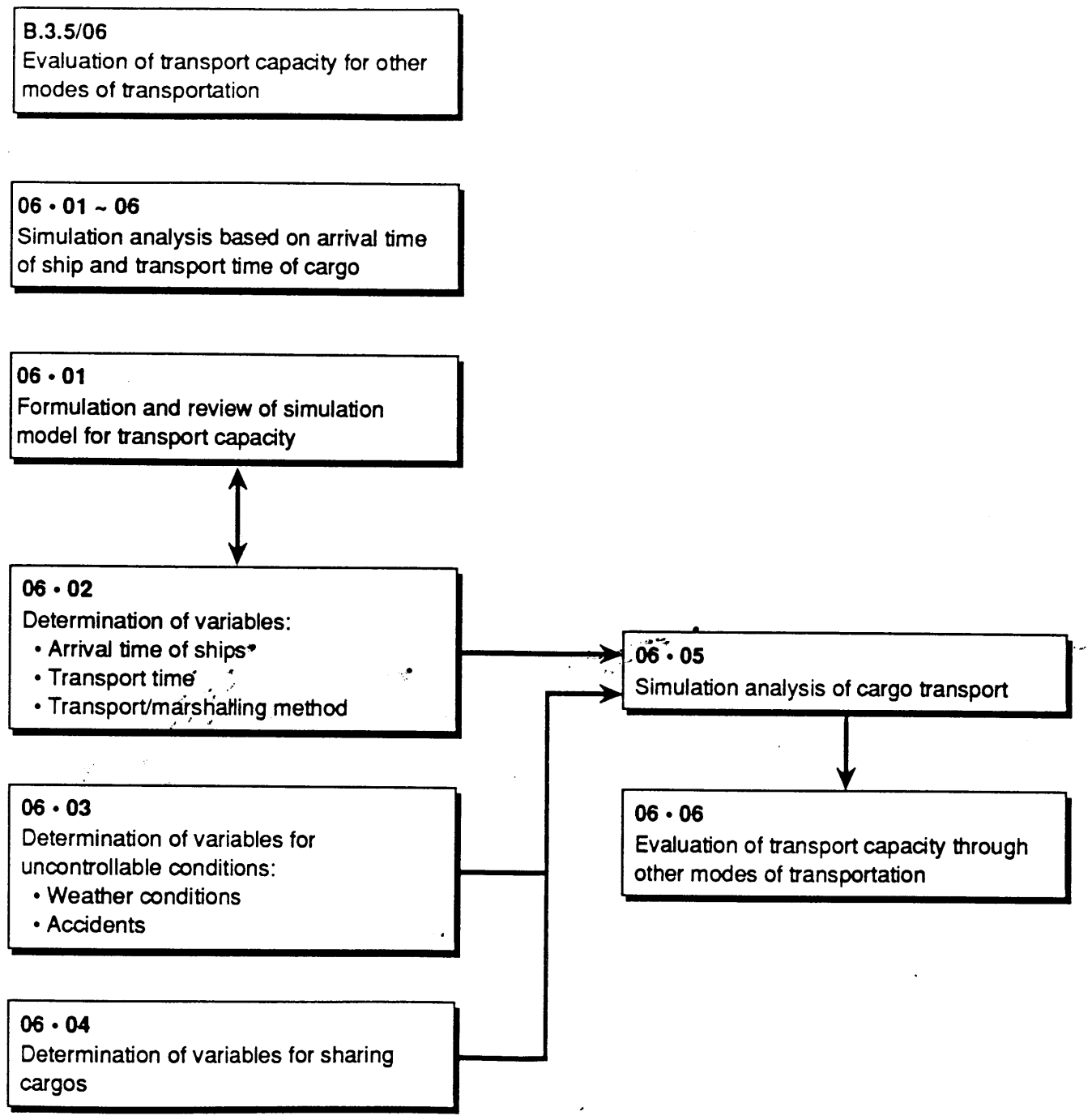
Output

B.3.4 05-06	Capacity of canal in number of transit vessels
05-07	Capacity of canal in cargo tonnage

Input

B.3.1 14•03	Future demand of cargo tonnage through restricted canal *(for each alternative)*
B.3.4 06•07	Transport time through other modes of transportation
B.3.5 02•02	Arrival time distribution by type and size of vessels
03•03	Occurrence, duration, and magnitude of uncontrollable conditions

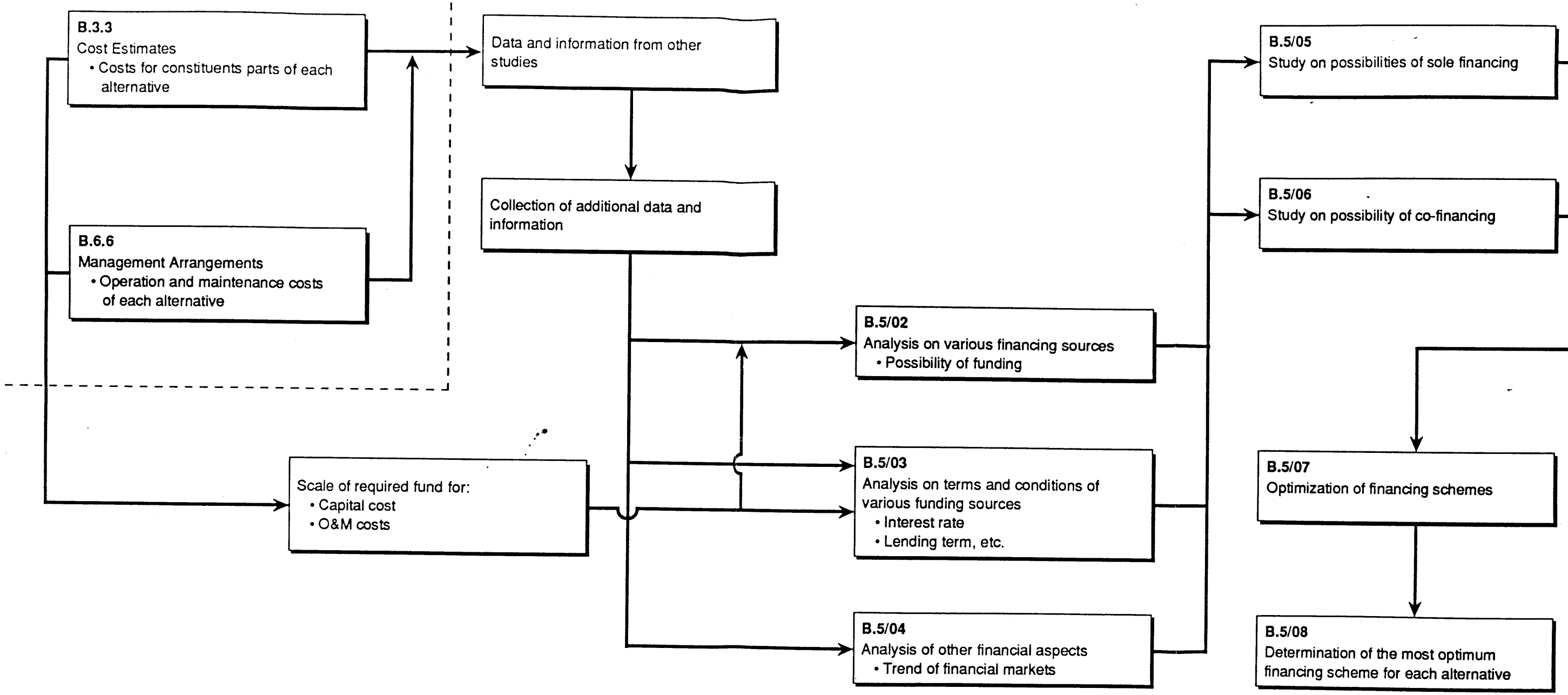
General Work Flow



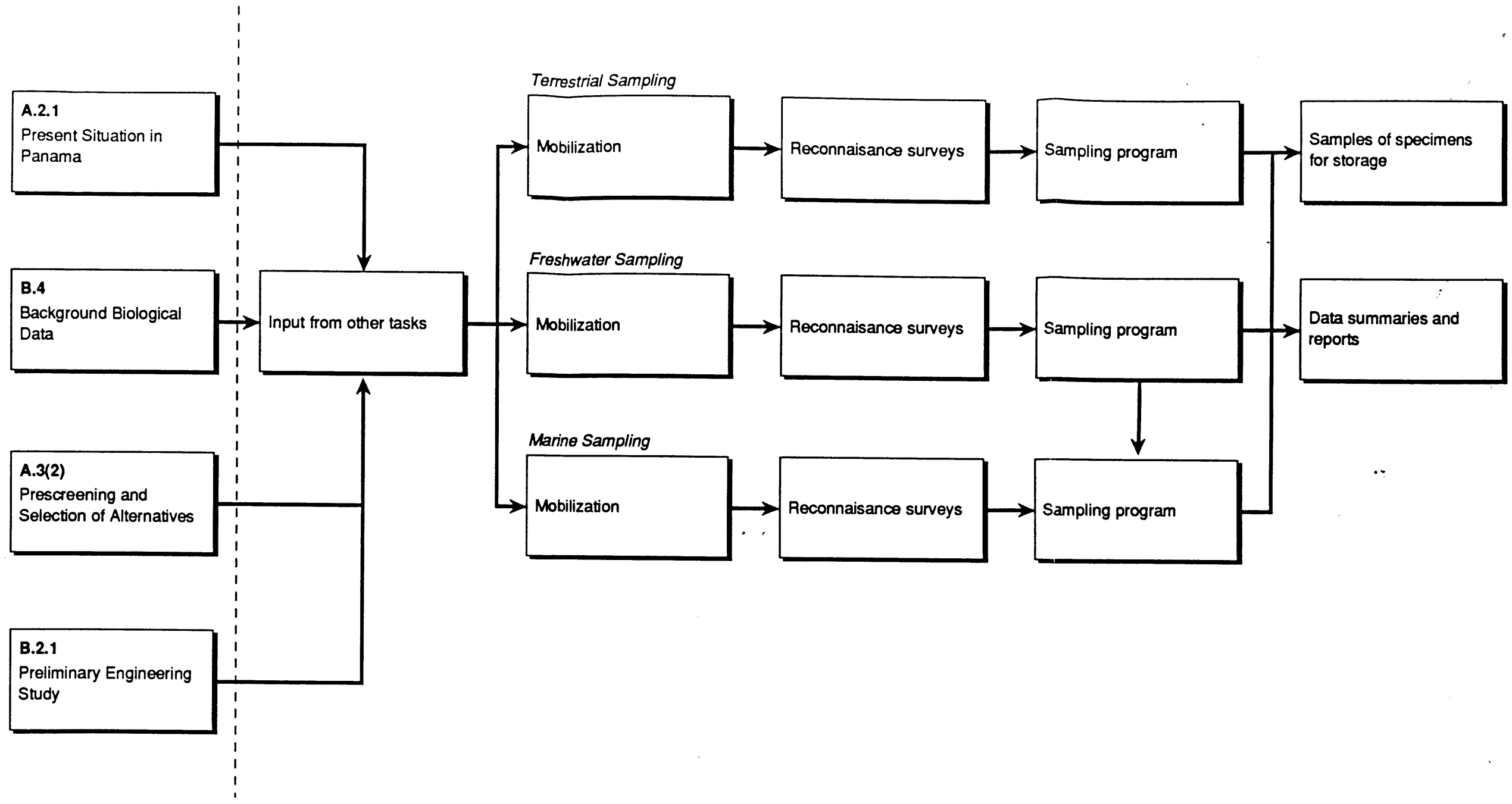
Output

B.3.5 06•06	Tranport capacity through other modes of transportation

Input		General Work Flow	Output	
B.3.2 B.3.3	Scale and capacity of each alternatives Costs data for respective alternatives	**B.3.5/07** Evaluation of maximum passable size of vessels **07 • 02 ~ 04** Simulation analysis based on optimization of scale of canal **07 • 01** Formulation and review of simulation model for optimization of scale ↕ **07 • 02** Determination of variables: • Scale and capacity of each alternative • Costs data • Others → **07 • 03** Simulation analysis of cost optimization with respect to scale ↓ **07 • 04** Evaluation of optimum scale *(max. passable size of vessels)* and optimum capacity *(max. nos. of transit vessels)*	B.3.5 07-04	Optimum scale and capacity

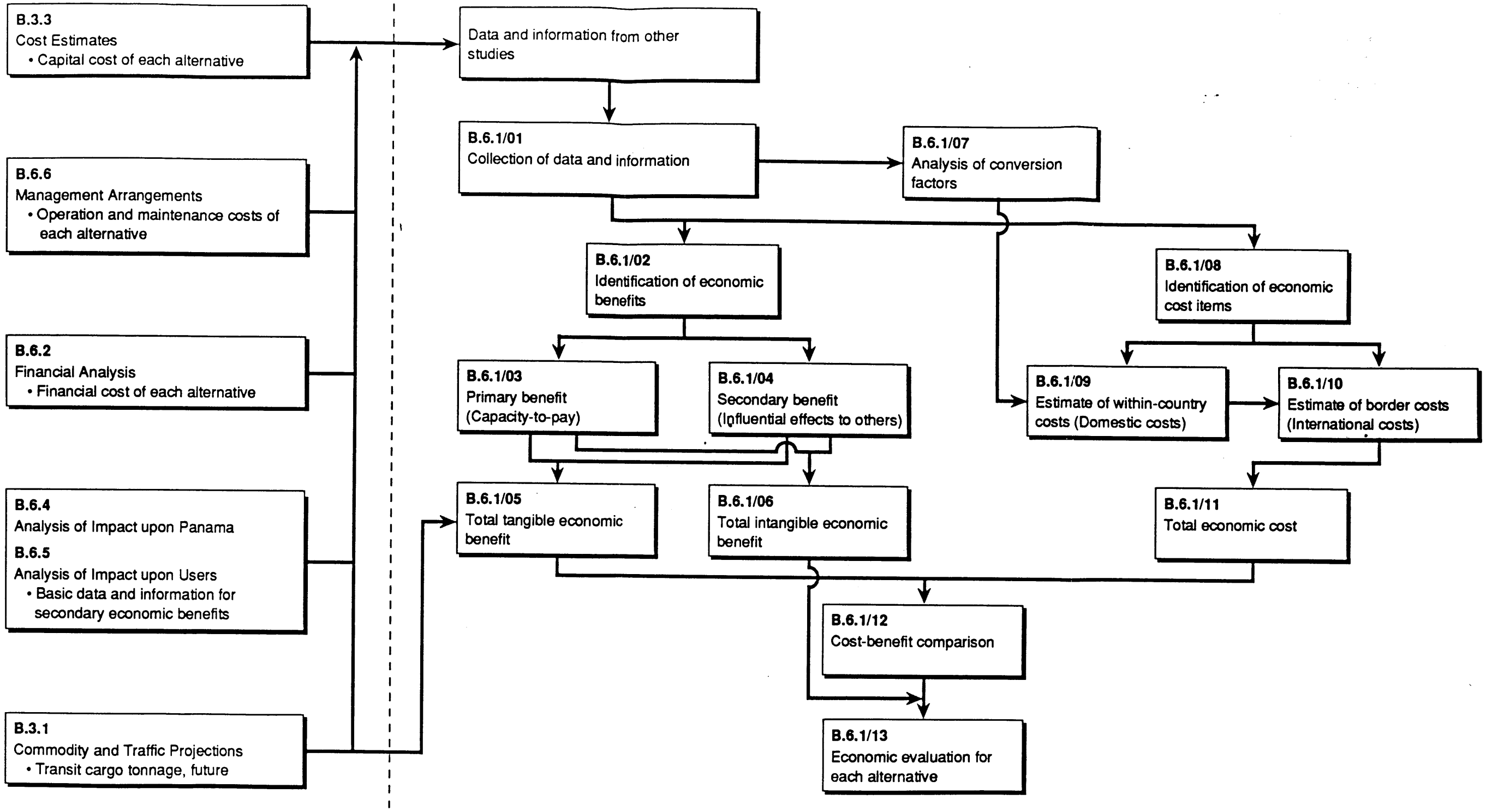


B.5
Financing Scheme


A.2.1
Present Situation in Panama
B.4
Background Biological Data
A.3(2)
Prescreening and Selection of Alternatives
B.2.1
Preliminary Engineering Study
Input from other tasks
Terrestrial Sampling
Mobilization
Reconnaisance surveys
Sampling program
Freshwater Sampling
Mobilization
Reconnaisance surveys
Sampling program
Marine Sampling
Mobilization
Reconnaisance surveys
Sampling program
Samples of specimens for storage
Data summaries and reports

Input		General Work Flow	Output	
B.5 02•02 03•02	Possible financing sources Terms and conditions of possible financing sources	**B.5/05 and 06** Study on financing structure **05 • 01 and 06 •01** Clarification of possible financing structures → **05 • 02** Study on possibilities of sole financing → **06 • 02** Study on possibilities of co-financing	B.5 05•02 06•02	Possibility of sole financing Possibility of co-financing
B.3.3 B.6.6 B.5 02•02 03•02 04•02 05•02 06•02	Requires capital cost for each project components Required operation and maintenance costs Possible financing sources Terms and conditions of possible financing sources Miscellaneous aspects of financing Possibility of sole financing Possibility of co-financing	**B.5/07 and 08** Optimization of financing scheme **07 • 01 and 08 • 01** Clarification of respective components of financing scheme: • Required fund • Possible financing sources • Terms and conditions • Others → **07 • 02** Optimization study of financing schemes for each alternative → **08 • 02** Determination of the most optimum financing scheme for each alternative	B.5 08•02	Most optimum financing scheme for each alternative

Input		General Work Flow	Output	
B.3.3 B.3.6	Required capital cost for each alternative Required operation and maintenance costs for each alternative	**B.5/01** Collection of data and information **01 • 01** Collection of data, information, reports, etc. → **01 • 02 ~ 04** Review, rearrange, analysis, tabulation, illustration, etc.	B.5 01•02 01•03 01•04	Possible financing sources Terms and conditions of various financing sources Miscellaneous financial studies
B.5 01•02 01•03 01•04	Possible financing sources Terms and conditions of various financing sources Miscellaneous financial studies	**B.5/02 ~ 04** Analysis of various financing sources, etc. **02 • 01, 03 • 01, and 04 • 01** Identification of various kinds of financing sources → **02 • 02** Analysis of financing sources: • Possibility of funding, etc. ↓ **03 • 02** Analysis of terms and conditions of possible financing sources ↓ **04 • 02** Analysis of other aspects of financing	B.5 02•02 03•02 04•02	Analysis of possible financing sources Analysis of terms and conditions of possible financing sources Analysis of other aspects of financing



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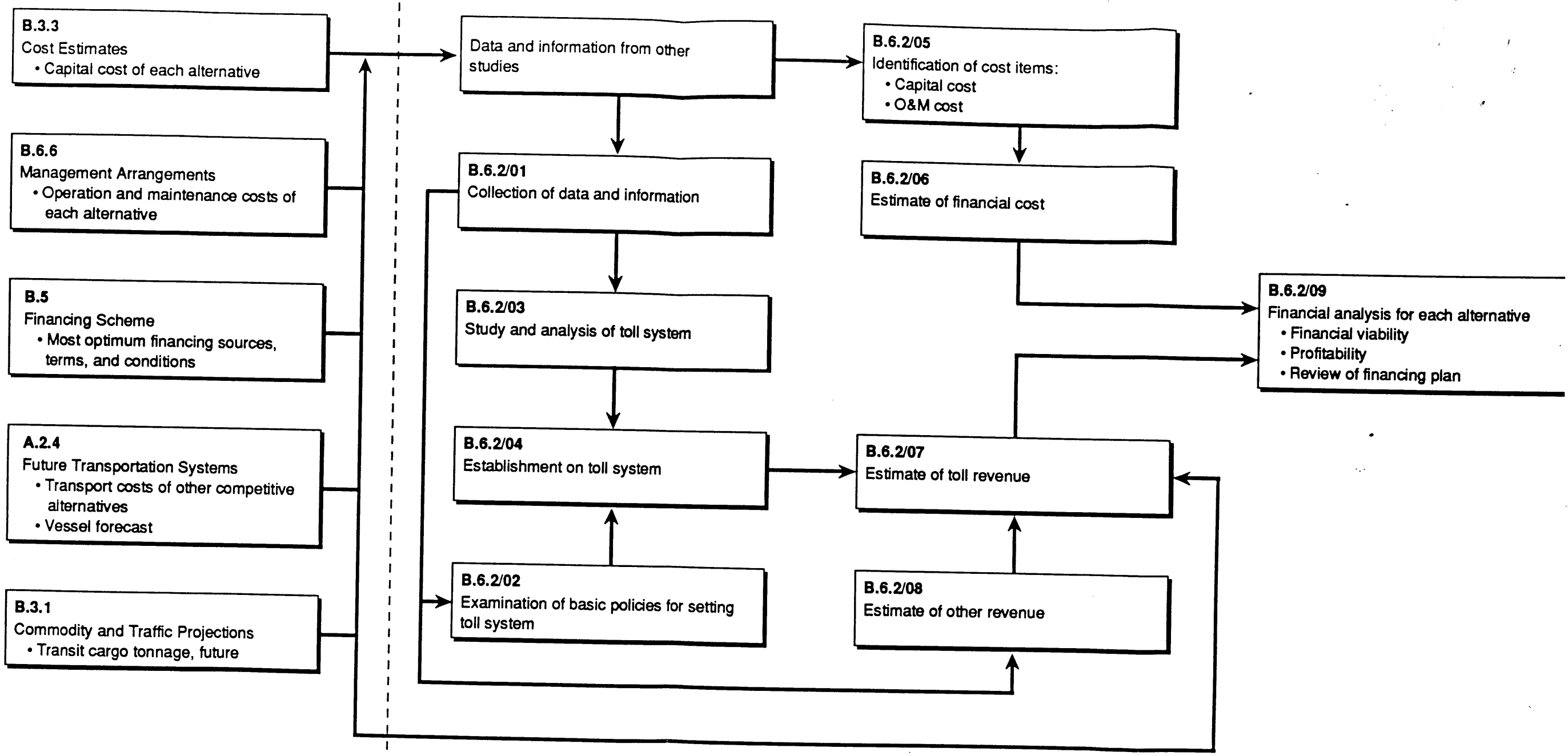
B.6.1
Economic Analysis

Input		General Work Flow	Output	
• B.3.1 B.3.3 B.6.3 B.6.4 B.6.5 B.6.6	Results of studies from: Commodity and Traffic Projections Cost Estimates Financial Analysis Analysis of Impact upon Panama Analysis of Impact upon Users Management Arrangements	**B.6.1/01** Collection of data and information **01 • 01** Collection of results of foregoing studies, data, information, reports, etc. → **01 • 02 ~ 06** Review, rearrange, analysis, tabulation, illustration, etc.	B.6.1 01•02 01•03 01•04 01•05 01•06	Commodity and traffic projections (B.3.1/14) Project cost for each alternative Financial cost Impact upon Panama and users Operation and maintenance costs (B.6.6/08•02) for each alternative
B.6.1 01•02 01•5	Commodity and traffic projections for each alternative Impacts upon Panama and users	**B.6.1/02 ~ 06** Estimation of economic benefits **02 • 01** Identification of economic benefits → **03 • 01** Estimate of primary economic benefits → **04 • 01** Estimate of secondary economic benefits **B.3.1/14 • 03** Future demand of cargo tonnage through restricted canal *(for each alternative)* → **05 • 01** Estimate of total tangible economic benefit for each alternative **06 • 01** Estimate of total intangible economic benefit for each alternative	B.6.1 05•01 06•01	Total tangible economic benefit for each alternative Total intangible economic benefit for each alternative

Input		General Work Flow	Output	
B.6.1 01•03 01•04 01•06	Project cost for each alternative Financial cost Optimization and maintenance costs	**B.6.1/07** Analysis of conversion factors **01 • 07** Identification of cost items to be converted → **07 • 02** Calculation of conversion factors	B.6.1 07•02	Conversion factors
B.6.1 01•03 01•04 01•06	Project cost for each alternative Financial cost Operation and maintenance costs for each alternative	**B.6.1/08 ~ 11** Estimation of economic costs **08 • 01** Identification of economic costs: • Costs of domestic services, materials, etc. • Costs of imported services, machinery, materials, etc. **09 • 01** Estimate of domestic costs **10 • 01** Estimate of international costs Conversion factors **11 • 01** Estimate of total economic cost for each alternative	B.6.1 11•01	Total economic cost for each alternative

Input		General Work Flow	Output	
B.6.1 01•04 05•01 11•01	Financial cost Total tangible economic benefit for each alternative Total economic cost for each alternative	**B.6.1/12** Comparison of economic cost and benefit **12 • 01** Preparation for cost-benefit comparison → **12 • 02** Calculation of cost-benefit comparison indicators for each alternative	B.6.1 12•02	Cost-benefit comparison indicators for each alternative
B.6.1 01•03 01•04 01•06	Project cost for each alternative Financial cost Operation and maintenance costs for each alternative	**B.6.1/13** Overall economic evaluation for each alternative **13 • 01** Preparation for overall economic evaluation → **13 • 02** Evaluation of economic feasibility of each alternative	B.6.1 13•02	Overall economic evaluation for each alternative



15962/26/f/Panama/232
8-31-90 tg/tg :6

B.6.2
Financial Analysis

Input

B.3.3	Required Capital Cost for Each Alternative
B.6.6	Required Operation and Maintenance Costs for Each Alternative
B.6	Most Optimum Financing Sources with Terms and Conditions
A.2.4	Future Transportation System
B.3.1	Commodity and Traffic Projection
B.6.2	
01-02	Details of toll system of present Panama Canal
01-03	Details of other existing toll systems

General Work Flow

B.6.2/01
Collection of data and information

01 • 01
Collection of data and information

→ **01 • 02 ~ 0 • 3**
Review existing toll system of transportation

B.6.2/02
Examination of basic policies for setting toll system

02 • 01
Identification of tolls policy objectives

→ **02 • 02**
Examination of each objective for setting toll system

B.6.2/03
Study and analysis on toll system

03 • 01
Study and analysis on toll system

→ **03 • 02**
Analysis of rate schedule

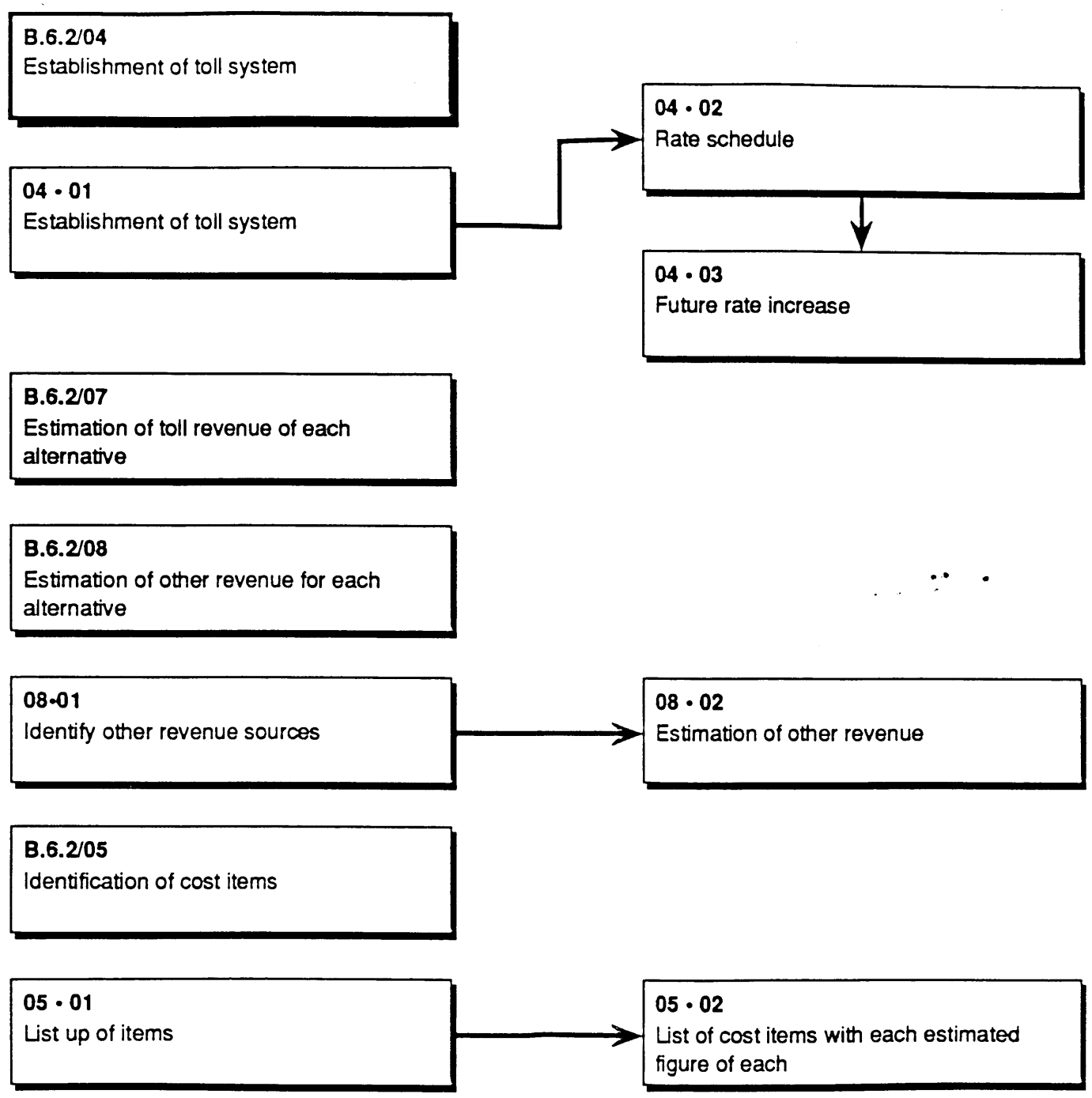
↓

03 • 03
Analysis of other important items

Output

B.6.1	
12-02	Cost-benefit comparison indicators for each alternative
02-02	Examination of each objective for setting toll system

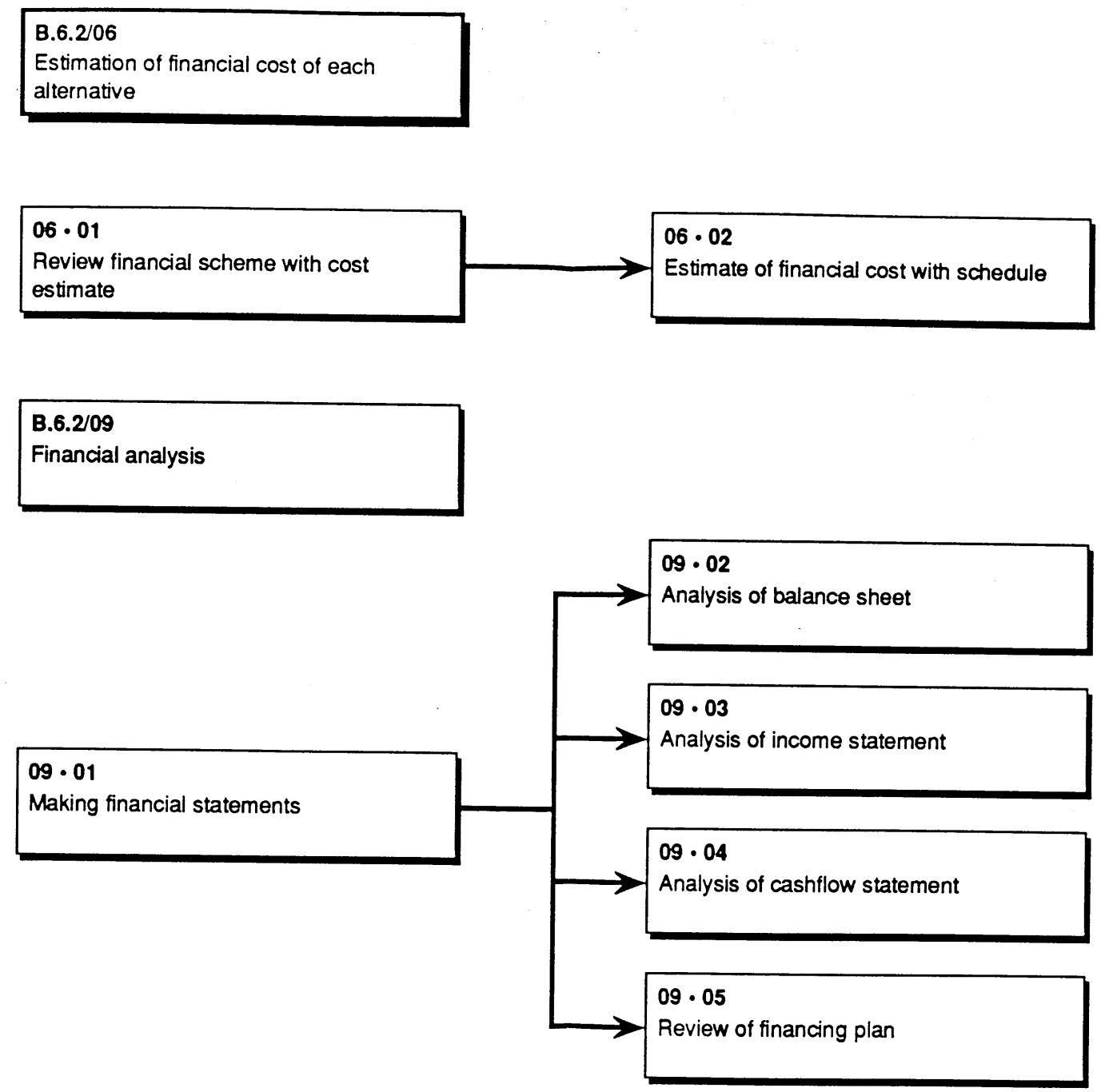
Input		General Work Flow	Output	
02-02	Examination of each objective for setting toll system		B.6.2	
03-02	Analysis of rate schedule		04-04	Rate Schedule
03-03	Analysis of other important items		04-03	Rate increase
04-04	Rate schedule		0-7	Estimate of toll revenue
04-03	Future rate increase		08-02	Estimation of other revenue
B.3.3	Required Capital Cost for Each Alternative		05-02	List of cost items with estimated figure of each
B.6.6	Required Operation and Maintenance Costs for Each Alternative			
B.5	Most Optimum Financing Sources with Terms and Conditions			
A.2.4	Future Transportation System			
B.3.1	Commodity and Traffic Projection			
B.3.3	Required Capital Cost for Each Alternative			
B.6.6	Required Operation and Maintenance Costs for Each Alternative			



Input

B.6.2 05•02	List of cost items with each estimated figure
B.5	Financial Scheme
05•02	List of cost items with estimated figure of each
06•02	Estimate of financial cost with schedule
07	Estimated of toll revenue
08•02	Estimate of other revenue

General Work Flow



Output

B.6.2/ 06•02	Estimate of financial cost with schedule
09•02	Analysis of balance sheet
09•03	Analysis of profit and loss statement
09•04	Analysis of cashflow statement
09•05	Review of rinancing plan

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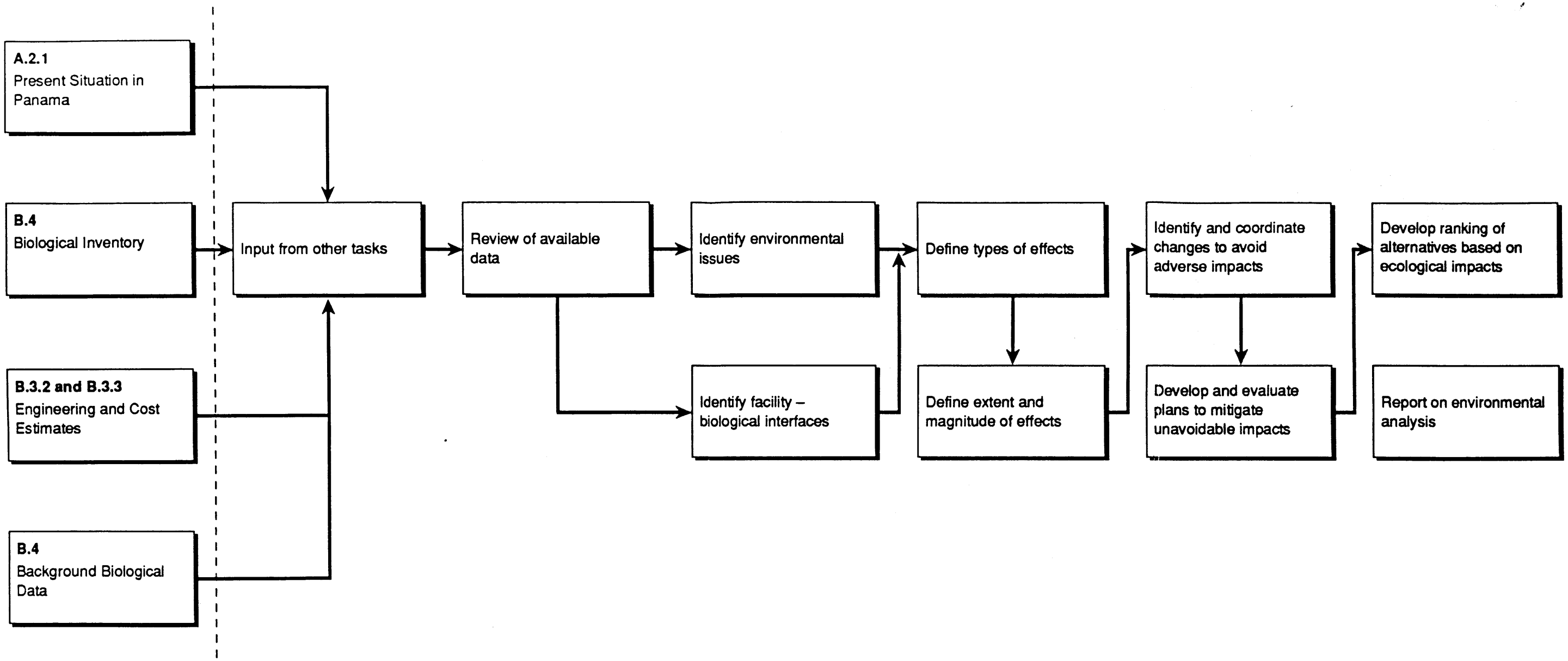
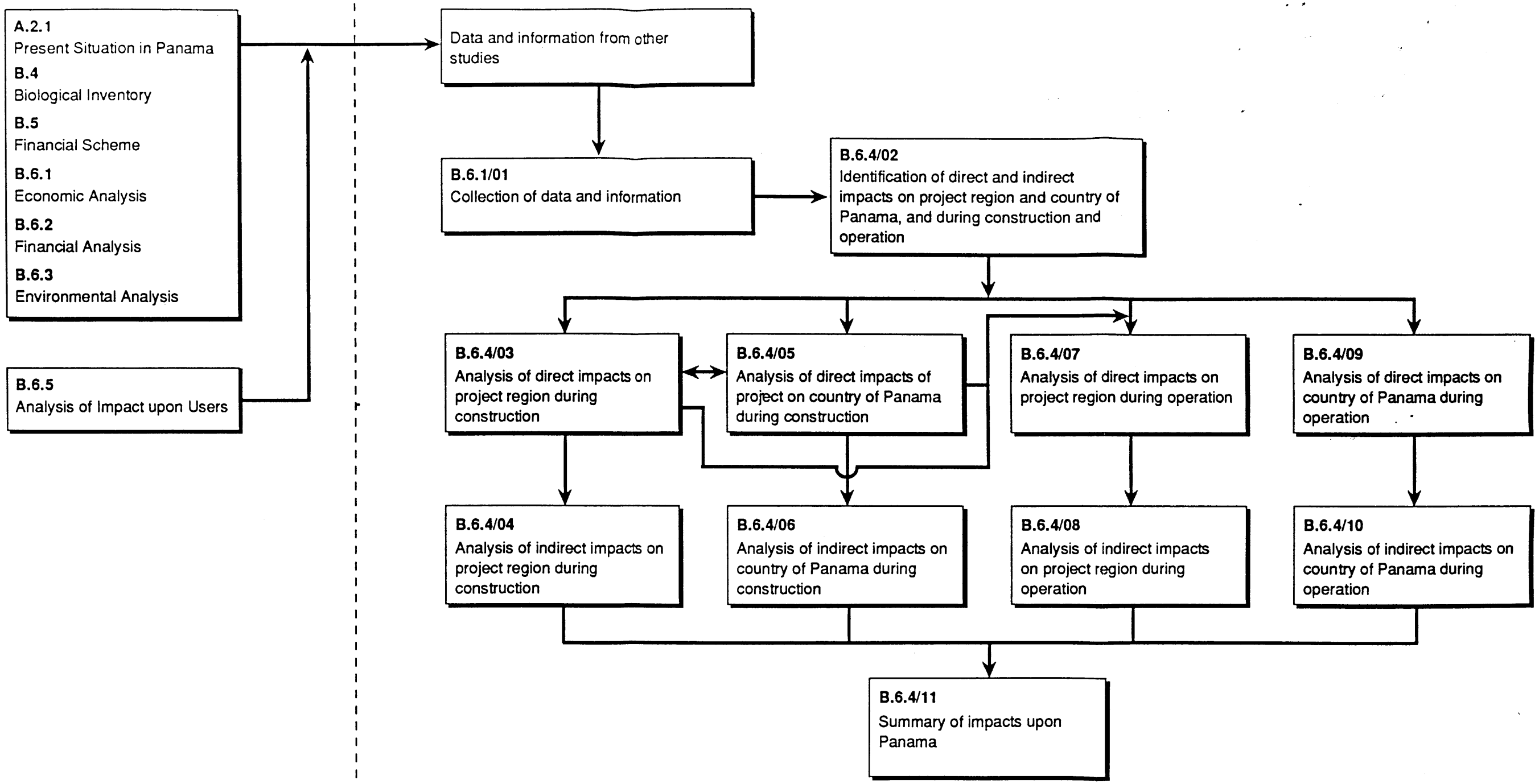
8-30-90 tg/lw :2

B.6.2
Financial Analysis
Input/Output Relationship

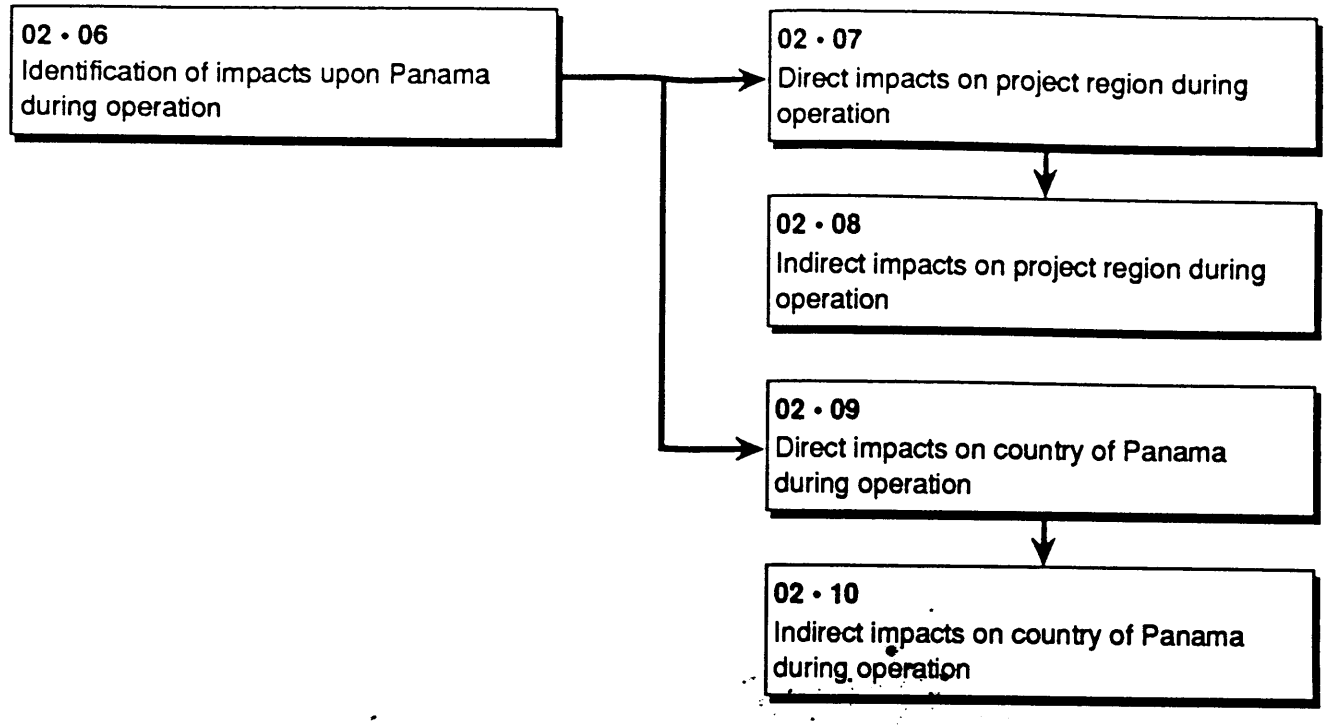
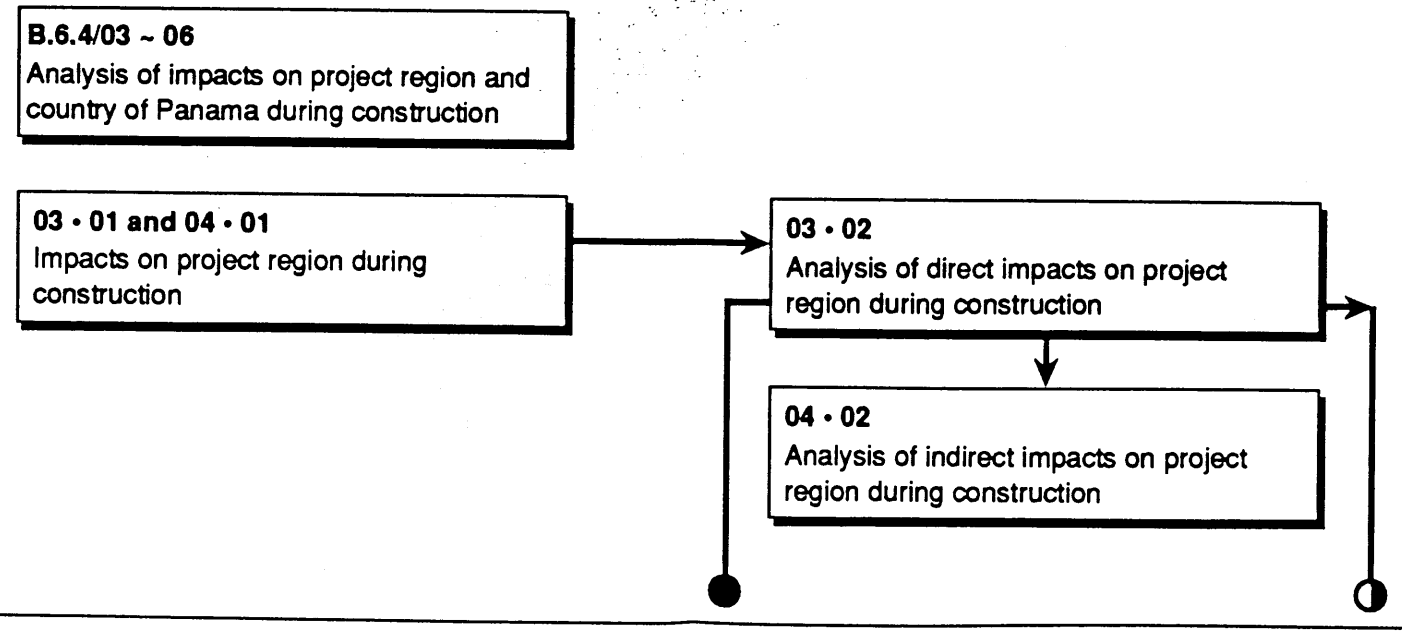

A.2.1
Present Situation in Panama
B.4
Biological Inventory
B.3.2 and B.3.3
Engineering and Cost Estimates
B.4
Background Biological Data
Input from other tasks
Review of available data
Identify environmental issues
Identify facility – biological interfaces
Define types of effects
Define extent and magnitude of effects
Identify and coordinate changes to avoid adverse impacts
Develop and evaluate plans to mitigate unavoidable impacts
Develop ranking of alternatives based on ecological impacts
Report on environmental analysis



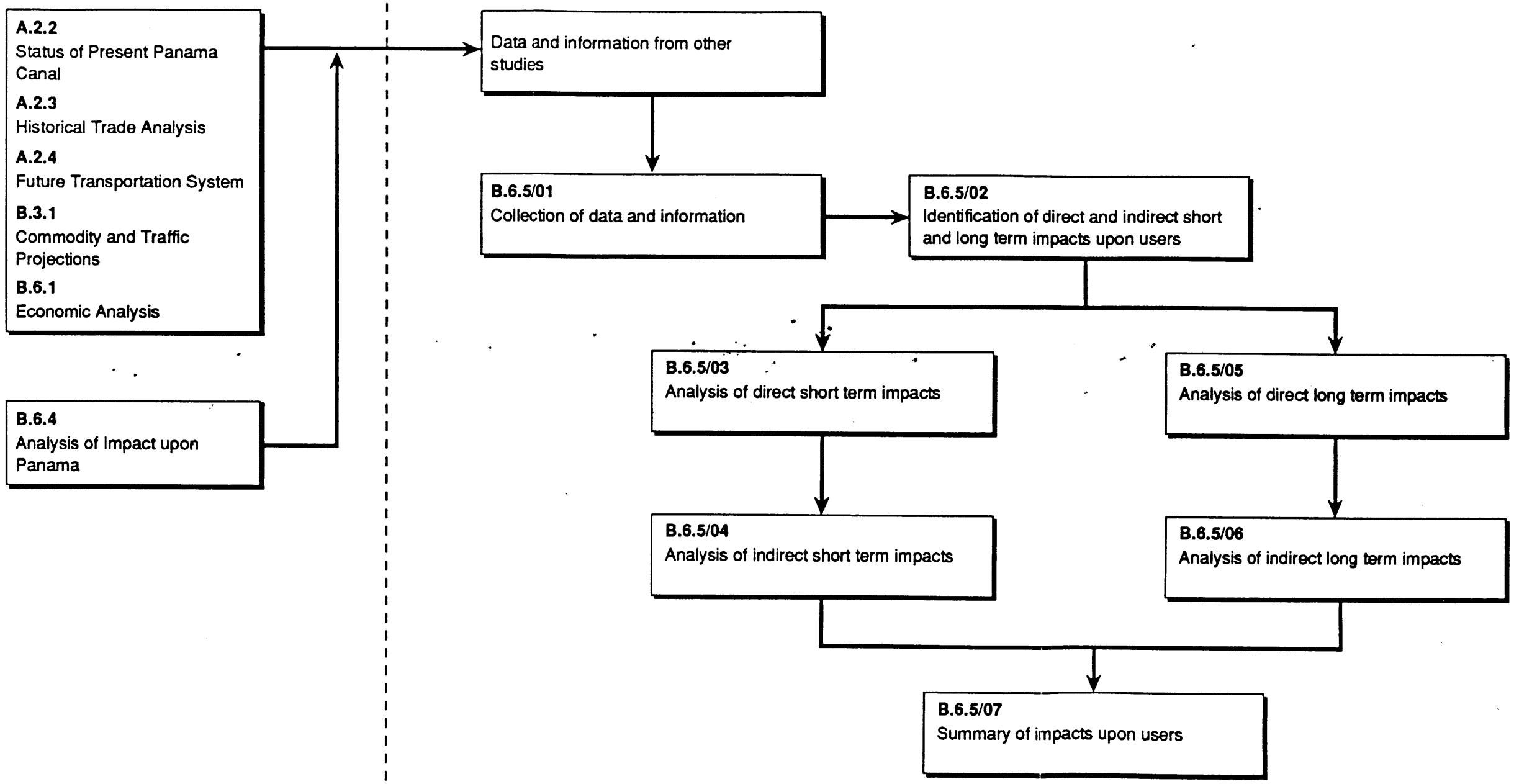
B.6.4
Analysis of Impact Upon Panama

15962/28/f/Panama/232
9-7-90 tg/fw :6

Input		General Work Flow	Output	
	Results of studies from:		B.6.4	
A.2.1	Present Situation of Panama	**B.5/01** Collection of data and information	01-02	Results of review and analysis of impacts upon Panama during construction
B.4	Biological Inventory		01-03	Results of review and analysis of impacts upon Panama during operation
B.5	Financial Scheme			
B.6.1	Economic Analysis			
B.6.2	Financial Analysis			
B.6.3	Environmental Analysis			
B.6.5	Analysis of Impact upon Users	**01 • 01** Collection of data, information, reports, etc. → **01 • 02 ~ 04** Review, rearrange, analysis, tabulation, illustration, etc.		
B.6.4		**B.6.4/02** Identification of direct and indirect impacts on project region and country of Panama, and during construction and operation.	B.6.4	
01-02	Impacts upon Panama during construction		02-02	Direct impacts on project region during construction
01-03	Impacts upon Panama during operation	**02 • 01** Identification of impacts upon Panama during construction → **02 • 02** Direct impacts on project region during construction	02-03	Indirect impacts on project region during construction
			02-04	Direct impacts on country of Panama during construction
			02-05	Indirect impacts on country of Panama during construction
			02-07	Direct impacts on project region during operation
			02-08	Indirect impacts on project region during operation
			02-09	Direct impacts on country of Panama during operation
			02-10	Indirect impacts on country of Panama during operation
		02 • 03 Indirect impacts on project region during construction		
		02 • 04 Direct impacts on country of Panama during construction		
		02 • 05 Indirect impacts on country of Panama during construction		

Input		General Work Flow	Output	
				
B.6.4 02•02 02•03 02•04 02•05	Direct impacts of project region during construction Indirect impacts of project region during construction Direct impacts on country of Panama during construction Indirect impacts on country of Panama during construction		B.6.4 03•02 and 05•02 04•02 and 06•02	Analysis of direct impacts on project region and country of Panama during construction Analysis of indirect impacts on project region and country of Panama during construction

Input		General Work Flow	Output	
		05 • 01 and 06 • 01 Impacts on country of Panama during construction → **05 • 02** An alysis of direct impacts on country of Panama during construction → **06 • 02** Analysis of indirect impacts on country of Panama during construction		
B.6.4 02•07 02•08 02•09 02•10	Direct impacts on project region during operation Indirect impacts on project region during operation Direct impacts on country of Pánama during operation Indirect impacts on country of Panama during operation	**B.6.4/07 ~ 10** Analysis of impacts on project region and country of Panama during operation **07 • 01 and 08 • 01** Impacts on project region during operation → **07 • 02** Analysis of direct impacts on project region during operation → **08 • 02** Analysis of indirect impacts on project region during operation **09 • 01 and 10 • 01** Impacts on country of Panama during operation → **09 • 02** Analysis of direct impacts on country of Panama during operation → **04 • 02** Analysis of indirect impacts on country of Panama during operation	B.6.4 07•02 and 09•02 08•02 and 10•02	Analysis of direct impacts on project region and country of Panama during operation Analysis of indirect impacts on project region and country of Panama during operation



B.6.5
Analysis of Impact Upon Users

Input		General Work Flow	Output	
B.6.4 03-02 and 05-02	Direct impacts on project region and country of Panama during construction	**B.6.4/11** Summary of impacts upon Panama	B.6.4 11-02	Summary of analyses of impacts upon Panama
04-02 and 06-02	Indirect impacts on project region and country of Panama during construction			
07-02 and 09-02	Direct impacts on project region and country of Panama during construction	**11 • 01** Results of analyses of direct and indirect impacts on project region and country of Panama during construction and operation → **11 • 02** Summary of analyses of impacts upon Panama		
08-02 and 10-02	Indirect impacts on project region and country of Panama during construction			

Input		General Work Flow	Output	
	Results of studies from:	**B.6.5/01** Collection of data and information	B.6.5	
A.2.2	Status of Present Panama Canal		01-02	Results of review and analysis of short term impacts
A.2.3	Historical Trade Analysis		01-03	Results of review and analysis of long term impacts
A.2.4	Future Transportation Systems			
B.3.1	Commodity and Traffic Projections			
B.6.1	Economic Analysis			
B.6.4	Analysis of Impact Upon Panama	**01 • 01** Collection of results of foregoing studies, data, information, reports, etc. → **01 • 02 ~ 03** Review, rearrange, analysis, tabulation, illustration, etc.		
B.6.5		**B.6.5/02** Identification of short and long term impacts upon users	B.6.5	
01-02	Short term impacts		02-02	Direct short term impacts upon users
01-03	Long term impacts		02-03	Indirect short term impacts upon users
			02-04	Direct long term impacts upon users
			02-05	Indirect long term impacts upon users
		02 • 01 Identification of impacts upon users → **02 • 02** Direct short term impacts upon users → **02 • 03** Indirect short term impacts upon users → **02 • 04** Direct long term impacts upon users → **02 • 05** Indirect long term impacts upon users		

Input		General Work Flow	Output	
B.6.5 02-02 B.6.5 02-03 B.6.5 02-04 B.6.5 02-05	Direct short term impacts upon users Indirect short term impacts upon users Direct long term impacts upon users Indirect long term impacts upon users	**B.6.5/03 ~ 06** Analysis of impacts upon users **03 • 01 and 04 • 01** Short term impacts upon users → **03 • 02** Analysis of direct short term impacts upon users ↓ **04 • 02** Analysis of indirect short term impacts upon users **05 • 01 and 06 • 01** Short term impacts upon users → **05 • 02** Analysis of direct long term impacts upon users ↓ **06 • 02** Analysis of indirect long term impacts upon users	B.6.5 03-02 and 05-02 B.6.5 04-02 and 06-02	Analysis of direct impacts upon users Analysis of indirect impacts upon users
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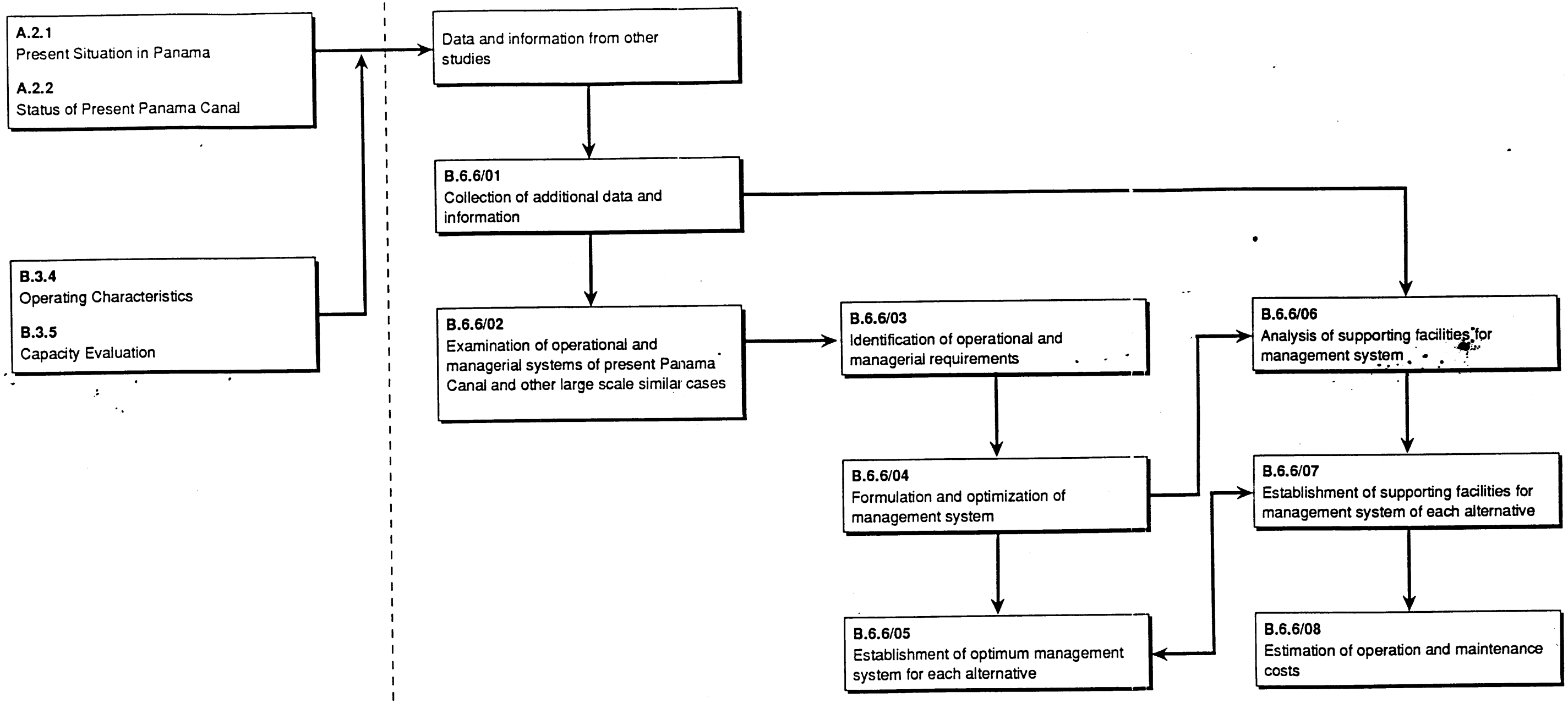

B.6.6
Management Arrangements

Input		General Work Flow	Output	
A.2.1 A.2.2 (B.3.4 B.3.5) • •	Operational and managerial services of present Panama Canal Operating characteristics of each alternative Operational and managerial services of other large-scale similar types of projects Other data, information, reports, etc.	**B.6.6/01** Collection of data and information **01 • 01** Collection of results of foregoing studies, data, information, reports, etc. → **01 • 02 ~ 03** Review, rearrangement, analysis, illustration, etc.	B.6.6 01-02 01-03	Results of review and analysis of operational and managerial services of the present Panama Canal and similar projects Data for operational and managerial requirements
B.6.6 01-02 01-03	Results of review and analysis of operational and managerial services of the present Panama Canal and similar projects Data for operational and managerial requirements	**B.6.6/02 and 03** Examination of operational and managerial services and identification of the requirements **02 • 01** Examination of operational and managerial services applicable to each alternative → **03 • 01** Identification of operational and managerial requirements ↓ **03 • 02** Assessment of the requirements for each alternative	B.6.6 03-02	Operational and managerial requirements for each alternative

Input		General Work Flow	Output	
B.6.6 03-02	Operational and managerial requirements for each alternative	**B.6.6/04** Formulation and optimization of management system **04 • 01** Development of conceivable management system for each alternative → **04 • 02** Optimization of management system for each alternative	B.6.6 04-02	Optimization management system for each alternative
B.6.6 04-02	Optimum management system for each alternative	**B.6.6/05** Establishment of optimum management system **05 • 01** Assessment of optimum management system for each alternative → **05 • 02** Establishment of optimum management system for each alternative	B.6.6 05-02	Management system for each alternative
B.6.6 05-02 •	Management system for each alternative Data and information	**B.6.6/06 and 07** Establishment of supporting facilities for management system **06 • 01** Analysis of supporting facilities applicable fo each alternative → **07 • 01** Establishment of optimum supporting facilities for management services for each alternative	B.6.6 07-01	Supporting facilities for management system for each alternative

Input		General Work Flow	Output	
B.6.6 05-02 07-01	Management system for each alternative Supporting facilities for management services for each alternative	**B.6.6/08** Estimation of operation and maintenance costs **08 • 01** Analysis of management system for each alternative → **08 • 03** Identification of cost items of management system and supporting facilities **08 • 02** Analysis of supporting facilities for management system for each alternative → **08 • 04** Estimation of operation and maintenance costs for each alternative	B.6.6 08-04	Operation and maintenance costs for each alternative

S • I • N • B • O • L

PANAMA: LOMOSA, SA
USA: BECHTEL CORPORATION
STONE & WEBSTER ENGINEERING CORPORATION
JAPAN: NIPPON KOEI CO., LTD.
INDUSTRIAL BANK OF JAPAN, LIMITED
OVERSEAS COASTAL AREA DEVELOPMENT
INSTITUTE OF JAPAN

September 18, 1990

Commission for the Study of
Alternatives to the Panama Canal
P.O. Box 2094
Balboa, Ancon
Panama, Republic of Panama

Attention: Members of the Secretariat

Subject: Final DPS

We are pleased to submit 15 copies of the Final DPS Report, composed of Volumes I and II. The Report incorporates revisions agreed upon in our July review with the Secretariat and requested in your subsequent letters.

Sincerely,

Charles P. Weiner
Study Coordinator

CPW:tr
Enclosures

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de las Alternativas
al Canal de Panamá
CENTRO DE INFORMACION

LOMOSA, SA •APARTADO 8340
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DETAILED PLAN OF THE STUDY OF ALTERNATIVES TO THE PANAMA CANAL

VOLUME I

Comisión de Estudio
de las Alternativas
al Canal de Panamá
CENTRO DE INFORMACION

SUBMITTED TO

COMMISSION FOR THE STUDY OF ALTERNATIVES TO THE PANAMA CANAL

S • I • N • B • O • L

PANAMA
LOMOSA, SA

USA
BECHTEL CIVIL, INC.
STONE & WEBSTER ENGINEERING CORPORATION

JAPAN
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INDUSTRIAL BANK OF JAPAN, LIMITED
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SEPTEMBER 1990

Preface

The Detailed Plan of the Study (DPS) of Alternatives to the Panama Canal has been prepared for the Commission for the Study of Alternatives to the Panama Canal. The SINBOL Consortium has prepared the DPS as a consultant to the Commission and under the direction of the Commission's Secretariat.

The DPS consists of two volumes:

Volume I — The description of the overall plan to execute and manage the study, including descriptions of the tasks to be performed by the Feasibility Analysis/Final Report (FA/FR) Contractor and the Component Study contractors.

Volume II — Terms of Reference for the Component Studies to be carried out by contractors other than the FA/FR Contractor and detailed work plans for prescreening tasks to be performed by the FA/FR Contractor.

The DPS has been prepared within the basic guidelines established by the Final Report of the Preparatory Committee on the Panama Canal Alternatives Study and according to guidance provided by the Commission and its Secretariat. The guidance provided by the Commission and the Secretariat includes:

- A directive to schedule the Study to be completed within a 30-month period.
- Restructuring of the Study to include selected Component Studies in the scope of work of the FA/FR Contractor as per the Commission's letter of August 13, 1990. The new study structure is described in detail in the body of Volume I.
- With regard to preliminary cost estimates for the Component Studies, SINBOL has provided its best estimates using as a basis the amounts budgeted and specified in the Preparatory Committee Report.

The ability to meet the 30-month schedule presented in the DPS is subject to the following conditions and understandings:

- The Study Commission and Secretariat will perform review and approval responsibilities in a timely and unified manner.
- All component contracts are completed as scheduled.
- Recognition that delays attributable to other contractors and or the Study Commission are likely to have a significant impact on costs and schedule.

- Although the overall cost of the Study is constrained by the budget proposed by the 1985 Preparatory Committee Report, the cost of the FA/FR Contract will be increased due to the additional manpower required by the FA/FR Contractor in Panama to assist the Secretariat in the Prescreening and other activities of the Study's preliminary phase.

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Section 1

General Description of the FA/FR Study

1.1 INTRODUCTION

The SINBOL Consortium has prepared the Inception Report issued on February 27, 1990 and the Interim Report issued on March 23, 1990 and submitted them to the Commission for the Study of the Alternatives to the Panama Canal. Detailed review meetings on the Interim Report were held between the Commission and the Consortium in April and for the Draft Detailed Plan of Study in July 1990.

During these meetings, a decision was made by the Commission to shorten the period of time allocated for the completion of the Feasibility Analysis/Final Report (FA/FR) Study from 48 months to 30 months. In order to meet this shortened schedule, a two-fold strategy was adopted.

- First, the FA/FR Contractor would prepare the studies of the present situation in Panama, the status of the present Panama Canal, historical trade analysis, and future transportation systems.
- Second, the FA/FR Contractor would prepare a preliminary analysis and screening of the alternatives with the objective of allowing the Commission to reduce the number of alternatives for further study by removing from consideration those that appear to be infeasible.

These steps will enable the work associated with preparing both the Component Studies and the final FA/FR report to be carried out more effectively and make it possible to meet the shortened time schedule.

1.2 DETAILED PLAN OF STUDY

The Detailed Plan of the Study (DPS) consists of two volumes:

Volume I	The description of the overall plan to execute and manage the study, including descriptions of the tasks to be performed by the Feasibility Analysis/Final Report (FA/FR) Contractor and the Component Study contractors.
Volume II	Terms of Reference for the Component Studies to be carried out by contractors other than the FA/FR Contractor and detailed work plans for prescreening tasks to be performed by the FA/FR Contractor.

Volume I describes the tasks that will be carried out by the FA/FR Contractor and Component Study contractors. Following is a brief overview of the work to be performed by the FA/FR Contractor:

- Prepare a preliminary analysis and prescreening of alternatives, including studies covering the present situation in Panama, the status of the Panama Canal, historical trade analysis, and future transportation systems
- Advise the Secretariat in selecting viable alternatives
- Assist and advise the Secretariat in selecting and overseeing the work of the Component Study contractors
- Prepare a feasibility analysis which incorporates the work of the FA/FR Contractor and the Component Study contractors
- Advise the Secretariat in recommending the best alternative
- Prepare a detailed investigation of the recommended alternative
- Prepare the final report
- Advise and assist the Secretariat in scheduling and managing of the study program

Figure 1-1 contains a task flow diagram that shows each of the tasks and their relationship with other tasks. It also shows which of the tasks will be done by the FA/FR Contractor, which will be done by the Component Study contractors and illustrates the critical path. A detailed description of each of these tasks is contained in Section 3 of this report.

1.2.1 List of Alternatives

The alternatives that will be investigated in the preliminary analysis and prescreening tasks are listed below. The main features of these alternatives are discussed in Section 2.

- Improvements to the Existing Canal
  - Status quo alternative (includes Gaillard Cut widening)
  - Non-lock improvements
  - Third Locks Plan
  - Terminal Lake Plan and Variations

  - Deep Draft Lock Canal Plan
  - Lopez-Moreno Plan
- Sea-Level Canal
  - 1970 Interoceanic Canal Studies, Route 10
  - 1970 Interoceanic Canal Studies, Route 14S
  - Vergara Plan
  - Nagano Plan
- Non-Canal Complementary Transportation Systems
  - Oil pipeline
  - Land bridge systems (railway and highway)
  - Appropriate parts of the Centerport Concept
  - Other

1.2.2 Preliminary Analysis and Prescreening Tasks

The tasks that will be prepared by the FA/FR Contractor for the preliminary analysis and prescreening of alternatives include the following:

- Analysis of the Present Situation in Panama
- Status of the Present Panama Canal
- Historical Trade Analysis
- Future Transportation Systems and the Significance of the Isthmus in World Trade
- Prescreening and Selection of Alternatives

Input from Component Studies will also be included in the prescreening effort.

1.2.3 Component Studies

The tasks that will be prepared by the Component Study contractors and their relationship to the overall study are shown in Figure 1-1. Because some of these tasks are closely related, they will be grouped into the following categories for the purpose of selecting Component Study contractors. The reasons for this grouping are

purpose of selecting Component Study contractors. The reasons for this grouping are discussed in Section 3, Part B. (preliminary studies for prescreening activities to be performed by Component Study contractors are incorporated into the TOR's of the component studies marked with an asterisk):

- Commodity and Traffic Projections*
- Engineering and Cost Estimates*
- Operating Characteristics and Capacity Evaluation*
- Background Biological Data and Biological Inventory*
- Financing Scheme and Financial Analysis
- Economic and Impact Analyses
- Environmental Analysis
- Management Arrangements
- Development of Additional Data

1.2.4 Feasibility Analysis and Final Report

The information from the preliminary analysis and prescreening tasks, together with input from the Component Studies, will be used to prepare the feasibility analysis. This will include economic feasibility, financial feasibility, environmental feasibility, and the analysis of the impact of the alternatives on Panama and on the users of the canal. The results of the feasibility analysis will be used to select a recommended alternative.

A detailed study of the recommended alternative will then be prepared. Additional data, as needed, will be developed and incorporated into this detailed study. An initial draft report will then be prepared, and after review by the Commission, a final report will be published.

1.3 SCHEDULE

Figure 1-2 shows the proposed schedule for the completion of the study. The initial data collection, prescreening, and selection of viable alternatives will be completed during the first 12 months of the study.

Concurrently, during the first five months, the Secretariat will accomplish the prequalification and selection of component contractors. The Component Studies will vary in the amount of time allowed for completion, but they are all scheduled to be finished by the end of the 20th month with the exception of the biological inventory. With this exception, the results of the initial investigations and the Component Studies will be available to the FA/FR Contractor beginning with the 21st month.

A feasibility analysis, including sensitivity analysis, will be prepared and a preferred alternative will be identified during the following two months. A detailed investigation of this alternative will then be prepared. Simultaneously, additional data will be developed as needed to complete the detailed investigation.

The final report, including appropriate time allowed for reviews, will be prepared during the final 7 months of the schedule. Thus, judiciously integrating activities will allow the report to be completed in 30 months from the time the team is mobilized.

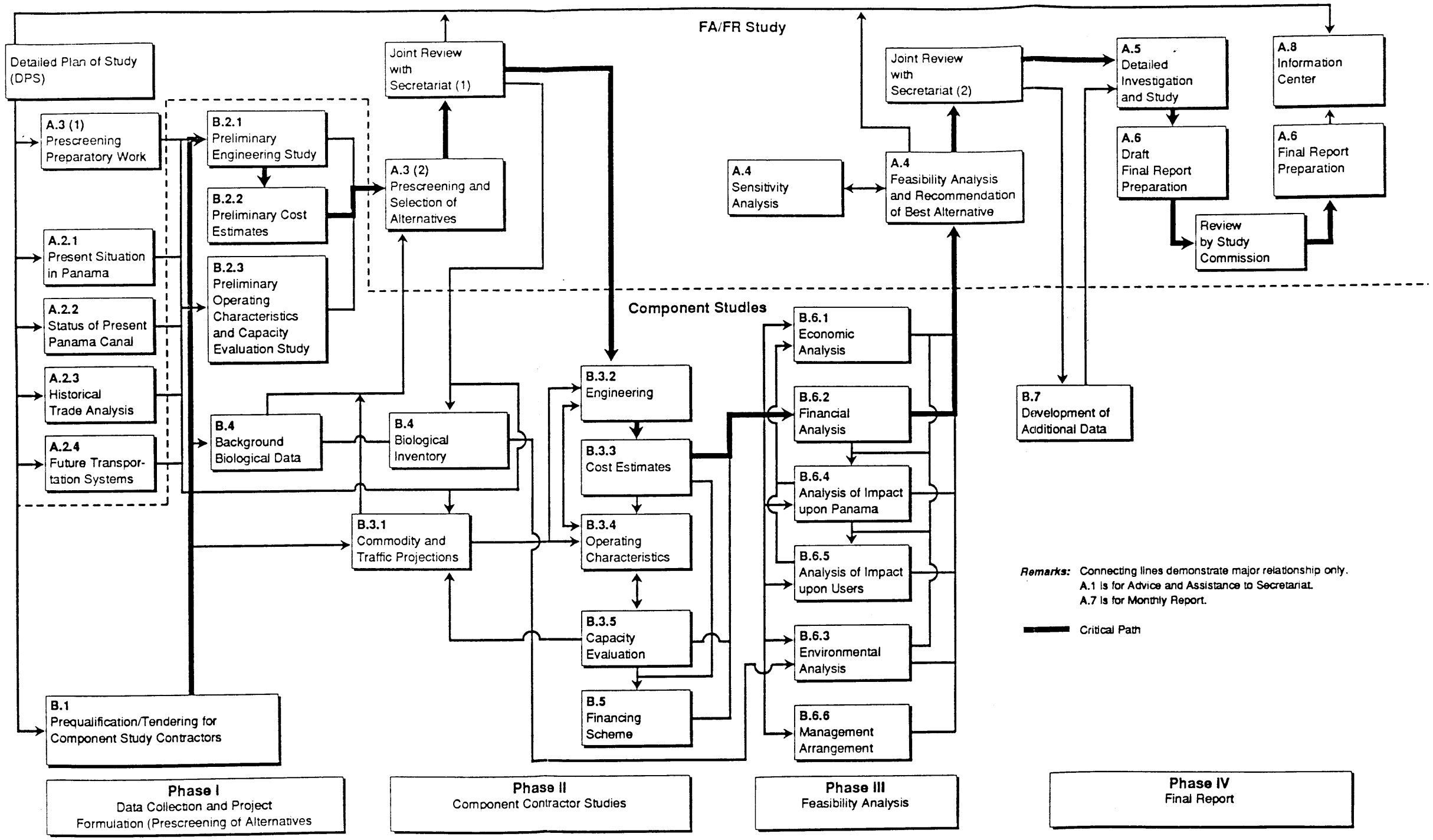

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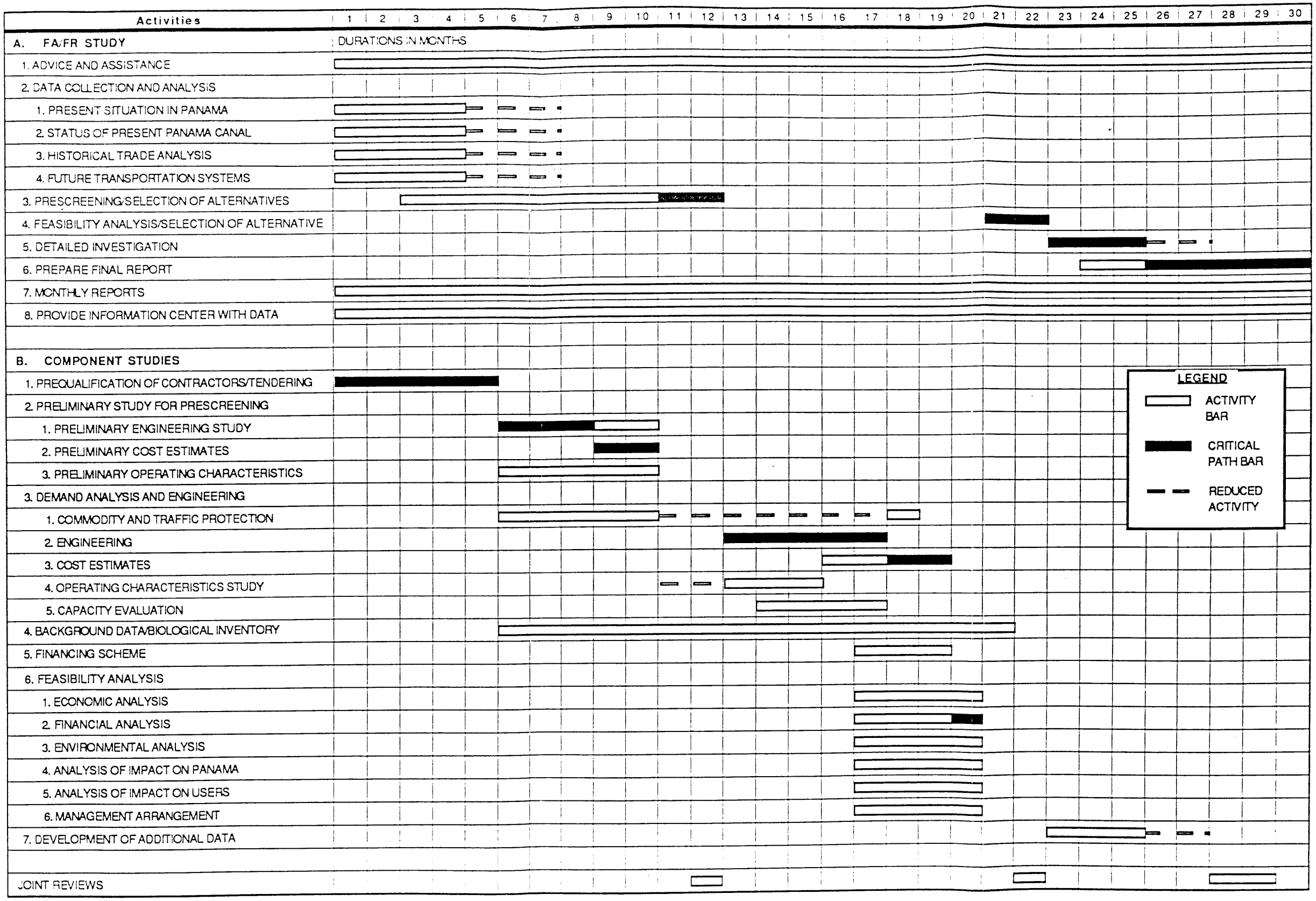
Figure 1-1
Overall Work Plan Flow



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PANAMA CANAL ALTERNATIVES STUDY

Figure 1-2
Study Summary Schedule

Section 2

Description of Alternatives

This section contains a list of the possible alternatives to be studied and analyzed. The possible alternatives may be broadly classified into three categories: improvements to the existing canal, construction of a sea-level canal, and non-canal alternative transportation systems. These are listed below:

- Improvements or enlargements to the existing canal
  - Status quo alternative (includes Gaillard Cut widening)
  - Non-lock improvements
  - Third Locks Plan
  - Terminal Lake Plan and variations
  - Deep Draft Lock Canal Plan
  - Lopez-Moreno Plan
- Sea-level canal
  - 1970 Interoceanic Canal Studies, Route 10
  - 1970 Interoceanic Canal Studies, Route 14S
  - Vergara Plan
  - Nagano Plan
- Non-canal complementary transportation systems
  - Oil pipeline
  - Land bridge systems (railway and highway)
  - Appropriate parts of the Centerport Concept
  - Other

During the prescreening phase, some of the alternatives on this list will be eliminated. The Commission will apply technical, financial, and environmental factors in the elimination process. Eventually, as the study proceeds, the preferred alternative will be selected and a detailed investigation of this alternative will be performed.

The alternatives are briefly described below.

2.1 STATUS QUO ALTERNATIVE (PRESENT PANAMA CANAL)

This will consider the Panama Canal as it presently exists. If the Panama Canal Commission's Gaillard Cut Widening Project proceeds, this improvement will be included in this base alternative. Similarly, other ongoing modifications such as navigational aids which will increase the capacity and/or efficiency of the present canal will be included in the status quo alternative.

2.2 NON-LOCK IMPROVEMENTS TO THE PRESENT PANAMA CANAL

These alternatives will include the proposed improvements discussed above if they are not yet approved and funded for construction and installation. Other improvements to the present canal (not including new locks and water level changes) will be addressed as part of this alternative. These possible improvements might include more efficient ship handling facilities which will result in faster transits; improved port facilities and marine support equipment; additional navigational aids to improve transit capabilities during bad weather and at night; additional widening and/or deepening of existing channels; removal of sills; additional or different water supply arrangements for lockage requirements; and improved water management systems.

2.3 LOCK IMPROVEMENTS TO THE PRESENT PANAMA CANAL

There are at least five lock improvement alternatives to be considered: the Third Locks Plan, the Terminal Lake Plan and its variations, the Deep Draft Lock Canal Plan, and the Lopez-Moreno Plan. Most of these previously published plans will have to be modified to provide for the maximum size and draft of ship selected for the planning of conceptual alternatives.

2.3.1 The Third Locks Plan

This plan was proposed in 1938 and major excavation was accomplished in 1940-1942. The plan was revised in 1947 and it is this version that will be studied. This plan calls for the construction of one additional lane of larger and deeper locks adjacent to the existing locks. Gatun Lake will remain at its present nominal 25.9 m MSL. Additional lockage water (fresh or possibly sea water) will have to be stored and possibly pumped.

2.3.2 The Terminal Lake Plan

This plan was initially proposed in 1943. It calls for abandoning the Pedro Miguel Locks, raising Miraflores Locks and constructing one lane of large locks at both Miraflores and Gatun. Gatun Lake will remain at its present level. A number of variations in the Terminal Lake Plan have been proposed. One of these variations replaces the locks at Gatun and Miraflores with two lanes of new large locks: Gatun Lake will be raised by about two meters. Additional lockage water (fresh or sea water) will probably be required.

2.3.3 The Deep Draft Lock Canal Plan

This plan was proposed in the Interoceanic Canal Studies 1970 (known as the Anderson Report). It consists of adding a lane of new, large, triple-lift locks at Gatun and constructing a separate lane of triple-lift locks at Miraflores together with a bypass around the existing Pedro Miguel locks. Gatun Lake will remain at 25.9 m MSL. Again, additional lockage water will probably be required.

2.3.4 The Lopez-Moreno Plan

This concept is a more recent proposal. This plan will lower Gatun Lake from 25.9 m to 16.8 m. The upper lift of Gatun Locks and the entire Pedro Miguel Locks will be eliminated. The plan provides for using the remaining existing locks plus adding two new lanes of locks. One lane will accommodate 250,000 DWT ships with drafts of up to 20.4 m. The other new lane will provide locks which are relatively small. This system will permit more efficient use of lockage water. All existing channels will be widened and deepened. Additional lockage water storage will probably be needed.

2.4 SEA-LEVEL CANAL ALTERNATIVES

The Interoceanic Canal Studies, 1970, initially considered 11 sea-level canal alternatives in Panama (plus five in Panama and Colombia). Four of the Panamanian routes (and one of the Panama/Colombia routes) were studied in detail. The recommended sea-level canal alternatives were Routes 10 and 14S. The Report of the Preparatory Committee limits the sea-level canal options for the present study to these two routes.

2.4.1 Route 10

The Route 10 sea-level canal lies about 16 km west of and generally parallel to the present Panama Canal. The Interoceanic Canal Studies 1970 proposed a design vessel of 150,000 DWT (a 250,000 DWT ship could transit during favorable currents). The 1970 data may have to be revised and updated depending on what design vessel is selected for the present study. Tidal gates or checks will probably have to be installed to limit canal currents to a maximum of two knots. The Route 10 alignment will permit continued operation of the present Panama Canal.

2.4.2 Route 14

Route 14S follows the general alignment of the present canal and consequently may have less impact on Panamanian infrastructure. The design vessel and tidal current criteria are the same as for Route 10. This routing results in a major lowering of the Gatun Lake, and it could interfere with the operation of the present canal during construction. The present canal would no longer be operable after completion of Route 14S.

2.4.3 Vergara Plan

The Vergara Plan is a variation on the sea-level canal plan recommended in the Anderson Report, and follows Route 10 with some modifications. The target size of vessels is 250,000 DWT, while the section of the canal is proposed to be 300 m in width and 25 m in depth. The plan also proposes the construction of berths protected by breakwaters at both entrances, instead of tidal gates to check the tidal current. As for excavation works, it recommends use of dredging rather than dry land excavation methods.

2.4.4 Nagano Plan

The Nagano Plan is another variation on the sea-level canal plan though the target size of vessels is increased to 300,000 DWT, and 500,000 DWT at high tide. The channel width will be 200 m and the depth, 33.0 m. Furthermore, in order to accommodate large vessels, an approach channel will be required at each end. The size of these channels will be 400 m in width, 35.8 m in depth, and 35 km in length at the Pacific end and 400 m, 33.4 m, and 5 km at the Atlantic end.

2.5 NON-CANAL COMPLEMENTARY TRANSPORTATION SYSTEMS

The present Panama Canal could be complemented by non-canal alternatives for moving commodities across the Isthmus. These alternatives include pipelines, land bridges, and other systems. The fundamental concept is to transport the cargoes from a ship on one side of the Isthmus to a ship on the other side in a manner that is more cost effective than expanding the present canal or other canal alternatives discussed above.

It is possible that these complementary systems can at least partially reduce the need for expansion of the present canal or postpone the construction of costly new canal alternatives. Each of these complementary alternatives will require supporting facilities consisting of moorings, port facilities, temporary product storage, processing and handling facilities, and related infrastructure.

A trans-Isthmus petroleum pipeline together with supporting facilities was constructed in 1982. This pipeline significantly reduced the number of daily canal transits. Pipeline alternatives which will augment the existing pipeline will be considered.

Many finished products are moved in standard sea containers or by similar means. An alternative which moves containers across the Isthmus by rail and highway will be considered.

A trans-Isthmus railroad presently connects the ports of Cristobal and Balboa. The Centerport feasibility study proposes improvements to the railroad and two ports. The ports would be used as major load centers for interlining and feeder service and the railroad would supplement the canal's transshipment operations. The project calls for a 10-year period of phased improvements. Appropriate parts of the Centerport concept will be considered as part of the non-canal complementary transportation systems.

Section 3

Explanation of Sectors

The purpose of this section is to provide a description of the tasks (work sectors) that will be done as part of the overall study. These tasks and their interrelationships are shown in the Overall Work Plan Flow diagram (Figure 1-1) in Section 1. The schedule for the accomplishment of these tasks is shown in Figure 1-2 in Section 1.

This Section is divided into two parts:

- Part A describes the tasks that will be performed by the FA/FR Contractor and is found under Tab A.
- Part B describes the tasks that will be assigned to Component Study contractors and is found under Tab B.

A. FA/FR TASKS

The FA/FR Contractor will, under the direction of the Secretariat, be responsible for the prescreening and selection of alternatives, the feasibility analysis, the detailed investigation, the tasks associated with preparing the final report, and the provision of advice and assistance to the Secretariat throughout the course of the study.

In preparing the preliminary analysis and prescreening of alternatives the FA/FR Contractor will undertake the following tasks:

- Analysis of the Present Situation in Panama
- Status of the Present Panama Canal
- Historical Trade Analysis
- Future Transportation Systems and the Significance of the Isthmus in World Trade
- Prescreening and Selection of Alternatives

The results of these tasks and preliminary results from the Component Studies will be used in the prescreening and selection effort. The Component Studies which will provide this preliminary information include the following:

- Background Biological Data
- Preliminary Engineering Study
- Preliminary Cost Estimates
- Preliminary Operating Characteristics and Capacity Evaluation Study
- Commodity and Traffic Projections

Upon the completion of this effort, the Commission will select those alternatives that appear feasible from technical, financial, and environmental standpoints, while eliminating those that are clearly infeasible. The Component Study teams will use this list of alternatives in preparing their detailed studies.

The FA/FR Contractor will take the results of the studies by the Component Study teams and in collaboration with the Commission, use these results to perform the following tasks:

- Conduct a detailed feasibility analysis of the selected alternatives
- Recommend the preferred alternative

- Conduct a detailed investigation of the recommended alternative
- Prepare a draft report for review with the Commission
- Prepare a final report

Detailed discussion of these tasks follows.

For the FA/FR tasks noted below, detailed work plans (DWPs) will be found in Volume II, with the summary explanations of these tasks included in the following explanation of study sectors:

- Present Situation in Panama
- Status of Present Panama Canal
- Historical Trade Analysis
- Future Transportation Systems
- Prescreening and Selection of Alternatives

A.1 ADVICE AND ASSISTANCE TO THE SECRETARIAT

FA/FR Contractor will provide advice and assistance to the Secretariat throughout the 30-month period while the overall study is being prepared. This task consists of coordinating, monitoring, and advising on potential problems; recommending revisions or modifications; and advising on methods that can improve the quality of the study. The FA/FR Contractor will also develop procedures, prepare progress reports, and perform other functions as directed by the Secretariat.

Coordination

The Study Coordinator will be responsible for providing daily coordination among the FA/FR Study Contractor, Component Study contractors, and the Secretariat. If he is absent for some reason, he will designate a member of the team to perform this function and ensure continuity.

Monitoring

A project control system will be developed which will monitor and assess the work and progress of the study. This project control system will be designed to control both the schedule and the budget and assure compliance with the study plan and the terms of reference. A detailed description of a proposed project control system is contained in Section 5 of this report. This system is flexible and provides practical tools to control the study, including coordination of Component Study deliverables with the FA/FR Study and among study teams as required.

Technical Evaluation

A system will also be set up to evaluate, through the Office of the Secretariat, the technical content of the study, including the technical work of the Component Study contractors.

Reporting

A monthly reporting system will be set up to provide information to the Secretariat on the progress of the study. The activities of the FA/FR Contractor and the Component Study contractors, the status of the schedule and budget, and the major milestones reached will be reported. A detailed description of the monthly reporting system is contained in Subsection A.7.

Advice

The Study Coordinator will advise the Secretariat on all matters regarding the study, including suggestions on ways to improve the study. He will also bring to the attention of the Secretariat any special problems that might arise during the course of the study or any special factors that might make it advisable to modify the DPS.

Assistance

The FA/FR Contractor will be available to assist the Secretariat in providing guidance to the Component Study contractors and in any other matters dealing with the FA/FR study. The Study Coordinator will coordinate these activities.

A.2 DATA COLLECTION AND ANALYSIS

A.2.1 Present Situation in Panama

The overall objective of this task is to provide both general and specific scie[illegible]c information as a basis for performing Component Studies of the alternatives to the Panama Canal. Particular emphasis will be placed on information referring to the impact and environmental analysis. This should serve for the analysis of certain social, economic, and geographic conditions related to the engineering work.

The study will cover, though generally, the whole physical, economic, cultural, and political environment of Panama; from geography to environmental aspects. It will focus particularly on the importance and impact of the present Panama Canal, and the geographic and geopolitical significance of Panama and the Isthmus in the development of world economy and trade. Special research studies, surveys, and investigations will be compiled on the economic, political, social, and geographical conditions in the country. The material will then be systematically classified and interpreted into elements that will be used to project future trends into the early decades of the 21st century.

Special emphasis will be given to the terrestrial and maritime studies with emphasis on the physical and human conditions in the areas which could be affected by future physical work on the Canal such as a third set of locks, a sea-level canal, or other transportation systems. The major elements of this task are described below.

Methodology

This study will consist of a literature search and, if necessary, interviews with PCC, STRI, University of Panama and Republic of Panama staff located in the Panama City metropolitan area. Emphasis for the following topic areas will be for the Canal, Route 10 and pipeline corridors. If an area or subject matter does not impact on or will not be substantially impacted by any alternative, it will not be subject to data gathering.

Natural and Physical Conditions

General and specific data on natural and physical conditions of land and sea in and around Panama will be studied. Specific data will relate to the present Panama Canal and the alternatives, and the study will be in sufficient detail for this purpose. Emphasis will be placed on collecting data in the areas that could be substantially

impacted by an alternative. Interviews, if necessary, will be undertaken with pertinent persons only.

The items of the study will cover, but not be limited to:

- Climatology and meteorology
- Oceanography, river systems, limnology, and hydrology
- Topography
- Geomorphology, soils, geology, and seismology
- Others

Terrestrial and Marine Environment/Ecology

In relation to terrestrial and marine environmental aspects and ecology in and around Panama, specific data such as of air and water quality, water temperature, river, lake and sea bed materials, etc. will be reported for further studies such as environmental analysis, formulation of conceptual alternatives, and engineering studies.

Geographical Aspects

In relation to geography in Panama, basic data (emphasizing the metropolitan areas of Panama City, Colon, Chorrera and Arrijan) will be collected concerning its special aspects, regional structure, evolution of physical, human and economic geography, endowment of natural resources and various aspects of the historical performance of the Isthmus. These will be analyzed where needed and will be rearranged for further studies, specially for the analysis of impact upon Panama, formulation of conceptual alternatives, and engineering studies.

Economic and Commercial/Financial Aspects

In relation to economic aspects of Panama, basic data will be collected concerning the following:

- Macro-economy
- Industrial structure
- Employment
- Commodity prices

- Balance of payment
- Characteristics of economic structure
- Development and current situation of economy
- Others

Socio-cultural Aspects

Together with the study on economic aspects of Panama, basic data on socio-cultural aspects of Panama will be collected in the alternative affected areas concerning population structure, infrastructure, urban and rural societies (i.e., skills and unemployment), etc. Their trends and changes will be for the use of further studies, such as the Analysis of Impact upon Panama.

Political Aspects

The basic data on the political aspects of Panama such as political system and structure will also be collected, together with other aspects. Their trends and changes will be used for further studies, such as the Analysis of Impact upon Panama.

Role of Panama in World Trade and Significance of the Panama Canal

In studying various aspects of Panama, analyses will be made to clarify the role of Panama in world trade and the significance of the present Panama Canal in the country of Panama.

The analyses will emphasize the following:

- Panama's geographic location and the historic processes which have given Panama its present status in the world trade.
- Influence of the present Panama Canal on the social, demographic and economic evolution or development of Panama.

The results will serve as the baseline for identifying and selecting the alternatives to the present Panama Canal.

Synthesis and Conclusions

The results of the above subtasks will be combined to provide a sense of the past and present economic, social and political situation in Panama, and a base on which to evaluate the future evolution of the country. Emphasis throughout this study will be on developing information that will help to evaluate the impact of the various canal alternatives if they are implemented.

A.2.2 Status of the Present Panama Canal

The information collected within this study forms a basis for a number of component studies. This report will be the source of information for existing conditions at the Panama Canal. The main source of information shall be the Panama Canal Commission and the extensive literature and graphical information that already exists on the present canal, as well as cargo statistics developed by the Commission. Notwithstanding, it will be necessary to carry out special investigations, interviews, surveys, and field inspections. The study team will have to make technical evaluations based on direct observations of the physical condition of the main facilities.

Topics that will be covered in this study include the following:

Physical Configuration of the Canal

The physical configuration of the existing canal within the geographical context of Panama shall be presented in graphical form. This information shall include not only the general canal configuration and the navigation channel, but also the lakes and rivers conforming the hydrographic basin. Overall description shall be complemented with applicable topographic, geodetic and hydrographic data. This description will also include all existing information on the Third Locks Plan.

Principal Features of Major Structures

The FA/FR Contractor team will prepare a physical description of the major canal structures and will complement it with an evaluation of their present condition. The information will include a discussion of the principal design criteria for each facility, as well as considerations of the particular problems affecting the facilities.

Principal Features of Supporting Structures

A physical inventory of the principal support structures will be prepared, including an evaluation of their present condition. The information will include engineering drawings and a discussion of the principal design criteria for each facility, as well as considerations of the particular problems affecting the facilities.

Present Operation Characteristics

Characteristics of present canal operation shall be presented, especially in relation with transit vessels.

- Distribution of types and sizes of vessels
- Transit time
- Waiting time
- Interval between vessels
- Anchoring operation
- Lock operation
- Navigation system
- Safety control and accident prevention systems

Management System

The main source of information for this section shall be the Panama Canal Commission. The organizational structure, the work force, the sources of income and the financial situation of the Commission shall be investigated as part of this task.

Maintenance System

A detailed presentation shall be made of the global maintenance system, including major and secondary structures and the waterway itself. The effectiveness of present maintenance and rehabilitation programs will be evaluated as an important factor in the effort to accurately determine the useful life of the existing canal.

Canal Cargo

The FA/FR Contractor will gather extensive canal cargo statistics generated by the Panama Canal Commission. The information shall be summarized in tabular and graphical form. The statistics will be utilized for the evaluation of the impact of fluctuations and increases of cargo volume in canal operation.

Transit Vessels

Panama Canal Commission statistics will be obtained concerning the transit of vessel characteristics. The information will be input into the evaluation of the effect of transit vessels on canal operation. Vessel statistics shall be grouped according to ship mix by type and size.

Load Ratio

Load ratio (laden vs in ballast) information will allow the evaluation of, among other things, the effect on operation efficiency and the determination of the actual maximum capacity under present conditions. The main source of information shall be Panama Canal Commission statistics. Information will be presented in tabular and graphical form, according to the following categories:

- Statistics of load ratio by type of vessels
- Statistics of load ratio by size of vessels

Evaluation of Major and Supporting Structures and Facilities

Based on the existing technical information, the field investigations by the FA/FR Contractor and interviews and surveys of qualified Commission personnel, an estimate of useful service life will be prepared for the principal and supporting canal facilities, taking into account their present condition, on-going maintenance and rehabilitation programs and the physical limitations of the materials and components of each facility.

Identification of Physical and Operational Constraints

An evaluation shall be made of the inherent limitations in design, configuration, geometric alignment and other specific physical and operational characteristics of the Panama Canal. Important input shall be provided by the Commission staff.

A.2.3 Historical Trade Analysis

This study supports the commodity and traffic projections and the analysis of impact upon canal users. The purpose of the study will be to collect and identify data and information concerning world and regional trade, to clarify demand and supply relationships of major commodity groups in the world market and examine international movement of major commodity groups.

Export and import of major commodity groups will be identified and cargo movement will be identified and quantified as the reflection of activities of the world economy. Major trade routes for maritime and maritime-related transportation systems in relation to the Isthmian route will be identified, and origin-destination relationships for major commodity groups will be prepared by country or region in relation to the Isthmian route.

Each of the major commodity groups will be treated as an objective of the study. Analysis will need to represent the minimum group of commodities having almost the same kind and level of value for both international trade and maritime transportation and be in sufficient detail so that demand analysis, economic analysis, etc., can be conducted. Major commodities are grouped as follows:

- Petroleum, crude
- Petroleum, products
- Coal and coke
- Ores
- Grains
- Automobiles
- Woods and wood products
- Fertilizers
- Metal and metal products
- Refrigerated cargoes
- Bananas
- Containerized cargoes
- Phosphates
- Alumina, bauxite

- Chemicals
- Sugar
- Food and agricultural products
- Miscellaneous

Trade route analysis will be carried out mainly for the demand analysis, economic analysis, impact analysis, etc. It will first be conducted on the world maritime or maritime-related transportation system as a whole, and then in detail for those related to the Isthmian route. The importance of the trade routes related to the Panamanian Isthmus seems to have changed gradually from decade to decade, but the importance of the Isthmus in relation to the world trade or its route has not changed.

Examples of trade routes (both eastward and westward) related to the Isthmus are as follows:

- US east coast - US west coast
- US east coast - South American west coast
- US east coast - Far East and Southeast Asia
- US east coast - Oceania
- US west coast - Europe
- US west coast - Africa/Middle East
- US west coast - Caribbean countries/Gulf states
- Caribbean countries/Gulf states - South American west coast
- Caribbean countries/Gulf states - Far East and Southeast Asia
- Caribbean countries/Gulf states - Oceania
- South American west coast - Europe
- South American west coast - Africa/Middle East
- South American east coast - US west coast
- South American east coast - South American west coast
- South American east coast - Far East and Southeast Asia
- South American east coast - Oceania
- Canada east coast - Canada west coast

- Central America east coast - Central America west coast

The origin-destination (O-D) relationship of cargo movement for major commodity groups will be identified by country or region, taking into account the trade routes above to identify which routes are more related to the Isthmus. Historical changes in the O-D relationship will be clarified in conjunction with major historical events in the world and regional economy and trade.

Data collected for this study will go back to 1978, and the base year of the study for future events will be the year 1990.

A.2.4 Future Transportation Systems and Significance of Panamanian Isthmus in World Trade

This study will support the commodity and traffic projections and the analysis of impact upon Panama Canal users. The purpose of the study will be to identify the present status of the maritime transportation system, to assess its future prospects, and to clarify the significance of Panamanian Isthmus in world trade. The coverage and accuracy required for this study will be detailed enough to provide the necessary data needed to forecast the commodity and traffic demand for each of the alternatives and to identify the future significance of the Panamanian Isthmus in world trade.

The study will start with collecting the necessary data concerning the present status and future prospects of the transportation systems. Then it will identify principal roles of the maritime transportation system and the complementary functions of land and air transportation systems (air only as applicable), assessing the general prospects for their future developments and assessing possible future technological innovations of the total system. The present status and future prospects of complementary modes of transportation such as the oil pipeline system, land bridges, etc., will also be studied and identified as a whole. The geographical importance of the Panamanian Isthmus in world trade will be assessed by determining the significance of the Isthmian trade route.

Maritime transportation systems related to world trade will be identified and studied first, then those related to the Panama Canal will be examined in more detail. This task will include historical trends and future development in type and size of vessels, principal features of the existing major seaports in relation to the Isthmian route and their future development plans, historical trends in technological innovation of oceangoing vessels, and historical trends in cost of maritime transportation. A transportation system complementary to the Panama Canal and its alternative will also be studied and identified. In the studies above, the identification of future prospects for maritime transportation and seaport developments will focus on how these developments will affect commodity flow through the ocean trade routes, including the Isthmian route.

In order to examine in detail the commodity flow on the ocean trade route, the distribution of type and size of vessels of world fleet and the Panama Canal transit vessels will be identified by each type of commodity group and its corresponding vessel. An example of the vessel types for the study will be the following:

- Dry bulk carrier
- General cargo ship
- Tanker
- Refrigerated cargo ship
- Full containership
- Roll on/roll off ship
- Vehicle carrier
- Combination carrier
- Liquid gas carrier
- Container/break bulk
- Passenger
- Others

The results of the studies and analyses of this study will provide a basis for the commodity and traffic projections, together with results of the historical trade analysis, and will furnish basic information to evaluate the capacity of the alternatives.

A.3 PRESCREENING AND SELECTION OF ALTERNATIVES

In the initial months of the Study it will be necessary to review and classify the various alternatives to the Panama Canal which have been proposed in the past as well as any other alternatives which should be examined at the time of the Study. These alternatives will be analyzed in conjunction with the basic study parameters to provide a definitive list of alternatives as the basis for preliminary engineering and cost estimates. With the results of the preliminary engineering and cost estimates as well as the other preliminary data collection tasks, the list of alternatives will be analyzed to identify those alternatives which clearly have the greatest potential for further examination.

Historically, the many studies of alternatives to the Panama Canal have used different study parameters such as the "design ship" and the projected transit cargo. In order to establish a rational basis for an initial comparison of alternatives the Contractor will have to examine these parameters in light of more recent information and develop a consistent set of basic parameters.

The FA/FR Contractor will initially review the literature concerning the alternatives to the Panama Canal which have been proposed in the past.

For these alternatives, the critical study parameters will be tabulated and classified to include:

- The design ship (where applicable)
- Capacity (cargo and vessels)
- Alignments
- Route/water surface profile
- Navigation style (one lane versus two lanes)
- Cross sections (bottom width, side slopes for various conditions)
- Lock chamber characteristics
- Excavation schemes
- Water usage requirements

Based upon this historical data and the preliminary data provided by the studies of Historical Trade Analysis (A.2.3) and Future Transportation Systems and Significance of the Panamanian Isthmus in World Trade (A.2.4), the FA/FR Contractor will develop and recommend consistent parameters for each major class

of alternatives (e.g., sea-level canal alternatives, lock canal alternatives, and non-canal improvement alternatives).

Following review and approval of these recommendations by the Commission, the FA/FR Contractor will next compile a set of alternatives based upon the historical list and such others as may be proposed by the Commission. For each major class of alternatives it is anticipated that certain parameters will be unique. These would include:

- Ship size or mix of sizes (length, beam, draft, displacement)
- Mix and tonnage of projected cargo

Other parameters may be varied within classes thus leading to a new set of alternatives within each major class. These variable parameters might include:

- Bottom width
- Bottom depth
- Lock chamber dimensions
- Number of lockage lifts
- Tidal control structures for sea-level alternatives

At the conclusion of this process of analysis and synthesis, the FA/FR Contractor will recommend to the Commission a list of alternatives which may include:

- Historical alternatives modified with consistent parameters
- Variations on historical alternatives
- New alternatives (for example, new single-lift locks with water storage basins)

The recommended list will cover the complete range of alternatives which the Commission will consider to be appropriate for examination. Of necessity, this phase of the work will involve intensive interaction with the Commission and Secretariat. Upon approval by the Commission of the list of alternatives, it will be furnished to the Component Study contractor for Engineering and Cost Estimates and Operating Characteristics and Capacity Evaluation.

The final step of the preliminary phase of the study is to use the data available which has been collected and evaluated to prescreen the list of alternatives and to select a

"short list" of those which have the best potential. Only those alternatives remaining on the short list will be considered further during the Study of Alternatives.

The criteria for prescreening will be:

- Engineering soundness
- Capacity to fulfill potential demand in a timely manner
- Capital cost for each alternative
- Approximate cost and benefit comparison for each alternative
- Relative environmental/socio-economic impacts
- Short-term impact on the existing Canal

The prescreening will provide the basis for a sound decision to eliminate from further detailed examination those alternatives which are clearly unsound, which do not meet demand projections, which are not competitive on the basis of capital cost, which would generate revenue shortfalls which could not reasonably be offset by higher tolls or other sources of funding or which have adverse impacts the severity of which is obviously much greater than other alternatives. These criteria have been selected to focus on factors with potentially substantial differences.

The methodology for the prescreening will follow these steps:

- **Step One.** During the initial stages of this study a complete list of alternatives will be developed and approved by the Commission. This list of alternatives will be input into the Preliminary Engineering Study (Task B.2.1), Preliminary Cost Estimates (Task B.2.2), and the Preliminary Operating Characteristics Study (Task B.2.3), and other component studies.
- **Step Two.** The preliminary results from the Commodity and Traffic Projections (Task B.3.1) will provide an initial projection of future demand for trans-Isthmian commerce as a function of time before prescreening. This projection will reflect a statistical projection of future traffic through the existing Canal plus an estimate of future demand for vessels which cannot currently use the Canal. The volume and types of commerce which could conceivably use complementary systems such as road or rail landbridges, pipelines, conveyor systems, etc. will be considered as an adjustment to the total projection.

- **Step Three.** The analysis of the status of the present Canal (Task A.2.2) and the Preliminary Operating Characteristics and Capacity Evaluation Study (Task B.2.3) will provide an analysis of the probable maximum capacity of the existing Canal and a confirmation that the useful life of the existing Canal under the present conditions of maintenance will extend to the economic horizon.
- **Step Four.** Combination of the data developed in Steps Two and Three will permit the estimation of the potential future demand which cannot be satisfied by the existing Canal. This increased demand will be stratified by ranges of vessel size to identify future demand for vessels of Panamax size or smaller and appropriate groupings of larger vessels.
- **Step Five.** During the Preliminary Engineering study and the preparation of preliminary cost estimates, all available data on the alternatives will be investigated to assess the soundness of the approach; to validate the existing cost data and to adjust capital costs to provide a comparable set of estimates; and to identify the phenomena which would cause environmental or socio-economic impacts. Concurrently, the impact on the continuity of operations of the existing Canal during implementation of each alternative will be estimated. The Preliminary Operating Characteristics and Capacity Evaluation Study will also evaluate approximate capacity for each alternative.
- **Step Six.** This step will comprise the analysis of the preliminary data on all potential alternatives and the preparation of a matrix to compare their engineering soundness, capital costs, and relative qualitative impacts. Approximate cost and benefit comparison will be carried out; the benefits considered will be limited to the direct benefits accruing from transportation (increased number of vessels transiting the canal and reduction of transit time). Based upon this body of data and analysis the FA/FR Contractor will recommend to the Commission those alternatives which clearly have the best potential for further investigation. The FA/FR Contractor will prepare a report to document the steps leading to this decision and the basis for the selection.

This report will include a tabulation of the data reviewed, the rationale for the study parameters, a description of the screening process, and the recommendation of the alternatives to be considered in the remainder of the Study.

A.4 FEASIBILITY ANALYSIS AND RECOMMENDATION OF BEST ALTERNATIVE

The purpose of this study will be to carry out the feasibility analysis for the prescreened alternatives and to select the best alternative. As shown in the general work flow and summary schedule, this work will be started after the Component Studies have been substantially completed.

The feasibility analysis will first review and refine the results of the Component Studies including their input-output relationship to verify consistency among them, and to clarify engineering soundness, economic feasibility, and financial viability for each of the prescreened alternatives. The best alternative will be recommended to the Commission, based on the results of the integrated feasibility analysis and the assessment of other factors influencing viability of the project such as impact of the project upon Panama and users, management arrangements for the project, and environmental aspects.

The FA/FR Contractor will have ensured that each Component Study is designed to produce the data necessary for the study as a whole, keeping consistency in depth and scope on all aspects (engineering, economic, financial impact, management, and environmental) for timely analysis of each prescreened alternative. All the prescreened alternatives will satisfy the functional requirements to provide the transit capacity to meet forecast demand.

The tasks involved in this study will be:

- To summarize the results of all the Component Studies related to the feasibility analysis including those by the FA/FR Contractor
- To clarify and determine the criteria and methodology to be used for integrated and consistent evaluation
- To identify uncertain factors and to conduct a sensitivity analysis
- To select and recommend the best alternative

Each task is outlined as follows:

Engineering Soundness: The results of engineering studies, as related to the project evaluation, will be reflected in the proposed designs, construction technology, and cost estimates. The first two will provide a basis for identifying technologically uncertain factors. Then, engineering soundness will be confirmed to check how the proposed design for each alternative will be realized through the proposed construction methods. The results of the cost estimates will be

incorporated in the economic and financial analyses The main task here will be to analyze and confirm in detail the engineering soundness of the special construction technology to be used for each alternative.

Economic Evaluation: The traffic estimate will depend heavily on the transit capacity and ease of transit which is treated as constraints on passage for each alternative and on the toll system adopted. Accordingly the economic evaluation of the alternatives will be carried out within a general framework of cost-benefit analysis in which both costs and benefits will differ between alternatives. They will be grouped broadly into three different levels for lock canal group, sea-level canal group, and non-canal group which will respectively have different scales of cost-benefit comparison.

The results of economic evaluation will be expressed in terms of different indicators such as internal rate of return, benefit-cost ratio, net benefit, and net present value. Evaluation of each alternative by adopting one indicator only will be misleading since each group of alternatives will have widely different development scales, transit capacities, impacts, and managerial and operational systems. Therefore, the economic evaluation for the alternatives will be made carefully taking into account the different features.

Financial Analysis: The results of financial analysis will be expressed not only by profitability of each alternative in the form of financial internal rate of return under the established toll system, but by financial viability of the operating entity and assessment of financial planning taking into account the implementation timing. Difference in financial scale for each of the alternatives will also be analyzed taking into account the involved risks to be managed. Thus, the results of financial analysis will be evaluated from these overall viewpoints.

Analysis of Impacts upon Panama and Users: The probable impact of each alternative upon Panama will be classified into those during construction stage and those during operation stage. It will also distinguish effects on the nation as a whole and those on the project region. Direct impact will be quantitatively analyzed to the extent that the data are available and methodology is applicable to distinguish national and regional effects.

An input-output table or some type of mathematic model for the macro-economic system will be used to measure the direct impacts upon Panama. Other impacts upon Panama will be no less important than the direct impacts, and will be carefully spelled out in the analysis even though they may be difficult to quantify. Impacts on canal

users will consist of direct effect due to savings in transport costs and travel time. Long-term effects will include the economic development induced by vitalization of world trade. The direct impacts upon Panama and users will be reflected in the economic evaluation as secondary economic benefit. Other effects will be summarized for evaluation.

Environmental Impact Analysis: The results of the environmental analysis will be summarized in a matrix indicating causal relationships between project components during construction and operation and ecological elements which would be affected. In addition, the relative effects of various sources of impacts will be considered. To the extent possible, an overall ranking will be developed based on the severity, extent, and type of ecological impacts. To accomplish this, a comprehensive consideration of positive and negative impacts associated with all aspects of each alternatives will be required.

Analysis of Management Arrangements: The analysis of management system will include considerations of the legislative structure required for procurement of investment capital, ownership and management of facilities, etc., and the organizational structure required for daily maintenance and operation, repair, safety measures, restoration of failures and accidents, and other activities. For each management arrangement formulated for each alternative, all the characteristics with respect to legislation, organization, staffing, management and operational task force, legal and institutional measures required as a prerequisite, etc., will be clarified and summarized for analysis.

Sensitivity Analysis: Uncertain factors related to project implementation will be classified into those originating from the environment surrounding the project, (external factors) and others due to the project itself (internal factors). The former will include prospects for the world economy and geopolitical factors. Prospects for the world economy will be reflected in the project benefits and costs, respectively through the traffic demand and the international market for project input. Geopolitical factors will also affect implementation timing of the project. These factors in general are difficult to forecast, but judgments will have to be made as to probable ranges of changes that may be encountered, and a sensitivity analysis will be conducted accordingly.

Uncertainties inherent to the project will also depend on assumptions in regard to construction technologies. Possible delays in construction, cost overrun, and other possibilities will be examined on the basis of analyses on construction conditions, adoption of alternative technologies, and other conceivable modifications of

construction activities. Sensitivity analysis will be conducted for the range of uncertainties thus determined. Major future events which may cause some structural changes will be identified and summarized for evaluation. They will include economic, physical and other events.

Clarification of Methodology for Evaluations

The most appropriate method of conducting the analysis of the selected alternatives will be a comprehensive method in which principal evaluation factors such as engineering soundness, economic feasibility, and financial viability of each alternative will first be evaluated, and then other factors influencing the viability of the project such as impacts upon Panama and users, management arrangements, and environmental effects will be clarified and summarized for each of the alternatives. In view of the number of potential alternatives and the complexity of issues to be compared, however, an integrated feasibility analysis employing different methods of ranking and weighting in accordance with priorities of the development judged from various aspects surrounding the project will be adopted. The basis for such judgment will become clearer as the study progresses. Final judgment for the evaluation will be done in consultation with the Study Commission.

Selection and Recommendation of the Best Alternatives

The selection of the best alternative will be made in several steps. First, each candidate alternative will be evaluated as to whether it has a sufficient transit capacity to meet a certain level of forecasted traffic demand. A combination of different alternatives, if it would satisfy the functional requirements, will be considered to have sufficient transit capacity.

Second, the alternatives, including the combined cases, will be analyzed by checking multiple evaluation indicators such as internal rates of return, benefit-cost ratio, net benefit, etc., taking into account their different features. The evaluation methods and threshold values will be set in close cooperation with the Secretariat of the Study Commission. One of the evaluation methods will be to assign relative weights, if possible, to the various indicators.

Third, the evaluation to select the best alternative will be made through the qualitative assessment from various viewpoints of environmental, managerial, and operational aspects, impacts upon Panama and users, financing requirements and other features inherent to the alternative, including its intangible economic benefit. Close cooperation with the Secretariat is considered of prime importance to perform the qualitative assessment of each alternative.

A.5 DETAILED INVESTIGATION AND STUDY

The purpose of this study will be to conduct additional investigations and studies for the selected alternative in order to refine the concept and to reduce the degree of uncertainty in the planning, design, estimate, and schedule. Most of this study will be dedicated to reviewing the design and estimate.

In the detailed investigation and study, the preliminary design of the best alternative will be reviewed by outlining the physical facilities to be constructed and refining their costs consistent with engineering information developed by the Component Study contractors. Its feasibility will be reconfirmed, and a conceptual plan for implementing the project will be prepared. However, the detailed investigation and study will not include a detailed design, detailed cost estimate, execution plan, financing plan, etc., that will be required for implementing the project.

In the study, the preliminary design of the selected alternative will be examined in sufficient detail to determine whether the engineering concepts could be refined or modified to provide:

- Increased capacity
- More efficient use of resources, especially water in the case of a lock canal scheme
- Reduced capital cost
- Improved siting of facilities to reduce cost and relocation impacts

The preliminary design will be further examined to optimize the basis for estimating the cost. Specifically, the FA/FR Contractor will investigate:

- Selection of construction approaches for major features, e.g., types of embankment designs
- Selection of material construction
- Sources for spoil disposal and/or beneficial uses for spoil
- Excavation methodology

As the design information becomes available or previous designs are revised, an environmental assessment will take place. Data from the biological inventory and the environmental analysis will be used as necessary to consider any new issues and optimize environmental compatibility of the final design. Similar efforts will be applied to the construction plan and schedule to minimize undesirable impacts.

The construction plan will be reviewed to identify possible improvements. Among the areas of investigation will be:

- Efficient use of available labor resources to avoid peaks and valleys and to emphasize the use of the Panamanian labor force.
- Efficient use of major construction equipment and facilities, e.g., dredges, concrete batch plants
- Efficient location of construction support facilities
- Realistic estimates of construction time for each activity
- Optimization of the construction schedule by the use of sophisticated scheduling tools.

The FA/FR Contractor will check all rates and material and equipment prices to ensure that they are the most realistic figures applicable to this work. The factors used for escalation and allowances for contingencies will be analyzed for appropriateness for the situation.

The FA/FR Contractor will also review and revise as necessary the concept proposed for operating and maintaining the alternative and the estimate for the cost of operations and maintenance.

During the detailed investigation, the FA/FR Contractor will also review and expand on the assessment of the environmental impacts of the selected alternative by adding the results of the biological inventory, which will be continuously carried out as scheduled. The major objective will be to validate the assessment prepared by the Component Study contractors including the measures proposed to mitigate unavoidable adverse impacts.

The FA/FR Contractor will review the Component Study contractors' environmental assessment to ensure that all likely efforts have been identified and their extent and magnitude have been properly defined. The Component Study contractors' scheme for avoiding and mitigating adverse effects will be evaluated with particular emphasis on formulating more cost effective approaches.

In the event that better approaches for avoidance and mitigation are identified, these schemes will be developed in sufficient detail to provide them as enhancements of the engineering concept.

Concurrently, any modifications and enhancements which result from the engineering and cost investigation will be analyzed for their effects on the environment. New or revised plans for mitigation will be provided to the engineering and cost team for inclusion in their review and revised cost estimate.

A.6 WRITING THE FINAL REPORT

Upon the completion of the tasks associated with the study, the FA/FR Contractor will prepare the final report. The report will incorporate the pertinent findings from the preliminary analysis, the Component Studies, and the detailed investigations performed after the selection of the recommended alternative.

The final report will be written in accordance with the following steps:

- A detailed preliminary outline will be prepared
- The outline will be reviewed with the Commission and approval obtained
- A draft report will be prepared following the approved outline
- The draft report will be reviewed by the Commission
- Appropriate changes will be incorporated into the draft report
- The final report will be published

A.7 PREPARING MONTHLY REPORTS

A monthly report will be prepared by the FA/FR Contractor and submitted to the Secretariat. These monthly reports will contain, but not be restricted to, the following types of information:

- Major activities and progress from the last reporting period
- Major milestones reached during the reporting period
- Awards of contracts for Component Studies, study completions, etc.
- Work to be accomplished during the coming reporting period
- Early warnings of problems that might arise in the future
- Reports on the status of past problems and their solution or recommended solution
- Status of the schedule including estimates of the percentage of the work completed; this will be reported for the overall study as well as for each of the Component Studies.
- Status of the budget including amount and percent spent and the amount and percent remaining to be spent

A project control system will be set up to assist in controlling the schedule and the costs of the Study. This system will provide the information needed for the monthly reports on the status of the schedule and the budget. The system that is proposed for use in controlling the Study is described in Section 5 of this report.

Emphasis in preparing these reports will be on providing information needed by the Secretariat to evaluate the work completed to date and the work that remains to be done.

A.8 PROVIDING INFORMATION CENTER WITH DATA

An Information Center will be set up by the Secretariat and will maintain a data base for the use of the Study Commission. The FA/FR Contractor will work closely with the Secretariat in setting up this center.

The FA/FR Contractor will provide to the Information Center copies of all approved study material, data, computer programs, drawings, maps, and special studies. The FA/FR Contractor will also provide to the center copies of data, reports, information, and other appropriate material that is gathered by team members during the course of the study.

The purpose of the center is to maintain an up-to-date data base for the use of the Commission, the Secretariat's staff, the participating governments, and members of the FA/FR Contractor and the Component Study contractors who are working on the study. The Information Center will be responsible for receiving and, in turn, making available existing data and reports to persons working on the study. It will not develop original data on its own for the use of the contractors.

The FA/FR Contractor will be available to advise the Secretariat on the design of the center and to recommend equipment, including both hardware and software to be used by the center. The FA/FR Contractor will also be available to advise the Secretariat on the retrieval system and the overall operation of the center.

Comisión de Estudio
de las Alternativas
al Canal de Panamá
CENTRO DE INFORMACION

B. COMPONENT STUDIES

The Component Studies will be prepared by Component Study contractors who will be selected through a prequalification and tendering procedure described in B.1 and B.2 of this section. These Component Studies are described in the rest of this section. The terms of reference for these Component Studies are contained in Volume II.

The contractors preparing some of the Component Studies will be required to provide preliminary results to the FA/FR Contractor to help in the process of prescreening and selection of alternatives. These include: Commodity and Traffic Projections, Engineering and Cost Estimates, Background Biological Data and Biological Inventory, and Operating Characteristics and Capacity Evaluation.

When the prescreening and selection of the alternatives is completed, they will be given to the component contractors for use in their detailed studies.

When the Component Studies are completed, they will become inputs into the detailed feasibility analysis.

The tasks that will be investigated in the Component Studies are listed below:

- Commodity and traffic projections
- Engineering
- Cost estimate
- Operating characteristics
- Capacity evaluation
- Background biological data and biological inventory
- Financing scheme
- Economic analysis
- Financial analysis
- Environmental analysis
- Analysis of the impact on Panama
- Analysis of the impact on users
- Management arrangements
- Additional data will be developed as required and where possible in conjunction with relevant Component Study contractors

A brief description of each of the tasks is contained in the rest of Section 3, Part B.

In some cases, the same analytical tools are required for more than one task. Therefore, it would be advantageous to combine these tasks and have them performed by the same contractor. These combinations will result in a more efficient conduct of the study as well as a reduction in the administrative burden of the Secretariat. The proposed combinations are discussed below.

- **Engineering and Cost Estimate.** The engineering and cost estimate are interdependent tasks and there will be benefits if they are done by the same contractor. Therefore, these tasks should be grouped into one Component Study.
  - Engineering
  - Cost estimate
- **Operating Characteristics and Capacity Evaluation.** The operating characteristics and capacity evaluation tasks are closely interrelated. Therefore, it is recommended that these tasks be done by the same contractor.
  - Operating characteristics
  - Capacity evaluation
- **Financing Scheme and Financial Analysis.** The financing scheme and the financial analysis are closely related. Therefore, these tasks have been grouped together into a single Component Study.
  - Financing scheme
  - Financial analysis
- **Economic Analysis and Analysis of the Impact on Panama and Canal Users.** Many of the same basic skills are needed to prepare the economic analysis and to determine the impact of the various alternatives on Panama and Canal users. Therefore, these tasks have been combined in a single Component Study.
  - Economic analysis
  - Impact on Panama
  - Impact on canal users

The remaining tasks are relatively independent and therefore were not combined with other tasks. Thus, with the combinations discussed above, the Component Studies will consist of the following:

1. Commodity and Traffic Projections
2. Engineering and Cost Estimate
3. Operating Characteristics and Capacity Evaluation
4. Background Biological Data and Biological Inventory
5. Financing Scheme and Financial Analysis
6. Economic and Impact Analyses
7. Environmental Analysis
8. Management Arrangement

The final task, Development of Additional Data, will be done as the need for additional data is determined. This will be done by either the Component Study contractors or by new contractors, depending on the type of additional data needed. This task will be performed during the feasibility analysis and the detailed investigation phase of the study.

B.1 PREQUALIFICATION OF CONTRACTORS/TENDERING

The FA/FR Contractor will assist and advise the Secretariat in the selection and the prequalification of contractors for each of the Component Studies. Assistance will be given in helping the Secretariat develop criteria and guidelines to be used in evaluating the qualifications of firms or organizations which are candidates for the prequalification list.

Potential contractors for this list will be selected from private firms, universities, professional organizations, government and quasi-government agencies, and other appropriate agencies. Potential contractors who pass the initial screening will be asked to submit a qualifications document to the Secretariat.

The FA/FR Contractor will assist the Secretariat in evaluating the qualifications packages and in preparing a short list of the organizations which have the technical qualifications to undertake the particular Component Study. This process will be done for each of the Component Studies.

For the study work that will be funded by the Japanese International Cooperation Agency (JICA), their procedures for qualifying and selecting contractors will be followed. This will be done in full consultation and coordination with the Secretariat. The JICA procedures are shown in detail in Appendix 2.

The FA/FR Contractor will provide assistance and advice to the Secretariat in tendering the Component Studies to selected contractors. Initially the FA/FR Contractor will assist the Secretariat in developing procedures and guidelines to govern the selection of firms and the awarding of the Component Study contracts.

The FA/FR Contractor will assist the Secretariat in evaluating the proposals that are submitted by the firms selected from the prequalification list. Based on the Secretariat's evaluation, the potential contractors will be ranked according to the responsiveness of their proposal to the Terms of Reference contained in the request for proposal and their general awareness about the tasks to be performed in the study.

The contractor ranked first on the list will be asked to enter into negotiations with the Secretariat. If these negotiations are successful, then a contract will be tendered. If the negotiations are not successfully concluded, the Secretariat will then start negotiations with the second firm on the list. This process will continue until a contract is successfully negotiated and submitted to the Board of Commissioners for approval.

B.2 PRELIMINARY STUDIES FOR PRESCREENING

Preliminary information from some of the Component Study contractors will be needed for the prescreening and selection of alternatives effort. These preliminary studies include engineering and cost estimates, operating characteristics and capacity evaluation, commodity and traffic projections and background biological data. The needs are discussed in this Section under the heading of the principal study of the same name.

B.3 DEMAND ANALYSIS, ENGINEERING AND OPERATIONS

B.3.1 Commodity and Traffic Projections

The purposes of this study will be to project the demand for cargo tonnage and number of vessels transiting through the Panamanian Isthmus to provide a baseline for the subsequent studies. The coverage and accuracy required for this study must be sufficient in detail for evaluating and assessing the prescreened alternatives and for analyzing the feasibility of the best alternative which will be selected as a result of the detailed feasibility analysis.

The demand analysis will include a short- and long-term forecast of the cargo tonnage and number of transit vessels through the Isthmian route. The short-term demand forecast will cover a time span of 10 to 20 years from the present, and will include general trends. It will provide a sound basis for making the decision to implement the project and also for forecasting the long-term demand. The long-term demand forecast will cover a time span of 30 to 50 years after the completion of the project, and will provide a firm basis both for financial and economic evaluation. The base year for the demand forecast will be 1990.

The demand analysis for the study will be performed taking into account major factors influencing the forecast, such as trends of world and regional economies and trade patterns, international and intercontinental trade routes, trend in the world fleet ship mix, technological innovation in oceangoing vessels, development of major harbors of the world, development of alternative modes of transportation, and trends in costs of ocean transportation and its competitive alternatives.

A canal crossing over the Panamanian Isthmus is considered to be a bridge moving goods across the Isthmus, connecting the Pacific and the Atlantic oceans. Alternatives to the Panama Canal will have constraints on passage. For instance, the dimensions of the existing locks of the Panama Canal preclude passage of ships longer than 1,000 feet length, wider than 106 feet beam and deeper than 39.5 feet draft, approximately 65,000 DWT. This size limitation and time required for passage through the locks will become progressively more constraining as the average size of vessels and number of transits increase. In order to clarify the volume of cargo tonnage and numbers of vessels which might transit through the Isthmian route without constraints on passage, a demand analysis will be made in two steps:

- Forecast potential cargo tonnage and number of transit vessels through the Isthmian route without any constraints on passage

- Forecast potential cargo tonnage and number of transit vessels through the Canal by other modes of transportation under constraints on passage inherent to each of the alternatives

Potential demand will be estimated by identifying shifting cargoes specific to the Panama Canal such as coastal, bypass, and sourcing shifts, in which coastal shifts are assumed to be shifts of cargo flows by the U.S. coast, e.g., containers moving on an intermodal basis from Asian countries to the U.S. east coast via U.S. west coast ports. Bypass shifts are assumed to be loss of cargo to the Isthmian route due to deployment of vessels too large to use the canal. Sourcing shifts are assumed to be changes in product sourcing patterns which involve cargo movements that do not currently use the Isthmian route. Restricted demand for each of the alternatives will be estimated by trimming the potential demand, taking into account limitation of maximum passable size of vessel, operational characteristics, toll levels, and other factors related to changes in cargo patterns.

The methods of demand forecast applicable to the Panama Canal and its alternative may be generally classified as aggregate and disaggregate methods. Both methods have advantages and disadvantages. An aggregate method can be used to express long-term demand trends, while a disaggregate method can be used to forecast short-term demand with fluctuations. Accordingly, it is necessary to review thoroughly the demand forecasts made during previous studies and to clarify those advantages and disadvantages inherent to each of the methods. The demand forecasts for the study may be made by using several methodologies, both aggregate and disaggregate. There could be, for instance, an aggregate extrapolation, simple and multiple regression, and ratio methods as well as a disaggregate method based on movement of major commodity groups. The results of these forecasts will be assessed by an outside group of senior economists and specialists, and the forecast for the study will be finally affirmed. Existing models will be used to the extent possible. Development of new models will be done only after consultation with and approval of the Secretariat.

The results of this study will be the cargo tonnage and number of transit vessels through the Canal and the transport cargo tonnage through other modes of transportation under constraints on passage inherent to each of the alternatives, and will provide a sound basis for formulating and evaluating the project in the following studies.

B.3.2 Engineering

Initially a preliminary report on engineering will be prepared to support prescreening and selection of alternatives. The contractor shall prepare preliminary layouts for approximately 15 alternatives and shall identify their major components. Information will be developed to a degree sufficient for the Commission to decide which alternatives should survive the prescreening. This effort will be primarily based on information provided by the Commission from previous studies. The level of detail shall be sufficient for conducting the prescreening effort.

The scope of this detailed study will be to prepare a preliminary design of each alternative that is selected through the prescreening process, including the appurtenant facilities inherent to it. The coverage and accuracy required for this study must be sufficient for preliminary assessment and feasibility analysis of alternatives.

The preliminary design will include a general layout of the project, and identify and quantify principal items of the work. Each design will be developed for capacities identified on the basis of the commodity and traffic projections.

The principal items to be included in this Component Study will be as follows:

- Technology review
- Basic plan and preliminary design for each alternative
- Preliminary construction planning

The technical literature will be reviewed to identify the latest proven developments in canal design, such as tidal gates and lock design. A water management strategy will be prepared for each alternative. Since all of the lock improvement alternatives would increase the number of lockages, means to conserve water will be considered for these alternatives. Measures might include reducing leakage through the spillway gates at Gatun Dam, increasing annual water storage capacity and replacing existing hydroelectric generation capacity within the Gatun Lake watershed with other forms of electric generation. Latest trends in the design of non-canal alternatives (including railways, pipelines, and highways) will be reviewed for technical practicality.

The preliminary design of each alternative will be made based on engineering criteria and conditions along the proposed route. The designs will be developed to the point where major items can be quantified and the effects of construction on present lock operations and on areas along the proposed alignments can be assessed. The volumes and types of material to be excavated will be estimated, and methods and

equipment to excavate and transport material will be recommended. The annual transit volume will be identified for each alternative, and factors such as the degree of technical difficulty and possibility of future expansion will be assessed. The extent of areas affected by each alternative will be identified for analysis of impacts on the environment and on Panama.

This study will result in:

- A preliminary design report for each alternative which includes engineering criteria and standards
- Basic plan and preliminary design with layouts, location maps, quantities, and areas affected by construction and operation

B.3.3 Cost Estimates

The initial effort of this task will be to prepare a capital cost estimate for each alternative. Information will be developed to a degree sufficient for the Commission to decide which alternatives should survive the prescreening. Readily available data or existing cost estimates will be reviewed and updated. For alternatives without available cost estimates, quantities will be estimated for the major components by applying updated unit costs from existing cost estimates.

The detailed study will be performed in conjunction with the engineering study to estimate the costs of each alternative that has survived prescreening. The estimate will reflect the route and engineering characteristics of the alternative, as well as construction, operating and maintenance costs, and other specifics that affect costs.

The cost estimates will be order of magnitude estimates, sufficiently accurate for preliminary assessment and feasibility analyses of alternatives. Criteria for the cost estimates, such as the method of analysis, escalation rates, interest rates, treatment of taxes and duties, and required level of accuracy of the cost estimate will be established by the FA/FR Contractor during prescreening, in sufficient time for input to the component contractor.

An overall project schedule will be developed for each alternative, including the obtaining of land access and construction permits, engineering, design, land acquisition, relocation and resettlement of populations within the affected area, and construction of the alternative. Guidance will be sought from the Study Commission and respective government agencies regarding the permitting procedures which would be expected to govern the approval process for this project, and the duration of the review process for permits. The overall project schedule will be used to develop a schedule of expenditures, so that costs of the various alternatives can be evaluated on a consistent basis (e.g., present worth).

A construction plan will be prepared for each alternative. This plan will identify how major construction activities will be sequenced to meet the milestone dates identified in the construction schedule. The route of the alternative will be divided into portions, the type and quantity of work in each will be identified, and a chart of equipment and personnel needs, by type and by year, will be prepared. A list of construction facilities required for each alternative and their approximate location will be prepared. Recommendations for accomplishing major work items by contract or force account will be provided, along with the rationale for the recommendation.

A conceptual management and operation plan will be developed, identifying the personnel required for administration of the alternative and its supporting facilities.

Operating and maintenance (O&M) costs will be estimated, including the type, frequency, and cost of major rehabilitations to be made during the project life. The estimate will also address such items as navigation aids, auxiliary operational equipment, safety systems, and cost of tug fleet.

The sensitivity of the cost estimate to changes in principal variables, such as rock type and excavation slopes in areas of major excavations will be analyzed. Results of these analyses will be used in selecting allowances for contingencies.

The cost estimate will address the cost of the principal items of work as well as the cost for construction roads, bridges, offices and camps, construction facilities, plants and equipment, consumables, environmental mitigation, construction management, engineering and administration, land acquisitions, compensation, and contingencies.

In all of the estimates, construction conditions in a tropical climate will be properly taken into account. These will include health and sanitary requirements, and others as appropriate.

For each alternative studied, a cost report will be prepared, including:

- Capital cost estimate
- Construction plan and schedule
- Operation and maintenance plan and cost estimate

B.3.4 Operating Characteristics

The purposes of this study will be to examine and analyze the operating characteristics of each of the prescreened alternatives, to evaluate transit time of vessels and their minimum ship-to-ship interval, to assess transport time for other modes of transportation, and to provide basic data for evaluation of transit capacity which is examined in the subsequent study.

This study will be done in two stages. The first stage will form a part of the preliminary study of the Operating Characteristics and Capacity Evaluation (B.2.3). This first stage will provide preliminary inputs for the prescreening and selection of alternatives. In the second stage, a detailed study will be prepared for Operating Characteristics (B.3.4) and Capacity Evaluation (B.3.5) of the alternatives selected for further investigation.

Analysis of operating characteristics will evaluate performance of vessels transiting through each of the alternatives. Such performance will be measured by transit time and the minimum interval between ships.

Operational characteristics will differ from one alternative to another in combination with type and size of vessels. Generally, transit time of vessels in the case of the lock canal alternative will be largely governed by lockage operation and passages through restricted waterways, while in the case of the sea-level canal alternative it may be affected chiefly by tidal motion in the canal and the restricted speed of vessels due to its hydraulic characteristics. Operational characteristics of each of the alternatives will be analyzed from the following viewpoints:

- Physical and configurational aspects
- Hydrographic and hydraulic aspects
- Hydrological aspects
- Meteorological aspects
- Navigational performance of vessels
- Managerial and institutional aspects

Physical and configurational aspects which will limit passage (e.g., dimensions and alignment of the channel, configuration of the locks, lock filling and emptying systems, effect of ship clearance dimensions on transit time, etc.) will be analyzed.

Hydrographic and hydraulic conditions will be a key factor for ship operations, especially in the case of the sea-level canal. Tidal motion in the canal will be analyzed to determine critical velocity of tidal current for each size of vessel and to evaluate time requirements for sailing, anchoring, temporary tie-up, and other speed-reduction operations.

Hydrological conditions will be one of the key factors in the case of the lock-canal alternative. The number of transit vessels will depend directly on the balance of water between inflow from the catchment area, direct rainfall into the reservoir, and water use for lockage operations. Controlling water level of the reservoir will also be indispensable in maintaining the water depth of the navigation channel for safe transit of vessels. In the sea-level canal, rushing flood flows into the channel from side rivers will be another problem which would hinder navigational operations of transit vessels. Hydrological characteristics of the alternatives will then be analyzed from these viewpoints especially in regard to the reservoir operation plan and navigation channel plan. In the analysis, the hydrological regime will also be taken into account to obtain affirmative results.

Meteorological conditions will provide further navigational characteristics of the alternatives. Since the alternatives will pass through a tropical, high humidity area, passages will occasionally be hindered by torrential rainfall, mist, or fog.

Navigational performance of vessels will be thoroughly examined for each type and size of vessel with respect to sailing speed, ship-to-ship interval, stopping distance, maneuverability of vessel in the restricted channel, etc. It will be analyzed in combination with other physical and navigational characteristics of the alternatives.

In addition to the technically-oriented characteristics above, non-technical characteristics in relation to managerial, institutional, and operational aspects shall be analyzed. These analyses will determine how efficient operation and safe and speedy transit could be attained through time-to-time management of passage, periodic maintenance, and safety control systems.

The safety control system will be examined to secure safe transit in each alternative and provide countermeasures against particular operational problems which may be characteristic to a given alternative. They will also provide recovery procedures from accidents which may interrupt operation. The safety control systems will also be studied to cover the objectives of day-to-day safety control system, long-term periodic safeguard system, and emergency safeguard system.

The operational characteristics of each alternative will be analyzed by examining those factors influencing the transit of vessels in time and minimum ship-to-ship interval and transport time for other modes of transportation and by formulating a simulation model for each type and size of typical vessel for canal alternatives and for commodity groups for other modes of transportation. The simulation model in the case of the lock canal, for instance, shall also be designed to analyze the transit time in each section of the canal such as entrance channels, locks, open waterway, restricted waterway, etc. Existing models will be used to the extent possible. Development of new models will be done only after consultation with and approval of the Secretariat.

The minimum ship-to-ship interval which will vary from section to section under different restricting conditions shall be analyzed in the model. In this case variables will be grouped into two kinds: the ones with regular and periodic occurrence, and those that occur irregularly or randomly. The latter variables will be re-evaluated in the subsequent study by generating random conditions. They will be occurrences of foggy or torrential rainy conditions, hydrological cycles, etc.

In the case of the sea-level canal the same analysis as above on the transit time and minimum ship-to-ship interval will be made on the simulation model. In this case, however, they will be affected by tidal current produced in the waterway, and maneuverability of vessels will be the main concern in the analysis. If a tidal check gate is installed in the waterway to mitigate tidal current, operating time of the gate will be an important factor restricting the transit time.

In the case of other modes of transportation which function as complementary transport means, distribution of type and size of arriving and departing vessels, and sharing of cargoes with the canal transit, etc. shall be carefully taken into account to formulate a simulation model.

The results of this study will be the average time in the canal, and minimum ship-to-ship interval or the average transport time through other modes and will be used for the subsequent study, Capacity Evaluation.

B.3.5 Capacity Evaluation

The purpose of this study will be to estimate the transit capacity of each of the prescreened alternatives, to evaluate the maximum passable size of transit vessel, and to examine flexibility and possibility for the future expansion when demand increases. The study will use the results of the operating characteristics study for each alternative as the principal component. This will provide an estimate of the transit capacity, and will also provide the information required for establishment of the safety control and operation systems.

As indicated previously, a preliminary study will be prepared on the Operating Characteristics and Capacity Evaluation (B.2.3) which will be used in the prescreening and selection of alternatives.

Simulation models used to evaluate the transit capacity could consist of two systems to:

- Evaluate transit capacity
- Evaluate maximum passable size of vessel

The capacity for each alternative will be estimated by analyzing arrival time of vessels, studying the optimum methods of transit such as random (first come, first served), convoy or semi-convoy method, and by evaluating passage time in the restricted and open waterways or in the locks under the conditions and assumptions anticipated in the former study, Operating Characteristics, which included unexpected accidents, unfavorable weather conditions, limited water usage during dry season or year, etc., as the irregular and random occurrences.

The maximum passable size of vessel will be evaluated by means of an optimization study comparing the cost required for each scale of the alternative and the respective transit capacity that could be expressed in number of transit vessels by the transit cargo tonnage.

The results of the capacity evaluation study will be the estimated transit capacity for each alternative expressed in the maximum cargo tonnage and number of transit vessels and the maximum transportation capability for other modes which will provide a baseline for the feasibility studies of economic and financial aspects, management arrangements, etc. and feedback data for commodity and traffic projections.

B.4 BACKGROUND BIOLOGICAL DATA AND BIOLOGICAL INVENTORY

The Background Biological Data and Biological Inventory is intended to review available literature and document biota which exists in areas of Panama which would be affected by construction and operation of any of the canal alternatives. The information collected will be used to characterize biotic and related abiotic conditions. The inventory will serve two primary purposes:

- Establishment of a study baseline
- Input to the environmental analysis

Information from the inventory can be used in the feasibility assessment and the detailed investigation of the selected alternative.

Studies conducted in the 1960s to evaluate the concept of a sea-level canal identified numerous gaps in our knowledge of biology in the Isthmian region. For the marine fauna, in particular, surveys found numerous new species and raised many questions concerning the taxonomic status of closely related Atlantic and Pacific forms. The studies were designed to consider routes from Colombia to Costa Rica on both coasts and did not address specific areas in detail or deal with seasonal, annual, or longer-term variation. This type of information remains to be collected.

The interoceanic canal studies also resulted in the gathering of information on terrestrial and freshwater habitats. These studies were designed primarily to provide information to address impacts of nuclear excavation and, therefore, focused on route selection and pathways of radionuclide transfer. As a result, the studies' results have limitations, as do the marine studies.

These limitations and the lack of biological data pertaining to important species found in Panama made it impossible to adequately predict biological changes which would potentially occur due to mixing of Pacific and Atlantic biota. In response, the National Academy of Sciences - National Research Council designed additional studies to be conducted if a sea-level canal is to be constructed. The basic scope was summarized in Appendix 16 of Annex V of the 1970 report of the Atlantic-Pacific Interoceanic Canal Study Commission. Of particular interest is the following:

> "Additional biotic surveys should be made. Specimens should be identified and stored nearby to facilitate proper identification of organisms that may be important. Additional ecological studies are required to determine which species are, or may become, important in relation to a

canal project. For the species of primary importance, information is needed concerning their ecological life histories, tolerances to environmental conditions, relations and interactions with other species, etc. Similar information is needed to describe better the biotic communities of major importance, their species composition, trophic structure, etc., and the physical and chemical characteristics of the habitats they occupy."

The program that was designed involved both field collections and laboratory experimentation. It was complex, long-term, and expensive; the estimated cost was $20 million.

It is important to note that, should a plan for a sea-level canal reach later planning stages, such studies are still warranted. The present study, however, has a different scope and context than those envisioned in the NAS-NRC plan, as well as a limited budget and schedule. The term biological inventory is still being used, but the goal of the inventory is no longer support for assessment but rather identification of impacts. In addition, the overall study goal is to recommend an alternative transportation system based on a feasibility analysis. These factors reduce the necessary level of detailed ecological data.

The biological inventory will document the biota which potentially can be affected by construction or operation of the alternatives. In addition to a literature review and biotic collections, measurements of abiotic conditions such as temperature, salinity, soil/sediment characteristics, etc. will be made. Collections will be made quarterly for 14 months in marine, freshwater, and terrestrial habitats. The study area will be limited to transportation routes and appropriate adjacent areas.

Initially, mobilization efforts will include reconnaissance surveys to aid in finalizing the study program. Items to be considered include: access to various parts of the study area, sampling in unique and widespread habitat types, and precise sampling locations. Survey methods will be directed by information from the review of previous studies conducted in Panama as well as from reconnaissance surveys.

During the period of mobilization and reconnaissance surveys, a comprehensive literature search and review will be conducted to obtain available ecological information. Publications and data compiled will be reviewed to determine their utility. A report will be prepared based on existing information to summarize existing ecology in the study area and identify additional information needs. A preliminary version of this report will be prepared for the FA/FR Contractor for use in the prescreening and selection of alternatives.

During the inventory, data collections will attempt to establish species occurrence and abundance. After analysis, samples and representative specimens will be stored in a facility associated with the Information Center. Storage material will allow review of initial taxonomic determinations if warranted by subsequent findings.

Data summaries and descriptive reports will be scheduled to provide the necessary input to other study activities. The scope of services for the component contractor will formalize the study items, levels of effort, and required schedule. The scope will be reviewed periodically and updated as necessary to respond to any revised alternatives, priorities, and decisions concerning alternatives for further or detailed consideration.

The results of this study will be:

- Report summarizing available literature
- Report sections describing the collection methodology and summarizing the results
- Samples and specimens for storage
- Data summaries and descriptive reports for other studies and the detailed investigation

B.5 FINANCING SCHEME

This study supports the financial analysis. The purpose of the study will be to formulate an optimum funding scheme for the preferred alternatives, and to provide basic data and information for the subsequent financial analysis. The coverage and level of detail required for the study will be sufficient to support the financial analysis.

Various financial sources will be analyzed and combined, if necessary, based on the best available knowledge of the Component Study contractor. The preferred financial scheme will be presented as the final outcome of this Component Study along with the criteria used to arrive at the recommended scheme.

After collecting the necessary data and information concerning macro-project financing activities of international financing organizations such as IBRD, IDA, IDB, ADB; government financing agencies such as OECF of Japan and Ex-Im Bank of the U.S.; and commercial banks, the optimization study for each alternative will be made.

The prescreened alternatives will have various scales of funding requirements. In the case of sea-level canal alternatives, more than 10 billion U.S. dollars may be required. For the case of lock improvement alternatives and non-canal complementary alternatives, several billion U.S. dollars may be required. When financing a macro-scale project with a huge funding requirement, such as the sea-level canal, total funds required, as well as the annual requirements (especially during the construction period) will be the main concern of lenders. Generally, such huge funding requirements will be met by co-financing, both to cover the funds requirement, and to mitigate financing risks to each lender.

In the study of the co-financing, therefore, the optimum financing scheme for each alternative will be pursued to find the best combination of terms and conditions, i.e., interest rate, lending term, grace period, repayment period, etc., for each of the lenders (international, governmental funds, and commercial). Even though project financing is becoming more popular among commercial banks, their financing is apt to cover rather low-risk components of the project such as purchase of construction machinery, plants, and the like, and the international or governmental financing agencies have to finance the higher risk components of the project such as civil engineering, etc. This general rule may not be applicable in the case of the sea-level canal, for which construction costs required to execute the large quantity of excavation and landslide protection works will be quite high. Accordingly, when formatting the financing scheme, these basic conditions of the project will be taken into account. The sharp fluctuations of capital market conditions should be evened

out for alternatives that have long construction periods (more than 10 years). However, the relationship between the lender and the borrower which is based on the situation of the current capital market, will not be completely ignored in determining a more realistic financing scheme for each alternative.

The results of this study will be the most optimum funding, together with terms and conditions for each of the prescreened alternatives, and will be used to carry out the financial analysis which follows.

B.6.1 Economic Analysis

The purpose of this study will be to identify and measure the economic benefits and costs of each of the selected alternatives by conducting cost-benefit comparisons and evaluating the project from an economic viewpoint, It will also provide basic data and information for the feasibility analysis and recommendation of the best alternative. The coverage and accuracy required for this study will be detailed enough to carry out the feasibility analysis from the economic viewpoint.

The economic analysis will start with the identification of economic benefits accrued and costs incurred for each of the alternatives. The economic benefit will consist of primary and secondary benefits which will further consist of tangible and intangible benefits.

The primary benefit of the project will be, as in other transportation projects, savings in time and cost. It will be expressed by the users' capacity to pay. In order to measure the primary economic benefit, the least costly method which could be considered under without-condition of the alternative, will be applicable. The least costly alternative could be, for instance, the second best lock or sea-level canal. Another means will be ocean trade routes competitive to the Isthmian route such as those via the Cape of Good Hope, Cape Horn, and the Suez Canal which now has the maximum passable capacity of vessels of 170,000 DWT. Other means, which have less capacity and therefore require the combination of several means, will be oil pipeline, landbridges in the continental U.S. and the like.

Most of the secondary benefits of the project will be identified in the impact analysis. Those will be measured from the extensive area not only in Panama but including user countries of the canal and other areas all over the world. These will be done for two distinct periods: construction and operation. Secondary benefits will be quantified to the extent possible in the impact analysis and will be converted to monetary value in the economic analysis. However, care must be taken to avoid double counting benefits. In measuring the economic benefits, non-economic items will be excluded. Total economic benefits will be calculated for each alternative taking into account annual increase in transit cargo tonnage.

The economic cost will consist of the project capital cost required during the construction period, and annual operation and maintenance costs. The capital cost will be measured for each alternative by using the results of the Cost Estimate study and from the Management Arrangement study. Measurement of the economic cost will be made by converting estimated capital cost into border cost, and thus exclude

transfer payments. Cost items to be converted will be labor, transportation, materials and goods, services, etc., that will be procurable in Panama as domestic goods and services. In measuring the economic costs non-economic items will be excluded. Total economic costs will be calculated as a sum of the border costs, converted and non-converted.

The cost-benefit comparison and calculation of economic rate of return will be made to check the economic feasibility in terms of monetary value for each of the prescreened alternatives by using total tangible economic benefits and total economic costs. Furthermore, the overall economic evaluation will be made for each alternative taking into account intangible economic benefits.

For the economic analysis, the base year will be the year 1990, and the measurement of monetary value will be based on the constant 1990 price. Measurement of the economic benefit will be made for the 50-year life of the project from the commencement of the project operation.

The result of all the studies together with other feasibility analyses will be used in the subsequent feasibility analysis and selection of the best alternative.

B.6.2 Financial Analysis

The purpose of this study will be to conduct a financial analysis for each of the prescreened alternatives, and to provide substantial data and information for the feasibility analysis and recommendation of the best alternative. The coverage and accuracy required for this study will be sufficient to conduct a consistent feasibility analysis for each alternative.

The financial analysis for each alternative will include the following steps:

1. Study and determination of toll system and estimation of toll revenue
   - As the basis for estimating the annual revenue for each alternative, the toll system common to each alternative will be determined. For this purpose, basic policy in setting the toll system will be carefully examined using the results of the traffic demand forecast, operating and management costs for each alternative and the costs of competitive modes of transportation.
   - The toll system will have to be established taking into account the basic policy of setting the toll system, results of vessel forecast, level of services, etc.
   - The toll revenue will have to be quantitatively calculated considering the existing toll systems. Expected increase in the toll will also be estimated. The revenue will be estimated based on the toll and traffic demand forecast for each alternative.
2. Estimation of other revenues
   - Revenues other than tolls were as much as 25 percent of the toll revenue for the FY1988 and they will also be analyzed in the financial evaluation. Revenue sources such as rent, electricity sales, etc., shall be identified and estimated quantitatively.
3. Identification and calculation of cost items
   - All the cost items required for construction, operation, and management will be identified and estimated for each alternative.

4. Financial analysis
   - The financial analysis for each alternative will be performed by using the same methodology as used in the analysis of the financial viability of large-scale development projects. These include:

     Financial viability: The financial viability for each alternative will be analyzed based on the financial statements including cash flow. In order to evaluate the results of financial analysis, the appropriate financial ratios such as debt coverage ratio will be used.

     Profitability of each alternative: To evaluate the profitability of each alternative, the Financial Internal Rate of Return (FIRR) will be used.

     Financial planning: Financial planning, such as funding sources, their terms and conditions, etc., will be further analyzed The financial planning in this study will further review and take into account characteristics of each alternative which will be analyzed as they relate to other studies. For instance, the following factors will be studied:

     - Funding sources and terms and conditions as they may be affected by the Management Arrangements study, will be examined.
     - Funding sources and terms and the affect of the scale of the total funding amount, will be examined for each alternative, especially in the case of co-financing.
     - Terms and conditions of funding affected by various kinds of risks will be examined.

   - The base year of the financial analysis will be 1990, and the cash flows will be expressed in constant 1990 prices.

The results of the financial analysis will be used for the feasibility analysis and recommendations of the best alternative.

B.6.3 Environmental Analysis

The Environmental Analysis will review and weigh the effects upon the environment of each of the alternatives recommended in the prescreening process. Measures to avoid adverse effects will be determined and approaches will be formulated to mitigate unavoidable effects.

The Environmental Analysis is intended to provide information for use in the feasibility analysis, selection of the best alternative, and the detailed investigation. The analysis will consider construction, operation, and maintenance of each alternative and address anticipated effects on the environment. The objective will be to characterize these potential effects to the extent possible.

The Environmental Analysis will be restricted to an ecological assessment with the remaining environmental elements being considered under the study, Analysis of Impact Upon Panama. The ecological analysis will be based on consideration of plans and designs for various canal alternatives in the context of the local marine, freshwater, and terrestrial ecosystems. Baseline information on species present will be provided by the Biological Inventory and other available sources of data.

Effects of each alternative will be identified and characterized to the extent possible. This is accomplished by identifying concerns; reviewing plans for construction, operation and maintenance; identifying facility-biological interfaces; listing potential effects of each alternative on biotic groups; and defining the extent and magnitude of these effects. A descriptive report will be prepared to report the ecological effects for each alternative. The evaluation will focus on important species, e.g., representative, sensitive, economically valuable, endangered. Where adverse effects are identified, consideration will be given to modifying plans and designs to eliminate or reduce effects. This effort will be done in consultation with engineering personnel.

After designs incorporating means to reduce environmental effects have been developed, unavoidable effects will be defined and methods sought to mitigate these effects. Plans will be developed as warranted for unavoidable effects associated with each alternative. Given enhanced designs and mitigation plans for each alternative, a methodology will be developed and used to rank alternatives.

The deliverables of this study will be:

- Recommended mitigation measures for each alternative
- A report describing the environmental effects of each alternative
- A ranking of alternatives based on environmental effects

B.6.4 Analysis of Impact Upon Panama

The purpose of this study will be to identify probable effects and impacts of each alternative upon Panama, to analyze and quantify them to the extent possible, and provide basic data and information for the feasibility analysis and selection of the best alternative. This study will be an inseparable part of the economic analysis in measuring secondary benefits of the project. Thus, the coverage and depth of the study will be limited to the measurement of the extent and size of effects and impacts; their monetary evaluation will be treated in the economic analysis study.

Probable effects and impacts of each alternative upon Panama will consist of direct and indirect effects. They will also be classified into effects occurring during construction and those associated with the operation of the project, including analysis of impact on human settlements in relation to project implementation.

Direct and indirect effects during construction, both on the nation as a whole and the project region, may include the following:

Effects on the Region

Direct Effects

- Creation of employment due to construction work
- Environmental impact due to discharge of waste water and disruption of land and water regimes
- Impact on economic activities resulting from a temporary closure or restricted use of existing canal

Indirect Effects

- Increase in regional income induced by incoming people
- Socio-cultural effects due to inflow of construction-related people including foreigners, such as inflation, security, and sanitation problems

Effects on Panama

Direct Effects

- Inter-regional migration of people related to construction work
- Limited resources and facilities available to other projects in regions

Indirect Effects

- Enhancement of the public image of the country in international arenas
- Increase in tax revenue and foreign exchange earnings from construction-related and other induced activities

Direct and indirect effects during the operation may include the following for the nation as a whole and for the region.

Effects on the Region

Direct Effects

- Employment created directly from the canal operation and indirectly from the much vitalized economy as mentioned below
- Long-term effects on land and water ecosystems

Indirect Effects

- Vitalization of economic activities induced by increased transactions by means of the improved and expanded canal
- Increase in land value along the canal route
- Acceleration of development of related facilities, both public and private

Effects on Panama

Direct Effects

- Increase in foreign exchange earning directly in the form of toll revenue and indirectly from increased international transactions

Indirect Effects

- Increase in tax revenue directly from the canal operation and indirectly from increased economic activities and also from enhancement of land and property value in the canal region
- Enhancement of the international position of Panama which will contribute to the stability of the Caribbean region

Direct effects will be quantitatively analyzed as far as the available data allows. Care must be taken, however, to avoid double counting of effects, particularly distinguishing national and regional benefits.

Indirect effects will be no less important than the direct effects, especially for such a major infrastructure project that will have large and long-lasting influences. In particular, the regional development, if successfully induced, with increased economic activities and enhanced land and property values, may make the project successful in a longer run not only economically but also financially. These indirect effects, therefore, should be carefully spelled out, although they are generally difficult to quantify.

As outlined above, the provable effects and impacts will have to be identified and analyzed from various viewpoints: economic, socio-cultural, geographic, political, environmental, financial, and others. For this, the study will have to draw upon almost all the other studies. The Present Situation in Panama and Economic Analysis studies will be useful inputs on economic and socio-cultural aspects, Biological Inventory and Environmental Analysis studies will be useful on environmental aspects, and Financial Schemes and Financial Analysis on financial aspects. Results of other studies may also be used.

The results of this study will be the measurement of the probable effects and impacts upon Panama, and will provide important and supportive information for feasibility analysis and recommendation of the best alternative.

B.6.5 Analysis of Impact Upon Users

The purpose of this study will be to identify and analyze the impacts of each alternative upon users and/or user countries including the markets served by ships using the interoceanic passage. Direct impact will be the main subject of the study, but some significant indirect impacts will also be identified and analyzed. These impacts will be quantified to the extent possible.

This study will be an inseparable part of the economic analysis in measuring secondary benefits of the project. As in the Analysis of Impact upon Panama study, the extent and size of effects and impacts will be measured in this study, while their monetary evaluation will be treated in the Economic Analysis study.

All assumptions and conditions used in this study will be compatible with those set up in other related studies. Impacts upon users will be classified into short-term (especially those during construction) and long-term (those during operational period) categories.

Short-Term Impacts

Short-term impacts will be, but not be limited to, the following:

Direct Effects

- During the construction of an alternative, demand for construction machinery and materials will be increased in the developed industrial countries, Central and South American countries and other developing countries, and demand for labor will be increased in Panama and the surrounding countries. As a result, their economies will be activated especially due to increase of income, international trade will then be expanded, and the canal cargo and traffic will be increased.
- During construction some of the alternatives would limit the traffic of the existing Canal and the use of relevant facilities. In some other cases, the existing Canal will be closed for some time. These effects on users and user countries will be significant.

Indirect Effects

- The construction activity will bring about increase of income in many countries, induce further effective demand, and finally will increase the canal cargo and traffic

Long-term Impacts

Long-term impacts will arise during operation of some of the alternatives. Significant impacts will be those mostly related to changes in increased size of vessels through the Isthmian route and to the saving in transportation costs and time. Long-term impacts will be, but not be limited to, the following:

Direct Effects

- If the alternative is passable to over-Panamax ships, some types of vessels now using the Suez or Cape of Good Hope routes due to their size will change their route to Panama even though the total volume of trade or their OD will not be changed.
- In the same case as above, some commodities now using more cost-effective modes of transportation will be able to resume use of the Isthmian route with transportation by oceangoing vessels. Such a case might be petroleum transportation from the Trans-Panamanian Oil Pipeline to larger oil tankers able to pass through the new canal.

Indirect Effects

- The increased size of vessels passing through Panama will induce some decrease in commodity prices in the world market by saving transportation costs, and this will activate new exports of commodities by shifting supplier countries or will promote new development of resources. It will also accelerate scrap and build in the shipbuilding business and will encourage extension and enlargement of the major seaports of the world.

The results of this study will be the measurement of the probable effects and impacts upon users and user countries and will provide important and supportive information for the feasibility analysis and recommendation of the best alternative.

B.6.6 Management Arrangements

The purpose of this study will be to establish an optimum management arrangement for each of the prescreened alternatives. The management arrangements will include, among others, the organization of management structure supplemented by supporting management facilities.

Feasibility analysis for the management arrangements will be performed as follows:

1. Data necessary for formulating an optimum management arrangement will be collected. Information relative to the operation of the existing Panama Canal and other organizations' operations similar in character and scale will be obtained.
2. Operational and managerial characteristics relevant to each of the alternatives will be identified and assessed in terms of operational and managerial requirements.
3. The conceptual alternative management system for each alternative will be formulated and will be evaluated in various aspects ranging from scale of manpower requirements, possibility of automatic operation, privatization, response to anticipated risks, flexibility and balance of workload, etc.
4. Through the evaluation process, the best management system for each of the alternatives will be chosen, and will be attached with outlined scope of its respective management organization structure.
5. The required supporting facilities for each alternative management system will be defined to allow cost estimates for the economic and financial analysis.

The results of the study for the management arrangement for each alternative will provide basic data for assessment and selection of the best alternative.

B.7 DEVELOPMENT OF ADDITIONAL DATA

In order to obtain further data and information required for the FA/FR, detailed investigation, development of additional data as required will be carried out by the Component Study contractors. Additional data required will be mostly for reviewing the design, estimates, and time schedule of the best alternative. Some other data will be required to refine and readjust the planning and evaluation, e.g., results of demand analysis, capacity evaluation, and economic and financial analyses.

These efforts will include field investigation to be conducted by the Component Study contractor or his subcontractor. Ground surveying, including profile and cross-sectional surveys as well as topographical surveys will be conducted for the sites of major structures and the alignment of the waterway which will govern a large part of the design. These ground surveys will also be carried out for areas where geotechnical investigations will be carried out. Specific sites, scope, and extension of the work will be identified after selecting the best alternative.

Geotechnical investigation including geological exploration, soil tests as well as materials surveying will be conducted for the sites of major structures. For the waterway where landslides are anticipated, special geotechnical exploration including slope stability analysis will be carried out. Specific sites, scope and extension for this work will be identified after selecting the best alternative and ground surveys.

Hydrological field investigation concentrated on clarifying the conditions of sea water intrusion into the canal waterway will be conducted at the entrance channel of both the Pacific and Atlantic sides under several different conditions of tidal range and released water flow from locks and a spillway.

Additional studies for the preliminary design of the major facilities of the best alternative will be conducted, and data for estimating their costs and preparing time schedules will be developed by the Component Study contractor in cooperation with the FA/FR Contractor. If it is judged that the re-estimated cost of the best alternative is so biased as to require refinement and readjustment of the results of basic planning and evaluation for the alternatives, the adjustments will be made to maintain the consistency of the study, and then the basis for selecting the best alternative will be confirmed. Objectives of refinement and readjustment will be, among others, the demand analysis, capacity evaluation, economic and financial analyses, etc.

All the necessary data for these studies will be developed upon approval of the Secretariat by the Component Study contractors in cooperation with the FA/FR Contractor.

Section 4

Study Work Plan

Comisión de Estudio de las Alternativas al Canal de Panamá
CENTRO DE INFORMACION

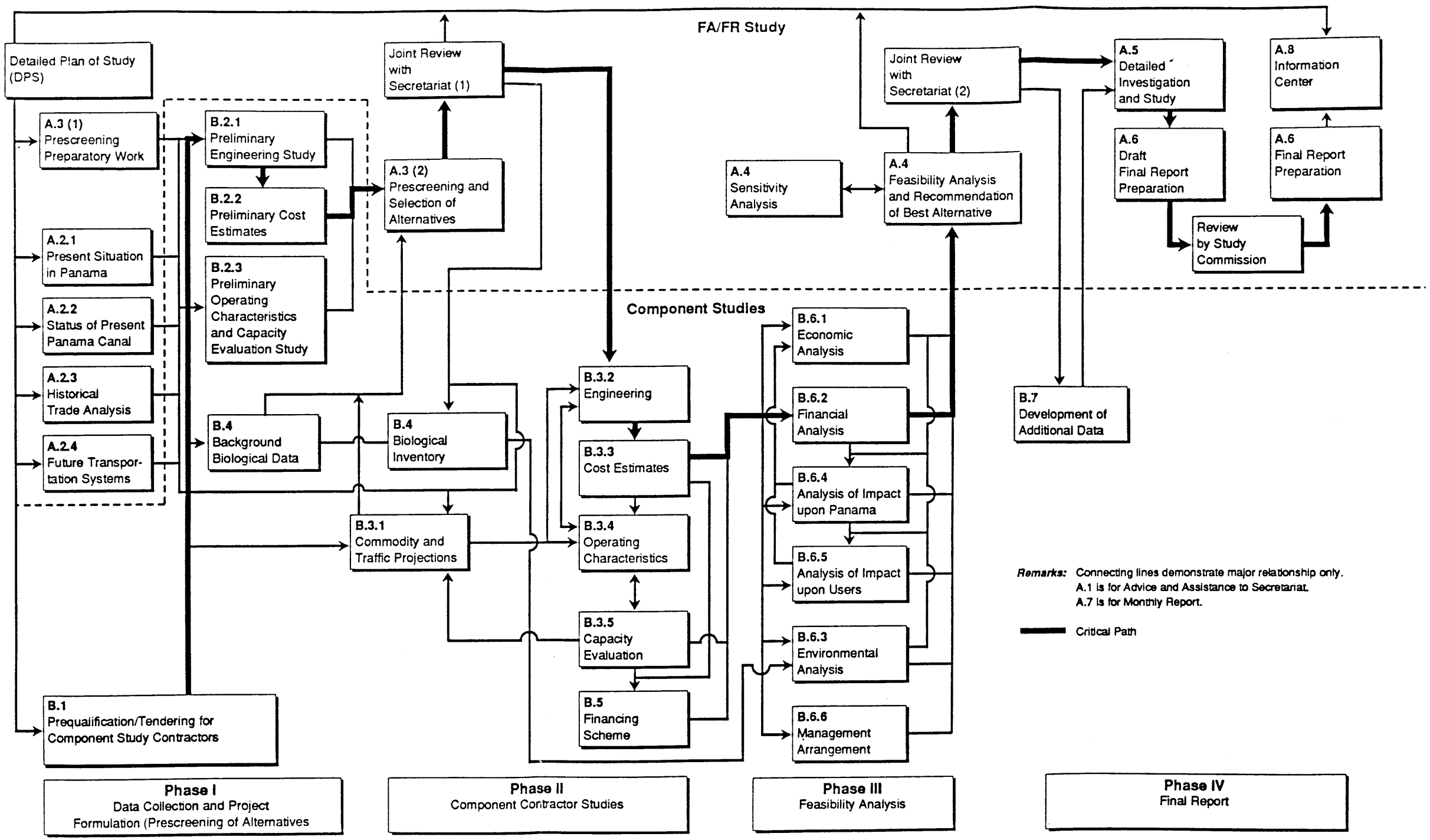
This work plan represents a systematic approach to the study that will insure that it will be done efficiently, on time and within budget, and that there will be proper coordination between the various contractors who prepare the Component Studies and between Component Study contractors, the Secretariat, and the FA/FR Contractor.

The major tasks associated with the overall study work plan are shown in Figure 4-1. These tasks were described in detail in Section 3 of this volume. The major steps in this study work plan include the following:

- Prepare the preliminary analysis and prescreening of the alternatives
- Select the most viable alternatives for further study
- Assist the Secretariat in prequalifying and selecting contractors for the Component Studies
- Assist the Secretariat in overseeing the work of the Component Study contractors
- Prepare detailed feasibility analysis and recommendations
- Prepare detailed investigation
- Prepare draft report
- Review draft report with the Commission and incorporate appropriate comments
- Prepare final report

The subtasks for each of these major tasks are shown in the flow charts at the end of this section. The critical path is shown by the dark lines in Figure 4-1 and Figure 4-2.

During the course of the study, members of the team from the FA/FR Contractor will be available to advise and assist the Secretariat on the overall management of the study. A project control system will be set up by the FA/FR Contractor to assist in this management process. The system will provide means to control schedules, costs, and study output. A proposed control system for the study is described in Section 5.



Remarks: Connecting lines demonstrate major relationship only.
A.1 is for Advice and Assistance to Secretariat.
A.7 is for Monthly Report.

Critical Path

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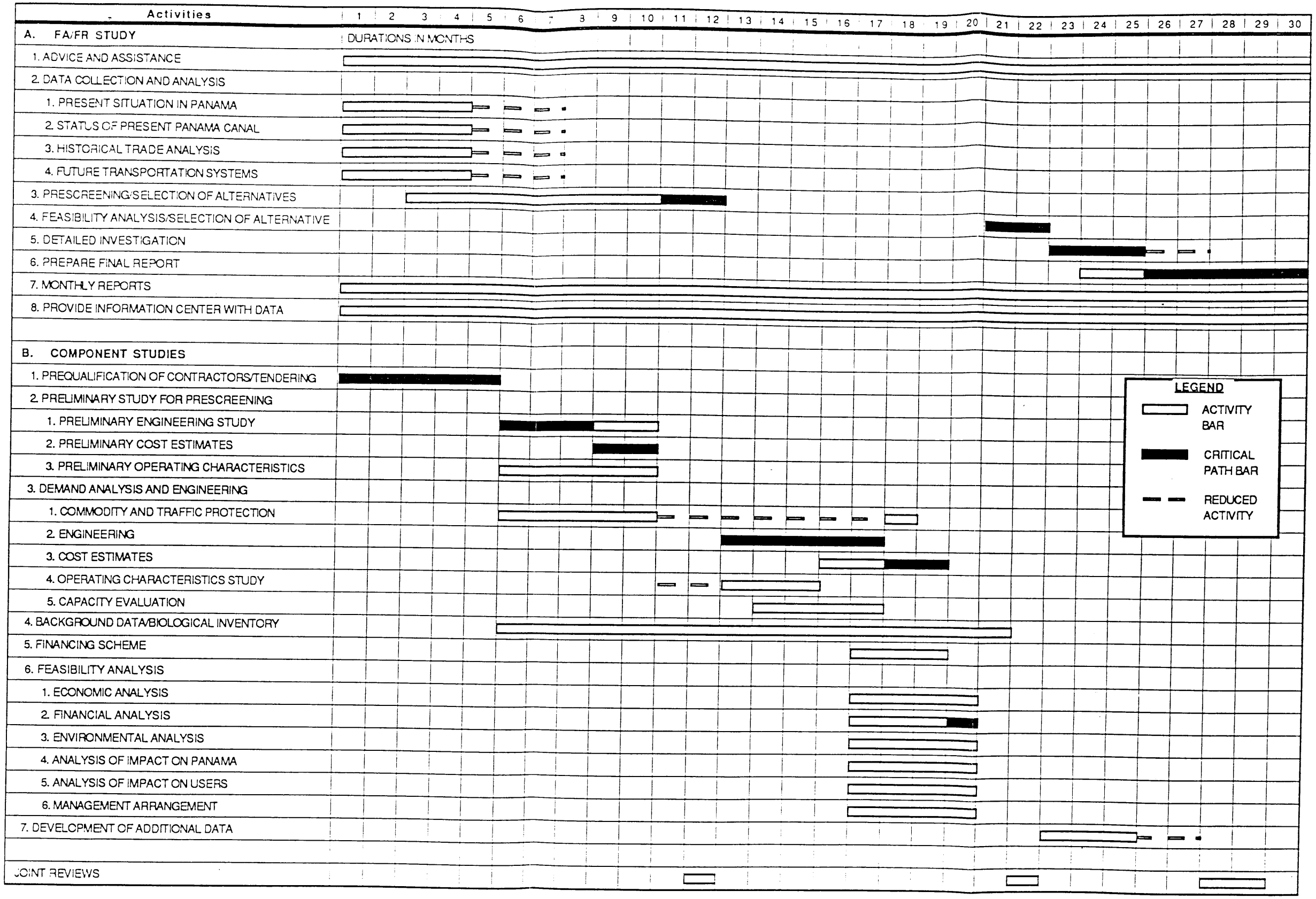
Figure 4-1
Overall Work Plan Flow



SINBOL

PANAMA CANAL ALTERNATIVES STUDY

Figure 4-2
Study Summary Schedule

The following briefly describes the overall flow of the work plan.

4.1 OVERSEE PREPARATION OF COMPONENT STUDIES

The Component Studies are to be prepared by outside contractors. The FA/FR Contractor will assist the Secretariat in setting up a management system that will help to select and oversee the work of these contractors. This will consist of the following steps in the work plan:

- Prequalify contractors for each of the Component Studies
- Issue terms of reference to the prequalified contractors
- Evaluate responses
- Select contractors
- Monitor for the Secretariat the Component Study contractors' work and assist the Secretariat in ensuring that the studies are done within the time and budget allowed and that they are technically complete, including establishing an agreed-upon work plan defining work products and schedules
- Assist the Secretariat in coordinating the effort of the Component Study contractors to ensure the exchange of needed information between contractors that are preparing studies which are closely related or interactive

Selecting and overseeing the preparation of the Component Studies will be an ongoing effort during the first 21 months of the study.

4.2 PRELIMINARY SCREENING OF ALTERNATIVES

The conceptual alternatives discussed in Section 2 will be classified and assessed in the preliminary analysis and prescreening process. Alternatives which appear to be unfeasible due to technical, financial, or other reasons will be dropped from further evaluation. The FA/FR Contractor will work closely with the Secretariat in developing the methods and criteria which will be used in selecting the alternatives for further analysis.

4.3 COMPONENT STUDIES

Although selected preliminary aspects of the Component Studies will be performed for the prescreening task, the principal Components Study activities will be performed mostly from month 13 through 20 (see Figure 4-2). The FA/FR Contractor will assure the interchange of information necessary among Component Studies as depicted in the input/output flow charts appearing in Appendix 2, Volume II.

4.4 DETAILED FEASIBILITY ANALYSIS AND RECOMMENDATIONS

At this point the results, including sensitivity analyses, of the Component Studies will be available. The major element in this task will be the development of a methodology to evaluate the potential alternatives. As the study progresses it will become clearer what the issues are and what the priorities of the Secretariat will be. The methodology, therefore, will be developed while working closely with the Secretariat and will contain a system of rankings and weightings designed to deal with the complexities of the issues. This methodology will be used in selecting the recommended alternative.

4.5 DETAILED INVESTIGATION

A detailed investigation will be prepared for the recommended alternative. This will include the details of the physical facilities to be constructed, preliminary schedule for implementing the alternative and the estimated capital and operating costs. Sensitivity analysis will be an essential element in this detailed investigation. The engineering and cost detail will be consistent with the level developed by other component study contractors.

4.6 PREPARE DRAFT FINAL REPORT

A draft of the final report will be prepared that will integrate the work of the contractors preparing the Component Studies, the final recommendations and the results of the detailed investigation. This draft report, together with its annexes, will contain, but not be limited to, the following:

- Summary, conclusions, and recommendations
- Background analyses derived from the component studies
- Demand projections

- Identification of alternatives, engineering analysis, cost estimates, environmental analysis, operating characteristics, capacity evaluation, and financing schemes
- Feasibility analysis of each accepted alternative including sensitivity analysis, and selection of preferred alternatives
- Feasibility analysis of each preferred alternative and selection of best alternative
- Detailed studies of the best alternative including preliminary design, overall costs, operating characteristics, financing, and project evaluation (economic and financial feasibility, environmental impact assessment, managerial system, and the impact on Panama and the user countries).

4.7 PREPARE FINAL REPORT

After appropriate reviews, the comments from the Commission will be incorporated into the draft report, and the final report will be issued.

4.8 STUDY SCHEDULE

Figure 4-2 shows the proposed schedule for the major tasks that will be undertaken by both the FA/FR Contractor and the Component Study contractors. Major milestones in this schedule include the completion of the preliminary analysis and screening at month 12, the completion of the Component Studies at month 21, selection of the recommended alternative at month 22, completion of the detailed investigation at month 25 and the preparation of the final report at the end of month 30. The critical path activities are shown by the dark bars.

Section 5

Management Plan

The study coordinator will be responsible for the overall coordination of the work of the FA/FR Contractor team. Staff review meetings will be held weekly with the key members of the team. The coordinator will also work closely with the Secretariat in overseeing the work of the Component Study teams and to ensure that their work is completed within the time allowed and within the budget allocated for the study.

5.1 REPORTS AND REVIEWS

The coordinator will be responsible for seeing that the monthly reports are prepared and submitted to the Secretariat. These reports will be an important management tool in that they will provide up-to-date summaries and pertinent information on the status of the study.

During the course of the study, reviews will be held with the Secretariat and the Commission as appropriate. For example, key reviews will be held after the following milestones are reached:

- Preliminary analysis and prescreening and the selection of alternatives to be included in the study
- Selection of component study contractors
- Completion of the feasibility analysis and the selection of the recommended alternative
- Completion of the detailed investigation
- Submittal of the draft final report

These reviews will ensure that the study is progressing according to schedule and that proper communication is maintained between the FA/FR Contractor and the Commission.

5.2 INFORMATION CENTER

The study coordinator will work closely with the Information Center and the study team to ensure that there is a proper exchange of information. The study team will provide data, reports, computer programs, maps, and graphics, as they are developed and approved. Conversely, the Information Center will provide materials in their files to the team members as needed.

5.3 STUDY CONTROL SYSTEM

The study control system will be an essential tool in the management of the study. It will provide up-to-date information to the study coordinator on the current status of the study. This information will in turn be included in the monthly report to ensure that the staff of the Secretariat and the members of the Commission are fully aware of the status of the study. The proposed study control system is described below.

The study control system which will be used for the duration of this study is flexible and will provide the appropriate level of schedule and cost control in a cost-effective manner. The management level reports generated by this system will provide practical tools by which to control this project. It will also provide a vehicle to identify any potential problems and corrective action required as well as the current progress and status of the study.

5.3.1 Schedule Control Techniques

Scheduling is critical to the execution of this study. Its primary function will be to provide a means by which the study's entire scope will be organized, planned, monitored, and reported against. The schedule control technique portion of the study control system will also be dynamic and flexible enough to meet any change or changes that may arise as the study progresses.

5.3.1.1. Scheduling Hierarchy

The scheduling control technique used will consist of multiple levels, each with progressively greater detail. The first level of schedule will be the management summary schedule consisting of activities that give a view of the entire scope of the project. The second and subsequent levels of schedules reflect ever greater detail which will be developed as more information becomes available. As each succeeding level of detail is determined it may result in some major changes and revisions to the summary schedule(s) above it. When completed, the system will reflect a true hierarchy that will ensure proper planning, scheduling, monitoring, and control of the project especially with regard to control of status and progress of Component Studies.

5.3.1.2. Schedule Roll-up

By using a hierarchy of schedules such as the schedule summarizing to the management summary schedule we will ensure the integrity of the schedule process.

As each detailed activity summarizes to a summary level activity we not only ensure proper progress reporting but also maintain the proper work sequence necessary to control inputs and outputs to the FA/FR Study and Component Studies, and time restraints, resulting in better control of the job.

5.3.1.3. Schedules

All schedules used on this project will be developed by using state-of-the-art computer software and will utilize a microprocessor-based critical path method system. The software system chosen for this is called PRIMAVERA Project Planner and Primavision from Primavera Systems Inc. A description of the Primavera system is contained in Appendix 3.

5.3.1.4. Schedule Progress Reporting

To ensure that progress is properly accounted for, actual progress will be reported on a monthly basis. This information will then be provided to the project controls staff for inclusion in the scheduling system. Project progress and status reporting will be on a monthly basis.

5.3.1.5. Deliverables

The project controls system will provide statused management summary schedules and any subsequent detail schedules that may be developed. A contract award plan/schedule shall also be provided and statused as required. The above schedule(s) and associated cost information will be provided in a monthly progress report.

5.3.2 Cost Control Techniques

The cost control techniques used on this study will ensure proper operation and maintenance of budget and actual expenditure tracking information.

5.3.2.1. Estimate/Budget

An estimate will be established for each major activity or task for this study. Together, these will form a budget. The budget will be loaded into the project control system against the items in the scheduling system. As actual expenditure information is provided, it will be loaded into the system and a series of computerized calculations and reports will be generated. This information will include physical percent

complete, budget cost-to-date, actual cost-to-date and other information. This will provide a vehicle for tracking and monitoring cost.

5.3.2.2. Cost Control

The project will establish spreadsheet-based budgets to allow monthly monitoring, control, and reporting of costs. A spreadsheet-based cost and commitment register will be established to report and monitor all Component Study agreements. The system will provide a monthly report of actual costs, compared to the Study Budget. Variances to the budget will be reported in both dollars and percent of budget. Significant variances or changes from the previous report will be reconciled and any actions planned will be noted in the monthly Progress Report.

5.3.2.3. Code of Accounts

A project procedure/system or code of accounts will be developed to track all project cost, including study subcontractors' cost. These codes will be used to help monitor, and control the progress of all costs associated with the project.

5.3.2.4. Change Order/Trend Program

The trend program is a control tool designed to track and control project scope, cost, and schedule. The trend program provides a mechanism for identifying changes in the study scope and services to be provided. It will also refine cost forecast as the project progresses. A monthly summary trend report will provided to the study.

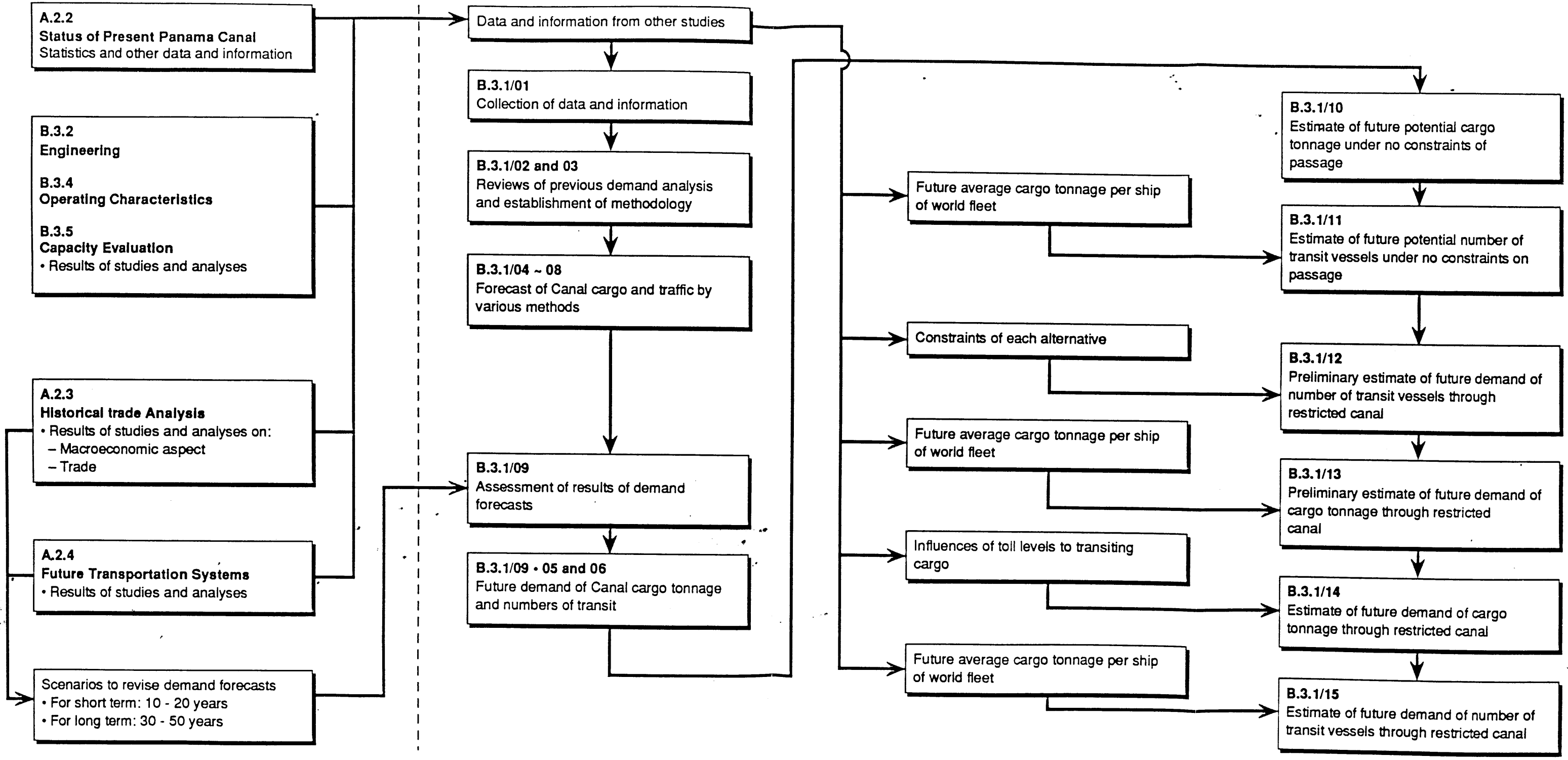
Concurrently the change order program will keep track of any changes made to the scope, both for the FA/FR Contractor and Component Study teams. The change order log will ensure that approved changes are uniformly initiated in both the cost and schedule.

5.3.2.5. Cash Flow

A cash flow will be developed at the start of the study and periodically updated. The cash flow will reflect the latest schedule and estimate (forecast). The cash flow will also provide a schedule of anticipated payments to the various study contractors.

5.3.2.6. Deliverables

The study controls task will provide, as stated in Cost Control Techniques above, spreadsheets for budget and cost control, change order/trend program logs and cash flows. These reports will be contained within the monthly progress report.



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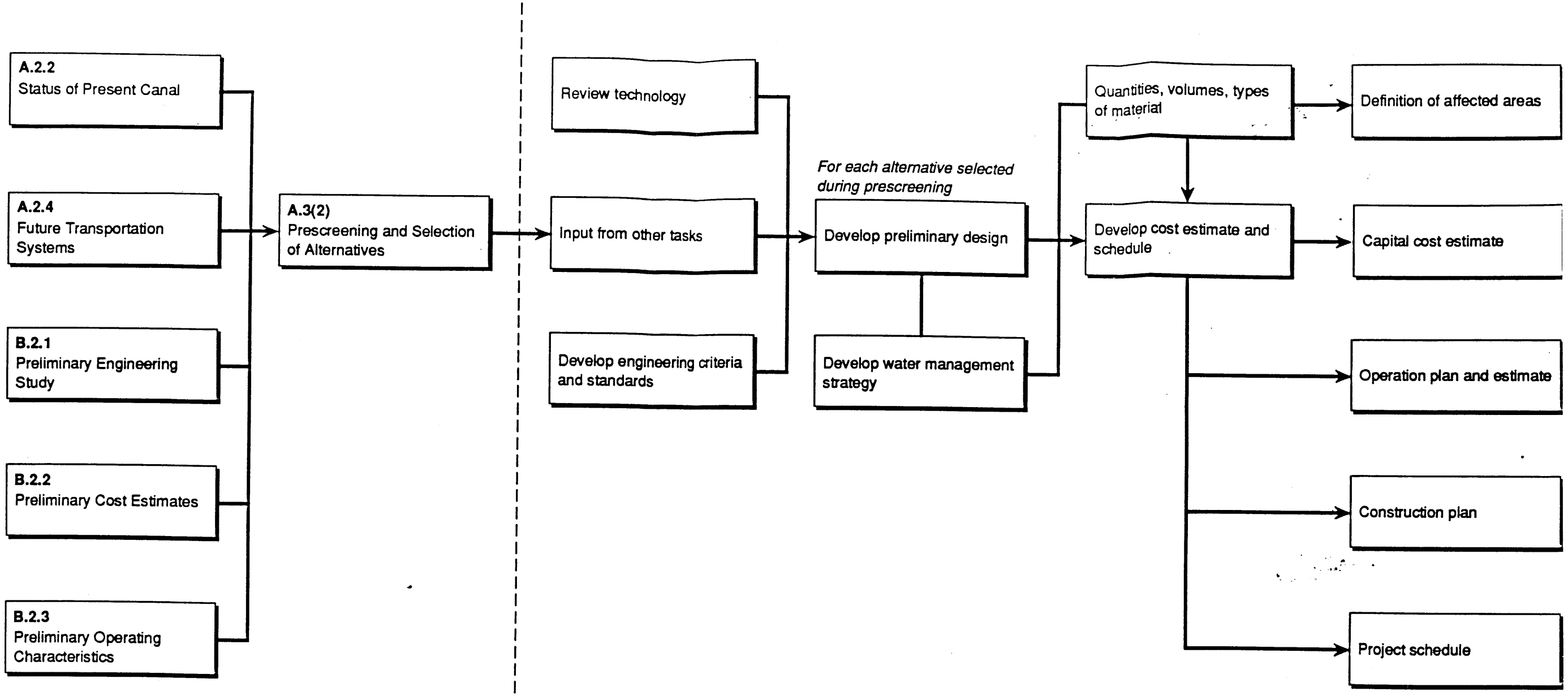
B.3.1
Commodity and Traffic Projections



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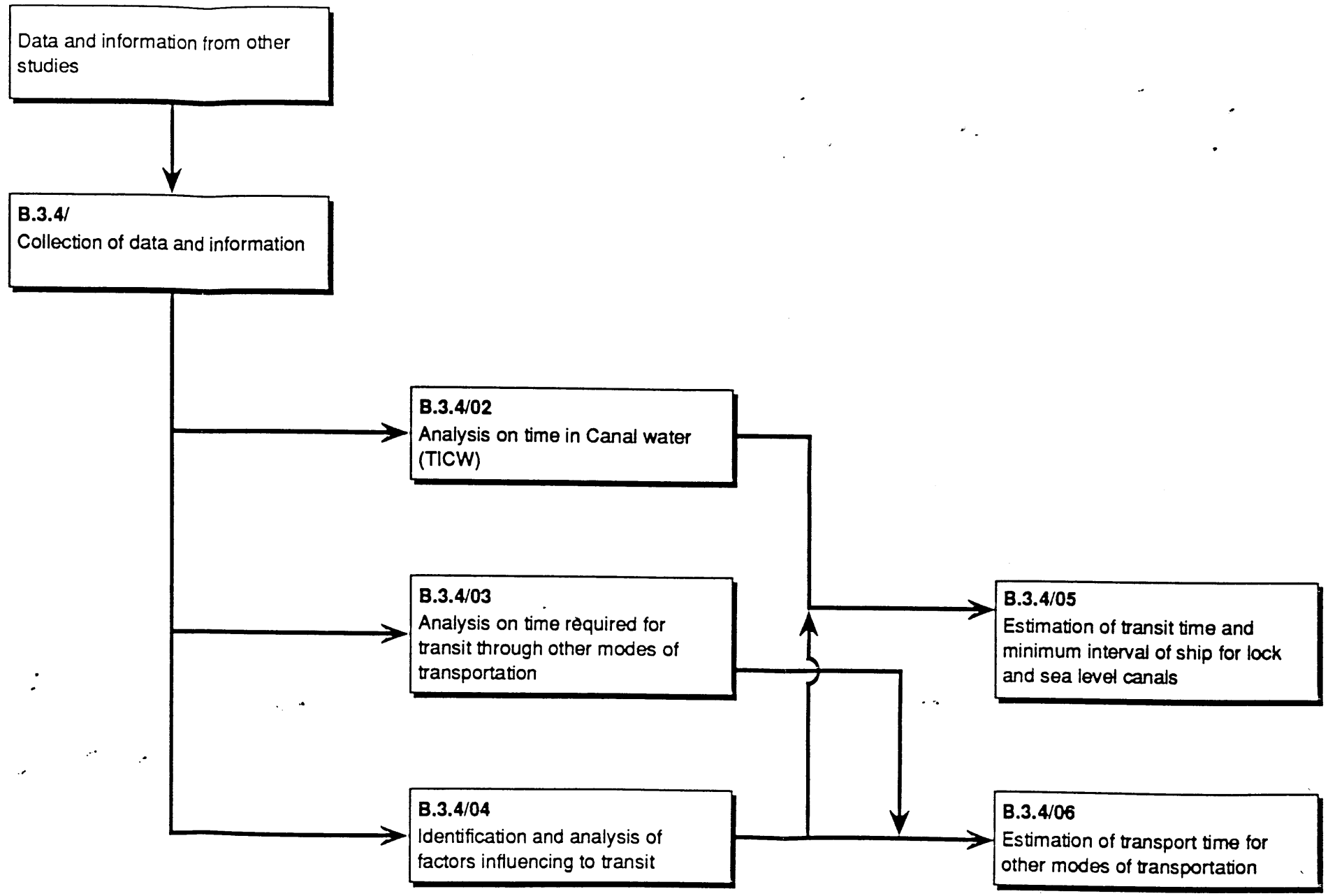
B.3.2 and B.3.3
Engineering and Cost Estimates



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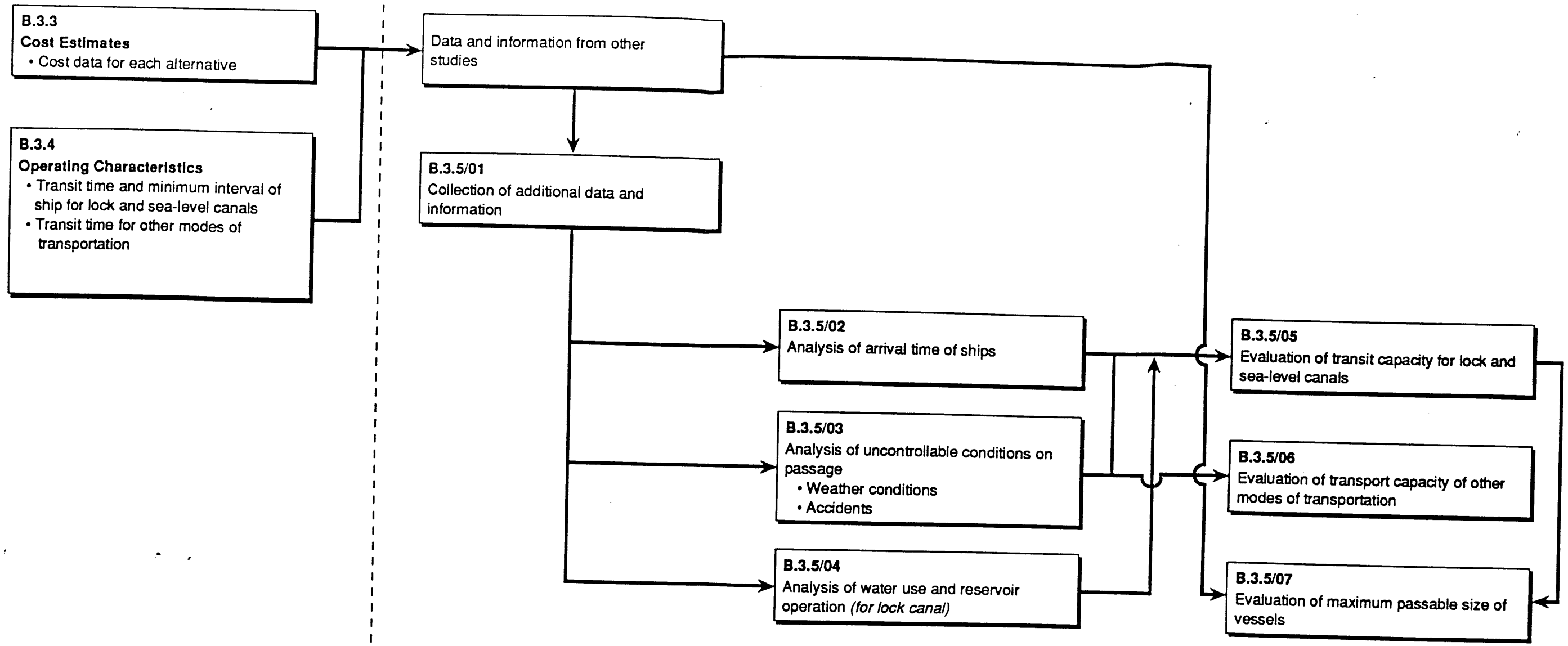

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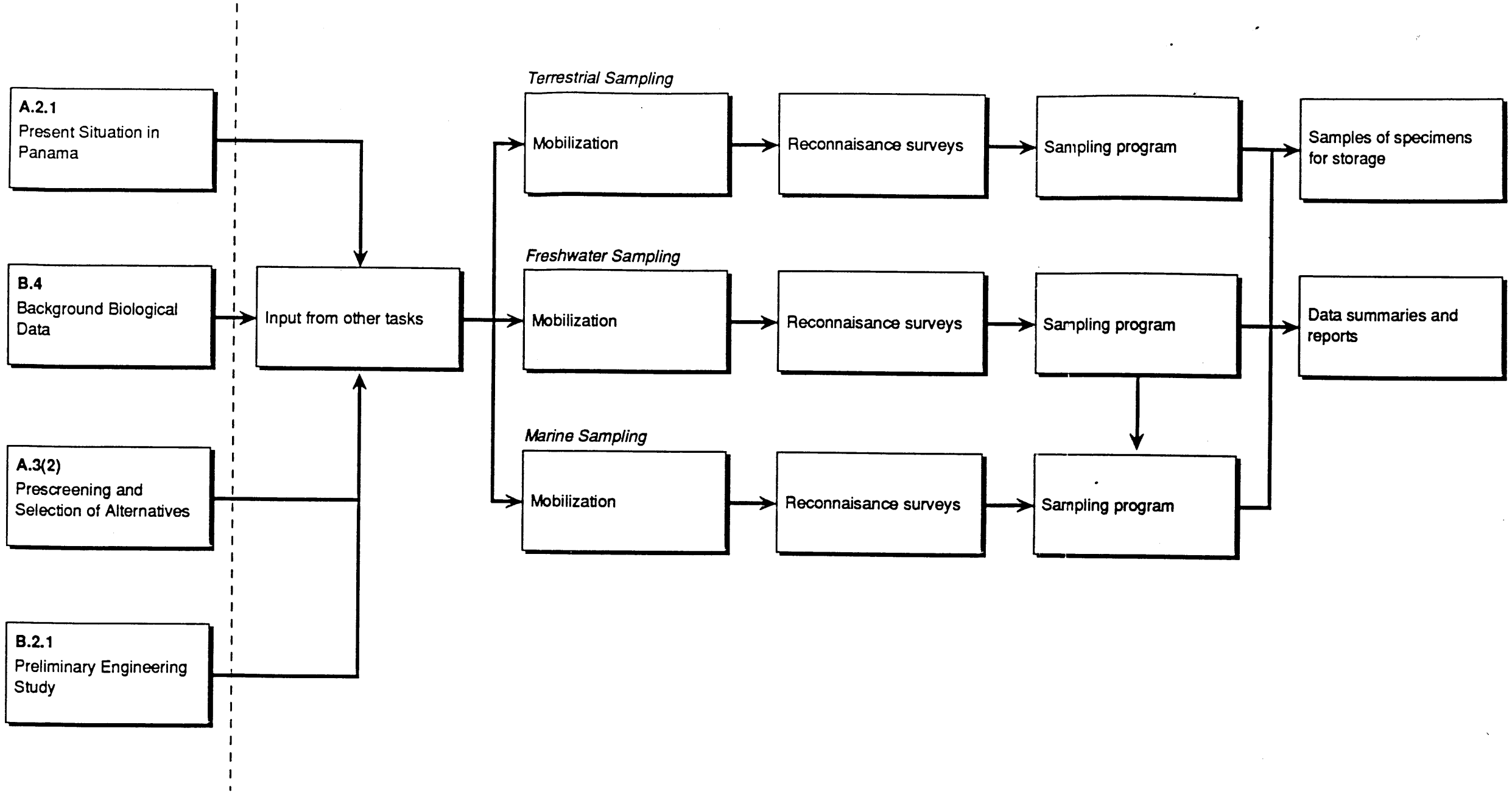
B.3.5
Capacity Evaluation



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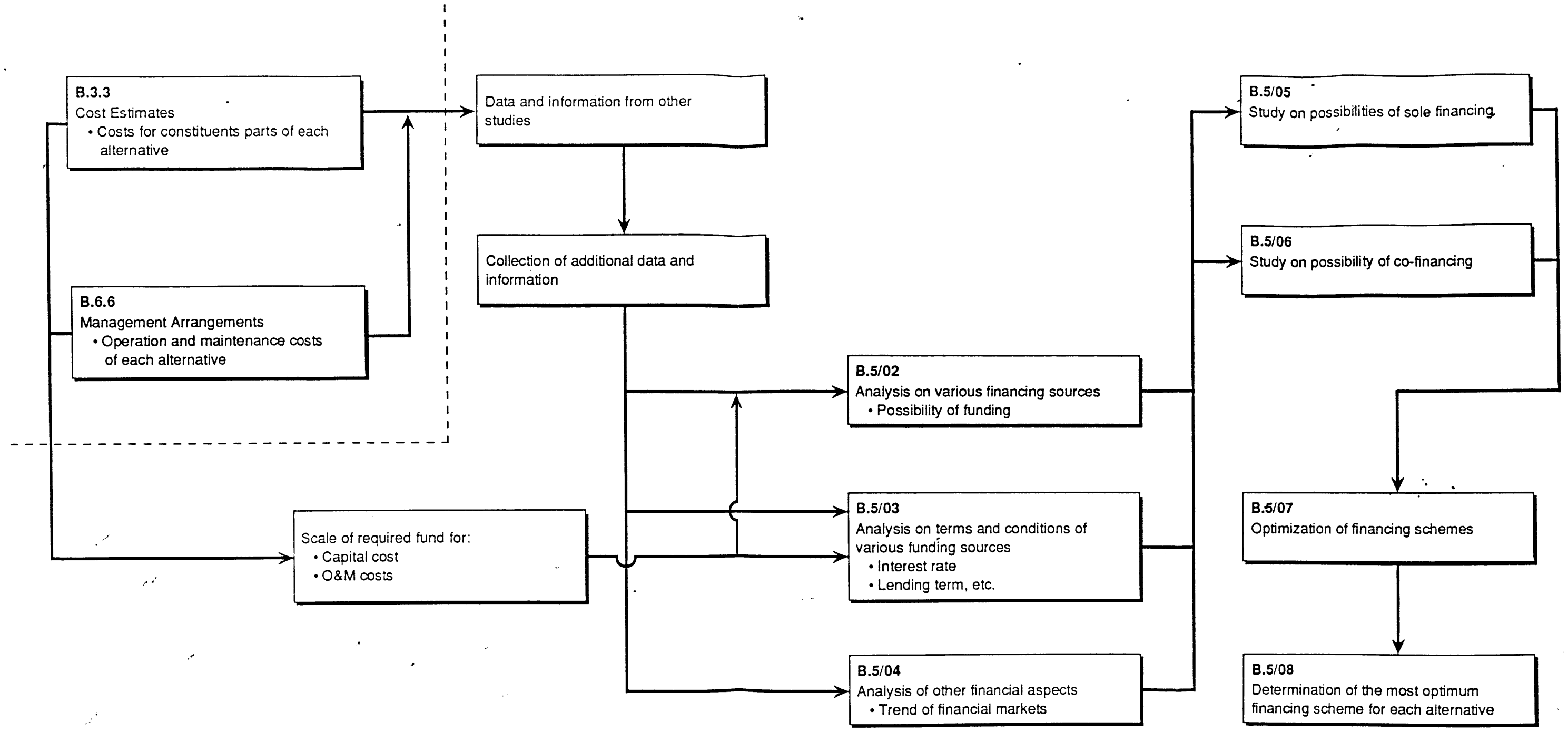
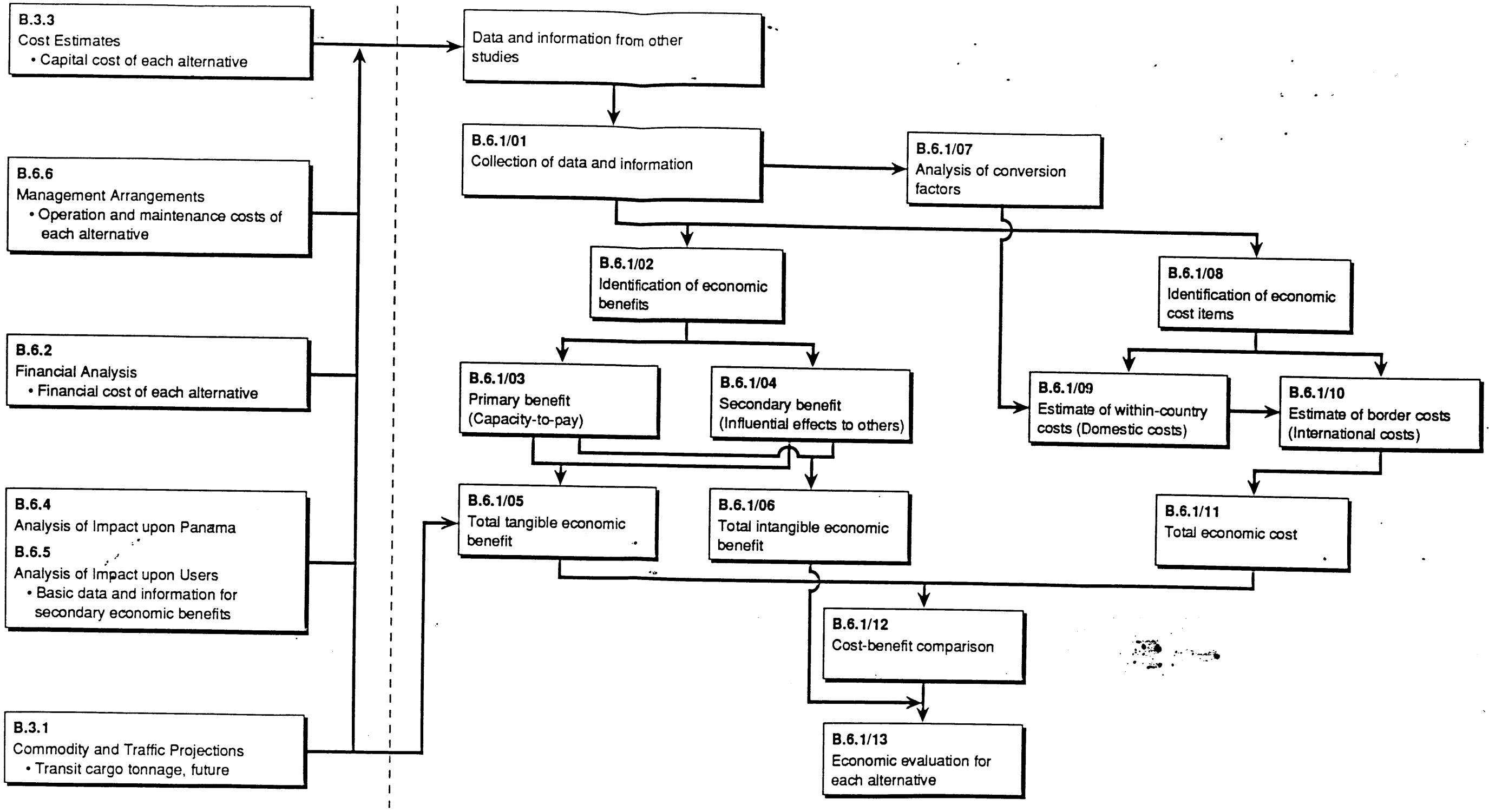


B.5
Financing Scheme



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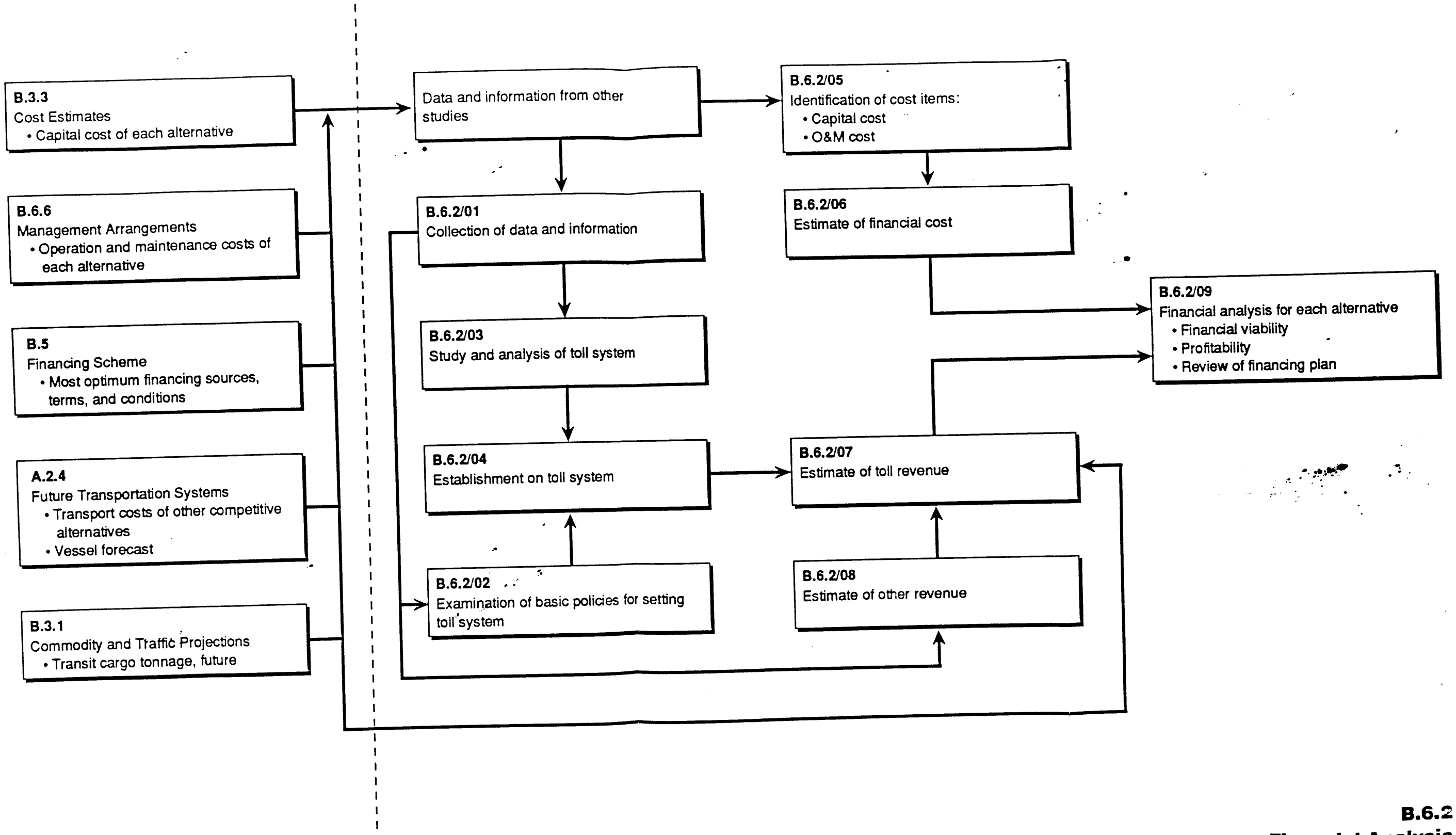
B.6.1
Economic Analysis



B.6.2
Financial Analysis

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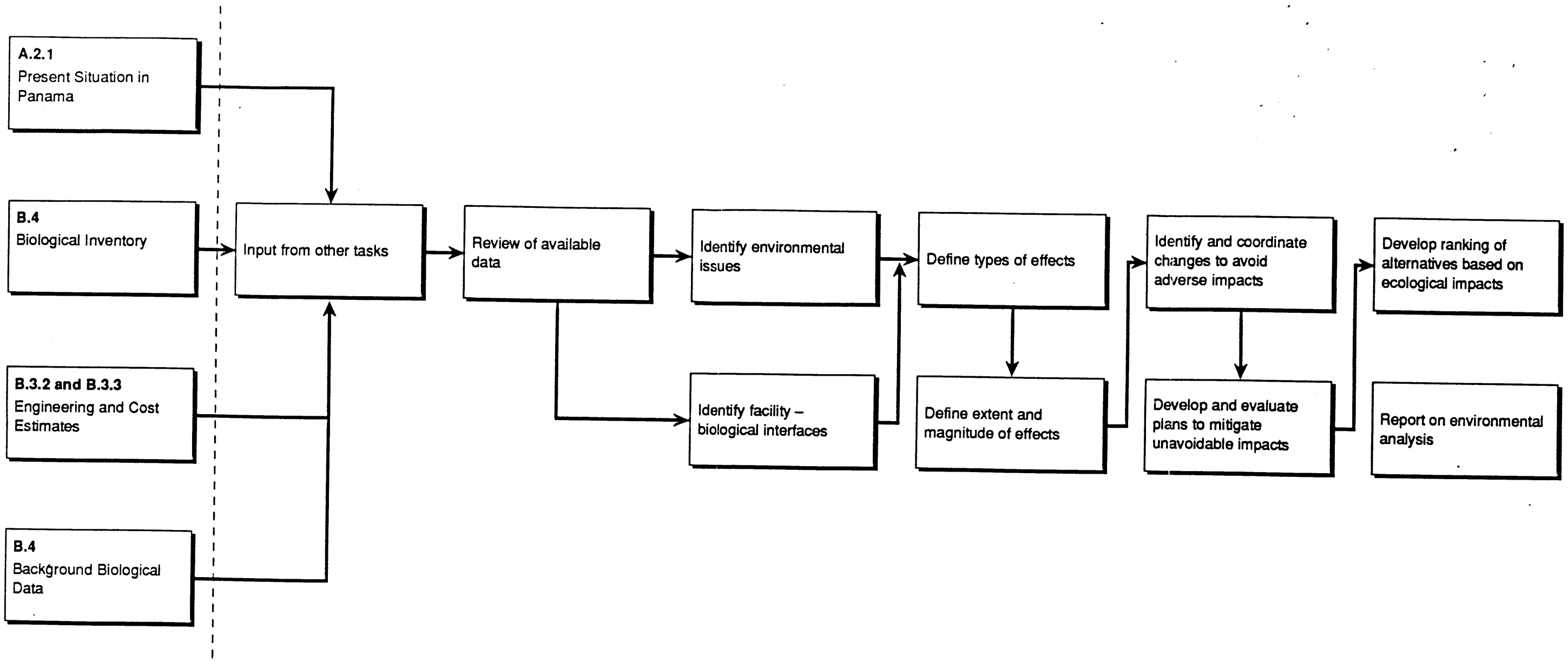
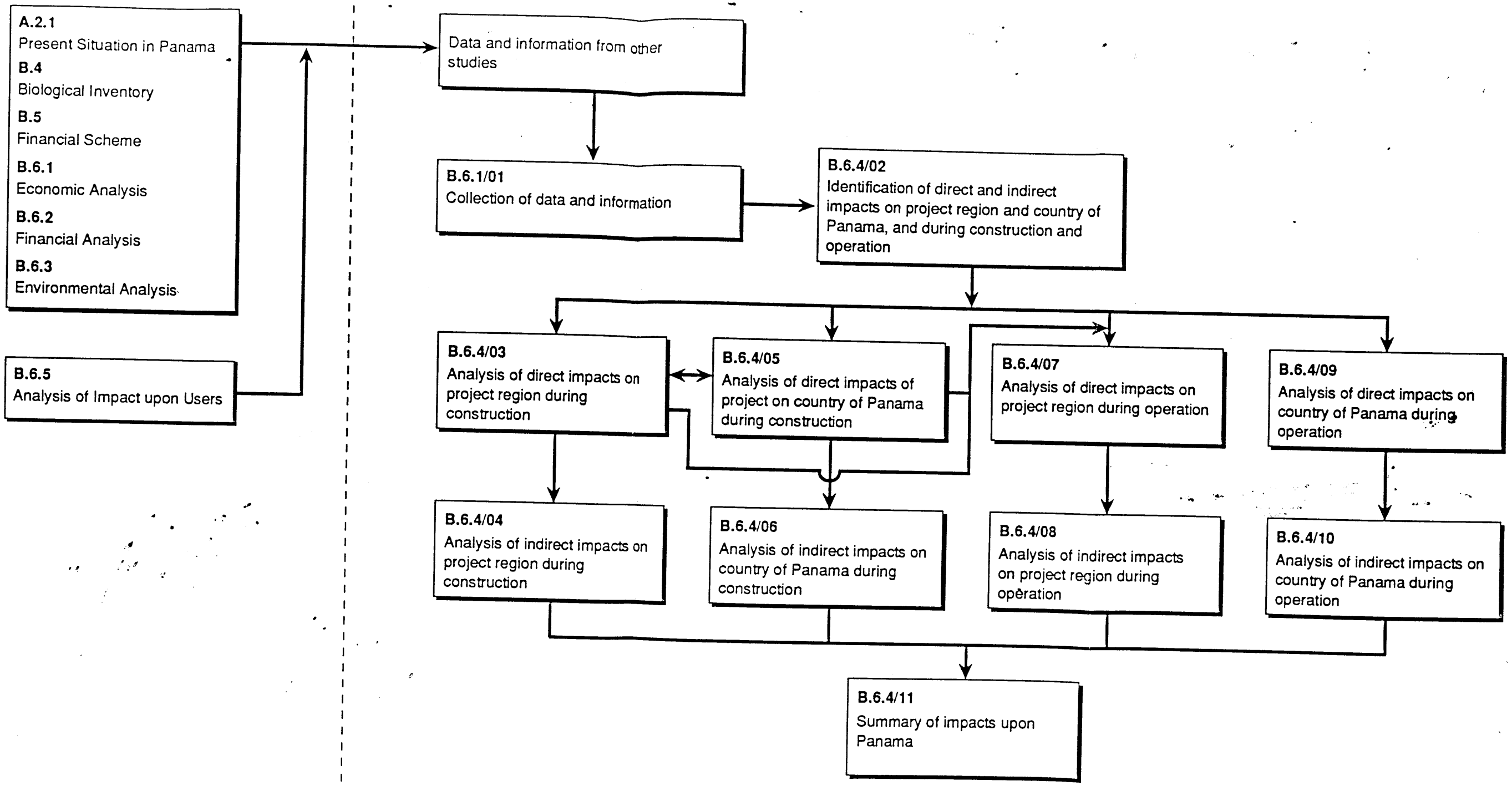

A.2.1
Present Situation in Panama
B.4
Biological Inventory
B.3.2 and B.3.3
Engineering and Cost Estimates
B.4
Background Biological Data
Input from other tasks
Review of available data
Identify environmental issues
Identify facility – biological interfaces
Define types of effects
Define extent and magnitude of effects
Identify and coordinate changes to avoid adverse impacts
Develop and evaluate plans to mitigate unavoidable impacts
Develop ranking of alternatives based on ecological impacts
Report on environmental analysis



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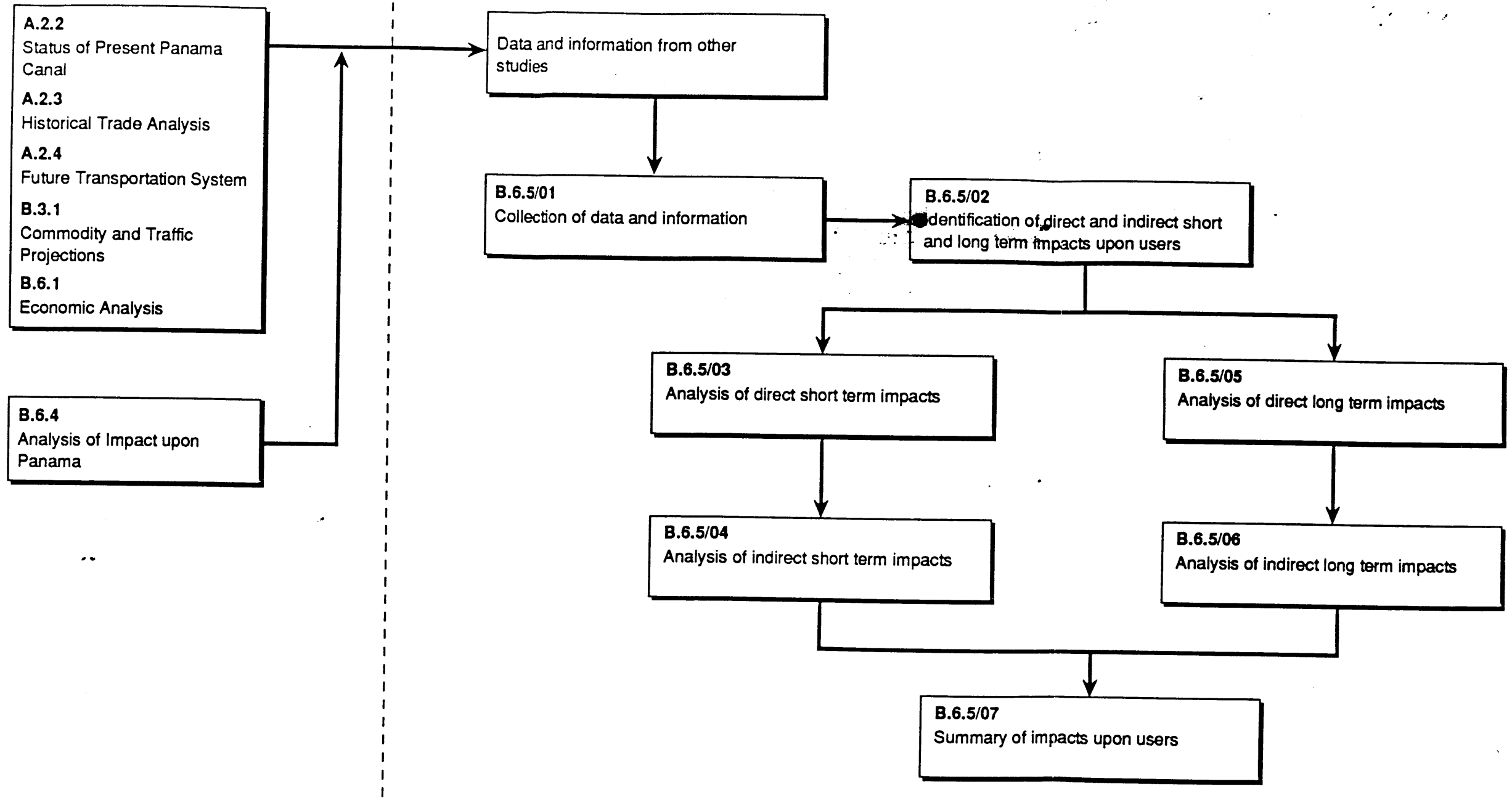
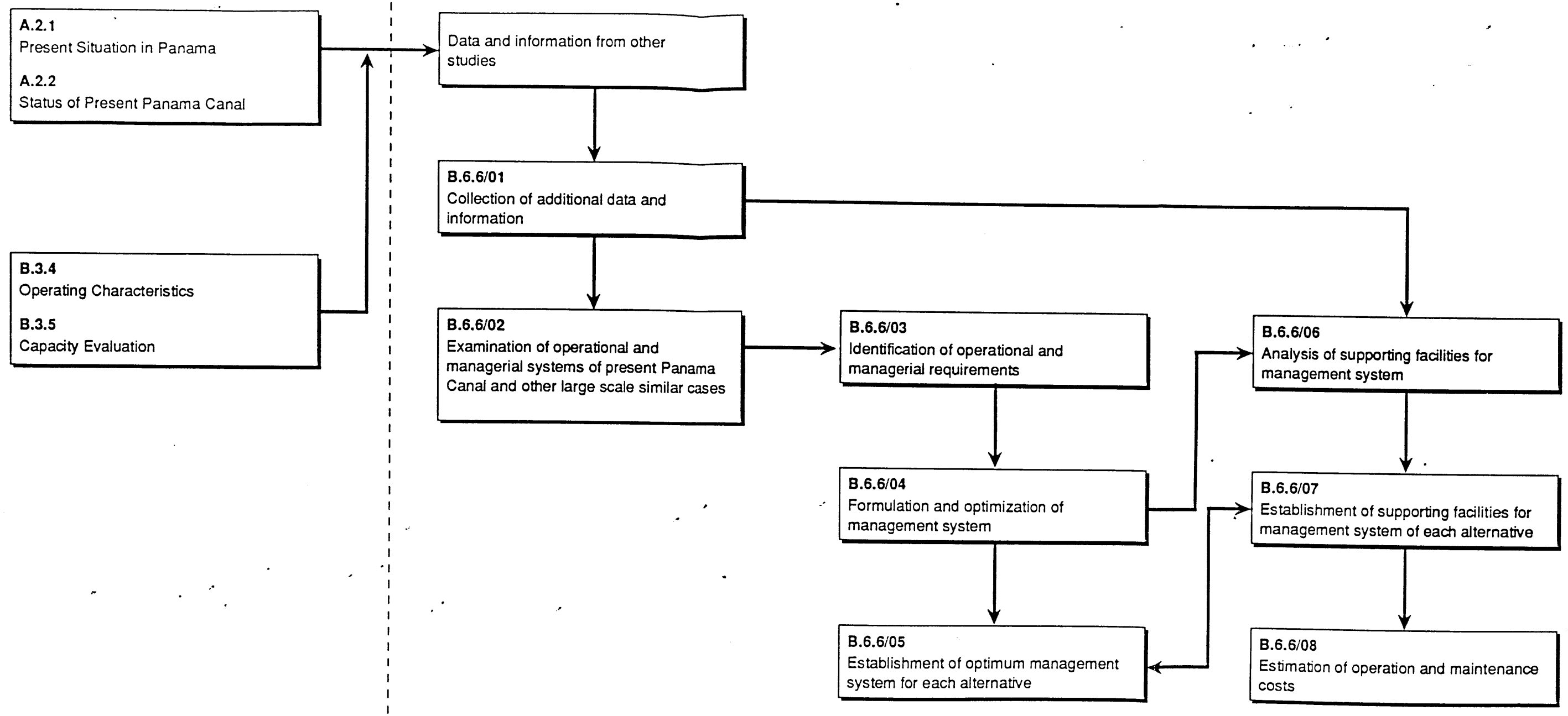
B.6.4
Analysis of Impact Upon Panama



B.6.5
Analysis of Impact Upon Users



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B.6.6
Management Arrangements