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PROCEDURES MANUAL

DEEP DRAFT NAVIGATION

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This manual is one of a series of guides to computing National Economic Development (NED) benefits of Federal water resources development projects. Basic guidance for NED evaluation is contained in the U.S. Water Resources Council's Economic and Environmental Principles and Guidlines for Water and Related Land Resources Implementation Studies (P&G). The two purposes of this manual are to explain the concept and application of NED evaluation to harbor project sponsors, and to assist the individuals who perform evaluation studies to comply with P&G requirements expeditiously. The evaluation procedures described in the manual apply to a wide range of harbor and waterway projects where sponsors cost-share studies and project implementation. The procedures are designated "Deep Draft Navigation" in the P&G, but apply to all commercial navigation projects not a part of the "Inland Waterways System". The manual covers theoretical and practical aspects of benefits evaluation, provides sources of information to identify and estimate future project use, and contains examples of benefit calculations.

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NATIONAL ECONOMIC DEVELOPMENT PROCEDURES MANUAL

DEEP DRAFT NAVIGATION

(Commercial Navigation Other Than Inland Waterway System)

by

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PREFACE

This manual is one of a series of guides to computing National Economic Development benefits. It was developed as part of the U.S. Army Corps of Engineers Planning Methodologies Program. It has been several years in preparation. The first draft of the manual was produced in 1985 by Howard E. Olson of the Navigation Division, Institute for Water Resources. This final version is dedicated to him.

The Planning Methodologies Program is administered by the Research Division, Institute for Water Resources. This manual was a cooperative effort of the Research Division, Michael R. Krouse, Chief, and the Navigation Division, Dr. Lloyd G. Antle, Chief. The present chapters I through V were produced by Richard L. Schultz of the Navigation Division. Dr. Kevin H. Horn and Dr. James G. Crew of Transportation Research and Analysis Center, Inc., both former Corps of Engineers employees, produced chapters VI through X under contract. Support and direction for this manual were provided by the Policy and Planning Division of the Directorate of Civil Works, through Robert M.Daniel, the technical monitor.

Review of the final draft of this manual was provided by members of an ad hoc committee representing the Corps elements concerned with the quality of deep draft navigation data and analytical procedures. A team consisting of John W. Bogue(CESPD), William C. Counce(CECW-PD), Charles E. Hill(CELMV), Maureen B. O'Connor(CENAD), and Michael S. Pelone(CENCB), provided initial comments and suggestions. Additional comments and suggestions were provided by staff members of the Washington Level Review Center and the Board of Engineers for Rivers and Harbors. Kirby B. Fowler(CECW-PD) helped revise and clarify some of the concepts presented. William Hansen of the Research Division, IWR, provided a comprehensive review to assure consistency with other NED manuals. Technical editing was done by Robert F. Norton of the Water Resources Support Center. Numerous versions of the chapters were typed by Shandra J. Myers of the Navigation Division.

Their assistance and the patience of everyone involved is deeply appreciated.

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CHAPTER I

INTRODUCTION

The purpose of this manual is to provide a practical guide for evaluating National Economic Development (NED) benefits of Federal projects to facilitate commercial navigation. The specific types of harbors and waterways to which it applies are described below. The procedures and guidance in this manual are intended to assist its users to perform NED evaluation correctly and expeditiously. They can be used selectively, with the appropriate procedures and level of detail dependent on the specific project.

APPLICATION OF THE MANUAL

WHERE IT APPLIES

Evaluation requirements and benefits are similar for all types of navigation projects. Analytical procedures differ for so-called "inland" and "deep draft" projects, and they are treated separately in evaluation guidance.

- Inland applies to waterways and harbors that function as an interacting system. Channel depths are more-or-less uniform and predominantly nine feet. Vessel sizes are homogenous, and most movements traverse multiple projects. Analysis focuses on the efficiency of the system and comparision of the costs of transportation by alternate modes. Most "inland" projects are riverine, but inland analysis also applies to coastal systems such as the Gulf Intracoastal and Atlantic Intracoastal waterways.

- Deep Draft applies to all other waterways and harbors that are not physically or functionally a part of an "inland" system, regardless of depth or location. Projects can be inland, but most are coastal. They include the so-called U.S. port system, which is an amalgamation of independent projects and ports that compete for commerce. Vessels and the way they operate are diverse, and analysis focuses on vessel efficiency and comparative transportation costs via alternate ports.

This manual applies to deep draft projects. It focuses on evaluation of harbors, but the procedures it describes apply to all of the "all other" waterway and harbor projects. The manual may be useful also in identifying vessel-related costs and benefits when primary project purposes are recreation navigation and commercial fishing.

WHAT IT APPLIES

NED benefits are contributions to national economic development that increase the value of the national output of goods and services. They are the basis for Federal investment in all types of water resource projects. The statutory authority for economic evaluation of Federal water resource projects is contained in the Water Resources Planning Act of 1965. The basic guidance for project evaluation is contained in Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G). Chapter I of the P&G gives the analytical framework for evaluating all types of water resource projects. Chapter II contains benefit evaluation procedures for specific types of projects. The procedures described in this manual amplify or simplify those given in the P&G, based on the actual experience and suggestions of Corps experts. Their intent is to assist the manual user in meeting the P&G requirements correctly and expeditiously. The way to meet study deadlines and budget targets is to get it right the first time.

TO WHOM IT APPLIES

This manual is primarily designed for Corps of Engineers planners who are conversant with the P&G requirements, but whose areas of expertise may not include navigation project analysis. The manual is also designed to be useful to the non-Federal sponsors of Corps navigation projects and navigation project studies. Pursuant to the Water Resources Development Act of 1986 (P.L. 99-662), all of the projects covered by this manual require non-Federal cost sharing of feasibility studies and construction. These projects are also distinguished from inland waterway system projects by a greater variety of vessel sizes and operating practices, and a greater variety of structural and non-structural alternatives that may be implemented by project sponsors and users. There is a real need for each partner to understand the needs and options of the others. This manual alone will not do that, but it should help produce the right questions.

Corps planners, particularly project managers, must be able to explain the concept of NED benefits and the need for rigorous study to customers whose main motivation for cost sharing is local economic development. In turn, the customers can provide their insight as to vessel operating practices, trade practices, and the real needs of the port. Corps planners are unlikely to have that amount of insight because they deal with all types of water resource projects. Exchange of information is needed prior to and during the reconnaissance phase as well as the feasibility study, so that the planning effort will consider sensible alternatives, and produce a recommended plan that is effective, efficient, and reasonably maximizes net NED benefits consistent with the sponsor's ability to pay. Distribution of this manual to interested non-Federal parties is encouraged.

ORGANIZATION OF THE MANUAL

SCOPE AND LIMITS

The focus of this manual is on economic analysis and the correct determination of NED benefits. The procedures it describes have application to all levels of studies for all sizes of commercial navigation projects, allowing for different levels of detail, and apply to most categories of waterborne commerce including all international overseas trade, and domestic coastwise and offshore services. The exception is domestic internal traffic that is associated with the inland waterway system. Although the conceptual basis for NED benefits is similar in all types of navigation projects, this manual does not cover inland waterway system analysis in order to make it a simpler and more useful reference for "all other" navigation projects.

This manual emphasizes the need to use correct costs in determining net benefits, but it does not cover the procedures involved in determining all costs. Almost all project costs are determined through engineering analysis and it is not practical to treat technical and complex subjects such as channel design in this manual. Different disciplines are involved, and typically the determination of project costs and benefits are independent efforts. The user of this manual should be aware of that aspect of the Corps planning process and the need to use other references if more engineering information or cost analysis is desired.

APPROACH AND RATIONALE

The organization of this manual roughly parallels that of the Principles and Guidelines. Introductory chapters cover the underlying planning and economic concepts, and the specific requirements and assumptions of the P&G. Seven subsequent chapters give methods and examples for evaluating "deep draft" navigation projects and presenting the results. The seven main chapters focus on specific study requirements such as Baseline Information, Fleet Forecasts, Commodity Projections, and Multiport Analysis, in order to facilitate reference according to subject matter and related procedures and problems. The chapters do not track the procedural steps outlined in the P&G exactly, but correspond sufficiently, so that cross-reference between the manual and P&G should be easy. This arrangement is to enable users to read the manual sequentially or to refer to it selectively.

OVERVIEW OF CHAPTERS

The emphasis in this manual is on "how to do it", and chapters IV through X constitute the bulk of the manual. Some information on "why to do it" is a necessary preface, and is provided in chapters II and III.

Chapter II. Basic Concepts and Principles. This chapter complements Chapter I in the P&G, and summarizes relevant material in the Planning Guidance Notebook, the Policy Digest, and other sources. Corps planners may find this a useful reference when considering innovative evaluation procedures. For anyone not familiar with the P&G it can be an introduction.

Chapter III. Overview of Project Planning and Evaluation. This chapter summarizes the study procedures and analytical requirements in Chapter II of the P&G that apply to coastal navigation projects. It reviews the P&G evaluation procedures to identify the problems that may be encountered in application.

Chapter IV. Baseline Information. This chapter explains the information needed to determine the study area, describe the planning setting, and calculate transportation costs. It identifies sources of information on vessels, commodity flows, and port practices, and illustrates their use in the calculation of transportation costs.

Chapter V. Fleet Analysis and Forecasts. This chapter provides background on vessel size trends and identifies the factors to be considered in producing a fleet projection or forecast. It describes the different approaches used to produce port-specific, with- and without-project fleets.

Chapter VI. Commodity Analysis and Projections. This chapter describes the procedures for projecting traffic trends and the analysis needed to produce and disaggregate trade forecasts. It identifies the information sources and forecasts that are useful in estimating future traffic at the project port.

Chapter VII. Multiport Analysis. The project port's share of commodity flows may change because of lower transportation costs. This chapter shows how comparative transportation costs via competing ports can be determined, and how this affects the with-project traffic estimates.

Chapter VIII. Describing the With- and Without-Project Conditions. This chapter shows the use of the planning setting in describing the without-project condition, how alternatives are incorporated, and how alternate plans are treated in the with-project conditions.

Chapter IX. Calculation of Benefits and Costs. Project costs and benefits are often the products of independent efforts. This chapter covers integration of the engineering and economic analyses. It describes the appropriate treatment of separable elements, associated costs, and incremental analysis, and the presentation of results to show project optimization.

Chapter X. Report Presentation. The final chapter covers general report requirements, and specific requirements not included in other manual chapters. These include documentation and sensitivity analysis.

CHAPTER II

BASIC CONCEPTS AND PRINCIPLES

The purpose of this chapter is to help the reader understand the logic of evaluation procedures that are described later, and how they apply to the specific project involved. It describes the objectives of Federal investment in navigation projects and the specific concepts and economic principles used to measure how well a project meets those investment objectives.

FEDERAL INTEREST

Verification of the Federal interest in a project is a prerequisite to project implementation. Federal interest is the basis for Federal participation in water resource projects. The extent of Federal interest is the basis for determining cost sharing and other project responsibilities. Study reports should have a conclusive statement of why such interest does or does not exist.

DERIVATION OF FEDERAL INTEREST

The Federal interest in projects to improve navigation is derived from the commerce clause of the Constitution. It is linked to the navigable waters of the U.S. by custom and by court decisions defining the Federal power to regulate commerce. The result is a Federal interest that is widespread geographically, but limited almost exclusively to improvements in or on the water. This has produced a U.S. port system that is unique because of the large number of Federal projects and competing ports, and because physical location is used to determine Federal and non-Federal responsibility for most project components.

DETERMINATION OF FEDERAL INTEREST

Federal interest in a project depends on whether it provides benefits to the public by facilitating commerce. The determination of Federal interest in navigation projects requires identification of the improvements needed, public purpose and access, and the commerce served. These considerations are discussed below.

Project Components. Federal participation in project components is limited to general navigation features such as channels, basins and protective works, and aids to navigation such as buoys and lights. Vessel berths, local access channels, and the facilities to accommodate and service vessels, or to load and unload cargo and passengers, are a local responsibility along with land, easements, and rights-of-way. If such facilities are required to achieve the benefits of the project, they are an integral part of the project; the cost of providing them is an associated cost of the project. Associated costs are part of the project's NED costs, and although they are paid by the non-Federal project sponsor, they offset NED benefits. The equity of non-Federal expenditures reducing project justification eludes many sponsors.

Public Purpose. The fundamental purpose of navigation projects is to facilitate the movement of vessels and the transportation of passengers and cargo. Public purpose requires that there be multiple users and project beneficiaries, or an expectation of multiple use in the future. When there is an initial single user, special project cost sharing provisions apply until the Secretary of the Army determines multiple use has commenced. Administratively, multiple use has been defined as including cargos transported for multiple shippers and receivers by a single carrier; single user has been defined as transportation by one or more carriers for the account of a single shipper/receiver.

Public Access. Federal projects must be open to public use for the projects' purposes. For safety and security reasons it may be necessary to limit access to the waterfront by the general public. For navigation projects, the access required is at least one location with the vessel or cargo service facilities needed to achieve project benefits, open to all users on equal terms. Most ports have a combination of public and private ownership of the waterfront. In single owner situations, current policy guidance is that a public body such as a port authority satisfies the requirement for public access, provided more than one cargo shipper or receiver uses or is anticipated to use the facility. Privately owned non-profit entities such as multi-member cooperatives also qualify, provided membership is not unduly restricted. Sole ownership by a private for-profit enterprise does not qualify, regardless of tariff provisions providing for public use.

Waterborne Commerce. The definition of waterborne commerce was expanded by Congress in 1932 to include recreation activities. Budget priorities for navigation projects may distinguish between recreation benefits and commercial navigation benefits, although both may contribute to national economic development. Accordingly, a distinction is made between commercial navigation and recreation navigation in stated project purpose, and this difference continues through evaluation procedures, cost sharing, and the priorities for project implementation. In reality, a project's benefits may be exclusively recreation navigation including sport fishing, or exclusively commercial navigation including commercial fishing, or benefits may be a combination of the two. For evaluation of recreation benefits, see specific guidance in companion manuals in this IWR series. When projects combine recreation and commercial navigation, cost sharing is determined from project features; and, funding priorities are determined by benefits. Current policy considers commercial navigation benefits to be a priority output, while recreation navigation benefits are not.

FEDERAL OBJECTIVE

The Federal objective is distinct from Federal interest, at least conceptually. It provides investment criteria for Federal participation in water resource projects. The Federal interest determines where the government can spend the taxpayers' money, and largely it has been defined by common law. The Federal objective defines where, in the national interest, the government wants to spend taxpayers' money. Basically, it is determined by legislation or administrative authority and has been subject to change over time.

BENEFITS VS. EFFECTS

Currently, the sole Federal objective for water resource projects is a net contribution to National Economic Development (NED) consistent with protecting the Nation's environment. Navigation projects authorized prior to October 22, 1976 were authorized to include Regional Economic Development (RED) benefits in project justification. Between September 1973, and March 1983, Environmental Quality (EQ) benefits were an objective co-equal with NED. These former objectives are now treated as accounts, and, along with NED and Other Social Effects (OSE), are used to evaluate effects of the project.

BENEFITS VS. TRANSFER PAYMENTS

Typically, the project sponsor's motivation for cost sharing is local or regional economic development (LED and RED, respectively). It may be difficult for the sponsor to see why LED or RED do not contribute to NED, particularly when only NED benefits count for project justification. The fact is, distinguishing RED and LED from NED can be difficult in practice, but conceptually they are different. Benefits to a specific place or region may be at the expense of other parts of the country, and generally this is true when waterborne commerce can be routed through alternate ports. Benefits which are switched from one region to another are viewed only as transfers from the national perspective, and result in no additional national economic development.

NED EVALUATION OBJECTIVE

A project with net NED benefits is economically justified and meets the Federal objective. In order to optimize the Federal investment, the P&G requires identification of the NED plan for the project. This is the plan that reasonably maximizes net NED benefits. The process used to determine economic justification and to identify the NED plan is benefit-cost analysis. This concept is widely used in government and elsewhere to screen investment alternatives. The things that are considered to be benefits and costs also vary widely, including those used by different Federal agencies. The NED benefits and costs for water resource projects, and applicable to deep draft navigation projects, are discussed below.

NED BENEFITS

NED benefits are contributions to national economic development that increase the value of the national output of goods and services. Those goods and services may or may not be marketed, but NED benefits must be expressed in monetary units for benefit-cost analysis. The conceptual basis for determining the value of NED benefits is willingness-to-pay by the users of project outputs. Generally the costs of, and return from, commercial activities are readily quantifiable. The valuation of safety and risk reduction requires special procedures which are explained elsewhere in this manual. The valuation of recreation experience requires specific procedures which are given in the P&G.

Navigation Benefits. The P&G explains the conceptual basis for navigation project benefits. The separate sections on inland and deep-draft navigation have examples to illustrate project contributions to NED. The benefits of navigation projects covered by this manual may be any or all of those shown for deep-draft navigation, and may include some of those shown for inland navigation when the project serves inland or coastwise commerce. All of the examples are commercial navigation benefits. In summary, they include:

- Reduced cost of transportation through use of vessels (modal shift), through safer or more efficient operation of vessels and/or use of larger and more efficient vessels (channel enlargement), and through use of new or alternate vessel routes (new channels or port shift).

- Increased net return to producers from access to new sources of lower cost materials, or access to new and more profitable markets (shift of origin or destination).

- Increased production through new or greater production opportunity (commercial fishing and offshore minerals), or new economic activities involving new commodity movements (induced movements).

Other NED Benefits. A navigation project may produce NED benefits incidental to the project purpose. A benefit that is recognized as a NED benefit by the P&G for any project purpose should be counted in the evaluation of the navigation project. Such benefits include recreation, storm (flood) damage reduction, location or land enhancement by filling with dredged material, and utilization of unemployed or underemployed labor. When a mixture of benefits is involved, navigation improvements may be authorized via a multi-purpose project. Such projects are rare. Most multi-purpose projects are on the inland waterway system. Historically, the analyst had the option of not counting all benefits of a project when the additional effort required would not affect justification. This is no longer an option because benefits can affect project funding priority and cost sharing.

The creation or expansion of port land by filling may be a beneficial use of dredged material. However, there is no Federal interest in a Corps project that is intentionally or effectively a land development project, and the budget priority for a navigation project is low when land enhancement is a large incidental benefit. The guidance for a Los Angeles-Long Beach Harbor study was that the extent of Federal interest would be determined from a net benefits optimization without land enhancement benefits. In other words, the NED plan used to determine Federal/non-Federal costs should not be affected by land enhancement benefits.

Other NED benefits of a navigation project may include reduced landside transportation costs, if it can be demonstrated that cost reductions will occur because of the project and would not occur without it. The basis for claiming such benefits is the P&G requirement to consider all transportation costs from origin to destination. Since the P&G does not specifically recognize landside transportation benefits, an obligation to claim such benefits and show associated costs does not apply. The acceptability and amount of such benefits will depend on how good a case can be made that the project is the proximate cause of the cost reductions, how well the cost reductions can be documented as part of origin-destination transportation costs, and whether all associated costs have been identified. Generally, this will limit benefits to the reduced cost of cargo handling or reduced inland transportation costs attributable to specific improvements in the immediate port area.

NED COSTS

NED costs are the economic value of resources consumed by or dedicated to the project, regardless of who pays for them. Because the monetary value of environmental impacts are not readily quantifiable, at least to everyone's satisfaction, the costs of restoration or measures to mitigate impacts are used as NED costs. There are no offsetting benefits for those costs. So far, no Corps project has provided environmental enhancement or improvement as a specified project output. If it were a specified output, the costs would be NED costs, but offsetting benefits could be claimed. Section 907 of the Water Resources Act of 1986 (P.L. 99-662) provides that enhancement benefits "shall be deemed at least equal to the costs of such measures."

Incremental Analysis. Economic justification applies to each useable increment of a project, including any existing improvements at the project site. Therefore, a basic requirement is to identify all project costs, with and without the improvements under consideration. The incremental NED benefits of the new improvement are compared with all incremental NED costs. The economic justification of the existing improvements, if called for, is determined by comparing existing benefits with the cost of operating and maintaining the existing improvements. The initial costs of constructing the existing improvements are excluded, based on the concept of "sunk costs".

Associated Costs. If new or additional port facilities are required to achieve the benefits of the project, they are a non-Federal responsibility. However, their cost is an associated cost that must be accounted for in the evaluation. Associated costs for vessel, cargo, passenger, or other port facilities may be handled by the "self-liquidating cost" concept. That is, the cost of the facility is assumed to be liquidated by user charges. That concept may be used only if benefits are reduced by the amount of user charges needed to recover associated costs. Actual user charges may not be based on full cost recovery, and it is generally desirable to handle associated costs as additional project costs rather than as a reduction to project benefits. Cost estimates may be available from the non-Federal interest responsible, or estimated as other project costs.

User Fees. Pursuant to the Water Resources Development Act of 1986 (P.L. 99-662), Federal user charges will be assessed for use of certain waterways (fuel tax) and harbors (harbor maintenance fees), and project sponsors may assess local user fees to recover their project cost share. These fees do not reduce the NED cost of the project. Conceptually, they are treated as transfer payments. If the evaluation procedure uses transportation or vessel operation costs that include user fees, and NED benefits are reduced thereby, the reduction that can be attributed to user fees can be included as an additional project benefit.

NED NET BENEFITS

Importance of Maximum Net Benefits. The comparison of NED benefits and costs is generally expressed as the ratio of benefits to costs. Economic justification requires that benefits exceed costs and therefore the B/C ratio must exceed 1.0. The B/C ratio is a convenient device to verify justification, but net benefits are a better measure of the contribution of the project to national economic development. The highest B/C ratio and maximum net benefits for alternate plans or different scales of a plan may not coincide. Conceptually, the most efficient use of resources is when benefits exceed costs by the maximum amount. Therefore, maximum net NED benefits are used as the sole determinant of the most efficient plan or plan scale.

Identification of Maximum Net Benefits. All reports should include information and data sufficient to define the upper (maximum net benefit) and lower portions of the net benefits curve for a number of alternative plans and plan scales. So that the relationship between costs and benefits is evident, the total benefit and total cost curves, and the incremental benefit and incremental cost curves should be shown for each alternative plan or plan scale. The relationship between costs and benefits, discounted to account for the time value of money and expressed in average annual values or equivalents, determines the most efficient plan.

BASIS FOR PLAN SELECTION

The P&G has a general requirement that all studies formulate and evaluate alternative improvement plans. The aim is to provide a basis for determining the completeness, effectiveness, efficiency and acceptability of the recommended plan. The comparison of NED benefits and costs serves as the basis for determining the efficiencies of the various plans, including the locally preferred plan if it differs from the Federally supportable plan (NED plan or granted exception to the NED plan). The cost of the Federally supportable plan is the foundation from which special cost sharing for the locally preferred plan is determined.

WITH- AND WITHOUT-PROJECT CONDITIONS

The bases for evaluating alternative plans are the assumptions of what the with- and without-project conditions will be in the project setting, over the expected life of the project. The purpose of making the distinction between with- and without-project conditions is to isolate the changes that are expected to occur as a result of the project, from changes that would occur if the project were not undertaken. In defining the with- and without-project conditions, the P&G require consideration of the alternatives available to project users. The objective is to identify the improvements really needed, and to establish the basis for measuring benefits.

PREVAILING CONDITIONS AND PRACTICES

Typically, the users of a navigation project have numerous alternatives as to the vessels used, operating practices, routing, and shoreside facilities. The bases for measuring benefits are the prevailing project site conditions and practices, including any alternatives likely to be implemented by project users, regardless of whether they coincide with design criteria or economic theory.

RISK ANALYSIS

A variety of vessels, with wide variation in their operating practices, use "deep draft" waterways and harbors. Analysis of vessel risktaking may be needed or desired in order to explain apparent deviation from Corps design standards for underkeel clearance and channel width, or to establish the value of safety benefits. This risk analysis must be based on actual deviation from Corps design criteria and intrusion into the "safety clearance zone." Accordingly, it is essential to identify actual vessel operating practices and the alternatives employed to minimize intrusion into the safety zone (tides, speed, trim). To the extent those alternatives permit use of larger or deeper vessels than implied by Corps design criteria, the alternatives are to be reflected in without- and with-project conditions. To the extent vessels actually intrude into the safety zone, risk-accepting behavior may be assumed, and vessel operating cost reductions can be attributed to any net reduction in risk. The benefit evaluation logic used is that transportation firms will accept risk up to the point where the incremental revenue from accepting risk equals the incremental cost of the risk. Equilibrium between incremental revenue and incremental risk cost may be assumed to occur at the actual operating drafts and clearances of the vessels intruding into the safety zone.

CHAPTER III

OVERVIEW OF PROJECT PLANNING AND EVALUATION

The purpose of this chapter is to provide a review of the planning and evaluation processes for navigation projects and to identify the specific areas where analytical problems are likely to occur.

PLANNING GUIDANCE

Principles and Guidelines (Executive Order 11747) is the basic guidance for planning and evaluating Federal water resource projects. Consistency with the P&G is a basic requirement in all studies and all supplemental guidance, including this manual. This consistency requirement is absolute with respect to basic principles and acceptable benefits. Flexibility is allowed in following the P&G's benefit evaluation procedures, but should be used for good reason. Specifically, evaluation procedures may need modification because of project-specific conditions. Standards, including the planning process, are covered in P&G Chapter I. Evaluation procedures are covered in P&G Chapter II. The P&G procedures directly related to the purpose of this manual are Deep-Draft Navigation (Section VII). Other procedures that may apply include Inland Navigation (Section VI), Recreation (Section VIII), and Commercial Fishing (Section IX).

Planning Guidance Notebook (ER 1105-2-100) is the principal reference for performing Corps water resource studies. It is an Engineer Regulation (ER) that consolidates P&G study requirements and others imposed by law (e.g. cost-sharing pursuant to P.L. 99-662) and policy determinations. The several parts of the Notebook cover study content and format, and economic and environmental considerations. The Notebook has been revised and reissued at irregular intervals to incorporate new requirements and guidance, with interim guidance provided via Engineer Circulars (EC's) and Engineer Pamphlets (EP's). The comparable engineering guidance is contained in Engineering After Feasibility Studies (ER 1110-2-1150) and Engineering and Design for Civil Work Projects (draft ER accompanying EC 1110-2-268). The ER's that provide engineering and design guidance are brief, but incorporate an amount of material similar to the Planning Guidance Notebook by reference to Engineer Memorandums (EM's).

Economic Guidance Memorandums. These update data used in planning studies. They have been issued as needed since 1989, in lieu of the Planners Reference Handbook which was issued annually. The data include the current discount rate used to adjust project costs and benefits for the time value of money ("present worth"), and values used in specific types of project studies such as unit day recreation values and vessel operating costs. The Handbook was published by the U.S. Water Resources Council prior to 1984. Thereafter it was prepared and issued as an EC by the Directorate of Civil Works Planning Division.

Other Guidance. The above-cited guidance identifies the basic requirements and assumptions to be used in planning studies. Numerous Corps publications provide additional information to explain study requirements and procedures. The most relevant references for the purpose of this manual are as follows: Digest of Water Resources Policies and Authorities (EP 1165-2-1, 30 June 1983) Hydraulic Design of Deep-Draft Navigation Projects (EM 1110-2-1613, 8 April 1983), Layout and Design of Shallow Draft Waterways (EM 1110-2-1611, 31 December 1980).

PLANNING STUDIES

The several distinct, but related, types of projects and studies to which this manual applies are identified below.

TYPES OF PROJECTS

Commercial navigation projects may be constructed pursuant to specific Congressional authorization, or under so-called "Continuing Authorities" delegated by Congress.

Congressionally Authorized Projects may provide any combination, and size, of general navigation features such as channels, jetties, breakwaters, and basins. Regardless of size, evaluation is required in sufficient detail to support a Chief's Report with recommendations to Congress.

Continuing Authority Projects are for specific purposes. They are subject to program or project limits on Federal expenditures, and thus are limited in size. There are six so-called "Special Navigation Programs" that may involve commercial navigation and to which this manual may apply. A listing of these projects follows. (legislative authority in parenthesis)

(1) Small Navigation Projects (Section 107, R&H Act of 1960). These differ from Congressionally authorized projects only in size. Evaluation is required. Procedures are the same as any other harbor or waterway project, except for level of detail.

(2) Snagging and Clearing for Navigation (Section 3, R&H Act of 1945). Evaluation is required. Any commercial or recreation navigation benefit may apply.

(3) Drift and Debris Removal (Section 202, WRDA of 1976). Evaluation is required. Benefits are generally commercial and/or recreation vessel damage reduction, but may include restoration or increase in property values and other NED benefits.

(4) Removal of Wrecks and Obstructions (Section 19, R&H Act of 1899). No evaluation is required.

(5) Modification of Bridges that Obstruct Navigation (P.L. 76-647, Bridge Alteration Act). Evaluation is required. Currently the program is administered by the Coast Guard. Evaluation uses U.S. Department of Transportation benefit-cost criteria.

(6) Mitigation for Shore Damage Due to Federal Navigation Projects (Section 111, R&H Act of 1968). Evaluation is required for cost allocation and justification of any additional purposes such as storm damage reduction and recreation.

TYPES OF STUDIES

The planning studies associated with commercial navigation projects have specific names and categories that are defined in planning guidance. This manual applies to all studies categorized as "implementation studies". Pre- and post-authorization studies are sub-categories of implementation studies, and include reconnaissance, feasibility, and reevaluation studies. The various studies and related study requirements are discussed below.

Study Level and Use of P&G. The implementation category is used to distinguish project-specific studies from broader Corps studies such as national or regional framework studies and river basin studies. Sometimes they are referred to as Level A, B, or C studies. The implementation or Level C studies may be called feasibility studies, but that term should be reserved for a specific sub-type of study. The important thing is that the P&G applies to all implementation studies, including related guidance such as this manual.

Study Authority. Generally, the pre-authorization studies covered by this manual will require specific Congressional authorization, and the post-authorization studies will not. Specific study authority, by way of legislation or resolutions of appropriate Congressional committees, is required if the project is to be Congressionally authorized. The continuing authorities programs generally allow the Corps to initiate studies, but in practice this license is reserved for emergency actions such as wreck removal. Except for such emergency work, all pre-authorization planning is performed in two phases. This two-phase planning process applies whether the authorization is directed by Congress, or via a continuing authority program with project approval by the Assistant Secretary of the Army for Civil Works.

Two-Phase Planning Process. Two phase planning was established administratively and incorporated into law via P.L. 99-662. The two phases are a preliminary or reconnaissance phase performed at Federal expense, and a final or feasibility phase normally cost-shared 50-50 by the Corps and the project sponsor. The purpose of phasing is to postpone the effort and expense of detailed engineering and economic evaluation until there is a determination by the Federal and local interest that an improvement is likely to meet an identified need.

Reconnaissance Studies. The purpose of the reconnaissance study is to produce a report that recommends for or against further study, with appropriate supporting information. The required information includes the following:

(1) definition of the problems, opportunities, and potential solutions;

(2) identification of an economically feasible potential project, project alternatives, benefits and costs, and environmental and other impacts;

(3) identification of the extent of Federal interest in the project, and local interest and support for the potential solutions; and,

(4) an estimate of the scope and cost of feasibility phase studies, if further study is recommended.

The reconnaissance phase study effort should be adequate, but no more than adequate, to develop the information that supports the report's recommendations. A rule-of-thumb used in budgeting for such studies is that cost should not exceed 20 percent of total cost of preauthorization studies. The report for a Congressionally authorized project is always called a reconnaissance report. For continuing authority projects, an abbreviated version called an initial appraisal may be used.

Feasibility Studies. The purpose of the cost-shared study phase is to produce a decision document that recommends the specific improvement or combination of improvements that meets Federal investment objectives with project sponsor support. Chapter 2 of the Planning Guidance Notebook describes the format and content for reports. The key report requirements are for a discussion of plan formulation including identification and assessment of problems, planning constraints, and alternative plans; a description of the selected plan; and the plan for project implementation including identification of responsibilities and cost-sharing. The level of effort required will vary with project size, and for most Congressionally authorized projects, detailed analyses of costs and benefits are shown in appendices to the main report.

In general, the level of detail in feasibility reports is related to project size. The engineering analysis may use conceptual design, but detailed design and cost analysis may be required. In the case of Congressionally authorized projects, reauthorization is required if final cost estimates exceed the feasibility report estimates by 20 percent, after allowance for price inflation. The same measure of accuracy is not applied to benefits or continuing authority programs, but it may be used as a guide. The decision document produced in this phase is called a Feasibility Report for Congressionally authorized projects, a Detailed Project Report for continuing authority projects.

Post-Authorization Studies. This manual applies to certain post-authorization studies that do not require specific study authority. These include reevaluation studies performed routinely prior to project construction, and to studies of completed projects pursuant to Section 216 of the R&H Act of 1970. The latter are performed when there is a significant change in physical or economic conditions, and their application to deep draft projects is limited. Reevaluation is required with all Congressionally authorized studies to demonstrate the economic efficiency of the recommended plan after completion of detailed design, and plans and specifications. The amount of study effort will depend on the extent of changes in design and the economic activities in the study area since completion of the feasibility report. At a minimum, the reevaluation will require updating of costs and benefits. The reevaluation report usually accompanies the General Design Memorandum (GDM), but may require consideration of subsequent Detailed Design Memoranda. In the case of continuing authority projects, detailed design is usually produced for the Detailed Project Report (DPR). Unless there is a significant change from the approved DPR, or an extended delay prior to construction, no further economic analysis is required.

PLANNING PROCESS

The P&G prescribes a planning process that applies to all types of water resource projects. The process is described using a series of steps. The same process and same steps apply to all types and levels of studies. The steps show the logical sequence for performing the overall study, and are summarized below.

STEP ONE: SPECIFICATION OF PROBLEMS AND OPPORTUNITIES, FEDERAL INTEREST, AND STATE AND LOCAL CONCERNS

All of the pre-authorization studies covered by this manual are initiated in response to perceived needs by local interests. The perception of problems and potential solutions is unlikely to be the same for everyone involved, and the first step is to sort out the real problems and determine whether they can be addressed within the Federal objective. Problems and opportunities are to be stated for both current and future conditions. This initial identification of problems and opportunities may be modified during the subsequent planning process.

STEP TWO: INVENTORY AND FORECAST OF PROJECT-RELATED RESOURCES AND CONDITIONS

The inventory and forecast is used to determine the potential of a navigation project to alleviate problems and realize opportunities. The brevity of the P&G's description of Step Two obscures the fact that it calls for two determinations. The first purpose of the inventory is to identify actual conditions; the second is to verify whether the problems and opportunities specified in Step One are correct. Step Two should determine whether a project will work, as well as whether it may be justified based on present and future commerce of the harbor or waterway. Respectively, steps One and Two identify the project wanted and the project needed. The subsequent steps are to determine the right project.

STEP THREE: FORMULATION OF ALTERNATIVE PLANS

Alternative plans are to be formulated in a systematic manner to insure that all reasonable alternatives are evaluated. Usually, a number of alternative plans are identified early in the planning process and become more refined as the study progresses. Additional alternative plans may be introduced at any time. Each alternative plan is to be formulated in consideration of four criteria: completeness, effectiveness, efficiency, and acceptability. Appropriate mitigation of adverse effects is to be an integral part of each plan.

STEP FOUR: EVALUATION OF EFFECTS

In order to evaluate and compare alternative plans in a systematic way, the P&G requires identification and measurement of the effects of the plans on the economy and the environment. The P&G specifies four accounts to be considered: National Economic Development, Regional Economic Development, Environmental Quality, and Other Social Effects. In the case of NED, and usually RED, positive and negative impacts are readily available in monetary values. EQ and OSE cannot be quantified in the same terms, and must be assigned social values. The process of assigning values is called appraisal. The process of using the values to measure or estimate the effects of each plan is called assessment.

STEP FIVE: COMPARISON OF ALTERNATIVE PLANS

The final screening process brings together consideration of economic efficiency and evaluation of effects. At this point, the best compatible elements of different plans may be combined, provided they are incrementally feasible and justified.

STEP SIX: PLAN SELECTION

The alternative plan with the greatest net economic benefit consistent with protecting the environment (the NED plan) is to be recommended unless there is an overriding reason for selecting another plan. An exception must be granted by the Assistant Secretary of the Army for Civil Works to support selection of a plan other than the NED plan.

EVALUATION PROCEDURES

The P&G gives NED benefit evaluation procedures for each type of water resource project. The procedures for evaluating transportation benefits of deep-draft navigation are shown in Section VII of Chapter II. Similar to the P&G description of the planning process, evaluation procedures are presented as a series of steps. Both sets of steps in the P&G are study requirements that must be addressed adequately. There are critical differences in how closely the planning steps and evaluation steps can be followed. Figure III-1 shows the evaluation steps in P&G Figure 2.7.4.

EVALUATION PROCEDURE SEQUENCE

The planning process steps in the P&G are numbered in the logical order for performing the overall study and for presenting the results in a report. The same sequence of steps applies to both. The evaluation procedures in the P&G are also presented as numbered steps. Those steps are in the logical order for presenting the results of evaluation in the report's economics chapter or economics appendix, but certain procedures cannot be performed in that order successfully. The P&G evaluation steps are a checklist, but should not be followed slavishly. Figure III-2 shows the evaluation sequence suggested in his manual.

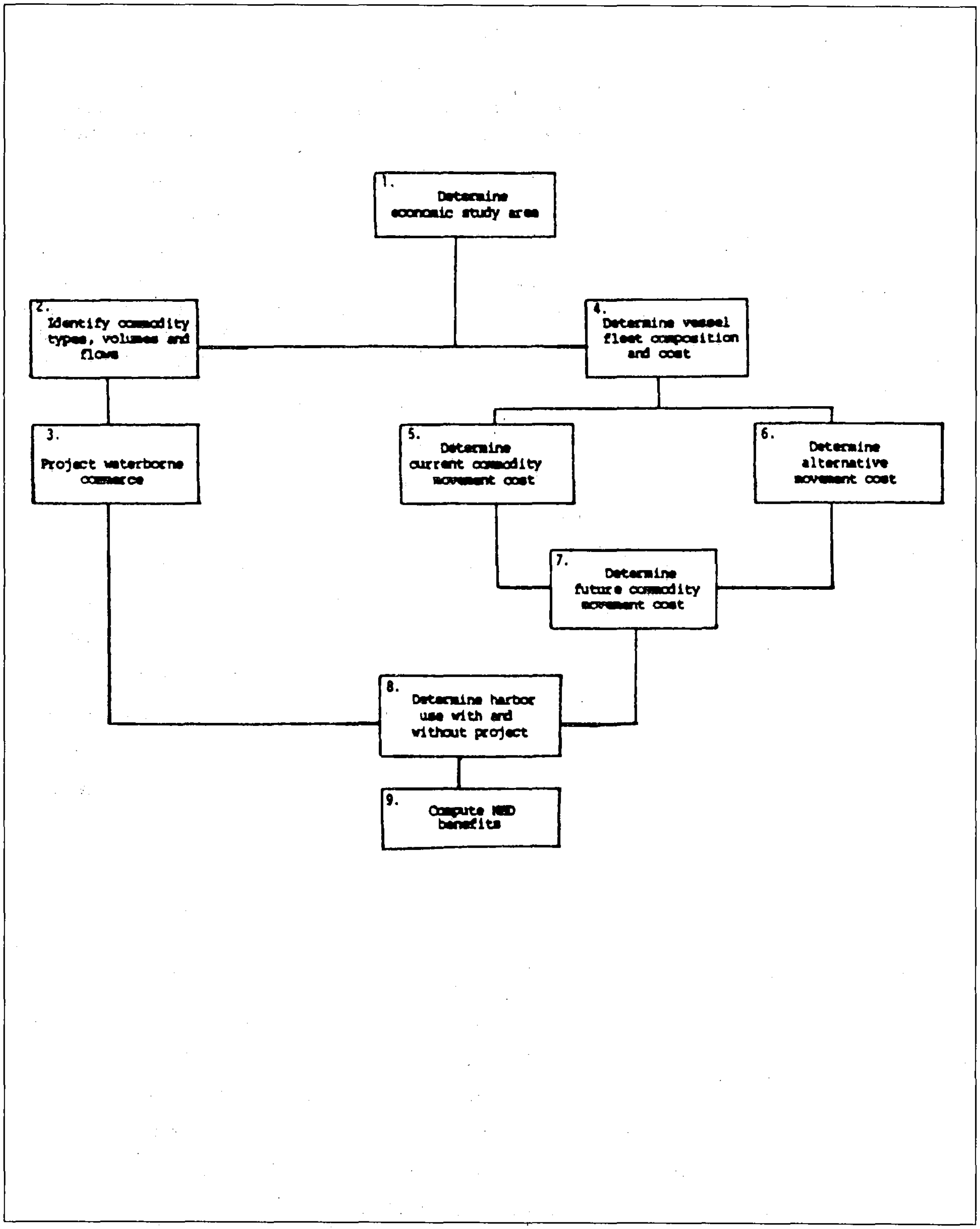


FIGURE III-1. ECONOMIC EVALUATION PROCEDURES, THE P&G STEPS

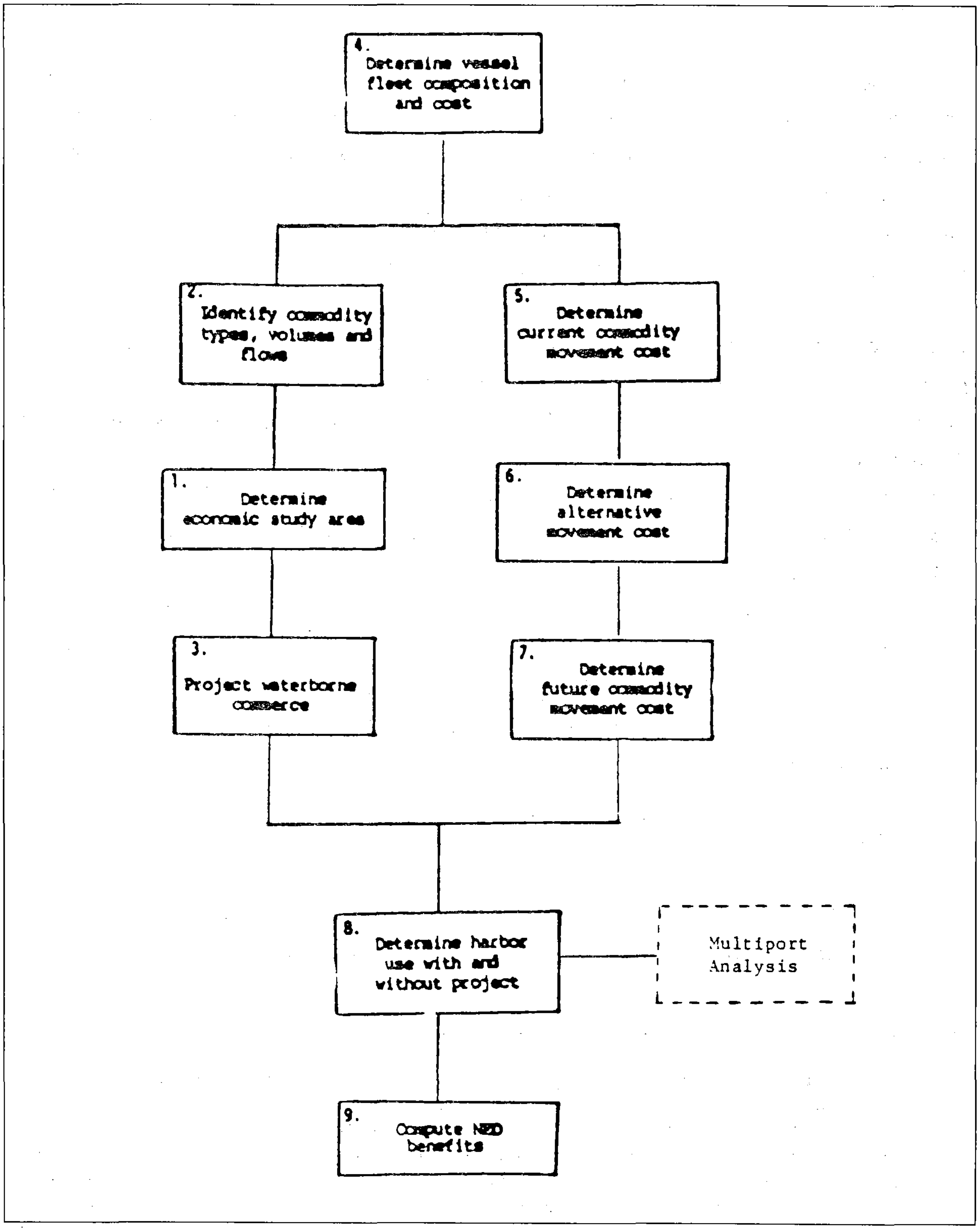


FIGURE III-2. ECONOMIC EVALUATION PROCEDURES, THE SUGGESTED SEQUENCE

ALTERNATE EVALUATION PROCEDURES

It is important to note that the evaluation steps shown in Figure III-1 apply only to transportation cost reduction benefits. In practice, transportation cost savings are the main benefit of commercial navigation projects. They tend to be the only benefits evaluated because they are easiest to claim and quantify. If additional transportation benefits can be identified, they can be quantified, and all project benefits should be evaluated.

Other deep draft transportation benefits include increased net return to producers and increased or new production due to greater production opportunity. The P&G recognize that these additional benefits may apply, but do not give specific guidance for evaluating them. The evaluator has a license to devise the alternate procedures needed to identify and quantify the additional benefits. This manual provides guidance for doing so. The general rule is to follow P&G guidance to the extent it is applicable; the procedures given cover the transportation costs that affect returns to producers. The general rule for use of alternate procedures is to cite a source in other planning guidance. Absent such a reference, alternate procedures should be used only after consultation with the Directorate of Civil Works, Policy and Planning Division.

EVALUATION STEPS

The following summaries supplement the descriptions of each procedural step shown in the P&G and identify some of the problem areas.

STEP ONE: DETERMINE THE ECONOMIC STUDY AREA

The inland trade region served by a port is called its hinterland. That hinterland usually consists of a number of cargo hinterlands defined by the inland origins or destinations of specific commodities. Collectively, the cargo hinterlands of actual and potential commerce of the project port define the economic study area. That economic study area is seldom limited to the immediate port area; typically, no more than half of a port's commerce is generated there. The port area and port area political jurisdictions are part of the planning setting, and it is critical to distinguish between planning setting and study area. Evaluation should focus on study area, but normally it is impossible to start with this step. It is necessary to identify commodity flows before describing the economic study area.

STEP TWO: IDENTIFY TYPES AND VOLUMES OF COMMODITY FLOW

The composition of a port's commerce is readily available from Waterborne Commerce of the United States. Those statistics cover about 2500 harbor and waterway points. Use of other sources of information is required in order to identify the domestic and overseas origins and destinations of specific commodities. A large number of origins and destinations can be involved even for a single commodity, and the study may cover multiple commodities. It may be impractical to trace all cargo flows, and some studies have tried to avoid the effort entirely. Generalized descriptions of domestic port hinterlands based on interviews or secondary sources have value for some purposes, but there is no substitute for data that trace at least some of the flows. Adequate origin-destination identification is needed to support traffic projections. Multiport analysis is impossible without it.

STEP THREE: PROJECT WATERBORNE COMMERCE

There are many acceptable ways to project or estimate a port's future commerce, but they have to be linked to the port's hinterland and the extent to which it shares commodity flows with other ports. That is the fundamental premise of the P&G and the reason why it calls for determination of the study area first (even though identification of cargo flows may be a prerequisite). The projections or estimates of port commerce should be a sensible share of trade route, national, and world trade, supported by analysis of the economic potential of the port's hinterlands. Simply stated, port traffic forecasts should not take commerce (and benefits) that belong to other ports. The validity of commodity projections will depend on accurate identification of hinterlands.

STEP FOUR: DETERMINE VESSEL FLEET COMPOSITION AND COST

Although the P&G shows this as the fourth step, it is usually advantageous to perform it first. It will identify the vessels, and therefore the cargos, that may benefit from harbor improvements (or verify problems and potential benefits previously identified). That identification will provide a basis for limiting or focusing study efforts on the commodities that are likely to be benefitted. The reduction in effort can be substantial, and this simplification is encouraged by the P&G. Identification of the present and future port fleets are separate but related efforts, and the P&G does not make a clear distinction between them. This step is a necessary prerequisite to the forecast of future with- and without-project fleets in Step Seven. It should identify the way actual vessels actually operate (lightloading and use of alternatives) so that the assumptions used to produce port-specific fleet forecasts are valid and can be supported.

STEP FIVE: DETERMINE CURRENT COST OF COMMODITY MOVEMENTS

The basic premise in NED evaluation is that cost considerations will determine the choice of cargo routings and the types of vessels used. In real life other considerations may apply, but transportation costs are the only scientific way to predict choice. Some studies have sought to minimize effort by looking at changes in vessel costs only. The P&G requires full origin-to-destination costs in order to determine whether there will be any change in hinterland size due to the project. Only if there is some other way to prove no change in hinterlands can inland costs be ignored.

STEP SIX: DETERMINE CURRENT COST OF ALTERNATIVE MOVEMENT

A variety of alternatives may be employed that can affect the need for and justification of the project. The alternatives include vessel operating practices, unconventional port facilities and vessels, and cargo routing through alternate ports. These so-called non-structural alternatives are implemented by non-Federal interests, and logic says that the ones deemed cost-effective are now employed. The P&G requires evaluation of such alternatives because their NED cost is independent of who pays for them. Simply because the P&G calls for evaluation of alternatives in Step Six, many studies have tried to do so all at one time. That is difficult to do. This manual suggests evaluation of specific types of alternatives at separate points throughout the study, in order to dispose of them in a systematic way.

Alternative	Evaluation	Disposition
Vessel Operating Practices	Baseline Information	Project Conditions
Unconventional Facilities	Baseline Information	Planning Setting
Unconventional Vessels	Fleet Analysis	Fleet Forecast
Alternate Ports	Multiport Analysis	Traffic Projections

STEP SEVEN: DETERMINE FUTURE COST OF COMMODITY MOVEMENTS

NED evaluation uses price levels at a common point in time for all cost and benefit estimates. Effectively, any difference in current and future commodity movement costs depends on improved efficiency in transportation. The project may permit or induce improvements in port facilities and rail or road infrastructure, but predominantly efficiency will improve because vessels can carry bigger loads or larger vessels can be employed. Since vessels tend to be larger and more efficient over time, there is a potential for attributing improvements to the project that would occur without it. The correct determination of the port fleets with- and without-project is critical. The project improvements may in fact attract more efficient vessels, but the competition for those vessels has to be taken into account. As with commodity projections, the port fleets should contain a sensible share of the vessel sizes in the world fleet and the port's trade routes and coastal range. Simply stated, fleet forecasts should not take the vessels and benefits that belong to other ports.

STEP EIGHT: DETERMINE USE OF HARBOR AND CHANNEL WITH- AND WITHOUT-PROJECT

This step integrates the results of preceding steps and multiport analysis. The latter is required to determine the effect of project investment on other Federal projects. It provides a final adjustment to the projected commerce of the project port. Provided the preceding steps have been performed properly, the multiport analysis requires only incremental effort, and the integration is simply a clear statement of with- and without-project conditions. Some studies show an excess of imagination with respect to changes produced by the project, but more often the problem is inadequate description of the without-project condition. It may be possible to glean the without-project condition from information that is shown elsewhere in the report, but it should be stated.

STEP NINE: COMPUTE NED BENEFITS

The final step is to determine the NED plan by comparison of alternate improvement plans. The net benefits for a single plan will show only whether it is justified. In order to demonstrate that the NED plan reasonably maximizes net benefits, some type of comparison is needed. The alternate plans that can be used for comparison purposes include (1) alternate or different types of improvements; and, (2) incremental scale of improvements. The number of alternative plans will depend on site-specific conditions. Many studies screen out alternative improvements in preceding steps, and this step is used only to optimize size. The accuracy of this step will depend on how closely costs and benefits are matched. When channel deepening is involved, the optimal depth must be identified to the nearest foot. Some studies have used substantially larger increments. In order to provide an acceptable level of precision, it is essential to anticipate the need for incremental justification early in the study, so that the economic and engineering analyses will have comparable levels of detail.

ANALYTICAL ASSUMPTIONS

The P&G provides certain assumptions that are to be used in describing the with and without project conditions. These assumptions apply to conditions that otherwise cannot be determined conclusively, or would require disproportionate study effort. The following assumptions are equally applicable to with- and without-project conditions, and should be used.

(1) Alternate harbor and channel improvements available to the transportation industry over the planning period include those in place and under construction at the time of the study and the authorized improvement projects that can reasonably be expected to be in place over the planning period.

(2) Authorized operation and maintenance is assumed to be performed in the harbors and channels over the period of analysis unless clear evidence is available that maintenance of the project is unjustified.

(3) In projecting commodity movements involving intermodal movements, sufficient capacity of the hinterland transportation and related facilities, including port facilities, is assumed unless there are substantive data to the contrary.

ANALYTICAL REQUIREMENTS

The P&G contains specific and general assumptions and requirements that are to be observed in NED evaluation. The specific procedures to meet analytical requirements are addressed elsewhere in this manual. Clarification of certain basic requirements follows:

ALTERNATIVES ANALYSIS

The P&G contains general requirements to analyze project alternatives and alternatives to the project. The latter are described in the assumptions to be used in describing without- and with-project conditions. Essentially, these are non-structural measures that can be implemented by non-Federal agencies and project users that reduce or eliminate the need for Federal project investment. The assumptions given for the without- and with-project conditions differ significantly. Without-project alternatives include an array of practices, facilities, and the use of alternate ports. The with-project assumptions are limited to operating practices that can be used in conjunction with a Federal improvement. This recognizes the impracticality of a Federal project, structural or non-structural, that is dependent on others for implementation.

SYSTEM ANALYSIS

The P&G does not contain a general requirement for system analysis. However, it is required in almost all navigation studies because the P&G emphasizes system considerations and requires evaluation of all reasonable alternatives. P&G procedures specifically require system analysis for inland waterways. The requirement is implicit in the deep-draft requirement for multiport analysis, and by extension applies to all commercial and recreational harbors. The inland requirement focuses on the waterway system and the effect of the project on system delays. The analysis for harbors requires consideration of project impact on the port system or alternate ports, and the transportation system or vessel fleet composition.

SENSITIVITY ANALYSIS

The P&G contains a general requirement to analyze risk and uncertainty in Chapter I and specifies certain sensitivity analyses for inland and deep-draft navigation in Chapter II. The general requirement is to identify all assumptions, predicted variables, estimated values, and parameter values which are critical to the report recommendation, and the value of each critical factor where the recommendation would change or feasibility would be questioned. The specific analyses which are, or may be, required address assumptions as to traffic projections, rates or vessel operating costs, and vessel fleet composition or characteristics. Whenever benefits are dependent on the size and life of a resource, as in commercial fishing, sensitivity analyses may be needed.

CHAPTER IV

BASELINE INFORMATION

Baseline information is the foundation for NED analyses and benefit calculations. It should describe what is happening at a harbor and why. The purpose of this chapter is to make the data acquisition effort as useful and as economical as possible.

USES OF BASELINE INFORMATION

There are three specific products to be produced from baseline information. Those direct products are summarized below and described further in subsequent chapter sections. They address specific evaluation requirements of the Principles and Guidelines (P&G), and there is explicit guidance for their use. Baseline information can be helpful in plan formulation also, but there is no specific guidance for that use. It is treated below as a data by-product.

DIRECT PRODUCTS OF BASELINE INFORMATION

The P&G calls for determination of the economic study area, the vessel fleet composition, and commodity flows in three separate procedural steps. The determinations have a common starting point in current and historical data. A comprehensive baseline effort is the most efficient way to acquire that data and make initial determinations. Analysis and forecasting of fleet composition and commodity flows are covered in subsequent manual chapters.

Description of the Planning Setting. This is used to describe with- and without-project conditions. The information needed includes identification of physical and institutional constraints, and port and vessel operating practices including use of alternatives.

Definition of the Study Area. This is used to determine the type and amount of port commerce that may be benefited. It is identified using vessel traffic and commodity flow statistics.

Determination of Transportation Costs. These are needed to determine the value of benefits. The costs include ocean and inland transportation, and port charges.

BY-PRODUCTS OF BASELINE INFORMATION

The P&G specifies considerations to be used in plan formulation but gives little procedural guidance. Typically, plan formulation relies on identification of problems and opportunities by local interests, and the individual formulating proposed solutions is unlikely to be the one responsible for NED evaluation. Regardless of whether there is routine communication between these individuals, there may be a need for information exchange.

Verification of Problems and Opportunities. The initial identification process relies heavily on extreme examples of problems (usually associated with commerce the port already has) or opportunities (usually commerce the port would like to attract). If baseline information does not support the problems and opportunities identified, or identifies new ones, the plan formulator should be notified promptly.

Identification of Problems and Opportunities. Plan formulation is easiest when local interests know exactly what they want and are willing to state it. When their perceived needs are not clear, or differ and conflict, use of independent judgement may be required. The plan formulator should be able to use baseline information as a reference when an authoritative description of the project setting is needed.

Realistic Alternative Plans. There are a number of operating alternatives that minimize the need for harbor and waterway improvements. The P&G requires NED benefits to reflect the alternatives employed, and project sponsors are unlikely to pay for improvements unless they are really needed. Improvement plans should reflect realistic with- and without-project conditions determined from baseline information.

DETERMINING THE RELEVANT INFORMATION

The key to having the right information at the right time and keeping the data acquisition effort within budget, is to be selective. If there is no identifiable use for data, collecting it is counterproductive. Other considerations follow.

DISTINCTION BETWEEN PLANNING SETTING AND STUDY AREA

It is important to recognize that for most navigation projects, unlike most flood protection projects, the planning setting and economic study areas are geographically different places. They are related, but except for small, purely local projects, describing the setting will not automatically describe the study area.

The planning setting is a set of assumptions covering the physical, economic, and policy conditions that will apply at the project site in the future. Those assumed conditions are very important in determining what project will be acceptable to local interests and can be implemented with cost sharing. However, only to the extent that port commerce originates or ends in the immediate port area is the setting relevant to future traffic levels.

The economic study area is the inland trade region served by the project port. The geographical extent of that region is determined by cargo origins and destinations, and the extent to which it coincides with the planning setting is port specific. Port traffic and project benefits will depend on the commerce of that region and the degree to which other ports share in it.

SEQUENCE OF DATA ACQUISITION

Many studies provide a disproportionate amount of information on the planning setting because that information is readily available. Ready availability is not the best guide to economy of effort.

The Place to Start. Voluminous socio-economic statistics for the planning setting may have little value for NED analysis. Information for the planning setting may or may not identify the relevant harbor traffic. Start with the information that defines the economic study area. This will also identify the planning setting information that is relevant.

Interviews to Explain Data. Interviews to obtain or interpret data may be necessary. The most productive use of interviews is not to obtain data but to explain it. Everyone is subject to selective memory. This manual lists sources of data that describe vessel and commodity movements. Start with acquisition of that data so interview questions will be more relevant. The data will show whether ships have unutilized capacity. The question to ask is "why."

Focus on Benefited Traffic. For NED evaluation purposes, vessel data and commodity data are more-or-less equally important. This manual suggests starting vessel information first, because it identifies the types and sizes of vessels impacted by channel constraints. The cargo in those vessels is the quickest way to identify relevant commodities. Relevant vessels and commodities are the ones that may benefit from channel improvements.

LEVEL OF DETAIL

It is essential to address the concerns of port interests by determining whether a project will help with their perceived problems. However, the P&G does not require a comprehensive analysis of all project commerce. What the P&G requires is a conclusive analysis of all traffic that produces project benefits. The P&G's focus on benefited traffic recognizes the need to conserve study effort. Another good reason for that focus is to isolate the effects of the project to make them readily apparent. Unnecessary information is to be avoided.

Data Focus. Data acquisition can be minimized by limiting it to the channels that have identified problems, and the vessels and cargo associated with those specific channels. If an interior channel is the identified problem, there is no need to analyze the whole harbor. If the channel serves most or all of the port's commerce, the problems are likely to affect only vessels above a certain size. Occasionally, when there is a question of whether there will be physical capacity to handle all port commerce, such as main or entrance channels, or port facilities, it will be necessary to account for all port traffic. In those cases, benefits usually can be derived from vessel costs without extensive commodity analysis. A comprehensive forecast of all port traffic will be needed, but projections of economic activity such as those by the Department of Commerce's Bureau of Economic Analysis (OBERS projections), will be sufficient for most, if not all, of the commodities involved.

Amount of Data. Baseline information must be adequate to document the existence of problems and to provide a basis for quantifying their costs and the benefits of the project. There are no good shortcuts such as limited sampling or interviews that will document what is happening at the harbor. The amount of data required will be roughly proportional to the number of different vessel sizes and commodity movements that may benefit from the project. Adequate documentation requires hard numbers. It doesn't have to be hard work.

WATERBORNE COMMERCE DATA SOURCES

Subsequent sections describe the source and use of specific data needed to identify commodity flows and vessel movements. The two basic sources for much of the data are the Corps of Engineers (domestic commerce) and the Foreign Trade Division of the Bureau of the Census (foreign commerce). An overview of the data available from those two sources is provided below, to avoid redundancy in subsequent sections.

CORPS OF ENGINEERS DATA

The Corps collects data on all domestic waterborne commerce from the vessel operators using Form 3925. The operators are required by law to provide the information, and may file electronically or by hard copy. Form 3925 captures both vessel and cargo information. Most coastwise vessel operators file on a vessel voyage basis, and the form will show almost all information needed for analysis including: vessel name and entering and departing drafts at each port of call, (reference elsewhere is needed for vessel dimensions and capacity), the terminals used or location of loading/unloading, and the type and amount of cargo loaded and unloaded. The 3925 information is entered into a computer, and subsequently aggregated into statistics published in the annual Waterborne Commerce of the United States. The aggregation process severs vessel from cargo statistics. Most analyses need to link the two, and that will require retrieval of the 3925 information from the actual forms or by scanning data tapes.

BUREAU OF THE CENSUS DATA

Almost all foreign trade statistics are based on data collected by Customs and processed and published by the Foreign Trade Division of the Bureau of the Census. Because the initial data acquisition is a by-product of tax laws, vessel and cargo information are collected and processed more-or-less independently. Cargo information (type of commodity, quantity, weight, and value) is obtained from import entries and export declarations; vessel information (entering and departing drafts, itinerary, and cargo declarations/vessel manifests) is filed as part of the vessel entry and clearance process. The vessel and cargo information are only brought together late in the processing, when the vessel manifests are reconciled with the reported imports and exports. The combined vessel and cargo data are contained in summary data tapes, TM 304 and TM 704, which are used by Census to transmit to the Corps the import-export tonnages published in Waterborne Commerce of the United States. None of the many trade statistics published by Census show the amounts of cargoes loaded and unloaded at each port by specific vessels, and it is necessary to obtain that information (if needed) from the summary data tapes or other sources. Commercial trade information services now have access to vessel manifest data, and they can link vessels, ports, cargo, and the cargo shippers' names and locations. However, the manifest data do not show vessel entering/departing drafts.

DATA AVAILABILITY

The Corps of Engineers and the Foreign Trade Division of the Bureau of the Census publish catalogs that show samples of their data products and provide ordering information. The Corps catalog is called Products and Services Available to the Public. It is published by the Navigation Data Center of the Water Resources Support Center, and is available on request. NDC Report 89-N-1 (August 1989) is the latest revision. Telephone requests can be handled via (703) 355-3059 or (504) 862-1404. The Bureau of the Census catalog is called Guide to Foreign Trade Statistics 19XX. 1991 is the latest revision. It is published and sold by the U.S. Government Printing Office, Washington, D.C. 20402. GPO stock number for the 1991 edition is 003-024-07257-2. Price is $13.00. Telephone numbers for more information are (202) 783-3238 (GPO) and (301) 763-5140 (Bureau of The Census Trade Data Office).

Most Bureau of Census data products are available on tapes as well as microfiche and hard copy. A variety of government and private customers use the tapes for trade analyses and forecasts. A limited number of commercial firms will extract from the tapes the specific information needed for navigation studies, for a fee. The commercial firms have developed programs for extracting tape data and experience in using them. It is not a routine service of Census, and the commercial services can be more timely and cost effective.

Manifest data per se are not available from Census. The limited number of commercial firms allowed access to manifest data maintain computer data bases; because of the huge amount of data involved, their usual practice is to provide selected information in the medium desired, or allow the customer electronic access to the data base. The summary data tapes, TM 304 and TM 704, are not publicly available, and their use is limited to Bureau of Census and the Corps. These tapes also contain a huge amount of data, and extraction of data for study purposes requires custom programming. For information on inland cargo origins and destinations, the manifest data may be essential. For information in the summary tapes, investigate alternatives.

The cost of data from commercial services, or tape data from Census or the Corps, will vary with the type and amount of data. It is necessary to get a price quotation based on the specific information desired. The commercial services may charge as little as $50.00 per table or page for data otherwise available in Census or Corps publications, and will charge over $100,000.00 for unlimited access to cargo manifest data. Other indications of cost are $2,500.00 more-or-less for the inland origins and destinations of a port's annual commerce (commodity summary), or $10,000.00 more-or-less if origins and destinations are shown for each ship. Cost for multi-port, multi-year commodity origins and destinations for regional or national studies might be on the order of $35,000.00. Cost of extracting tape data by the Corps or Census will usually exceed $2,000.00. Points of contact for government sources are: Chief, Products and Services, Waterborne Commerce Statistics Center, (504) 862-1470; Contracting Officer, Foreign Trade Division, Bureau of the Census, (301) 763-5961. Commercial trade data sources include the following:

Journal of Commerce PIERS (Port Import-Export Reporting Service). The newspaper, Journal of Commerce, provides complete coverage of trade and shipping, and publishes manifest information. PIERS pioneered access to Customs manifest data and creation of a nationwide, multi-year, computer data base. It is the service most frequently used to identify inland origins and destinations. PIERS also publishes quarterly analyses of the liner trades. Two World Trade Center, 27th Floor, New York, NY 10048. (212) 837-7000.

Trade Information Services, Inc. A specialist in trade data, TIS uses Census data to publish monthly and quarterly statistics that are similar to Census publications (directly comparable in the case of TM/TA 380 and 780), but may be available sooner. TIS also offers manifest data similar to PIERS. 146 N. Canal Street, Suite 313, Seattle, WA 98103. (206) 632-6100.

DRI/McGraw-Hill. A large research organization that maintains multiple data bases, DRI offers a wide variety of services and publications. In association with Temple, Barker and Sloane, Inc., DRI publishes quarterly commodity and shipping statistics and forecasts at the national level as part of their World

Sea Trade Service. Port specific detail is available. (IWR-N is a subscriber.) In association with Lloyd's Maritime Information Services, Ltd., DRI can integrate vessel information (dimensions, itinerary) with U.S. trade statistics. International Research Group, 1750 K Street NW, 9th Floor, Washington, DC 20006, (202) 663-7827.

COMMODITY INFORMATION

Cargo information is used for an initial determination of the economic study area, and to provide the basis for commodity flow projections or forecasts. The information needed includes the size and composition of cargoes (annual tonnage by commodity or commodity categories), the origins and destinations of the cargoes (inland or hinterland, and external), and the inland transportation modes. The commodities that comprise the port's commerce are easily identified. Only slightly greater effort is needed to identify external origins and destinations (the foreign country, or U.S. port for coastwise traffic). The major effort will be to identify inland origins, destinations, and transport modes. Budget your resources accordingly. There is no good substitute for defining the port's hinterlands/economic study area, or calculating inland transportation costs with precision. The desirable level of precision for both commodity analysis and transportation costs is county-level. The P&G recognizes the amount of work involved, and its requirement to identify commodity flows is absolute only with respect to those that may provide project benefits. Vessel information will help you identify the relevant traffic.

DETERMINING RELEVANT COMMODITIES

Focusing on the commodities that produce benefits will save time and effort, even though the initial short list may need modification later. Typically, a preliminary list of relevant commodities is provided by the stated concerns of local interests, the request or authorization for the study, or the specification of problems and opportunities. Commodities so identified are relevant, regardless of whether the project will help. The effort in baseline investigations should be to narrow that list and making it more specific, not identifying additional concerns. Considerations to produce the initial short list are as follows:

Actual Commerce. The purpose of most navigation projects is to lower transportation costs by better utilization of present vessels, or by use of larger, more efficient vessels. Predominantly, this involves existing commodity flows. The data on vessel sizes and their actual drafts will generally identify the commodities (or portions thereof) that may benefit. The benefits may differ or be non-existent, depending on the location and ownership of terminal facilities. This manual suggests starting the identification process with vessel data.

Potential Commerce. New or increased movements are usually viewed as opportunities by port interests. Usually they are actual commerce at competing ports. Unlike the commodities associated with problems, which are finite in number, some potential commerce may be only in the mind of the beholder. In order to reasonably limit the baseline effort, it may be necessary to determine which prospective movements are serious candidates. The best assurance that new or larger movements actually can be realized is some evidence that the necessary port facilities will be provided. The best evidence of that will be the existence of port development plans and facility feasibility studies.

DETERMINING PORT HINTERLANDS

The U.S. origins and destinations of port commerce, or "hinterlands", are commodity-specific for most liquid and dry bulk cargos. Those commodity flows usually can be identified with reasonable accuracy and effort. The hinterlands for manufactured goods, especially containerized cargos, are usually diverse and simplifying assumptions may be appropriate. If the project port is the only port that can or is serving these hinterlands, defining the study area is relatively easy. If that determination is conclusive, then--and only then--multiport analysis may be unnecessary. More often, the port's hinterlands are shared with competing ports and the identification of those ports is also required.

Preliminary Identification. There are two basic approaches to identifying cargo hinterlands. One is to trace overland movements to or from the port (and competing ports if appropriate). The other is to estimate overland transportation costs by the modes used, and use the simplifying assumption that lowest cost determines port routing. To start or for very rudimentary analysis, the geographic midpoint between ports can be used to identify whether there are important origins or destinations at the margin. The rate structures of pipelines and railroads and the existence of captive customers can distort hinterlands considerably. Interviewing terminal operators will help in identifying such factors, especially if preceded with a preliminary identification.

Final Identification. The desirable level of information for identifying domestic origins and destinations of relevant commodities is by county. Most serious port studies have used that degree of precision because it helps with forecasting, including use of "OBERS" projections. Data on actual origins and destinations may show aberrations because many factors influence routing decisions. Judgement may be needed to discard "outliers" and simplify hinterland boundaries. The basic simplifying assumption used in NED analysis is that costs determine transportation decisions. Actual overland transportation costs, or in their absence appropriate transportation cost algorithms, should be used for final identification of hinterlands. Ultimately those costs will be used for benefit calculations and multiport analysis. The combined hinterlands are the project study area. Subsequent analyses may modify the study area boundaries. The point is that final study area identification is likely to be one of the last steps in NED evaluation.

COMMODITY DATA SOURCES

Tabular summaries are the best way to organize commodity data for their indicated uses. Summaries should also be shown in the main study report or its "Economics Appendix", to provide support for forecasts and benefit calculations. The key to economy in data collection and preparation of the "paper trail" summaries is to use the least number of sources that provide adequate data. Regardless of the number of sources used, it is essential to have consistency in the commodity classifications and units of measure used. There are a number of different commodity classification systems. Census had a system based on tariff schedules (TSUSA, schedules A, B, etc.). Starting in 1989, their foreign trade statistics use the Standard International Trade Classifications (SITC, developed by the U.N.) or the harmonized tariff classifications (HTUSA). The Corps has used a unique system, Commodity Classification for Shipping Statistics or CCSS. The Corps will convert to SITC in Waterborne Commerce statistics for 1990, lock PMS statistics for 1991. Other domestic statistics may use STCC, CCTS, or SIC codes. Check your references for the classifications and type of tons used. Corps statistics and most domestic carriers use "short" tons of 2000 pounds. The Maritime Administration still uses "long" tons of 2240 pounds. Most of the rest of the world uses metric "tonnes" of 2204 pounds. Steamship and port tariffs frequently use "revenue" tons based on weight or measure (1 long ton=40 cu ft, 1 tonne=1 cubic meter). Census simply uses pounds.

Port Commerce Data. Historical statistics are readily available from Waterborne Commerce of the U.S. A multi-year summary of all port commerce is the usual starting point, and should be displayed in the report. It will show the importance of different trades (domestic, foreign) and indicate growth trends of the commodity categories. An additional summary identifying the specific commodities associated with problems and opportunities to be addressed by the project is also needed. If specific channels are involved that are not separately authorized projects, statistics may not be published in Waterborne Commerce. The alternatives are to obtain cargo information from terminal operators or carriers, or have the Corps Navigation Data Center extract the data from its computerized records. Use the Port and Dock Code Book to identify the relevant waterway segment or port facilities. It is desirable to have five or more years of comparative data, but that amount of information may be impractical if the data has to be obtained by interview or a search of NDC records. Some indication of growth trends should be shown.

Port Trade Route Data. The traffic categories used in Waterborne Commerce of the U.S. (coastwise, import, export) are too broad for commodity forecasting purposes or calculation of transportation costs. For domestic commerce, port-to-port commodity movements can be obtained from the Corps Waterborne Commerce Statistics Center in New Orleans, or from a summary published by the Maritime Administration. Except for "inland" traffic, the Corps does not publish origin-destination statistics. For other domestic traffic, it will be necessary for WCSC to extract vessel-specific Form 3925 data, or provide a summary of commodity movements similar to "inland" statistics from aggregated data. The Maritime Administration annual publication is called Domestic Waterborne Trade of the United States. It uses Corps data to show origin-destination quantities for major commodity categories. Its level of detail may or may not be adequate for study purposes.

For overseas commerce, the best sources of data are the Bureau of Census publications TM/TA 380 and 780 (monthly and annual waterborne imports and exports, respectively). They are available in hard copy and other media, and show the U.S. loading/unloading port, commodity weights and/or values, and foreign origin/destination country and port or port range. No other Census publication has the same combination of information. The Customs port or district is used when other modes of transportation are involved. TM/TA 380 and 780 do not identify the specific vessels involved, and simply show three types of vessel service: "liner", "tramp", and "tanker". That is not a fatal disability for study purposes. Baseline vessel information will identify the amount of ship capacity associated with the trade route tonnages, and vessel itineraries will identify the ports of call in the overseas countries. If it is deemed necessary to determine imports and exports by specific vessels, cargo information may be available from terminal operators or steamship agents. If cost is not critical, that information can be extracted from TM 304 and 704 data tapes by Census or the Corps, or extracted from vessel cargo manifest data by commercial services.

Port Hinterland Data. In addition to identifying the economic study area for commodity analysis and forecasting, baseline information should identify the extent to which the port's hinterland overlaps the hinterlands of other ports. That information is essential for multiport analysis. Unfortunately, there may be no single source that identifies inland origins and destinations conclusively. Theoretically, inland transportation costs should determine hinterland boundaries, but those boundaries are greatly skewed by the economics of transportation modes, and by the type and quality of services offered at competing ports. Potential single sources, after preliminary identification of relevant commerce as described elsewhere, are the terminal operators and steamship agents involved. They know who their customers are, and generally, who is using competing ports. However, they may be unwilling or unable to cooperate if they believe the information is sensitive, or if a lot of record retrieval is required. The alternatives or supplemental sources are vessel manifest data and inland transportation statistics.

The most useful vessel manifest data are available from commercial services such as the Journal of Commerce PIERS. Bureau of Census data tapes also contain the names and addresses of cargo shippers and receivers, but some interpretation of that data is needed. Many imports are consigned to banks, and exports may show the exporter's office or representative rather than place of origin. The commercial services have developed concordances to identify actual origins and destinations. Their origins are more accurate than their destinations, and nobody has a "bulletproof" system. It may help when Customs requires use of zip codes on its forms. The Journal of Commerce started as a manifest reporting service over 100 years ago, and still publishes manifest information daily. The Journal also has two weekly publications, the Import Bulletin and the Export Bulletin, that are almost exclusively manifest information (ship's cargos nationwide, liner and bulk). Inspection of the bulletins will show whether their information will be adequate, or more expensive PIERS reports will be needed for port/multiport analyses.
Inland transportation statistics, except for rail, do not routinely provide useful origin-destination data. However, certain publications may be helpful. The periodic Commodity Transportation Survey by Census will be most useful for identifying hinterland modal shares. 1987 was the latest Survey. The next Survey is budgeted for 1993 and may provide more information on transportation of imports and exports. Reports entitled Domestic and International Transportation of U.S. Foreign Commerce 19XX show the results of special origin-destination surveys in 1970 and 1976 sponsored jointly by the Corps, USDA, and USDOT. Port hinterlands were identified by state, distance from port, and mode used. The statistics are out-of-date, but illustrate the

factors that determine hinterlands. The Petroleum Yearbook will show the points served for virtually all energy-related pipelines.

Rail origin-destination statistics are in the ICC Waybill Sample. It is an annual, one percent sampling, and identifies the rail origin and termination points using "Standard Point Location Codes". It does not show whether commodities have been or will be waterborne commerce, but this can be inferred from the rail siding location code. The IWR Navigation Division at WRSC has annual Waybill Sample tapes, and can screen them for specific points and commodities. So far there has been no charge for this service.

A number of Federal agencies, trade associations, and private enterprises publish commodity-specific surveys, outlooks, and yearbooks or other periodicals that may be helpful in identifying hinterlands. These publications may identify the coastal range participation in commodity movements, but seldom provide port-specific shares. Accordingly, they are more useful for analyzing the project port's hinterlands than for identifying them. The specific publications are too numerous to list here. Contact the U.S. Department of Agriculture (Economic Research Service), Energy (Energy Information Administration), or Interior (Bureau of Mines), or an appropriate trade association for publications lists or advice on relevant publications.

Corps and other Federal agencies' port or multiport studies (Delaware River, Galveston Bay) may be useful. Contact IWR-N or HQUSACE for the studies that may be relevant.

VESSEL INFORMATION

Vessel information is used in the analysis to determine future port fleet composition, and to identify how vessels operate at the project port. The information needed for fleet analysis includes the size distribution and capacity utilization of the present port fleet, and the limits on vessel sizes due to channel constraints at the project port and elsewhere on the vessels' itineraries. The data that best identify capacity utilization and channel constraints are the actual drafts of vessels, and the maximum loadline drafts of those vessels. Identification of channel width or other constraints will require additional vessel dimensions such as length and beam. It will be necessary to use multiple sources to determine the actual vessels serving the port, and to determine their actual drafts and how and where they operate. Adequate research effort will be rewarded. Identification of the vessels actually affected by channel constraints provides a way to limit data acquisition and analysis to relevant port traffic and practices. For that reason, vessel information is the recommended starting point for baseline data acquisition.

IDENTIFYING POTENTIAL BENEFITS

Project benefits occur when existing vessels can be used more efficiently, or more efficient vessels can be used. A comparison of actual vessel drafts with the fully loaded drafts of those vessels will provide initial identification of vessel under-utilization. Additional information will be needed to determine whether the under-utilization or "lightloading" is due to channel constraints at the project port or to other factors. Additional investigations will be needed to identify other inefficiencies such as vessel delays to utilize tides, and other operating practices. Lightloading attributable to channel constraints is the best evidence that there will be immediate project benefits.

IDENTIFYING THE STUDY AREA

The commodity movements that define the study area are those affected by channel constraints. Constrained vessels usually can be linked with specific commodity flows because data sources for actual vessel drafts normally show the port terminal used. Alternately, vessel draft data can be used to verify the problems that have been identified with specific commodities or channels.

IDENTIFYING THE PLANNING SETTING

Waterborne Commerce statistics may show vessel drafts greater than those inferred by applying Corps channel design criteria to the available channel depths. The unexpectedly deep drafts are one clue to port and vessel operating practices that affect the realization of project benefits. A number of alternatives can be used to cope with channel constraints, often at some cost in efficiency. To the extent those practices exist and can be identified by vessel data or investigations, they are a relevant part of the planning setting. Some or all of the practices are likely to be used after channel improvement.

VESSEL DATA SOURCES

Vessel traffic statistics in Waterborne Commerce of the U.S. have certain limitations. They show the deepest drafts of vessels entering and departing the harbor, but do not identify the specific vessels, their size, or whether they are partially or fully loaded. Additional vessel data are needed, but Waterborne Commerce statistics are nonetheless important. They can identify historical trends and show whether vessels with the deepest drafts are growing in terms of numbers and relative to overall port fleet population. They will also show whether the deepest drafts exceed the authorized channel depth, indicating use of tides by vessels, or other conditions that should be recognized in with- and without-project conditions. The total number of vessels will indicate whether it will be practical to develop information on all vessels, or whether it will be necessary to restrict the data search.

Theoretically, sampling should suffice when the port under study has a large number of vessel movements. In practice, that may produce insufficient information on the relatively small number of vessels actually impacted by channel constraints, and it may overlook significant seasonal variations. The better alternative is to focus on the types and sizes of vessels that are or will be impacted by channel constraints, and obtain information on all of those vessels. Stratifying the fleet by channels used and vessel size will produce a relevant population that will seldom exceed 500-600 vessels. If those vessels are loaded in one direction only, it may not be necessary to obtain both inbound and outbound drafts. The data then has to be reduced to a distribution by size categories to be useful in analyses.

For display and analysis purposes, summarize the port fleet in categories that are one-foot increments of loadline draft. The total amount of deadweight in each category gives the fleet size distribution that can be used to produce or apply fleet forecasts. The average deadweight in each category is the starting point for determining transportation costs and project benefits. The total amount of deadweight in all categories is needed in order to derive fleet capacity utilization. If the specific drafts and deadweights for all vessels are not obtained, the average lightloading and total deadweight for the "all other" vessels will have to be estimated. The several options to do that include sampling, interviews, and observation.

Port Vessel Fleet Data. A one-year record of all commercial vessel calls is the desirable minimum to identify port fleet composition. If small craft such as barges and fishing vessels do not affect channel capacity, they can be disregarded or shown simply in terms of numbers of trips. The larger vessels need to be identified by name, so that size data can be located. A number of sources show vessels in port, enroute, or scheduled to call. They include local and trade papers including Lloyd's List (daily) and Lloyd's Shipping Index (weekly), the weekly magazine Shipping Digest, and company schedules. Rather than piece together a year of data from those sources, it may be advantageous to use sources that provide a chronological record of vessel calls, especially for large ports. Those sources include the records of local terminal operators and steamship agents, Customs Form 1400 and Form 1401 (monthly summaries, available at the Custom House), and extracts from vessel manifest data and Census' summary data tapes TM 304 and 704. Some of those sources provide more than one type of the vessel data needed. No one source provides all. Terminal records may and Customs forms 1400 and 1401 will show actual ship drafts. The latter also shows the vessel's prior and future ports of call. Actual drafts are also in manifest data and Census' summary tapes. None of the above show vessel dimensions or deadweight capacity. Customs records show net and gross registered tonnage (volume measures). Unless a very large number of vessels is involved, a visit to the Custom House followed by use of a ship size reference is the way to go.

Vessel Size Data. The usual source for deadweight capacity, loadline drafts, length, beam, and other vessel "characteristics", is Lloyd's Register of Ships, published annually by Lloyd's Register of Shipping (U.S. sales office phone 212/425-8050). The same information is also available electronically from Lloyd's Maritime Information Services, Ltd., and on PC diskettes from Fairplay Information System, Ltd. (U.S. sales phone numbers 203/359-8383 and 518/537-6682, respectively). Lloyd's and Fairplay both maintain data on upwards of 25,000 vessels. Data for ships on order/under construction, ship movements, charter fixtures, and vessel casualties, are also available from LMIS and FISYS. For Lloyd's publications such as the Index and Voyage Record, contact Lloyd's Press at 212/529-9500. The American Bureau of Shipping Record and H. Clarkson's Tanker Register and Bulk Carrier Register are other annual publications that contain vessel size information.

Deadweight is a measure of vessel capacity expressed in tons. Most references now use metric "tonnes". All of the vessel size sources will show a maximum draft and related deadweight based on loadlines assigned by classification authorities. The maximum loadline draft will be for "tropical saltwater" or "summer freshwater", depending on the vessel's occupation. Additional loadlines are assigned for other waters and seasons, and "Winter North Atlantic" usually is the one with greatest freeboard/least draft. The terms "design" or "service" draft are sometimes used. These are considerations in optimizing ship shape and power. They refer to the draft at which the vessel is expected to operate based on cargo density, which may be something less than maximum loadline draft (a lot less for containerships). Cargo weight will always be something less than maximum deadweight. The point is, measure both with the same type of tons. Actual deepest drafts are likely to vary seasonally, and may exceed the loadline draft because of vessel trim.

Vessel Draft Data. Port authorities, ship pilots, and the U.S. Coast Guard are interested in vessel drafts but seldom keep useful records. The vessel and terminal representatives responsible for cargo loading and discharge do record drafts, but the information may be stored where it is inaccessible. Vessel logs show arriving and departing drafts; sometimes the vessel owner's office has copies or summaries. By far the best sources for draft data for vessels in foreign trade are Customs Forms 1400 and 1401. These are monthly summaries of all vessels trading foreign (including U.S. flag) that enter (1400) or depart (1401) the jurisdiction of a Customs port. The forms show vessel name, its deepest draft on arrival (1400) and departure (1401), where it stops in the port, and previous and subsequent ports of call. The one-line entries are chronological and visual inspection is the fastest way to identify relevant vessels. The equivalent source for vessels in the domestic trades is Corps of Engineers Form 3925.

Alternate sources for actual drafts are manifest data or summary tapes SM 304 and 704, but extracting drafts from those sources is not routine. All of the sources normally show only the deepest drafts entering and departing. Both bow and stern drafts are needed in order to identify the amount of actual vessel trim. If available, the notes of the Customs officer attending the vessel's docking and departure may show both drafts. The loading/unloading records of the vessel or terminal operator will show both drafts, as does the vessel log. The problem is access to those records. Absent such records the prevailing practice can only be approximated by inquiry or spot observations.

Vessel Capacity Utilization Data. It is possible to identify the actual amount and type of cargo on every vessel, but it is seldom worth the effort required. Commodity statistics are the simplest way to identify total cargo tonnage, and can be related to fleet deadweight capacity with load factors. Some numbers for vessel fleet utilization or load factors are needed in order to estimate the fleet capacity required for projected port cargo tonnages. Generally, the current overall utilization for the vessels in a specific trade, based on total cargo tonnage versus total associated vessel deadweight, is an acceptable approximation. The cargo tonnage on any specific vessel can be estimated, based on its actual draft. Similarly, for use in refining fleet forcasts, load factors for specific vessel size categories can be derived from the lightloading analysis that is described in a subsequent section.

If vessel-specific data are desired, the amount of effort required will depend on whether the vessel is in domestic or foreign trade, and whether the vessel loads and unloads cargo at one or more ports. For vessels in domestic trade, Form 3925 should provide sufficient information, regardless of the number of port calls. For vessels in foreign trade that call only at the project port, alternative data sources are the loading/unloading records of the vessel agent or local terminal, the manifest filed at the Customs House (Form 1302) or equivalent information from manifest data vendors, or a search through Census' TM 304/TM 704 data bases. For foreign trade vessels with multiple port calls, typical for containerships and other vessels in liner services, the cargo that remains on board at the project port affects vessel draft and fleet capacity. To account for that cargo, it may be necessary to determine the sequence of the vessel's U. S. port calls, and the amounts loaded and unloaded at each port. Use of Census' 304/704 data for that purpose requires a special matching with vessel movement files (TM 385/TM 785). A special analysis of manifest data from commercial sources is a better alternative.

Vessel Itinerary Data. Vessel routes are seldom as direct as the great circle distance between the cargo origin and destination ports. Itinerary data should identify whether the vessels in the study sail direct or have multiple port calls, and what the channel and berth depths are at those ports. Voyage duration is more important in transportation costs than actual distance, and time between ports reflects the deviations due to weather and traffic. Sources for vessel itineraries are the vessels' local agents, sailing schedules, trade publications, and Customs Forms 1400 and 1401. The sources other than Customs forms may also provide trip duration. Lloyd's Voyage Record (daily and weekly) shows the four to six recent port calls for almost every vessel in the world, hence is expensive. Distances Between Ports, formerly U.S. Navy Hydrographic Office Publication 151, now published by the Defense Mapping Agency, Hydrographic Center, is one of several sources for distances. World Port Index 19XX, formerly Navy Publication H.O 150 and now published annually by the Defense Mapping Agency, shows channel and berth depths for over 7000 ports (16 five-foot increments of depth, 0-5' to 71-75', plus 76' and over). Fairplay World Ports Directory, by the publisher of the weekly magazine Fairplay, shows more specific depths, the size of the largest vessel to call, and water density. There are similar publications by Lloyd's and others. As information, Panama Canal limits are 950' by 106' and 39' 6" freshwater draft (equivalent to 38' 8" saltwater), Suez Canal limits are 210' beam (no length limit) and 53' draft. Saltwater draft can be converted to freshwater draft using the ratio of water densities, 1.025 salt, 1.000 fresh, if the waterplane area of the vessel is constant in the range of "sinkage".

LIGHTLOADING ANALYSIS

Vessels seldom operate at their deepest loadline draft for numerous reasons. There may be channel constraints somewhere on the vessel itinerary, the vessel's weight or cubic capacities may not match the density of cargos carried (typical for containerships), or the amount of cargo available simply does not equal vessel capacity. The purpose of lightloading analysis is to determine the lightloading attributable to constraints at the project port and attributable to other factors, so both can be accounted for in the calculation of transportation costs and project benefits. The lightloading due to other factors can be combined and treated as normal or "inherent" lightloading. It is necessary to account for it because an assumption that unconstrained vessels always load fully would drastically understate the cost of vessel transportation. The basic assumption in channel improvement benefits is that the pattern of normal or "inherent" lightloading by unconstrained vessels will apply to the vessels that lightload due to without-project conditions.

Table IV-1 shows examples of lightloading analyses. Lightloading analysis is treated in this chapter because it identifies the type of data needed, and that data helps to identify relevant port practices and other information needed. For each of the one-foot draft categories used to summarize the port fleet, the analysis should identify the number or share of vessels in that category by each incremental foot of lightloading, up to a reasonable maximum lightload or "all other" subcategory (for outliers). The draft categories and lightloading subcategories should be carried forward to the transportation cost and benefit calculations. That increases the number of calculations drastically, but they can be performed easily with a PC. Cost and benefit calculations should be in one-foot increments because that is how projects should be optimized. For fleet analysis and forecasting, the use of an overall load factor may be acceptable or necessary. In effect it is the average lightloading, which can be determined from the analysis.

TABLE IV-1

DISTRIBUTION OF VESSELS WITH ACTUAL DRAFTS LESS THAN MAXIMUM DRAFTS

(number of vessels "lightloaded" and overall percentage)

Draft Actual vs Maximum (ft), Newark Containerships Inbound - 35' Channel

Maximum	<0	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	>13
<30	13	10	23	27	41	23	9	3	3	2		1				
30			1	3	6	7	6	5	4	4	7	4				1
31	2	2	1	3	4	6	6	12	9	7	5	3	2			
32	3				4	2	6	6	3	1	1	1				
33			3	4	7	11	8	12	1	3	3	3	1			
34		2	2	5	9	11	13	13	13	11	3		1	1		
35					1		4	1			1					1
36		1		1	5	2	5	6	3	5	4	8	16	17	38	29
37						1	1		1		2					
38			1	1	3	7	4	11	18	15	16	7	8	9	4	4
39			1	1		2	4	4	2	2	6	2		2	1	
41									1	2	3	10	2	3		
43											1	4	2	2		2
% <35	4.2	3.2	6.9	9.7	16.4	13.9	11.1	11.8	7.6	6.5	4.4	2.8	0.9	0.2	0.0	0.2
% >34	0.0	0.3	0.6	0.9	2.8	3.8	5.6	6.9	7.8	7.5	10.3	9.7	8.8	10.3	13.4	11.3

Draft Actual vs Maximum (ft), Houston Tankers Inbound - 40' Channel

Maximum	<0	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	>13
36			1													
37	2	2	1													
38		5	3	1												
39		4		1												
40			7	1	1	1										
41			2	3												
42					3	3	2	1								
43						2	7	1								
44							3	5	6							
46										1		1				
47										1			1			
49													1	1		
>49																2
%	2.6	14.5	18.4	7.9	5.3	7.9	15.8	9.2	7.9	2.6	0.0	1.3	2.6	1.3	0.0	2.6

Draft Actual vs Maximum (ft), Newark General Cargo Vessels Inbound - 35' Channel

Maximum	<0	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	-11	-12	-13	>13
<30	8	4	12	15	8	11	11	12	12	4	9	9	4	3	4	5
30			1		7	11	18	18	14	8	4	4	3	2		6
31				1	6	16	14	8	8	9	6	12	11	3	2	4
32				2	2	2	2	4	8	14	7	7	5	3	2	3
33							1	2	4	5	6	5	3	3	3	
34										1				2		
35							1	1		1	6	5	2	4	3	2
%<35	1.9	0.9	3.1	4.3	5.4	9.5	10.9	10.4	10.9	9.7	7.6	8.7	6.1	3.8	2.6	4.3
%>34	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.0	0.0	4.0	24.0	20.0	8.0	16.0	12.0	8.0

The range of lightloading will vary with the type of vessel and specific trade. The number of one-foot lightload increments to show before the maximum for "all others" should account for most (say 90%) of the vessels, and can only be determined from the data. For most bulk carriers and tankers, analysis is needed for one loaded direction only. For liner vessels such as containerships and parcel tankers, analyses of both arrival and departure drafts are usually needed. The use of maximum drafts only can be misleading because most vessels operate with some amount of trim. If these are the only drafts available, they must be adjusted using some estimate for average trim. Use of the average of actual bow and stern drafts is better. The ideal is two analyses, based on average and maximum draft. That will identify the actual amount of trim used. In order to identify the pattern of unconstrained vessel lightloading, the statistics and analyses should include vessels whose design drafts are two to five feet less than the channel depth. Because various operating alternatives are often employed, such as tideriding, a clear pattern of constraints may not show until vessel design drafts plus two feet exceed the channel depth minus average tides.

PLANNING SETTING INFORMATION

Responsibility for a complete description of the planning setting may or may not reside in the individuals responsible for NED evaluation. The various port-related institutions, and the way they interact, are key factors in implementation of the project. However, economic analysis does not deal with implementation or financial feasibility directly. They are considered elsewhere in the study, but it may be desirable to acquire historical and socio-economic data for that purpose as part of baseline information. The information that will be needed for economic analyses includes the port facilities, conditions, alternatives, and practices that affect the amount of project benefits which may be realized.

PORT FACILITIES AND PHYSICAL CONDITIONS

There are numerous reasons why port facilities may not be in the most advantageous location with respect to the harbor's channels. The physical location of the facilities can be a clue that institutional or other constraints limit the utilization of channels. The objective of baseline investigations is to determine whether port facilities can accomodate projected port traffic, and if not, the alternatives and associated costs to do so. A natural extension of this effort is to identify new facilities that may optimize the harbor improvements or otherwise affect the need for and scale of the project.

Maps are the usual device for showing location. It is likely that a series of maps or map overlays will be required to show all the desirable baseline information. Along with channel and facility locations, relevant information includes political boundaries, overland transportation routes, topography, water depths, and land use or zoning. There are various sources and it may be necessary to integrate existing maps or information. Specifically, it is desirable to identify all waterfront land use and zoning at least in a general way, in order to show the potential for port facility expansion and where port activities have been preempted by other development or dedicated uses such as parks.

Facility Capacity. The physical dimensions of port facilities and their associated channels are readily available in the Corps of Engineers Port Series and other publications. The approximate annual throughput of cargo at any or all facilities may be obtained by inquiry, and the exact amount can be determined by screening Waterborne Commerce data tapes as described heretofore. For relevant commodities, it will be necessary to account for actual quantities through specific terminals in order to have an accurate basis for computing benefits. Since many terminal operators consider their business volume to be proprietary information, ingenuity will be required in aggregating annual throughputs and capacity estimates to produce numbers given to the public in the study report.

The adequacy of port facilities must be accounted for in NED evaluation, specifically including the costs of improvements or expansions needed to realize the benefits of channel improvements. Since terminal capacity is at best an estimate, and individual estimates may be biased for competitive reasons, it is advisable to supplement terminal operator interviews with comparative estimates based on the criteria of some independent authority. One source is the Maritime Administration's Handbook for Estimating Terminal Cargo Handling Capacity. For the new facilities that may be required to handle "new" commodity movements attributed to channel improvements, specific information on facility location, size, and cost should be available in port development or facility feasibility studies.

Table IV-2 is adapted from the Maritime Administration Handbook. Because the rate of cargo transfer between ship and shore seldom constrains capacity, it uses storage capacity as the basic determinant of berth capacity. Both berth size and storage area or quantities should be readily available for existing or proposed facilities. A table of similar brevity should be adequate for summarizing port facilities in the study report. The relevant information for that purpose includes number of berths, berth depths, annual throughput, and theoretical capacity.

TABLE IV-2
APPROXIMATE ANNUAL CAPACITY OF CARGO BERTHS

Type Cargo	Approximate Berth Size	Storage Capacity (Area or Quantity)	Annual Capacity
Break Bulk	500'	2 acres bldg. + 2 open	90,000 tons
Container	850'	5-20 acres open	90,000 FEU
Tanker	850'	500,000 bbl.= 10+ acres	tank cap. x 12(1)
Coal	850'	direct, ex-rail	1-2 ships/wk.(1)
Coal	850'	stacker/reclaimer=20+ acres	storage cap.x 12(1)
Grain	750'	2-5,000,000 br. = 15 acres	silo cap. x 24(1)
Ores&Minerals	750'	direct to/from rail cars	1 ship/wk.(1)
Ores&Minerals	750'	via shipside stockpile	6 ship/yr.(1)
Ores&Minerals	750'	via stacker/reclaimer	stockpile x 6(1)

(1) Turnover rate varies with trade. Local inquiry will be needed.

Facility Berths and Access Channels. The water depths at berths used by vessels that may benefit from the project are as important as channel geometry. Berths deeper than the channel depth are a good indication of use of tides (and channel deepening benefits). Berth depths a foot or two shallower than the channel are common because no provision for vessel squat and roll is needed. Berths shallower than that need to be explained, particularly if there have been previous deepenings. Additional deepening may require expensive structural changes.

Climatological Data. Data on the height and duration of the tide cycle will be needed to calculate the cost of vessels using tides. Data on the frequency of weather conditions may be needed if increased channel widths will reduce delays or damage due to winds, waves, currents, or low visibility, provided a threshold level for "bad weather" can be established.

Summary information on tides and weather accompanies each port shown in the Corps Port Series. The four-volume Tide Tables 19xx by National Ocean Survey (U.S. Department of Commerce, NOAA) shows time and height of tide for places worldwide. Volume 2 covers East Coasts North & South America, Volume 3 covers the west coasts, plus Hawaii. Order from the Defense Mapping Agency. Weather Service records may be available locally, and are published by National Climatic Data Center, NOAA, for states (Climatological Data. XXXX), and 300 cities (Local Climatological Data. XXXX). Annual statistics may be published separately or as a 13th month. The ultimate source for wind and wave statistics is Summary of Synoptic Meteorological Observations (SSMO) by National Climatic Data Center. It consists of 18 multi-volume sets. Set 10 covers Alaska. Set 11 covers all other coastal North America (Vol.2 St. Lawrence-New York, Vol.3 Atlantic City-Miami, Vol.4 Guantanamo-Corpus Christi, Vol.5 Baja California-San Francisco, Vol.6 Pt. Arena-Vancouver I.). Order weather/wind/wave publications from the National Technical Information Service. National Climatic Data Center (Ashville, NC 704/259-0218) will help identify the right one.

FACILITY ALTERNATIVES

Unconventional solutions for handling cargo are generally treated as non-structural alternatives to the project in NED evaluation. Adversarial treatment of these alternatives late in the evaluation produces two big problems. Without a preliminary screening to identify potentially feasible alternatives there can be an unwieldy number of candidates. Without adequate information on physical and financial feasibility there is no good way to dispose of them. The way to handle facility alternatives is to determine whether they should or should not be part of the project setting. Table IV-3 lists unconventional facilities that are in common use and candidates to be non-structural alternatives. Subsequent sections provide more information on unconvential facilities. If facility alternatives will not be considered in economic evaluation, the subsequent sections are optional reading.

TABLE IV-3
U.S. WATERBORNE COMMERCE VIA UNCONVENTIONAL FACILITIES

Type Facility	Approx. Annual Tonnage (000) Tanker	Dry Bulk
Transshipment Ports	90,000	< 10,000
Lightering, Midstreaming	50,000	< 1,000 (1)
Marine Pipelines	40,000 (2)	- 0 -
Very Long Piers	15,000	< 1,000
Offshore Platforms	5,000	- 0 -
Artificial Islands	- 0 -	- 0 -

(1) Peak coal movement at New Orleans was 10 million tons
(2) Includes unutilized Lousiana Offshore Oil Port capacity

Typically, the need for a channel project arises because it is desirable to bring the ship to port facilities where cargo can be stored and transferred between transportation modes. The basic alternatives are to extend the facilities to where the vessel is (marine pipelines, conveyors, or very long piers) or to transship the cargo using another vessel offshore or in another port (lightering and transshipment ports). Site adaption produces apparent variety, but the basic alternatives are small in number. There is no need to explore exotic variations such as use of helicopters. The point is to determine whether alternatives that have been proven in service elsewhere have application at the project port.

The following paragraphs describe the physical conditions and approximate costs for actual applications. Provided there is a suitable site in the right location, the approximate costs will indicate whether the facility may be a feasible alternative at the project port, and whether additional information is needed to determine if it is implementable. Since all facilities including non-structural alternatives are a non-Federal responsibility, there are numerous reasons why some apparently attractive alternatives are not implemented. An assurance of a large, immediate volume of business is usually a prerequisite to financing because most unconventional facilities are suitable only for certain cargos, and all costs have to be recovered promptly. Although almost all physical conditions can be accommodated by facility design, the alternative still has to provide vessel turnaround competitive with conventional facilities. Design transfer rates are achieved about 30 percent of the time at conventional facilities, and the days allowed for loading or unloading in vessel charters are more useful indications of actual turnaround time. Port Performance Index, by Carl Plumlee (Public Works Consultants, Carmel Valley, CA) gives tons per hour statistics for a variety of ports and commodities, including some unconventional facilities.

Transshipment Ports. The advantage of transshipment ports is that they can expedite vessel turnaround by transferring cargo via storage. Tanker terminals in the Bahamas and Caribbean islands are the biggest U.S. use of transshipment ports because they unload very or ultra large crude carriers in two to three days versus as much as 16 days for VLCC or ULCC discharge via lightering. (Average lightering time is much less.) The Bahamas and Caribbean islands have ten transshipment facilities because their location requires little deviation for U.S. crude imports, and they have deep natural depths. Six of the terminals can accommodate vessels of 500,000 dwt. and drafts of 90 to 119 feet. About half the terminals are associated with refineries, and all terminals except one transship via storage. Their approximate charges are 14 to 20 cents per barrel including 15 to 30 days storage. A Cayman Islands facility offers direct vessel-to-vessel transfer at 5.75 cents per barrel.

Grain transshipped via Lower St. Lawrence elevators is the second largest use of transshipment ports for U.S. commerce, and excluding barge-to-ship transfers which are intermodal transfers, it is the only U.S. dry bulk commodity transshipped in large volumes. The Canadian elevators charge about 4 cents per bushel for a round turn, and the combined cost of lake carrier ($12.00-$17.00 per ton) and transfer, approximates the differential for Great Lakes direct versus Lower St. Lawrence loadings. However, ocean rates at the latter are lower than U.S. East Coast ports. Transshipment of drybulks other than grain is limited because the commodity volume and strategic location needed to justify transshipment facilities seldom coincide. There have been proposals for coal and grain transshipment terminals in the Bahamas and Caribbean but none have been built. There is a bauxite and manganese ore transshipment terminal in Trinidad, but it has only 35 feet of water.

With the deepening of Mobile Harbor and the Lower Mississippi, the multipurpose bulk plants at those ports may be able to provide transshipment alternatives. Current vessel to vessel transfer charges are about $1.00 to $1.50 per ton direct and $2.00 to $4.00 per ton via storage. Charges for specific commodities can be determined by inquiry. Seaborne Trade and Transport are monthly publications by Drewry Shipping Consultants Ltd. that analyze specific vessel trades, and they contain information on transshipment facilities for petroleum, coal, ores, and minerals. References previously cited for vessel itinerary information show some terminal charges.

Transshipment of general and containerized cargos is more-or-less routine because trade volumes do not support direct service between all ports. This type of transshipment occurs in load center ports, generally outside the U.S. A few container feeder services have operated between the Great Lakes and Montreal, Boston and New York, Baltimore and Norfolk, but these have been marginally competitive with overland carriers at best. In addition to the feedership (or barge) operating costs, there are two additional handlings of the containers at a cost of about $75.00 each.

Lightering. In the U.S., most lightering is to partially discharge large vessels. The need for accurate weights and grades in international trade inhibits its use for exports, particularly grain. Occasionally lightering is used for full discharge of very large tankers in the Gulf of Mexico. It is used routinely to lighten tankers offshore of Gulf Coast ports, and at anchorages in New York Harbor, Delaware Bay, and San Francisco Bay, It has been proposed for topping off coal vessels at various locations, but only test shipments have been handled in the Gulf of Mexico, the Lower St. Lawrence, and

Canada's Strait of Canso. A variant called "midstreaming" has been used on the Lower Mississippi to load coal vessels direct from river barges.

Oil lightering in the Gulf of Mexico is performed by "small" tankers, usually 25,000 to 50,000 dwt., foreign flag. Cost of the lighterage service is about 27 cents per barrel (65 cents using U.S. flag vessels). In addition, there is the cost of delay time for the lightered vessel. The New York, Delaware Bay, and San Francisco oil lighterage is generally performed with barges, and the reported costs, including tugboat hire, range around 20 cents per barrel. Self-unloading vessels in the 19,000 to 38,000 dwt. range have been offered for Gulf coal topoff at $5.00 per ton, and $3.00 per ton in Delaware or Chesapeake Bay. The quotes include and exclude, respectively, the coal terminal charges at the initial loadout port. Coal terminal transfer charges range from 65 cents per ton in Norfolk to over $2.00 in New Orleans, with lower rates on the Great Lakes and higher rates on the West Coast.

<u>Pipelines and Conveyors</u>. These are the commonly used devices to link vessels with shoreside storage, and there are numerous actual and proposed applications within ports as well as outside them. The offshore applications are more widely recognized because they are more numerous, especially marine pipelines, and because some are notable engineering feats. They include the ore loadout facilities in Brazil, Chile, Peru, New Zealand and Australia, two of which use slurry pipelines, and the Louisiana Offshore Oil Port (LOOP). The LOOP facility is really a hybrid that includes a pumping platform as well as vessel buoys and underwater lines, and two-thirds of its $700 million cost was for shoreside storage and transmission lines. Most of the U.S. offshore tanker berths are simply mooring buoys and a submersible line. A number are located on the California coast because of benign weather conditions, and collectively they handle more oil than LOOP.

Because the within-port applications typically supplement dredging schemes or address dredging constraints, they are more attractive as alternatives. Examples range from a four-inch floating products line used at Nantucket because berth dredging was delayed by environmental concerns, to a proposed consolidated tanker terminal in the Los Angeles outer harbor, which would connect with tank terminals located on interior channels where further deepening is impractical. A more modest variation has been considered for the Chelsea River in Boston. Some Gulf Coast ports have multi-user tanker piers (usually a pair) to conserve use of waterfront, with pipelines serving several inland tank farms. Similar use of conveyors is rare, but a conveyor system to move ore from a lakefront terminal to Cuyahoga River points was proposed at Cleveland because of the cost of bend easing and bridge replacement. At Jacksonville, the utility has installed a lengthy conveyor to receive coal from the main harbor channel instead of the shallower nearby channel. Slurry pipelines have been built to transport coal between interior points, and there have been proposals to use them for U.S. coal exports. So far they have not been a viable alternative as port facilities.

Dry bulk unloaders cannot cope with ship motions, so the only U.S. use of offshore facilities has been for oil. Within harbors, either pipelines or conveyors may have application. Unlike transshipments, the cost of pipeline or conveyor alternatives is highly site-specific and sensitive to volume. Incremental extension of either might cost on the order of $250.00 per foot for acceptable capacities for shipload quantities, with an effective limit of about 2500 feet before costs go up exponentially for repumping or flights of conveyors. A simple ship mooring with multiple buoys might cost up to $500,000; a pier within the harbor or a single point mooring for tankers offshore will cost upwards of $2 million. For a very rough approximation, estimates or actual charges have ranged from 25 to 50 cents per ton for the additional cost of having storage 2000 feet or more from the tanker berth or waterfront transfer facility, to about $3.00 per ton for the use of LOOP.

Very Long Piers. Although tankers routinely load and/or discharge via marine pipelines, there are operational limitations. Vessels moored to multiple buoys are subject to weather interruption. The alternative is use of a mechanically sophisticated and much more expensive single buoy that allows the vessel to swivel. Either buoy system requires some type of platform to provide supplemental pumping when discharge is more than about a mile offshore. Neither system is economic if dredging is required, because of the large range of vessel movement. The unsupported reach of conveyors is far less and, although a pile-supported one in Tasmania extends a mile offshore, it is desirable to base them on a conventional pier. For such reasons some very long piers have been built. The Richmond Long Wharf in San Francisco Bay extends 4200 feet to natural depths of 35 feet. The Leonardo (NJ) Navy Pier in Sandy Hook Bay serves the Earle Ammunition Depot and is the longest U.S. pier at 11,000 feet. There are other U.S. piers in the 1400-1700 foot range that handle dry bulks or oil, and exceptional piers elsewhere in the world. Typically, long piers have been used in bays or estuaries where there is some weather protection and insufficient natural depths for using anchorages or moorings. Since piers cost about ten times as much as pipelines or conveyors, foot for foot, site-specific conditions generally dictate their use.

Platforms and Islands. The ultimate facility alternative is to provide cargo storage where the vessel is. The cost of doing so in very deep water is prohibitive but there are practical applications of offshore structures. For comparison purposes, the approximate cost of raw land in port areas is about $4.50 - $5.00 per square foot, when available. The 1972 U.S. Deepwater Port Study by IWR estimated the cost of building an artificial island in Delaware Bay in alternate water depths. Adjusted for inflation, the IWR costs are about $5.00 per square foot in two-foot water depth, $15.00 in 20 feet, $45.00 in 35 feet. The costs for conventional shipside working areas with conventional depths (bulkheaded solid fill and pile-supported piers) range from about $50.00 to $200.00 per square foot. The estimated cost of a platform in Mobile Bay (for barge to ship transfer of coal) was about $220.00 per square foot, but costs for platforms in 50 to 110 feet of unprotected water may be as much as $1,000.00 per square foot of top deck surface. As information, the Mobile estimates were $22 million for the platform, and $31 million for associated equipment, 55 feet of water alongside.

Conventional shipside working surfaces are generally considered to be too valuable to use as storage areas. Due to even higher costs, platforms are used only for terminal equipment and operations. Similar to the LOOP platform, the Drift River Terminal in Cook Inlet is an offshore platform connected by submarine pipeline to onshore storage. However, it is a loadout terminal (the second largest shipping point for Alaska crude) and tankers berth alongside in 60 feet of water. Two examples of artificial islands to provide storage are the "Sea Island" crude transshipment terminal off South Riding Point, Bahamas, and a salt transshipment terminal off the northeast coast of Brazil. The Bahamas terminal is only 4000 feet offshore, but has berth depths of 85 and 100 feet. The Brazil terminal is almost nine miles offshore, with less than 20 feet alongside for small shuttle vessels. It is a steel-bulkheaded rectangle of about four acres, able to store 100,00 tons, and uses an overwater conveyor to a separate platform-mounted shiploader to load vessels up to 35,000 dwt. size. An acre will support high-density storage for about 35,000 tons of coal, 80,000 barrels of oil.

TABLE IV-4
MARINE TERMINAL SELECTION CRITERIA

Limitations on Use	Fixed Piers & Platforms	Multi-Buoy Mooring	Single Point Mooring
While berthing			
Waves	3-4′	6-8′	6-8′
Wind	25 kts	25 kts	25 kts
While moored			
Waves ahead	10′	10′	over 15′
Waves abeam	3-4′ (1)	3-4′ (est)	NA
Wind	50 kts	20-40 kts (1)	60 kts
Transferring Cargo			
Waves	3-10′ (2)	3-10′ (2)	10-12′
Wind	30kts	25-35 kts (1)	40kts
Distance offshore	Close	Medium	Furthest
Manouver area & seabed required	Small	Moderate	Large
Unberthing ease	Fair to good	Poor	Excellent
Tugs used	Required	Usually no	Usually no
Launches used	Sometimes	Required	Required
Investment	High	Low	Moderate (buoys) High (structure)
Susceptability to damage	Moderate to High	Low	Low/Mod (buoys) Mod/High (fixed structure)

(1) Depends on wind velocity and direction
(2) Depends on wave height and direction
Source: Beazley, Raymond A. and Ralph P. Schlenker, "A Rational Approach to Marine Terminal Selection" (Paper delivered at Ocean 73, 4th Annual International Conference on Engineering in the Ocean Environment, Seattle, October 25, 1973).

Marine terminal selection criteria shown in Table IV-4 provide a tool to screen facility alternatives. The Petroleum Yearbook regularly gives construction costs for most types and sizes of pipelines. Occasionally it will show information on tanker facilities that relates tanker size to pipeline size. For more information on conveyors, piers and other structures, contact vendors and look for notices of construction contract awards.

PORT PRACTICES AND OPERATING CONDITIONS

The actual capacity of a facility or channel will be more or less than its design capacity, depending on the demands of port commerce and the operating conditions acceptable to the individuals involved. Although the same or similar safety and environmental regulations apply at all U.S. ports, there are port-to-port variations in practices that tend to persist over time because of local labor agreements, or, in the case of ship pilots, state licensing and supervision.

Port-specific variation in facility utilization may occur because of noise and emission regulations, and working hours can be limited by land transportation services or the availability of operating personnel. The ability to work around the clock or during rain or inclement weather, and the size of work gangs, usually are negotiated at the local level, even for national or regional labor contracts. These local differences can have a significant effect on cargo handling costs as well as port capacity. Relevant information needed to determine vessel tide delay costs include the normal starting and working times, and premium pay and non-working times.

Port-specific variation in channel utilization is more prevalent for numerous reasons including geography and climate. Vessel operation practices have a great impact on project economics, and they are the focus of this and the next section. Practices may vary widely because navigation safety depends on individual judgements. The marine environment requires some acceptance of risk in vessel operations even though most people are "risk averse". The amount of risk acceptance at any one port is effectively determined by ship pilots, since there is no law or regulation that defines vessel safety as such or minimum safe clearances. The amount of risk acceptance or risk avoidance varies from port-to-port because physical conditions differ and because different pilots are involved. The actual amount of risk-taking in a port is likely to be less than that implied by Corps channel design criteria, because various expedients or alternatives are employed to avoid or reduce risk. Those alternatives are covered in the next section.

Certain vessel operation practices are likely to prevail in both with- and without-project conditions. These include the minimum acceptable underkeel clearance, and the use of traffic control or one-way traffic in narrow channels. The latter is sometimes proposed as a "non-structural alternative". It can impose significant delay costs on vessels, which for some (small) vessels are unrelated to benefits. That is one reason Coast Guard traffic services are advisory. Only pilots have enough authority to stand the heat of enforcing one-way operations. As with underkeel clearances, what they practice now is likely to be what they will accept in the future. Another prevailing practice may be peaking in vessel arrivals or departures. This will reflect the specific mix of traffic at the project port.

Similar to the facility alternatives discussed earlier, vessel operation alternatives are sometimes proposed or treated as "non-structural" alternatives. Unlike facility alternatives, which may or may not be disposed of as part of the with- and without-project conditions, vessel operating alternatives are part of the with- and without-project conditions. The following section should be used as a checklist. Some or all of the alternatives will be familiar, and would have been accounted for automatically in the calculation of harbor transportation costs. For the vessel operation alternatives that are less familiar, the information provided will be helpful.

VESSEL OPERATION ALTERNATIVES

Under the Ports and Waterways Safety Act of 1972, the U.S. Coast Guard was given broader powers to regulate vessel navigation for purposes of marine safety and environmental protection. Pursuant to a Memorandum of Understanding between the Corps and Coast Guard in 1977, administration of relevant preexisting Corps regulatory authorities was transferred to the Coast Guard, and safety regulations were consolidated in 33 USC. Previous Corps regulations covering speed limits, designation of restricted areas and anchorages, and certain vessel operations such as passing and tow size and assembly were republished in 33 USC 200+. Additional Coast Guard powers including vessel environmental features such as double bottoms, and vessel traffic control are published in 33 USC 1 to 199. The Coast Guard published proposed rules for minimum underkeel clearances and tug assistance, but did not publish final rules after receiving numerous protests.

For numerous reasons, navigation regulations provide for latitude in the way ships are operated. Absent a more specific measure, the standard for vessel operation is the safest and most economical way. Deviations from that standard are used by the people whose jobs depend on getting ships into and out of ports. Collectively, those deviations are treated herein as alternatives. The individuals involved may view them otherwise. The most commonly used alternatives are described below.

Underkeel Clearance. The minimum underkeel clearance used in most ports will be between 1.5 and three or more feet, depending on local prevailing practice. Worldwide it is about two feet, which approximates the safety clearance in Corps design criteria. Occasional lesser clearances may be observed, particularly at the shallowest port on the itinerary of a vessel. However, statistics showing zero clearances indicate some risk reduction measure has been overlooked, or the channel is really deeper than project depth. When vessels actually use less underkeel clearance than called for in Corps channel design criteria, the intrusion can be treated as risk acceptance, and a subsequent section describes the derivation of implied risk cost for NED benefit purposes. Because vessel operators do prefer to avoid risk, substandard clearances are the "alternative" least likely to be used. The other alternatives described below reduce risks due to channel constraints, and are the alternatives more likely to be used.

Use of Tides. Whenever there is a predictable water depth greater than the official Corps controlling or project depth, it is likely to be used by the deepest draft vessels. Use of tides will involve vessel delay costs, can involve shoreside terminal delay costs, and may involve additional costs related to vessel and terminal scheduling. Imputed risk costs may apply if tideriding produces channel congestion. No costs are involved for using cyclical lake levels, or actual water depths exceeding "controlling" channel depths due to datum differences.

For cost estimation and benefit calculation purposes, vessel arrival and departure times are assumed to be random. Reported maximum drafts in excess of channel depths identify only the most tide-dependent vessels. When available, the actual times of channel transits will give a better indication of the extent of tide delays. Depending on the specific port, there may be a significant difference between highest and lowest high tides, and the width of the tide window that can be used by different vessels. Interviews that supplement statistics will be needed to identify the extent of the practice, and the extent to which it affects cargo handling as well as vessel operating costs.

Reduced Speeds. The flow of water displaced by ship movement produces a lowering of the water surface adjacent to the ship. This so-called "vessel squat" increases with vessel speed and the degree to which the vessel fills the channel cross-section. Changes in vessel direction produce roll that also increases with speed. Channel design criteria may call for an allowance of four or five feet for squat and roll of large vessels at (or above) the usual speeds or speed limits in harbor channels (usually six to eight miles per hour). In practice, constrained vessels may operate at the slowest speed that maintains "steerage way" (usually two to three miles per hour), and may operate slower with tug assistance. When necessary, vessel operators reduce speeds and depend on the safety clearance to absorb squat and roll.

The simplest measure of the cost of reduced speeds is the additional vessel time required for channel transit, plus the cost of tug assistance beyond that normally needed for docking and undocking. The additional time can be determined by comparing the transit times of large constrained vessels with those of smaller unconstrained ones (preferred), or by comparing constrained vessel speeds with design criteria or legal speed limits (whichever is lower). If it is possible to identify an increase in vessel sizes or drafts attributable to reduced vessel speeds, an alternate calculation of project benefits can be based on risk reduction, using one-half the transportation savings of the larger/deeper risk taking vessels. Benefits based on either risk reduction or cost reduction may be appropriate, but not both.

Navigation laws everywhere have a requirement to reduce speed if there is a question of safety, and speed reduction will not be perceived as an alternative by vessel operators. It can be treated as such for evaluation purposes. The speed reduction may be due to channel depth, and/or channel width and passing clearances. If there are multiple reasons for speed reduction and the project does not fix all, there may be no benefits. If the project fixes multiple problems, the benefits are limited to the actual cost reduction. Benefits cannot be counted twice.

Reduced Trim. Most commercial vessels have a long flat bottom and operate most efficiently on an "even keel". Bow and stern draft markings are based on that attitude. Many vessels appear to steer better with the stern deeper in the water, and most vessels operate that way provided there is enough water to do so. For draft-constrained vessels, trim reduction is an alternative of choice because it may cost them nothing. Outbound vessels can and usually are loaded for zero trim. Inbound trim will vary more because of fuel used and other factors.

Along with use of tides, trim reduction accounts for most disparities between actual vessel sizes and the largest sizes anticipated by applying channel design criteria. The design criteria provide an allowance for the amount of trim considered desirable for the design ship, which may be on the order of two or more feet, bow versus stern. Port-specific statistics show progressively less trim is used as vessel drafts approach the channel limit. At the limit, trim was generally zero to less than one foot. The trim reduction at the project port will be needed for lightloading analysis.

Ballast and Bunkering. Empty or underloaded vessels of all types may use ballast to bury their propeller and rudder; containerships are one of the few types that routinely ballast when loaded, for stability reasons. Ballast discharge may be determined by environmental regulations. Taking on ballast at the pier is preferable so that the vessel is ready for sea, but it usually can be performed outside the port. This is one of the minor alternatives, but it may be used to maximize payload and limit draft when necessary. Ask the vessel operators if it occurs, and if there are any delay or other costs.

Vessel fuel is often called "bunkers", from the name of the ship compartment where coal was carried. Similar to ballasting, it is usually desirable to fuel vessels during cargo loading or unloading. If draft limits apply, the fueling may be done at an anchorage in the harbor using barges, or at another pier in the port, or the vessel may call at another port for bunkers. Those alternatives cost progressively greater vessel time and incidental expenses, which may be offset or increased by different fuel prices at the delivery points. If ships take on fuel in the project port, the fuel vendors and the vessel operators should be contacted to determine any effect of channel depths on bunkering practices and volume.

The effect of draft limits on vessel fuel costs may be significant if the alternative is to bunker for one way only instead of a round trip. Most vessels have fuel capacity for about 60 days and fuel can account for two feet of draft for bulkers and tankers, and four feet for containerships. The full capacity is seldom needed or used, but it gives the vessel operator more flexibility to bunker wherever prices are best. Vessels usually bunker on each major leg of their voyage. Since fuel is cheaper in California than the Far East, transpacific operators will fuel there for a round trip. At Oakland, some of the transpacific containerships take fuel for one way only, because of the channel constraints there.

Alternate Vessel Itinerary. Loading vessels deepest at their deepest port of call has compelling logic, but there are reasons why that does not always happen. The extent to which logical itineraries are, or can be, used affects the need for improvements at the project port. The extent to which future vessels call at shallower ports before and after the project port will be crucial in realizing improvement benefits. The vessel itineraries produced as part of baseline information are likely to show use of some alternatives that are helpful, and some that are not. These practices should be explained so that the with- and without-project conditions reflect the alternatives likely to be employed.

Itineraries will indicate whether vessels call at bulk transshipment or top-off ports. Subsequent analyses will address whether they will continue to do so. Baseline information should identify vessels that could do so and why they do not--vessel deviation costs, port costs, shippers unable or unwilling to split shipments. Vessels that routinely make multiple port calls may in effect have no alternative as to port rotation. Products tankers usually call in geographical rotation. Liners such as containerships will almost always make their first inbound and last outbound calls at the ports where competition is strongest, regardless of channel depth.

PORT INSTITUTIONS

An assessment of port-related institutions and their interaction may be needed to establish the most likely future with- and without-project conditions. To the extent that the institutions now have a visible or predictable impact that can limit realization of project benefits, they should be identified in NED baseline information. Two areas to focus on are described below.

Land Use. Port development usually has to compete for use of the waterfront, and it doesn't compete successfully when there is de facto economic zoning. The most efficient cargo handling is at ground level and almost any type of high-rise structure, regardless of purpose, can outbid port facilities for a waterfront site. Local zoning may or may not reflect this. Coastal Zone Management was intended to address it. Baseline information should identify which entities are involved in zoning, and the specific regulations or restrictions that are relevant.

Support Services. Port activities depend on a variety of public and private entities for basic services such as safety, security, and utilities, and specific services such as vessel repair and certification of cargo weights and grades. The absence of cargo surveyors, a Board of Trade, or Maritime Exchange may affect the ability of a port to attract and service new commodities. Amenities such as housing and recreation are significant for vessel home ports. The obscure factors that impede benefit realization are unlikely to surface except in baseline investigations.

DETERMINATION OF TRANSPORTATION COSTS

The P&G calls for use of current transportation costs in NED evaluation, and says that those costs are to include the full origin-to-destination costs including necessary handling, transfer, storage, and other accessorial charges. For both theoretical and practical reasons it is necessary to interpret just what costs are costs, and whether all of those costs have to be counted in evaluation.

In economic theory, the concept of marginal costs is fundamental. The P&G recognizes this, and also the difficulty in determining those costs. Therefore, it recommends use of actual or simulated market prices to measure the value of outputs. In the case of ocean transportation, rates are volatile and there is evidence that they are unrelated to long run costs. Inland carrier rates may correspond more closely to marginal costs, but under deregulation the effective rates may be unobtainable. The practical solution for ocean carrier costs has been to estimate operating costs based on sampling, and provide for vessel replacement. Section 7a of the Department of Transportation Act of 1966 (P.L. 89-670) requires use of prevailing overland carrier rates for inland waterway studies; for the navigation studies covered by this manual any combination of actual rates or cost estimates based thereon may be used. Efforts to identify and apply marginal costs more precisely can be more work than they are worth.

Historically, deep draft navigation studies have focused only on the incremental change in ocean transportation costs attributable to channel improvements. That simplifies the analysis greatly and it may still be acceptable if there are conclusive reasons why the channel improvement will not affect the vessel fleet composition or the commerce of other ports. That may be true for some small ports or projects, and the point is to do what is sensible. That includes contacting the Planning Division of HQUSACE early in the study for concurrence that multiport analysis and inland transportation costs can be omitted. For many projects the only conclusive way to identify impact on other ports is by multiport analysis using complete origin-destination costs. Using only "benefited" commodities in that analysis is, in effect, looking only at those at the margin. That may be valid if their land transportation rates are equalized (actually and not assumed to be), but looking only at costs at the margin should not be attempted without approval.

OCEAN TRANSPORTATION COSTS

Channel improvements benefits are directly related to vessel operating costs. If the costs go down due to fuel price fluctuations, competitive pressures, or technological improvements, benefits will be decreased in the same proportion. This can cause great stress. The P&G identifies the Corps Water Resources Support Center as the source for vessel costs, but gives a license to develop port-specific vessel costs. The license should be used for unique vessels or vessel fleets, not for shopping for higher costs.

Vessel Operating Costs. The Corps has issued information on deep draft and shallow draft vessel operating costs more-or-less annually since the 1960s. The basic effort has been to determine actual costs for representative sample vessels, and to present those costs for basic vessel types in the array of sizes desired by Corps planners (deep sea tankers, drybulkers, containerships, and general cargo vessels; inland towboats and coastal tugs by horsepower, barges by type and size). The information has been published as part of the Planners Handbook, and most recently in Economic Guidance Memorandums. Copies can be obtained from CEWRC-IWR-N.

The three major components of vessel operating costs are vessel replacement or financial costs, fuel, and fixed operating costs including crew and all other costs. In some cases, costs for individual components can be adjusted or used selectively to estimate costs for vessel sizes and types not shown. Vessel information is provided so that transportation costs can be calculated based on the costs shown. Fuel cost can be adjusted for speed and prices at bunkering locations of vessels serving the project port. IWR may be able to produce operating costs for the types of vessels for which costs are not routinely published. Alternatively, there are consultants who can do so.

Vessel Transportation Costs. Vessel operating costs per day or per hour must be converted to voyage or ton-mile costs for most study purposes. The actual ton-mile or transportation costs will depend on how fully laden the project port vessels are on their voyages, and many other factors. Cargo deadweight or payload seldom exceeds 95 percent of the nominal deadweight used to display operating costs by vessel size. The tons per inch (TPI) immersion factors are applicable only to incremental changes in draft in the usual range of loaded vessel drafts. The additional assumptions needed to produce transportation costs include the vessel lading on all loaded and light legs of its voyage, idle and productive port time, and sea time that reflects voyage circuity and weather delays. The validity of those assumptions will affect transportation costs as much or more than the accuracy of daily vessel costs. When vessel costs (or benefits) appear to be too low, the problem usually is that the transportation costs are unrealistic, not the operating costs.

Transportation costs can be calculated using project port information on vessel itinerary, load factors, and voyage cycle time previously described. Alternately, there are the assumptions as to voyage circuitry, load factors, and port and sea time, that are used in vessel fleet forecasts to estimate effective annual capacity of ships. The port-specific information will be most readily available for bulk carriers and tankers, especially those operating one port to one port. For liner vessels and other vessels with complicated itineraries, port-specific information is desirable, but use of "effective capacity" assumptions may be a necessary expedient. It is generally accepted that liner vessels spend about 60 percent of their time in port, and about 15 percent loading and unloading cargo. A very helpful explanation of assumptions is in Merchant Fleet Forecast of Vessels in U.S. Foreign Trade, May 1978, by Temple, Barker and Sloane for the Maritime Administration. It is out of print, but copies may be available. Its forecasts are dated, but its assumptions are explicit and easy to understand.

Vessel productivity will vary according to the type of vessel and conditions on its trade routes. Vessel voyage records show actual experience, but there is no readily available collection of such statistics. Of necessity, generalized values are shown in Table IV-5 for the adjustments to vessel capacity needed to calculate transportation costs. The table is derived from various sources, and identifies the adjustments needed. Its "representative" values may not reflect extreme variations in real life, but may be useful in the absence of more specific information for the vessels at the project port.

TABLE IV-5
ADJUSTMENTS FOR ESTIMATING ACTUAL VESSEL CAPACITY

Cargo Carried	General Cargo	Container Ship	Neo Bulk	Dry Bulk	Tanker
Cargo Capacity Factors	(adjust ship dwt for fuel, stores, water)				
<20,000 dwt.	.90	.85	.90	.90	.90
20-70,000 dwt.	.90	.90	.92	.92	.92
70-120,000 dwt.	NA	NA	.95	.95	.95
>120,000 dwt.	NA	NA	.97	.97	.97
Cargo Density Factors	(adjust weight capacity for cubic limits)				
all sizes	.66	.77	1.00	1.00	1.00
Cargo Load Factors	(adjust for average vs. full payload)				
heavy leg	.85	.85	1.00	1.00	1.00
other legs	.85	.85	- (varies) ------		
Voyage Duration	(in days, depends on itinerary and cargo)				
Unproductive Port Time	(total for entering/clearing/holidays/etc.)				
U.S. - North Europe	7	4	3	1	1
Central & W.C.South Am.	10	8	4	2	1
Med. & EC South Am.	23	10	5	3	1
Australasia, Pac. Is.	27	14	5	3	1
E & W Africa, Red Sea,	35	16	15	12	1
Loading & Unloading	(for each loaded leg of the voyage)				
<20,000 dwt.	7.0	2.0	4.5	3.0	2
20-70,000 dwt.	8.0	3.0	7.0	4.0	2
70-120,000 dwt.	NA	NA	9.0	6.0	2
>120,000 dwt.	NA	NA	NA	7.5	3
Sea Time (depends on actual distance, plus one day for each canal)					

Comment on Vessel Payloads. It may be necessary to restate commodity forecasts in the tons used to measure vessel capacity, or vice versa. For display purposes, Table IV-5 shows payloads for general cargo and container vessels on a weight basis. That is not the customary measure of capacity for those vessels, although it is desirable to use for benefit analysis. Because of the light density of their cargoes, payload is usually determined by the cubic capacity of general cargo vessels (usually 50 to 60 cubic feet per deadweight ton) or the number of container "slots" or spaces on containerships (usually measured in TEU or twenty-foot equivalents). Containership deadweight may be anywhere between 12 to 22 tons per TEU, depending on the vessel owner's preference, but most container weights are in the low end of that range. (Highway weight limits are one reason.) Containerized Cargo Statistics, published annually by the Maritime Administration, shows average container ladings for major ports and trade routes. A number of sources show the density of specific commodities, but "broken stowage" (inefficient utilization of space) is also a factor in vessel capacity, particularly general cargo vessels. Modern Ship Stowage and A Shipper's Guide to Stowage of Cargo in Marine Containers are references with comprehensive information. Both were Government Printing Office publications, but are now out of print. Most people in the maritime industry now use Thomas' Stowage (The Properties and Stowage of Cargoes), by Brown, Son & Ferguster, Glasgow.

Comment on Vessel Speeds. The vessel operating costs published by IWR-N show "representative" speeds for major ship types. They can be used to simplify cost calculations, even though individual actual speeds may be a few knots faster or slower. However, average effective speeds of vessels may be as much as 30 percent slower than "representative" because of bad weather and course deviations for various reasons. As a result, sea time and transportation costs will be understated if actual or representative speeds are applied to the most direct port-to-port distances. The simplest solution is to inflate the travel distance by assuming some voyage circuity. Table IV-6 shows trade route distances that include an allowance for circuitry.

Delay Costs. The cost of delays is a significant factor in ocean transportation costs. The adjustment in Table IV-5 for unproductive port time covers delays waiting for tides or better weather, awaiting inspections or clearance, or because the vessel cannot work cargo due to strikes or holidays. The adjustment is appropriate for delays elsewhere than the project port. There, the cost of delays should be determined with reasonable precision because any cost reduction attributable to the project flows directly to project benefits. Delays due to weather or awaiting tides are accounted for as additional port or sea time of cargo vessels. This understates the value of the time somewhat because it does not reflect lost employment opportunity. The difference is so slight it is not worth pursuing. For fishing vessels and pleasure boats, lost opportunity is the customary measure of delay cost.

TABLE IV-6
TRADE ROUTE ROUND TRIP DISTANCES

TRADE ROUTE (U.S. Coast-Foreign Range)	BULK AND TANKER DISTANCES	LINER AND NEOBULK DISTANCES
Atlantic-E.C. South Am.	9000	13500
Atlantic-W.C. South Am.	6500	9000
Atlantic-Caribbean	3500	5000
N. Atlantic-N. Europe	7000	8000
N. Atlantic-Med.	9000	12000
Atlantic-Far East	19000	27000
S. Atlantic-Med.	9000	12000
Gulf-Med.	11500	15500
Atlantic-W. Africa	10000	14000
Pacific-W. Africa	16500	22000
Atlantic-S. & E. Africa	15000	20000
Gulf-S. & E. Africa	16000	28500
Pacific-S. & E. Africa	21000	28500
Atlantic-Austrailia & N.Z.	19500	26500
Gulf-Austrailia & N.Z.	18500	25500
Atlantic-S.E. Asia	20500	28000
Gulf-S.E. Asia	23000	31000
Pacific-S.E. Asia	14000	19000
Atlantic-India to Red Sea	23500	29500
Gulf-India to Red Sea	24694	33500
Gulf-Caribbean	3500	4500
Gulf-EC South Am.	10500	14500
Gulf-N. Europe	10000	12000
Gulf-Far East	21000	26500
Pacific-Caribbean	8000	10500
Pacific-EC South Am.	15500	17000
Pacific-WC Central Am.	9500	13000
Pacific-N. Europe	17500	24000
Pacific-Med.	21500	29000
Pacific-Austrailia & N.Z.	14500	19500
Pacific-India to Red Sea	21500	29000
Pacific-Far East	11500	16500
Gulf-WC South Am.	5500	10500
Atlantic-WC Central Am.	4500	6000
Gulf-WC Central Am.	2500	3500
Intercoastal Pac.-Atlantic	11500	15500
Intercoastal Pac.-Gulf	11000	15000
Lakes-N. Europe	7500	10500
Lakes-Med.	11500	15500
Lakes-Far East	26000	35000
Round-the-World	NA	27500

Source: Merchant Fleet Forecast of Vessels in U.S.- Foreign Trade, by Temple, Barker & Sloane, Inc. under Contract No. 6-38091, U. S. Department of Commerce, Maritime Administration, Washington, DC, May 1978

The costs, and to some extent the frequency, of weather and tide delays of cargo vessels increase with vessel size. Project port delay costs can be quantified in the calculation of per ton transportation costs, or as a separate calculation. A separate calculation is preferable for weather delays because it can handle seasonal variation. Calculating tide delay costs as part of transportation costs is preferable, because delays are related to vessel sizes.

The basic assumption in calculating tide delay costs is that vessel arrival and departure times are random. The simplest calculation uses the mean high and mean low tide heights at the project port, and the daily duration of intermediate heights based on relationships shown in the <u>Tide Tables</u>. The tide required will depend on vessel draft, and the useable tide window and maximum amount of tide that can be used will be determined by the vessel's channel transit time. Cost of delay time for each channel transit by a tide-dependent vessel is its daily operating cost (sea cost for entering vessels, port cost for departing vessels), minus the daily duration of useable tides. Tide heights will vary with port location and moon phase. Figure IV-1 shows the more-or-less typical variation in average tides.

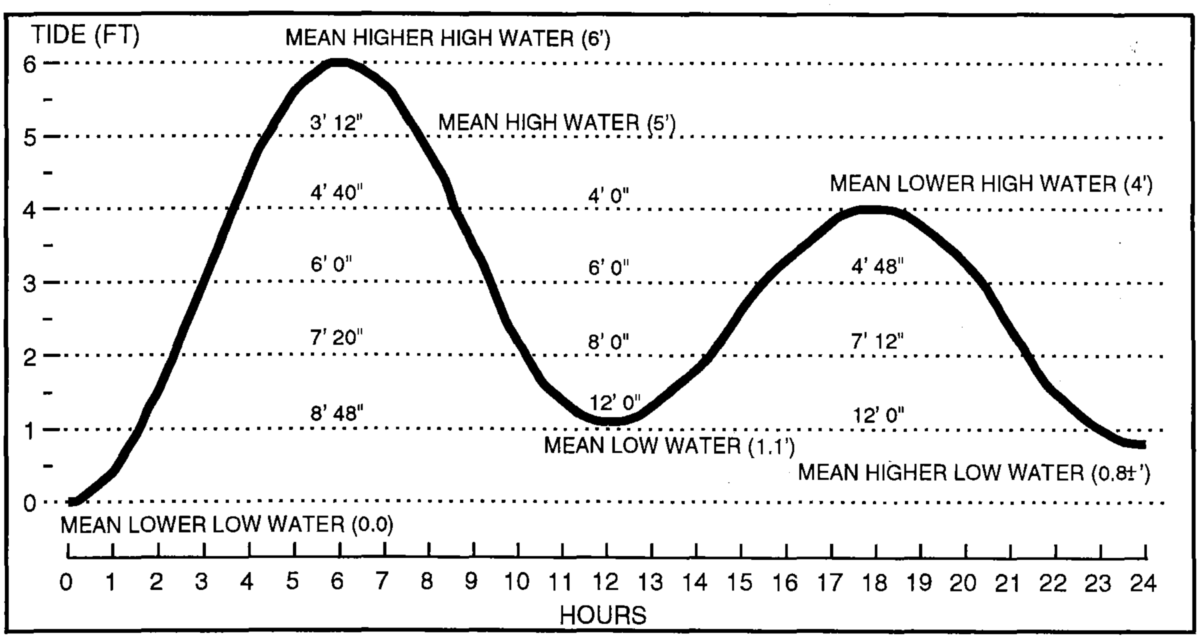


FIGURE IV-1. HEIGHT AND DURATION OF AVERAGE TIDES AT RICHMOND, CALIFORNIA
Duration of tides per 12-hour cycle in hours' and minutes"

Some studies have used an average amount of delay for vessels of a given size, based on vessel operator records or observation. Some simplification is necessary in calculating tide delays, but not that much. Using one-foot increments of tide and ignoring fractions is appropriate because that is the level of precision in most vessel navigation. Applying assumptions as to "average" delay may overstate or understate delay costs. Use of the mean high and low tides may also understate delay when tides are not symmetrical.

Table IV-7 is based on the tides at Richmond, California shown in Figure IV-1. The table shows a comparison of "tide windows" for the different average tides. Remarkably deep drafts that show up in Waterborne Commerce statistics usually reflect occasional use of spring tides. Since the opportunity to use those tides is limited almost entirely to outbound vessels, the average of the extremes is usually more representative. It produces more delay time than the overall average "mean" tide.

TABLE IV-7
ESTIMATED DAILY TIDE AVAILABILITY AT RICHMOND, CALIFORNIA
(tide duration in hours' and minutes")

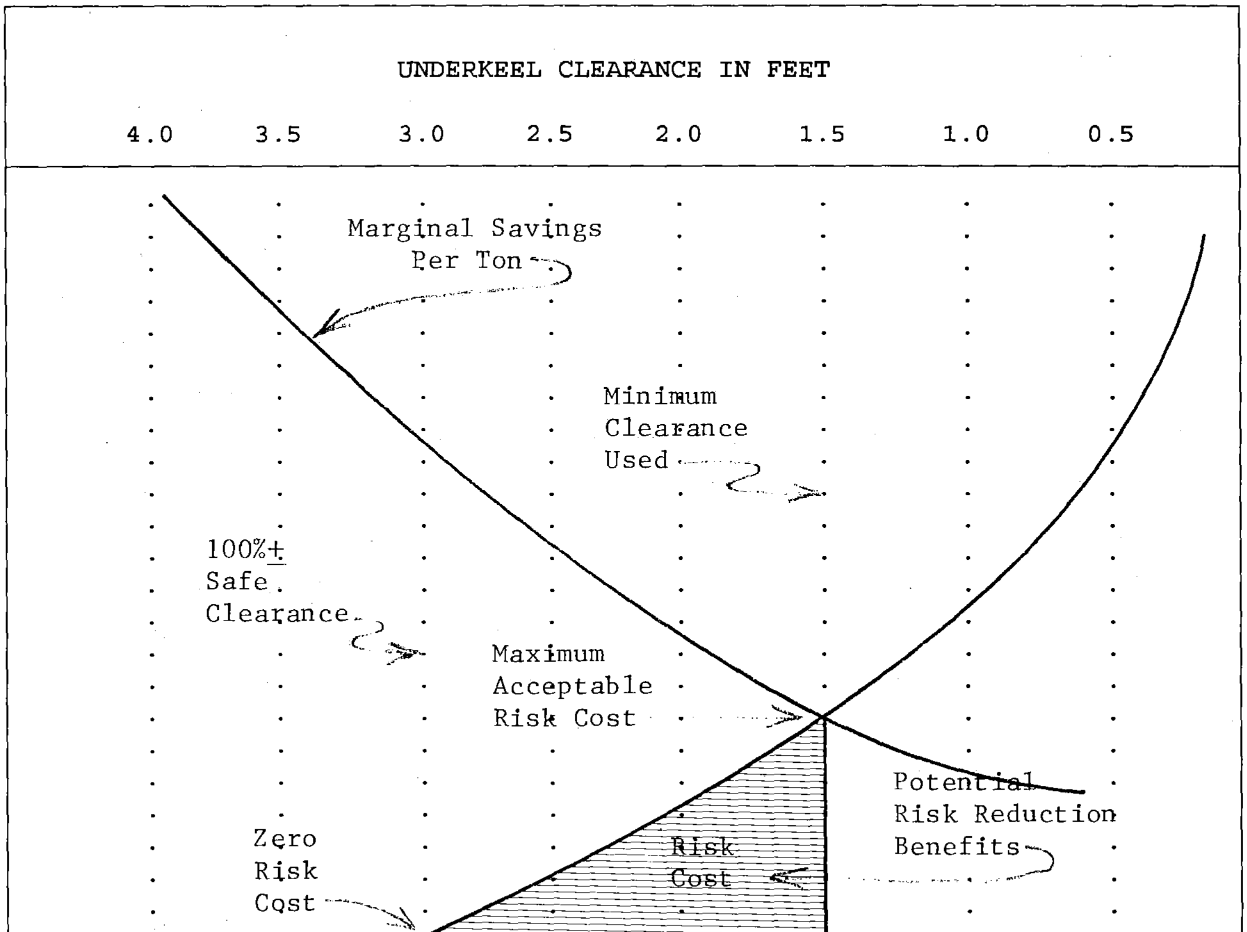
Tide Available	Spring Tides	Neap Tides	Average of Extremes	Mean Tide
+5	6'24"	NA	3'12"	NA
+4	9'20"	NA	4'40"	8'0"
+3	12' 0"	9'36"	10'48"	12'0"
+2	14'40"	14'24"	14'32"	16'0"
+1	17'36"	24' 0"	20'48"	24'0"

Vessel Damage and Risk Costs. Project benefits for vessel damage or risk reduction may apply because of deeper or wider channels, or better weather protection. There are basic differences between damage reduction and risk reduction or improved safety, and the baseline information needed to estimate benefits attributable to the project.

Damage reduction benefits are usually associated with pleasure or fishing craft because of the large number of small craft and their potential for frequent but relatively minor damage due to grounding or collision. Accident statistics are available for small craft (Coast Guard annual publication Boating Statistics 19XX, ex. CG-357). Quantifying small craft safety benefits is usually impractical because of the diversity of operators and their practices. The availability of statistics for large vessels is usually the reverse. Their collisions are infrequent and tend to be catastrophic and unrelated to channel constraints. Their groundings seldom require shipyard repairs, but may result in difficult to determine costs such as suspension of hull insurance. Damage statistics for large vessels may not be useful, but their deviations from safe clearances are more apparent. Therefore, it is generally more rewarding to claim safety benefits for large vessels, based on risk reduction.

A cost for risk taking is needed to determine safety benefits, and may be needed to justify the safety margins designed into Corps projects. In lieu of actual damages, we rely on logic and economic theory to determine risk cost. The logic is that vessel operators will use substandard clearances as long as their perceived benefits from doing so (revenues, job security) exceed their perceived costs from potential damages. The economic theory is that the perceived benefits may be unrelated to costs for numerous reasons, and the appropriate comparison is between the marginal savings in the cost of transportation and the marginal costs attributable to risk taking. Provided there is a pattern to the risk taking at the project port (vessels above a certain size use a safety clearance less than the Corps design standard), the point at which decreasing cost savings intersects increasing risk costs can be identified, and related values can be determined.

Figure IV-2 illustrates the procedure for underkeel clearance. For that example, marginal cost savings per ton were derived from estimated average transportation costs at various increments of draft, payload and underkeel clearance for a 40,000 deadweight ton vessel. Marginal savings at the actual draft (43 cents per ton at 1.5-foot clearance) are the risk cost for the last ton loaded. Assuming risk is zero at the Corps standard clearance (3-foot), the vessel's total risk cost is about one-half the product of additional tonnage carried because of risk acceptance and the savings per ton at maximum acceptable risk (38,000 -35,000 * .43 * .5 = $645.00). Accounting for the nonlinear curves of savings and risk costs would produce a more accurate number. Average transportation costs will change with vessel size and route, and total project risk costs will require similar calculations for all cargoes carried on relevant ship sizes. Risk costs must be calculated for the with- and without-project channels, to determine the amount of cost reduction and project benefits.



VESSEL STATISTICS

DRAFT IN FEET	35.5	36.0	36.5	37.0	37.5	38.0
PAYLOAD IN TONS	35,000	36,000	37,000	38,000	39,000	40,000
AV. COST PER TON	$17.14	$16.67	$16.22	$15.79	$15.38	$15.00
SAVINGS PER TON	$0.51	$0.47	$0.45	$0.43	$0.41	$0.38

FIGURE IV-2 IDENTIFICATION OF RISK COST OF SUBSTANDARD UNDERKEEL CLEARANCE.

Quantification of risk cost requires identification of two safety clearances, the amount that everybody agrees is safe, and the smaller amount that vessel operators are willing to use. Corps manual EM 1110-2-1613, Hydraulic Design of Deep-Draft Navigation Projects, is a good guide to risk-free depth and horizontal clearances, but it is advisable to check with project port pilots and vessel operators to determine their standards. Identification of the substandard clearance actually used will require statistics that demonstrate a pattern to risktaking. That is, a plateauing of vessel drafts somewhere deeper than the generally recognized safe depth, or a plateauing of sizes bigger than the largest size considered safe for the channel width. The Corps design criteria usually call for two or three feet of safety clearance under the deepest point of the ship. In practice a two-foot clearance is common and in a few ports it may be 1.5 feet. Depending on the specific port, that could leave a difference of 0.5 to 1.5 feet to be accounted for by risk.

The concept can be applied to "oversize" as well as "overloaded" vessels as shown in Table IV-8, provided a lower level of precision is acceptable.

TABLE IV-8
IDENTIFICATION OF RISK COST FOR OVERSIZE VESSELS

Vessel Dwt. (payload)	Vessel Revenue	Revenue Per Ton	Marginal Rev. Per Ton	Risk Cost Per Ton
15,000	$480,000	$32.00	--	--
20,000	510,000	25.50	$ 6.50	$1.50(1)
30,000	560,000	18.67	6.83	2.50(1)
40,000	600,000	15.00	3.67	3.67

(1) Intermediate values estimated from graph.

The vessel sizes used in Table IV-8 were taken from the Portsmouth (NH) Harbor study. The port is naturally deep but has swift currents and constrained maneuvering room. Based on Corps channel design criteria, the channel could be considered risk-free only for vessels up to 15,000 dwt. However, larger vessels routinely used the channel, with a distinct plateauing of sizes at 40,000 dwt.

The calculation of risk costs and risk reduction benefits is performed apart from transportation costs, and the results displayed separately. In the case of "oversize" vessels, the per ton costs are applied to the tonnage of cargo expected to move in the specific sizes and could be integrated into transportation costs easily. In the case of "overloaded" vessels, it is possible to calculate the risk cost for the actual increments of reduced clearance by specific vessels or vessel types, but that is time-consuming. Provided the vessel fleet is reasonably homogenous and there is essentially just one difference between zero risk and acceptably safe clearances (typically 2′ vs. 3′), risk costs or benefits can be taken as one-half the deepening benefits for the initial deepening increment equal to that difference (e.g. one-half the benefits of deepening a 35-foot channel to 36 feet when the difference is 2′ vs. 3′).

If project benefits have been calculated based on substandard but actual underkeel clearances, the accounting for risk will add benefits. Alternately, if benefit calculations used the standard risk-free clearance but vessels use less (e.g they operate in a 35-foot channel as though it were 36 feet deep), accounting for risktaking reduces those benefits. In either case, the improvement project should reduce the need for risk reduction measures by vessel operators (slower speeds, etc.). To the extent those cost reductions can be quantified they are benefits. The amount of trim reduction, but not its cost, is usually identifiable. Conceptually, there is some basis for trying to count the trim reduction (which may be one or more feet) along with the reduction in actual safety clearance. It is a clear sign that vessel operators recognize the cost of risk. However, there is no basis in planning guidance for using trim reduction that way. Absent an identifiable cost, trim reduction can only be used to explain actual drafts.

Risk costs and tide delays are both likely to apply with, as well as without, the project. The project is still likely to have delay and risk reduction benefits, but they are for the net reduction. A net reduction is likely because, typically, there will be a smaller number of larger vessels that can be delayed, and the opportunities and incentive to accept risk will be reduced.

Summary of Ocean Transportation Costs. The following calculations of ocean transportation costs show how baseline information is used. The costs are for a hypothetical movement of bulk grain to the Mediterranean from a U.S. Atlantic Coast port with a 40-foot channel, with 50 percent of the vessels returning light and 50 percent backhauling steel. Specific assumptions and data sources are as follows:

- Vessel Fleet. The January 1, 1988 world fleet of bulk carriers with loadline drafts of 28 to 45 feet was used. The distribution of vessel sizes by draft was provided by the Maritime Administration. A segment of the world fleet was used to simplify calculations. A more scientific way to determine the upper size limit would use transport cost lightloaded.

- Vessel Lightloading. A "typical" distribution of actual drafts was derived from statistics in a Newark Bay study report(see Table IV-1). It was assumed that this lightloading reflected trade route draft constraints and no specific adjustment was needed for itinerary. The same distribution of lightloading was used for all loaded vessels, with inbound vessel drafts reduced an additional foot to account for fuel consumption.

- Vessel Payloads. Factors shown in Table IV-5 were used to adjust deadweight to payload, which was further reduced for lightloading. Vessel immersion rates in tons per inch (TPI factors) shown in IWR's 1987 vessel costs were used, with interpolation for intermediate sizes, to determine net payload.

- Voyage Distance and Duration. Tables IV-5 and IV-6 were used. For vessels loaded both ways, the average of bulk and neo-bulk distances was used (10,500 miles or 31 sea days at 14 knots). Total port time was based on loading and unloading, both directions (11 working and 8 non productive days). Distance and duration for vessels with one way grain loads were 9000 miles, 27 sea days, and 7 port days.

- Tides. Duration and height are based on the average of spring and neap tides at Richmond, shown in Table IV-7.

- Vessel Operating Costs. IWR's 1988 vessel costs (issued in late FY89) were interpolated to world average deadweights for loadline draft.

- Underkeel Clearance. A total of 3 feet was allowed for safety clearance and trim, squat, and roll. This is the clearance that the largest vessels are likely to use, and smaller vessels may use fewer draft reduction measures. For simplicity, the example understates tide dependency and does not calculate risk costs.

The following calculation of costs is for a single vessel with a deadweight of 50,578 tonnes (metric) at a loadline draft of 40 feet. It has an immersion rate of 140 tonnes per inch, and is assumed to be 1' lightloaded both ways. Its costs are $13,927 per sea day, $9,681 per port day. Costs are calculated per tonne. Alternately, vessel capacity could be converted to short tons.

Vessel Payloads

50,578	tonnes	- ship deadweight
X .92		- allowance for fuel, stores, water
46,532	tonnes	- cargo deadweight
-1,680	tonnes	- allowance for 1' lightload
44,852	tonnes	- payload using 2' tide at U.S. port
3,360	tonnes	- 2'lightload in lieu of tide delay
41,492	tonnes	- payload without use of tide

Voyage Costs

	One-Way Load	With Return Load
Distance	9,000 miles	10,500 miles
Sea Time @ 14 knots	27 days (26.8)	31 days (31.3)
Port Time	7 days	19 days
Sea Cost	$376,029	$431,737
Port Cost	$ 67,767	$183,939
Voyage Cost	$443,796	$615,676
Cost per Tonne, 1' light	$ 9.89	$ 6.86
Cost per Tonne, 3' light	$10.70	$ 7.42

Tide Delay at U.S. Port

	Outbound	Inbound
Tide Needed	2 feet	1 foot
Time Needed	.3945 port day	.1333 sea day
Delay Cost	$3,819	$1,856
Potential Revenue	$33,230 @ 9.89	$11,525 @ 6.86
Acceptable Delay Cost	$3,819	$1,856

Ocean Transportation Costs

	One-Way Load	With Return Load
Voyage Costs	$443,796	$615,676
Tide Delay Costs	$ 3,819	$ 5,675
Total Costs	$447,615	$621,351
Cost per Tonne	$ 9.98	$ 6.93

Average Cost per Tonne/Short Ton Grain	$8.46/$7.67
Incremental Cost per Tonne/Short Ton Steel	$3.87/$3.52
Average Cost per Tonne/Short Ton All Cargo	$7.95/$7.21

The following tables show a calculation of costs for the entire port fleet, using a PC and LOTUS 1-2-3. Additional tables would have been required to show separate fronthaul and backhaul costs.

TABLE IV-9

VESSEL PAYLOADS IN TONNES IN NORMAL RANGE OF ACTUAL DRAFTS

MAX DRAFT	VESSEL #	FLEET TTL DWT	AVG DWT	CARGO DWT	CARGO...... TPI	CARGO PAYLOAD IF LIGHTLOADED....... 1 FT	2FT	3FT	4FT	5FT	6FT	7FT
45	73	5163900	70738	67201	174	65113	63025	60937	58849	56761	54673	52585
44	82	5399300	65845	60578	167	58574	56570	54566	52562	50558	48554	46550
43	148	9290400	62773	57751	160	55831	53911	51991	50071	48151	46231	44311
42	113	6990600	61864	56915	153	55079	53243	51407	49571	47735	45899	44063
41	218	12545800	57550	52946	147	51182	49418	47654	45890	44126	42362	40598
40	165	8345500	50579	46532	140	44852	43172	41492	39812	38132	36452	34772
39	85	3651900	42964	39526	133	37930	36334	34738	33142	31546	29950	28354
38	172	7154400	41595	38268	126	36756	35244	33732	32220	30708	29196	27684
37	356	13480800	37867	34838	119	33410	31982	30554	29126	27698	26270	24842
36	410	14314300	34913	32120	102	30896	29672	28448	27224	26000	24776	23552
35	512	16173500	31589	29062	95	27922	26782	25642	24502	23362	22222	21082
34	359	9636700	26843	24696	90	23616	22536	21456	20376	19296	18216	17136
33	373	9092800	24377	22427	85	21407	20387	19367	18347	17327	16307	15287
32	373	8842400	23706	21810	80	20850	19890	18930	17970	17010	16050	15090
31	284	5790400	20389	18350	75	17450	16550	15650	14750	13850	12950	12050
30	225	4164800	18510	16659	70	15819	14979	14139	13299	12459	11619	10779
29	109	1678800	15402	13862	65	13082	12302	11522	10742	9962	9182	8402
28	50	701300	14026	12623	60	11903	11183	10463	9743	9023	8303	7583

TABLE IV-10

VESSEL TRANSPORTATION COST PER TONNE IN NORMAL RANGE OF ACTUAL DRAFTS (1)

MAX DRAFT	%FLEET DWT	AVG DWT	COST PER DAY.... SEA	PORT	TRANSPORTATION COST FULL AND LIGHTLOADED... FULL	1 FT	2 FT	3 FT	4 FT	5 FT	6 FT	7 FT
45	0.036	70738	15914	10963	5.99	6.18	6.39	6.61	6.84	7.09	7.37	7.66
44	0.038	65845	15406	10619	6.44	6.66	6.89	7.15	7.42	7.71	8.03	8.38
43	0.065	62773	15086	10404	6.61	6.84	7.08	7.34	7.63	7.93	8.26	8.62
42	0.049	61864	14992	10340	6.67	6.89	7.13	7.38	7.65	7.95	8.27	8.61
41	0.088	57550	14571	10072	6.97	7.21	7.47	7.74	8.04	8.36	8.71	9.09
40	0.059	50579	13927	9681	7.59	7.87	8.18	8.51	8.87	9.26	9.69	10.16
39	0.026	42964	13196	9247	8.48	8.84	9.23	9.65	10.12	10.63	11.19	11.82
38	0.050	41595	13064	9168	8.68	9.03	9.42	9.84	10.31	10.81	11.37	11.99
37	0.095	37867	12659	8913	9.24	9.64	10.07	10.54	11.05	11.62	12.26	12.96
36	0.101	34913	12311	8688	9.75	10.14	10.56	11.01	11.51	12.05	12.65	13.30
35	0.114	31589	11970	8495	10.50	10.92	11.39	11.90	12.45	13.06	13.73	14.47
34	0.068	26843	11482	8220	11.87	12.42	13.01	13.67	14.39	15.20	16.10	17.11
33	0.064	24377	11219	8071	12.79	13.40	14.07	14.81	15.63	16.55	17.59	18.76
32	0.062	23706	11140	8026	13.06	13.67	14.33	15.05	15.86	16.75	17.75	18.88
31	0.041	20389	10748	7805	15.01	15.78	16.64	17.60	18.67	19.89	21.27	22.86
30	0.029	18510	10525	7679	16.21	17.07	18.03	19.10	20.30	21.67	23.24	25.05
29	0.012	15402	10158	7471	18.84	19.96	21.23	22.66	24.31	26.21	28.44	31.08
28	0.005	14026	9995	7379	20.37	21.61	23.00	24.58	26.40	28.50	30.97	33.91

TABLE IV-11
VESSEL TIDE DELAYS IN FRACTIONAL DAYS (2)

MAX DRAFT	COST PER DAY SEA	PORT	OUT-FULL	IN-FULL -1 FT	-1 FT -2 FT	-2 FT -3 FT	-3 FT -4 FT	-4 FT -5 FT	-5 FT -6 FT	-6 FT -7 FT
45	15914	10963	NA	NA	NA	0.8667	0.8055	0.55	0.3945	0.1333
44	15406	10619	NA	NA	0.8667	0.8055	0.55	0.3945	0.1333	0
43	15086	10404	NA	0.8667	0.8055	0.55	0.3945	0.1333	0	0
42	14992	10340	0.8667	0.8055	0.55	0.3945	0.1333	0	0	0
41	14571	10072	0.8055	0.55	0.3945	0.1333	0	0	0	0
40	13927	9681	0.55	0.3945	0.1333	0	0	0	0	0
39	13196	9247	0.3945	0.1333	0	0	0	0	0	0
38	13064	9168	0.1333	0	0	0	0	0	0	0
<38	NA	NA	0	0	0	0	0	0	0	0

TABLE IV-12
ADJUSTED DISTRIBUTION OF VESSEL SIZES WITH "ACCEPTABLE" LIGHTLOADING (3)

MAX DRAFT	SHIP REV PER FT/PORTCOST FULL	-1 FT	-2 FT	-3 FT	...ADJUSTED OUTBOUND DWT DISTRIBUTION... FULL	-1ft	-2ft	-3ft	-4ft	-5ft	-6ft
45	1.141	1.177	1.216	1.258	NA	NA	NA	82.82	14.38	1.75	1.05
44	1.214	1.256	1.300	1.348	NA	NA	55.44	27.38	14.38	1.75	1.05
43	1.220	1.262	1.307	1.355	NA	24.91	30.53	27.38	14.38	1.75	1.05
<43	"NORMAL" DISTRIBUTION				7.71	17.2	30.53	27.38	14.38	1.75	1.05

MAX DRAFT	SHIP REV PER FT/SEACOST FULL	-1 FT	-2 FT	-3 FT	....ADJUSTED INBOUND DWT DISTRIBUTION... FULL	-1ft	-2ft	-3ft	-4ft	-5ft	-6ft
45	0.786	0.811	0.838	0.867	NA	NA	0	82.82	14.38	1.75	1.05
44	0.837	0.865	0.896	0.929	NA	0	55.44	27.38	14.38	1.75	1.05
43	0.841	0.870	0.901	0.934	0	24.91	30.53	27.38	14.38	1.75	1.05
42	0.816	0.843	0.872	0.903	0	24.91	30.53	27.38	14.38	1.75	1.05
41	0.843	0.872	0.903	0.937	0	24.91	30.53	27.38	14.38	1.75	1.05
40	0.915	0.949	0.986	1.026	7.71	17.2	30.53	27.38	14.38	1.75	1.05
<41	"NORMAL" DISTRIBUTION				7.71	17.2	30.53	27.38	14.38	1.75	1.05

TABLE IV-13
AVERAGE TIDE DELAY COSTS PER VESSEL VOYAGE (4)

MAX DRAFT	%FLEET DWT	AVG DWT	COST PER DAY SEA	PORT	...........COST OF TIDE DELAY........... FULL	-1FT	-2FT	-3FT	-4FT	-5FT	-6FT
45	0.036	70738	15914	10963	NA	NA	NA	15911	13207	9169	5386
44	0.038	65845	15406	10619	NA	NA	15408	12790	8879	5216	1416
43	0.065	62773	15086	10404	NA	15093	12529	8698	5110	1387	0
42	0.049	61864	14992	10340	13084	12452	8644	5078	1378	0	0
41	0.088	57550	14571	10072	10987	8414	4945	1343	0	0	0
40	0.059	50579	13927	9681	8072	4747	1290	0	0	0	0
39	0.026	42964	13196	9247	4527	1233	0	0	0	0	0
38	0.050	41595	13064	9168	1222	0	0	0	0	0	0
<38	0.589	NA	NA	NA	0	0	0	0	0	0	0

TABLE IV-14

TRANSPORTATION COST PER TONNE WITH ADJUSTED FLEET AND TIDE DELAYS (5)

MAX DRAFT	%FLEET DWT	AVG DWT	........AVERAGE COST FULL	-1FT	-2FT	-3FT	AND LIGHTLOADED -4FT	-5FT	.... -6FT	AV COST BY DRAFT
45	0.036	70738	NA	NA	NA	6.87	7.07	7.26	7.46	6.91
44	0.038	65845	NA	NA	7.16	7.38	7.59	7.81	8.06	7.30
43	0.065	62773	NA	7.11	7.31	7.51	7.73	7.96	8.26	7.40
42	0.049	61864	6.82	7.12	7.29	7.48	7.68	7.95	8.27	7.35
41	0.088	57550	7.12	7.37	7.57	7.77	8.04	8.36	8.71	7.65
40	0.059	50579	7.76	7.98	8.21	8.51	8.87	9.26	9.69	8.35
39	0.026	42964	8.60	8.87	9.23	9.65	10.12	10.63	11.19	9.41
38	0.050	41595	8.71	9.03	9.42	9.84	10.31	10.81	11.37	9.59
37	0.095	37867	9.24	9.64	10.07	10.54	11.05	11.62	12.26	10.25
36	0.101	34913	9.75	10.14	10.56	11.01	11.51	12.05	12.65	10.73
35	0.114	31589	10.50	10.92	11.39	11.90	12.45	13.06	13.73	11.59
34	0.068	26843	11.87	12.42	13.01	13.67	14.39	15.20	16.10	13.27
33	0.064	24377	12.79	13.40	14.07	14.81	15.63	16.55	17.59	14.36
32	0.062	23706	13.06	13.67	14.33	15.05	15.86	16.75	17.75	14.61
31	0.041	20389	15.01	15.78	16.64	17.60	18.67	19.89	21.27	17.03
30	0.029	18510	16.21	17.07	18.03	19.10	20.30	21.67	23.24	18.46
29	0.012	15402	18.84	19.96	21.23	22.66	24.31	26.21	28.44	21.83
28	0.005	14026	20.37	21.61	23.00	24.58	26.40	28.50	30.97	23.66
OVERALL AVERAGE COST PER TON WEIGHTED BY DEADWEIGHT DISTRIBUTION										10.95

Notes to tables IV-10 through IV-14

(1) Average cost for grain and backhaul steel. Actual vessel rates may differ for front and backhaul cargos. Computed as 50 days seacost + 26 days port cost ÷ payload x 3, to reduce the number of tables shown. Separate calculations for front and backhaul cargos are the usual way this is done.

(2) NA indicates vessels that cannot transit the channel using tides, without draft reduction by lightloading. The upper limit of acceptable lightloading was assumed to be in the normal range of actual drafts, based on comparison with transport cost by fully loaded smaller vessels.

(3) In order to establish the maximum amount of acceptable tide delay, many studies use an arbitrary assumption of one-half day. A more scientific approach used here is to compare revenue foregone if lightloaded another foot, with the cost of the required tide delay. Payload per foot of immersion x average transport cost was used to approximate revenue. The higher cost of seatime offset the draft reduction of inbound vessels due to fuel consumption, but adjustments to both inbound and outbound fleets are almost identical.

(4) Computed as the cost of a fractional port day for vessels delayed outbound plus 50% of the cost of a fractional seaday for inbound vessels. This assumes backhauls were distributed proportionate to fleet capacity.

(5) Computed by adding transport cost per ton for applicable vessel sizes (Table IV-10) and voyage tide delay costs (Table IV-13).4

INLAND TRANSPORTATION COSTS

To satisfy P&G requirements, it is necessary to determine inland transportation rates or costs. Because inland origins and destinations usually outnumber the vessels' trade routes, a disproportionate amount of effort may be required. One alternative is to limit the number of inland movements to those of significant size. To do that, you still need a preliminary identification of the port's hinterland and the principal commodity movements. The most useful alternative is to use costs in lieu of rates. The point is that the task can be done. It may not be time-consuming, and need not be expensive. Trying to define hinterlands and perform multiport analysis without sufficient rate and cost information can be more time-consuming and far less productive.

Most NED analysts know enough about carrier tariffs to appreciate their complexity and the difficulty of identifying the commodity classification and routing that produces the most favorable rate. The analyst may not have the skills to deal directly with tariffs, but there are various ways to get help from experts. In some cases, actual effective rates can be picked up in baseline interviews, and may be available in prior studies, or analyses and articles in professional journals or trade publications. On request, most carriers will provide a reasonable number of quotes. If there is a local port authority with a traffic expert, that may be another source of free expertise. More than one or two dozen quotes is likely to be considered unreasonable by those sources. For more rates or those not readily available, it will be necessary to hire an expert. Traffic services charge $50.00 to $75.00 per quote, hence it is a good idea to limit rate acquisition to the rates really needed.

Costs are almost always adequate for initial identification of port hinterlands, and may be adequate for benefit calculations and multiport analysis. For simple applications such as identifying the hinterlands of two ports with more-or-less identical depths and vessel costs, inland costs can be assumed to be linear and hinterland boundaries will be determined by inland route length. When vessel costs are not equal, or more than two ports are involved, it will be necessary to mimic the non-linearity typical of actual rates. The simplest way is an allowance for terminal costs plus the linear ton-mile cost. This is the basis for most cost algorithms and transportation cost models. Several models are available that range from those that simply estimate modal costs to multimodal system models that can be used to determine port routing. Models that can determine port routing will facilitate multiport analysis, but one model may not have the combination of modes needed for the project port's analysis. It may be necessary to use a combination of models or manual calculations. Sources for cost or rate information follow.

Modal Costs. For preliminary identification of hinterlands, it may be desirable to use some generalized costs for truck and rail transportation. Sources for such costs are statistics by the Interstate Commerce Commission (rail and truck), the Federal Power Commission (pipelines), and trade associations such as the Association of Amercian Railroads and the American Trucking Associations, Inc. The problem with their statistics (and generalized costs) is that averaging may hide variations due to commodity or volume mix and local or regional conditions. The average costs shown in Table IV-15 may be used for rough estimating purposes, subject to that caveat. More recent mode- and commodity-specific data sources are suggested. Table IV-15 shows truck and rail costs for truckloads and carloads, less than truckload and less than carload quantities, and trailer on flat car services.

TABLE IV-15
NATIONAL AVERAGE TRUCK AND RAIL COSTS

	Truck		Rail	
Type Service	Ton/Mi Revenue	Vehicle/Mi Expense	Ton/Mi Revenue	Car/Mi Expense
TL/CL	9.86¢	$1.39	3.09¢	$1.86
LTL/LCL	14.33¢	4.04	NA	NA
TOFC	NA	NA	4.76¢	1.90

The vehicle and car mile expenses in Table IV-15 are from the 1987 Interstate Commerce Commision Transport Statistics in the United States. Ton-mile revenues are from AAR and ATA analyses. ICC statistics have been drastically curtailed since 1975 and at present cover only Class I truck and rail carriers. Because ton-mile costs and revenues vary widely according the commodity, haul length and backhaul, the vehicle mile and car mile costs are more appropriate for estimating purposes, provided they are adjusted for load size and terminal costs. The truck vehicle-mile expenses shown in Table IV-15 reflect (approximately) $1.31 per ton for terminals and overheads plus $1.35 per mile for truckloads, and $2.19 per ton plus $1.85 per mile for less than truckload/general freight carriers.

Trucking statistics are limited, and for local moves, cartage, or container drayage to ramp locations, inquiry at the port will be the best source for costs. The ICC Rail Waybill Sample previously cited captures the revenues associated with the movements between specific sidings. Similar to most statistics, its revenues can be a blend of rates for unit trains, multiple and single cars. As a source for specific cost levels it has limitations, but its blended rates are probably more representative of effective costs for specific movements. Even more important, if you use the Waybill Sample for identifying hinterlands it can automatically give you rail costs.

Cost Models. Computer cost models have proliferated since rate deregulation, along with negotiated contract rates. There are alternatives, but the recommended one is to use the models the Corps has available. Those models are the property of Reebie Associates, and subscribers to its model service are provided with programs on floppy discs that can be run on a PC/AT or equal. There are separate models for rail, truck, and water costs. The rail model is Uniform Rail Costing System (URCS) based, and an accompanying submodel is used to compute rail distances. Models are menu-driven and need from five minimum to 16 maximum inputs. The truck and water models require more inputs than the rail.

CEWRC-IWR-N subscribes to the Reebie model service. Copying the diskettes is prohibited, and impractical because Reebie updates them quarterly. IWR-N will provide a reasonable number of Reebie cost quotes without charge. A larger number of model runs is subject to negotiation. The models are available directly from Reebie for about $5000, $1000, and $2000 for rail, truck and barge respectively. Consideration has been given to multiple subscriptions that would make a full set of models available for about $4000.

Before the wide availability of computer models, a Corps contractor developed a series of rate-based cost algorithms for almost all commodities moving on inland waterways. The St. Louis District updated the algorithms for several years but they may not be current. For more information, contact CELMS-PD-E.

Analysis Models. Computer cost models can handle only one commodity movement at a time and may have to be told what route to take. (Reebie's have internal route networks.) With increasing complexity in programming, computers can determine the lowest cost routing between any two points, the lowest cost mode and routing, and the lowest cost modes and routings for multiple origins or destinations. Most of these sophisticated models owe something to the DOT Transportation Systems Center network models. Most were developed to analyze specific commodity flows such as coal and grain, but at least one can handle multiple commodities (but not at one time). The more recent models have been compressed so that they can be run on a PC, but probably none are cost effective for simply computing costs. However, the right one may be your best solution for multiport analysis.

A grain flow model developed by Texas A&M with IWR funding assistance was used in the Galveston Bay study multiport analysis. The Department of Energy has a coal transportation model that was used for the Mobile analysis. Both models are bi-modal (rail and barge) and compute for multiple origins simultaneously. They are available for the cost of computer time and updating. Time can cost up to $15,000 since they run on mainframes, and updating cost is additional. The more economical model is one developed by the Electric Power Research Institute to analyze utility coal movements (rail and water, including coastwise and intercoastal). It has been modified to incorporate general freight cost levels, runs on a PC, but can handle only one movement at a time. It may be made available for Corps use. Contact IWR-N if interested.

Rate Services. Similar to cost models, there are many commercial services available to supply rates. Most of these services are attractively priced for volume users on a subscription basis. For the limited number of quotations needed for a Corps study, prices for individual quotes may range from $35.00 for a readily available tariff rate to $75.00 or more for a difficult to determine contract rate. If familiarity with port traffic appears advantageous, someone at the port may be able to recommend a firm. If broader capability is indicated, geographic or multimodal, a recommended source is Tennessee Valley Authority. Its traffic services are available only to government entities, and charges will approximate those of commercial firms. However, acquisition of TVA services using intragovernmental transfer of funds may be faster and simpler. For information, contact the Water Resources Navigation and System Modification Section, Knoxville, (615) 632-7184.

PORT, TERMINAL, AND CARGO TRANSFER COSTS

Identification of port expenses is part of the P&G requirement to account for all transportation costs. They are not included in the deep draft vessel operating costs produced by IWR-N. They may or may not be included in ocean vessel rates. Port expenses include a number of charges, for use of facilities (wharfage and dockage), for vessel loading and unloading (stevedoring), cargo transfer to or from the inland carrier (receiving and delivery), and services such as tug assistance, pilotage, and inspections. Those charges are a large part of overall transportation cost. They can affect port selection, but are unlikely to be affected by channel improvements. Other expenses such as tug assistance and pilotage are relatively insignificant in overall costs, but can be reduced by channel improvements. Although it may be desirable to analyze only the costs affected by channel improvements, the appropriate way to package them is as part of port expenses per the P&G requirement.

The components of port expenses are more-or-less the same in all ports, but cost levels and the way charges are billed vary regionally and from port to port. Table IV-16 shows the usual components of port expenses and comparative costs by coastal range for a hypothetical general cargo vessel. The table shows typical sources for the individual cost items, but your most helpful source will be someone at the project port who is familiar with the various charges and tariffs and willing to explain them. That person is likely to be concerned with costs at competing ports, and you should be able to get all the port expense information needed from one source.

TABLE IV-16
U.S. PORT COSTS PER TON, BREAKBULK GENERAL CARGO
(10,600 dwt. vessel, 2 days to load/unload 2500 tons)

Item & Source	North Atlantic	South Atlantic	Gulf	Pacific	Great Lakes
Wharfage (a/c cargo)(1)	$ 1.92	$ 1.90	$ 0.98	$ 3.32	$ 0.40
Dockage (a/c ship)(1)	1.08	1.12	0.58	0.67	0.19
Receiving & Delivery (2)	13.35	5.50	5.81	10.45	12.00
Stevedoring (3)	28.75	20.00	18.50	25.00	25.00
Pilotage (4)	0.79	0.65	0.48	0.51	2.04
Tug Assistance (5)	0.96	0.60	0.72	0.72	- 0 -
Linehandling (6)	0.20	0.20	0.20	0.20	0.20
Customs & Govt. Services (7)	0.15	0.15	0.15	0.15	0.15
Agency & Inspec. Fees (7)	0.60	0.60	0.60	0.60	0.60
Assessments, etc. (7)	- 0 -	- 0 -	- 0 -	0.50	0.58(8)
Total	$47.80	$30.56	$28.02	$42.12	$41.16

(1) Terminal owner or terminal operator tariff.
(2) May be negotiated rate or in terminal tariff.
(3) Negotiated rate, generally considered proprietary.
(4) Tariff rate based on vessel size and/or draft.
(5) Tariff rate based on time and/or service.
(6) May be published, based on time or service.
(7) Combination of published fees and negotiated rates, local inquiry needed.
(8) Seaway tolls net after Harbor Tax credit.

Although port expenses in foreign ports approximate those in U.S. ports, the prevailing practice in NED analysis is to disregard them because a disproportionate amount of effort could be involved with multiple overseas origins and destinations. For analysis of domestic coastwise or domestic offshore movements, it may be necessary to identify both origin and destination port costs in order to determine if channel improvements produce a shift in port routing or transportation mode. If any U.S. harbor user fees (Federal or local) are included in transportation costs, offsetting benefits should be shown. Alternately, as transfer payments, the fees can be omitted from both costs and benefits. (see Chapter II)

Although stevedoring and cargo receiving and delivery charges are the biggest port expenses, those costs may not be readily available because they are generally negotiated and are considered proprietary. In the absence of more specific numbers, the approximate costs shown in Table IV-17 may be useful. The actual charges for the costs in Table IV-17 and preceding Table IV-15 are billed based on various measures including cargo weight or cargo cubic measure. They have been converted to a weight basis when necessary for display purposes.

TABLE IV-17
RECEIVING/DELIVERY AND STEVEDORING COSTS AT U.S. PORTS, 1985
(cost in dollars per short ton)

	North Atlantic		South Atlantic		Gulf		Pacific	
Type Cargo	R/D	Stev.	R/D	Stev.	R/D	Stev.	R/D	Stev.
Containers	$3.40	$7.50	$2.44	$7.50	$3.50	$7.66	$3.48	$7.33
Steel (1)	3.50	5.50			2.55	5.50	3.85	6.05
Lumber	4.00	20.00			3.65	18.50	(logs)	26.08
Vehicles	3.84	15.16	3.46	13.65				
Grain (2)	3.03	1.04	5.25	0.51	2.15	0.75	3.75	0.88
Coal, direct (3)	0.71	0			0.25	0	3.52	0
Coal, via pile (4)	1.78	0.20			0.50	0	5.02	0
Fuel Oil (5)	0.30	0.03	0.30	0.03	0.30	0.03	0.35	0.03

(1) Great Lakes $3.50 R/D, $5.50 Stevedoring.
(2) R/D by elevator. Great Lakes $2.45 R/D, $0.45 Stevedoring.
(3) Great Lakes $0.50 R/D, Stevedoring does not apply.
(4) Great Lakes $1.00 R/D, Stevedoring does not apply.
(5) Terminal throughout charge, does not include pumping labor cost.

CHAPTER V

FLEET ANALYSIS AND FORECASTS

The benefits of a navigation improvement project reflect the vessel fleets assumed to use the harbor in the future. Those assumptions will be subject to scrutiny because benefits can be inflated by overestimating the impact of a project on fleet composition. Doing so may use the efficient ships and benefits that belong to other projects. This chapter describes vessel fleet forecasting procedures and the derivation of port- or project-specific vessel fleets.

WITH- AND WITHOUT-PROJECT VESSEL FLEETS

The P&G requires a determination of the composition of the vessel fleet expected to serve the project harbor. The requirement recognizes that the composition of the fleet may change over time, and larger or newer vessels will be more efficient, but the P&G does not say that there will be distinct with- and without-project fleets. Channel improvements will reduce costs for the vessels that do use the harbor, by reducing delays and enabling vessels to load deeper, and may induce use of larger and more efficient vessels. However, the extent to which fleet composition will change because of the project, will depend on the availability of larger and more efficient vessels and the ability of harbor users to employ them.

MAXIMUM PROJECT IMPACT ON FLEET COMPOSITION

In the past, some Corps studies have used hypothetical vessel fleets to estimate project benefits. Future fleets were arrived at by analysis of the harbor's trade routes and identification of the most efficient vessel size or sizes for each route, based on the channel dimensions with- and without-project. The hypothetical approach is theoretically pure, and has some useful logic for disaggregating fleet forecasts. Because it does not account for which harbor gets the most efficient vessels, it is generally unacceptable for final determination of project benefits.

Individual vessels may be dedicated to serving a specific port because their dimensions are optimal for the port's channel. These vessels must be accounted for in fleet forecasts, but rarely is a port served only by such vessels. Generally, only where vessels are chartered on a trip by trip basis (coal, grain, oil, and other world bulk or neobulk trades) can port fleet composition quickly reflect channel improvements. The most likely rate of change can be predicted only after analysis of the many factors that determine actual vessel employment.

MINIMUM PROJECT IMPACT ON FLEET COMPOSITION

There are several reasons why composition of a harbor's fleet may not change because of a project, or will change slowly over time. The sizes of vessels in liner service reflect compromises based on freight available, schedule frequency, and channel dimensions at all of the ports where the vessels routinely call. The sizes of liner vessels (container, general cargo, parcel tankers) will grow over time as operators replace vessels, but operators do not replace all of their vessels because of one port deepening.

The sizes of vessels in U.S. domestic trades are among the slowest to change because replacements must be built in the U.S. Employment opportunities are limited; and, similar to liner vessels, bulk oil and ore carriers are sized for a range of ports. Replacements tend to be for vessels that are worn out. Most domestic vessels are actually or effectively in dedicated service, and a port's future fleets may be static or change dramatically depending on port-specific factors. World fleet forecasts have little relevance. In some special cases, such as fishing craft, vessel sizes reflect traditional crew size and operating practices, and may not change over time.

ALTERNATIVES TO DETERMINE FUTURE FLEETS

Similar to the commodity projections needed for navigation improvement studies, the determination of a harbor's future fleets requires analysis and judgement. Similarly, there are two basic approaches: "top down" by disaggregation of comprehensive forecasts, and "bottom up" projections or forecasts based on analysis of the project port fleet. Reasons for using the "top-down" or "bottom-up" approaches follow.

WORLD FLEET FORECASTS

Fleet forecasts by industry experts are the best way to go for vessels in foreign trade. This includes both chartered vessels and liner vessels. The logic in starting with the world fleet is that virtually all of the vessels will be subject to redeployment as opportunities arise. If the world fleet is disaggregated properly to the project port level, that will address the question of whether there will be enough benefit-producing vessels, and whether those vessels belong to the project port or elsewhere.

Because of the multitude of factors that need to be considered, the cost of producing a world fleet forecast for each navigation study would be prohibitive. It is usually necessary to rely on available forecasts. Historically, this has been a problem because most readily available studies cover selected vessel types and have a short forecast horizon. (Drewry regularly publishes such forecasts in <u>Seaborne Trade and Transport</u>.) A comprehensive, long-range forecast is now available in <u>Fleet Forecasts for the United States to 2020</u>, prepared for the Corps of Engineers in 1990 by DRI/McGraw-Hill, Temple, Barker & Sloane, Inc., and Lloyd's Maritime Information Services, Ltd. Prior to the 1990 forecast, the most recent comprehensive forecast was <u>Merchant Fleet Forecast of Vessels in U.S. Foreign Trade, May 1978</u>, by TBS for the Maritime Administration. That earlier forecast is still useful for its explicit descriptions of the assumptions used.

<u>Fleet Forecasts for the United States to 2020</u> provides forecasts by vessel type and trade routes of U.S. coastal ranges. Most other readily available forecasts are not at the coastal range level. None of these forecasts, or historical statistics, are likely to have the mixture of vessels that actually occurs at specific ports. It is necessary to disaggregate the forecasts, or otherwise relate them to the actual mix of vessels at the project port. The alternate ways are described later in this chapter.

PORT FLEET PROJECTIONS

Fleet forecasts by study personnel (or performed under contract) have been used when current comprehensive forecasts were not available. They will be needed in future studies where the port commerce involves vessel types not covered by available forecasts. That includes most U.S. flag vessels and domestic trades, and may involve dedicated vessels. Historically, most study-specific forecasts have been port fleet projections that relied heavily on trend analysis to identify world fleet trends, and expert or local opinion to arrive at with- and without-project port fleets. The weakness or fatal flaw in that approach is that it may not account adequately for the distribution of benefit-generating vessels among competing ports.

Port fleet projections may appear simpler to do than disaggregating comprehensive forecasts, and more certain to capture fleet change due to the project. However, the labor saved by not disaggregating has to be balanced against the extra effort needed to support fleet share. Some estimate of the universe that provides the port fleet will be needed. Simple projections are an useful option when the study involves a limited number of vessels or a captive fleet (e.g., fishing). When projections are used for more complex studies, they need to be supported by the analyses used in forecasts.

VESSEL FLEET COMPOSITION

A wide variety of statistics are used to describe the size, shape and capacity of vessels. To avoid drowning in numbers, most fleet forecasts and fleet projections use only deadweight or a similar measure of capacity to describe vessel sizes. To use those forecasts or projections in Corps studies, it is necessary to determine the critical vessel dimensions--vessel draft when channel deepening is involved, length and beam when channel width or bends are the problem--from the capacity measure shown. The usual solution is to use statistics for a large number of vessels. The deadweight/draft and other relationships of individual vessels differ, but the average relationships for a fleet will not change significantly over time. Most fleet forecasts and projections also use a limited number of vessel size ranges, to simplify the analyses and display of results. A distribution of vessel sizes within each range will be needed, to determine change in overall fleet composition in the future time periods. Using the overall distribution of fleet capacity, instead of capacity distributions by size range, simplifies the calculation of transportation costs. However, the distribution must be stratified into appropriate increments of the critical vessel dimension. For channel deepening studies, that will be one-foot increments of vessel draft (see the following section). Last but not least, the same type of tons must be used to measure vessel capacity and vessel cargoes. Most vessel statistics are in metric tons. Most commodity forecasts are in short tons. It may be necessary to restate one or the other.

WORLD FLEET SIZE DISTRIBUTION

Tables V-1 through V-9 show distributions by draft of average and total deadweight (metric tons) for major vessel types, based on statistics for the 1989 world fleet. For calculation of transportation costs in channel deepening studies, average vessel deadweights are used to determine ocean transportation cost by incremental vessel deadweight/draft, the distribution of total deadweight/fleet capacity is used to determine average transportation cost for the port fleet at alternate channel depths. Deadweight distributions are shown for the size ranges used in Fleet Forecasts for the United States to 2020, and for all vessels of the specific type.

Because of variations in vessel geometry, actual average deadweights do not increase uniformly with maximum loadline draft. Therefore, "smoothed" overall average deadweights are also shown in Tables V-1 through V-9. The "smoothed" deadweights are based on regressions using data for all vessels of each type shown. Analysis of the data showed almost all actual drafts were within the range of 15% less to 10% greater than the central trend (20% shallower in the case of containerships), and this is consistent with vessel design practice. There are some deviations from the central trend due to Panama Canal and other constraints; these are not reflected in the smoothed drafts produced by simple logarithmic regression. Drafts for containerships above 50,000 dwt. have plateaued at 43 feet because of berth depths, including Post-Panamax sizes.

TABLE V-1
AVERAGE TANKER DEADWEIGHT BY DRAFT

MAX	................DEADWEIGHT SIZE CATEGORIES..................							ACTUAL	SMOOTHED
DRAFT	<10000	10K-40K	40K-80K	80K-100K	100K-175K	175K-250K	>250K	DWT	DWT
<15	3509							3509	NA
15	2136							2136	2288
16	2449							2449	2805
17	3117							3117	3396
18	3712							3712	4066
19	3764							3764	4822
20	4071							4071	5669
21	5181							5181	6611
22	5568	10935						5640	7656
23	5979	15243						8202	8808
24	6838	12621						8731	10073
25	8498	13287						11763	11457
26	8711	15855						13754	12965
27	9339	14909						14030	14604
28		16272						16272	16379
29		16503						16503	18295
30		20128	46624					21758	20359
31		22179	54381					22425	22577
32		25219						25219	24954
33		28373	42039					31697	27497
34		30462	47023					31938	30211
35		31553	47187					32465	33103
36		33259	52863					34527	36178
37		34442	44223					36805	39443
38		36766	49132		113512		41141	42517	42903
39		34510	54245	81283	113996		52357	52357	46566
40		39181	59803	85226	112500		72727	72242	50436
41			56516	85921			62234	62234	54520
42			64043	86990				71608	58824
43			64295	86475	151630			75674	63355
44			63455	87572	121293			78488	68118
45			67266	89703	101032			84456	73121
46			71002	89225	108983			88972	78368
47			61528	93440	107557			93665	83867
48			77102	90123	110711			99613	89624
49				93801	118815			107445	95645
50			69999	97187	126724			120884	101936
51				98319	126416			117476	108505
52				83935	129774	180305		117778	115356
53				83957	136450			115453	122498
54				99900	131604	180377		132608	129935
55					131854			131854	137675
56				81282	146749			145742	145724
57					145547	178380		152843	154089
58					138849	176162		151287	162775
59						195097	256000	203797	171790
60									181141
61					159571	233344	258000	212040	190833
62					173792	223256		210890	200873
63					159999	229644	258055	232787	211268
64						231579	259399	240431	222024
65						232598	255610	244530	233149
66						228143	260105	254294	244648
67						236466	266636	261836	256529
68						235027	271545	260995	268798
69							274828	274828	281461
70						225770	277997	264070	294526
71							279910	279910	307999
72							297455	297455	321887
73							329819	329819	336196
74							398848	398848	350934
75							362793	362793	366107
76							393168	393168	381722
>76							453574	453574	NA

TABLE V-2
TOTAL TANKER FLEET DEADWEIGHT BY DRAFT

MAX DRAFT	<10000	10K-40K	40K-80K	80K-100K	100K-175K	175K-250K	>250K	TOTAL DWT
	....	DEADWEIGHT	SIZE CATEGORIES	....				
<15	701875							701875
15	301184							301184
16	345279							345279
17	501837							501837
18	393466							393466
19	451691							451691
20	333837							333837
21	429997							429997
22	824110	21870						845980
23	454402	365832						820234
24	253016	227184						480200
25	59488	199305						258793
26	130667	570792						701459
27	28016	238550						266566
28		992569						992569
29		709646						709646
30		1227798	186494					1414292
31		2883286	54381					2937667
32		1992281						1992281
33		1588885	756702					2345587
34		2802497	423207					3225704
35		3565509	330310					3895819
36		7217281	792950					8010231
37		3891973	1592035					5484008
38		1764790	1523081		113512			3401383
39		379614	3037715	81283	113996			3612608
40		274269	3887174	6562393	112500			10836336
41			3277920	1202896				4480816
42			3906649	2609703				6516352
43			2443212	2853671	3442			5300325
44			1522928	3065030	121293			4709251
45			807190	2960198	202064			3969452
46			213005	4907353	217966			5338324
47			123056	2149116	537787			2809959
48			77102	1261720	1549951			2888773
49				1876027	2851552			4727579
50			69999	485933	3674994			4230926
51				688234	1896244			2584478
52				839351	2984798	180305		4004454
53				503740	1228048			1731788
54				99900	1974066	180377		2254343
55					11998718			11998718
56				81282	9391932			9473214
57					2037656	713520		2751176
58					277698	713520		991218
59						1170579	256000	1426579
60								0
61					797857	1866750	516000	3180607
62					521376	2009307		2530683
63					521376	2066796	1032220	3620392
64						6947362	3631583	10578945
65						6047544	7157093	13204637
66						1368859	7022848	8391707
67						1655260	9865533	11520793
68						3055346	8689444	11744790
69							10168629	10168629
70						903080	3057968	3961048
71							3918739	3918739
72							5949102	5949102
73							19129490	19129490
74							4387327	4387327
75							2176755	2176755
76							1179504	1179504
<76							4535739	4535739
TOTAL	5208865	30913931	25025110	32227830	43128826	28878605	92673974	258057141

TABLE V-3
PERCENTAGE OF TOTAL TANKER FLEET DEADWEIGHT BY DRAFT

MAX DRAFT	................DEADWEIGHT SIZE CATEGORIES..................							TOTAL DWT
	<10000	10K-40K	40K-80K	80K-100K	100K-175K	175K-250K	>250K	
<15	0.272							0.272
15	0.117							0.117
16	0.134							0.134
17	0.194							0.194
18	0.152							0.152
19	0.175							0.175
20	0.129							0.129
21	0.167							0.167
22	0.319	0.008						0.328
23	0.176	0.142						0.318
24	0.098	0.088						0.186
25	0.023	0.077						0.100
26	0.051	0.221						0.272
27	0.011	0.092						0.103
28		0.385						0.385
29		0.275						0.275
30		0.476	0.072					0.548
31		1.117	0.021					1.138
32		0.772						0.772
33		0.616	0.293					0.909
34		1.086	0.164					1.250
35		1.382	0.128					1.510
36		2.797	0.307					3.104
37		1.508	0.617					2.125
38		0.684	0.590		0.044			1.318
39		0.147	1.177	0.031	0.044			1.400
40		0.106	1.506	2.543	0.044			4.199
41			1.270	0.466	0.000			1.736
42			1.514	1.011	0.000			2.525
43			0.947	1.106	0.001			2.054
44			0.590	1.188	0.047			1.825
45			0.313	1.147	0.078			1.538
46			0.083	1.902	0.084			2.069
47			0.048	0.833	0.208			1.089
48			0.030	0.489	0.601			1.119
49				0.727	1.105			1.832
50			0.027	0.188	1.424			1.640
51				0.267	0.735			1.002
52				0.325	1.157	0.070		1.552
53				0.195	0.476	0.000		0.671
54				0.039	0.765	0.070		0.874
55				0.000	4.650	0.000		4.650
56				0.031	3.639	0.000		3.671
57					0.790	0.276		1.066
58					0.108	0.276		0.384
59					0.000	0.454	0.099	0.553
60					0.000	0.000	0.000	0.000
61					0.309	0.723	0.200	1.233
62					0.202	0.779	0.000	0.981
63					0.202	0.801	0.400	1.403
64						2.692	1.407	4.099
65						2.343	2.773	5.117
66						0.530	2.721	3.252
67						0.641	3.823	4.464
68						1.184	3.367	4.551
69						0.000	3.940	3.940
70						0.350	1.185	1.535
71							1.519	1.519
72							2.305	2.305
73							7.413	7.413
74							1.700	1.700
75							0.844	0.844
76							0.457	0.457
>76							1.758	1.758
TOTAL	2.018	11.979	9.698	12.489	16.713	11.191	35.912	100.000

TABLE V-4
AVERAGE BULK CARRIER DEADWEIGHT BY DRAFT

MAX DRAFT	................SIZE RANGES (000 DWT)................ <20	20-40	40-80	80-100	100-175	>175	ACTUAL DWT	SMOOTHED DWT
23	12721						12721	8353
24	12366						12366	9574
25	14034	22916					15144	10912
26	12137	22356					14924	12374
27	13125	28398					13464	13964
28	15266	37564					16897	15691
29	16090	23068					16210	17558
30	17246	24277					18289	19573
31	18185	24485					21344	21742
32	19344	25154					24780	24071
33	18205	26776	49662				26681	26565
34		28092	43773				28573	29233
35		32775	42585				33926	32078
36		34720	42947				36972	35109
37		37050	44395				39499	38331
38		37692	46254				42574	41751
39		37879	46614	87916			45344	45376
40		39722	56284				56163	49211
41			60001	87179			60424	53263
42			63314	86942			64139	57539
43			65948				65948	62046
44			67069	92067			67426	66790
45			71342	85014	111695		73946	71778
46			73578	81853			76268	77016
47			74439	80013			74717	82511
48			70304	80694	108992		92245	88270
49			75390	94413	112669		103445	94300
50					124244		124244	100607
51					111942		111942	107199
52					125013		125013	114082
53					137334	183063	139461	121263
54					135086		135086	128749
55					132221		132221	136547
56					148471	186739	158454	144664
57					152749	203723	160208	153107
58					146819	184259	159299	161882
59					162331	197013	189581	170998
60						198997	198997	180461
61					153265	197986	183079	190278
62								200457
63						240000	240000	211003
64								221926
65						225362	225362	233231
66								244927
67						260000	260000	257019

TABLE V-5
TOTAL BULK CARRIER FLEET DEADWEIGHT BY DRAFT

MAX DRAFT	.............SIZE RANGES (000 DWT)................						TOTAL DWT
	<20	20-40	40-80	80-100	100-175	>175	
23	101765						101765
24	49464						49464
25	98238	22916					121154
26	97092	67068					164160
27	577493	28398					605891
28	580104	112693					692797
29	1850391	46136					1896527
30	2673159	655486					3328645
31	3473406	4701159					8174565
32	502935	9508119					10011054
33	163842	8541460	99324				8804626
34		7978020	393954				8371974
35		15535366	2682851				18218217
36		9027100	4208766				13235866
37		5112954	3063244				8176198
38		1846929	3006481				4853410
39		643946	3123117	87196			3854259
40		39722	7654611				7694333
41			11400205	261536			11661741
42			5255088	260826			5515914
43			10617669				10617669
44			4627758	92067			4719825
45			2853677	510082	111695		3475454
46			1986609	1064094			3050703
47			1414334	80013			1494347
48			140608	161387	435968		737963
49			150779	377651	1126686		1655116
50					745465		745465
51					1007474		1007474
52					4000419		4000419
53					5630690	366126	5996816
54					5403423		5403423
55					4098863		4098863
56					2524003	1120433	3644436
57					5346200	1222337	6568537
58					1468186	921293	2389479
59					486993	2167144	2654137
60						2387959	2387959
61					4293	395971	400264
62							0
63						240000	240000
64							0
65						1352172	1352172
66							0
67						520000	520000
TOTAL	10167889	63867472	62679075	2894852	32390358	10693435	182693081

TABLE V-6
PERCENTAGE OF TOTAL BULK CARRIER FLEET DEADWEIGHT BY DRAFT

MAX DRAFT	................SIZE RANGES (000 DWT)................ <20	20-40	40-80	80-100	100-175	>175	TOTAL DWT
23	0.056						0.056
24	0.027						0.027
25	0.054	0.013					0.066
26	0.053	0.037					0.090
27	0.316	0.016					0.332
28	0.318	0.062					0.379
29	1.013	0.025					1.038
30	1.463	0.359					1.822
31	1.901	2.573					4.474
32	0.275	5.204					5.480
33	0.090	4.675	0.001				4.819
34		4.367	0.002				4.583
35		8.504	0.015				9.972
36		4.941	0.023				7.245
37		2.799	0.017				4.475
38		1.011	0.016				2.657
39		0.352	0.017	0.048			2.110
40		0.022	0.042	0.000			4.212
41			0.062	0.143			6.383
42			0.029	0.143			3.019
43			0.058	0.000			5.812
44			0.025	0.050			2.583
45			0.016	0.279	0.061		1.902
46			0.011	0.582	0.000		1.670
47			0.008	0.044	0.000		0.818
48			0.001	0.088	0.239		0.404
49			0.001	0.207	0.617		0.906
50					0.408		0.408
51					0.551		0.551
52					2.190		2.190
53					3.082	0.200	3.282
54					2.958	0.000	2.958
55					2.244	0.000	2.244
56					1.382	0.613	1.995
57					2.926	0.669	3.595
58					0.804	0.504	1.308
59					0.267	1.186	1.453
60					0.000	1.307	1.307
61					0.002	0.217	0.219
62						0.000	0.000
63						0.131	0.131
64						0.000	0.000
65						0.740	0.740
66						0.000	0.000
67						0.285	0.285
TOTAL	5.566	34.959	34.308	1.585	17.729	5.853	100.000

TABLE V-7
CONTAINERSHIP DEADWEIGHTS BY DRAFT

MAX DRAFT	AVERAGE VESSEL DEADWEIGHT DWT SIZES <10000	>10000	ACTUAL DWT	SMOOTH DWT	TOTAL FLEET DEADWEIGHT DEADWEIGHT SIZES <10000	>10000	TOTAL DWT	PERCENT FLEET DEADWEIGHT DWT SIZES <10000	>10000	TOTAL DWT
<12	2094		2094	1110	14657		14657	0.052		0.052
12	2914		2914	1416	14570		14570	0.052		0.052
13	2598		2598	1772	25977		25977	0.092		0.092
14	2683		2683	2180	34881		34881	0.124		0.124
15	2625		2625	2645	23625		23625	0.084		0.084
16	3735		3735	3169	85896		85896	0.304		0.304
17	3972		3972	3755	23831		23831	0.084		0.084
18	3928		3928	4407	78564		78564	0.278		0.278
19	4486		4486	5128	112153		112153	0.397		0.397
20	6000	10164	6320	5920	144004	20328	164332	0.510	0.072	0.582
21	6961		6961	6786	278442		278442	0.987	0.000	0.987
22	7249	10731	7556	7730	224709	32192	256901	0.796	0.114	0.910
23	6995	10758	7650	8755	132913	43031	175944	0.471	0.152	0.623
24	8417	13439	9254	9863	42086	13439	55525	0.149	0.048	0.197
25	8776	11766	9225	11057	298385	70598	368983	1.057	0.250	1.307
26	8465	14096	12357	12341	177767	662525	840292	0.630	2.348	2.977
27	9207	14344	14095	13717	27621	846272	873893	0.098	2.999	3.096
28		13790	13790	15187		510248	510248		1.808	1.808
29		14536	14536	16755		188962	188962		0.670	0.670
30		19474	19474	18424		837397	837397		2.967	2.967
31		20548	20548	20195		1582169	1582169		5.606	5.606
32		21036	21036	22073		946602	946602		3.354	3.354
33		23168	23168	24059		1668078	1668078		5.911	5.911
34		28007	28007	26157		2436571	2436571		8.634	8.634
35		30409	30409	28369		2371913	2371913		8.404	8.404
36		35722	35722	30697		1964720	1964720		6.962	6.962
37		34263	34263	33145		1815959	1815959		6.435	6.435
38		39621	39621	35715		4516769	4516769		16.004	16.004
39		41797	41797	38409		2089863	2089863		7.405	7.405
40		40071	40071	41231		160285	160285		0.568	0.568
41		45002	45002	44183		1395067	1395067		4.943	4.943
42		46759	46759	47267		187035	187035		0.663	0.663
43		51757	51757	50486		2122027	2122027		7.519	7.519
44										
45										
TOTALS					1740081	26482050	28222131	6.166	93.834	100.000

TABLE V-8
GENERAL CARGO VESSEL DEADWEIGHTS BY DRAFT

MAX DRAFT	AVERAGE VESSEL DEADWEIGHT DWT SIZES <10000	>10000	ACTUAL DWT	SMOOTH DWT	TOTAL FLEET DEADWEIGHT DWT SIZES <10000	>10000	TOTAL DWT	PERCENT TOTAL DEADWEIGHT DWT SIZES <10000	>10000	TOTAL DWT
<12	2067		2067	1383	93946		93946	0.344		0.344
12	1837		1837	1524	49603		49603	0.182		0.182
13	2079		2079	1857	70701		70701	0.259		0.259
14	2770		2770	2229	166212		166212	0.609		0.609
15	2644		2644	2642	195647		195647	0.717		0.717
16	3538		3538	3098	339620		339620	1.244		1.244
17	3312		3312	3597	304740		304740	1.116		1.116
18	3884		3884	4141	330113		330113	1.209		1.209
19	4711		4711	4732	325031		325031	1.191		1.191
20	4528		4528	5369	344110		344110	1.260		1.260
21	6119		6119	6055	648644		648644	2.376		2.376
22	7140		7140	6791	878186		878186	3.217		3.217
23	6250	12186	6910	7577	350024	85301	435325	1.282	0.312	1.595
24	6886	11717	7293	8415	599108	93734	692842	2.195	0.343	2.538
25	7612	11689	8677	9306	753564	409108	1162672	2.760	1.499	4.259
26	8369	12537	9949	10251	493774	451337	945111	1.809	1.653	3.462
27	8548	13579	11771	11250	393229	1113514	1506743	1.440	4.079	5.519
28	9133	13221	11917	12305	273993	846164	1120157	1.004	3.100	4.103
29	8477	14534	14488	13417	8477	1889475	1897952	0.031	6.921	6.952
30	9368	15511	15447	14586	28105	4451618	4479723	0.103	16.306	16.409
31		16916	16916	15814		4854912	4854912		17.784	17.784
32		18001	18001	17101		2610182	2610182		9.561	9.561
33		18155	18155	18448		1797343	1797343		6.584	6.584
34		22380	22380	19857		1544209	1544209		5.656	5.656
35		21860	21860	21327		262320	262320		0.961	0.961
36		25663	25663	22861		76990	76990		0.282	0.282
37				24458			0		0.000	0.000
38				26120			0		0.000	0.000
39		41687	41687	27847		166749	166749		0.611	0.611
40										
41										
42										
43										
44										
45										
TOTAL					6646827	20652956	27299783	24.348	75.652	100.000

TABLE V-9
ROLL-ON ROLL-OFF VESSEL DEADWEIGHTS BY DRAFT

	AVERAGE VESSEL DEADWEIGHT				TOTAL FLEET DEADWEIGHT			PERCENT TOTAL DEADWEIGHT		
MAX	DWT SIZES		ACTUAL	SMOOTH	DWT SIZES		TOTAL	DWT SIZES		TOTAL
DRAFT	<10000	>10000	DWT	DWT	<10000	>10000	DWT	<10000	>10000	DWT
<12	1293		1293	988	56025		56025	0.759		0.759
12	1927		1927	1311	65527		65527	0.888		0.888
13	1864		1864	1636	26101		26101	0.354		0.354
14	1819		1819	2007	100063		100063	1.356		1.356
15	3309		3309	2428	138991		138991	1.883		1.883
16	3210		3210	2902	192620		192620	2.610		2.610
17	3941		3941	3431	201002		201002	2.723		2.723
18	3759		3759	4018	184200		184200	2.496		2.496
19	4272		4272	4664	170894		170894	2.315		2.315
20	5783	10300	5838	5374	462605	10300	472905	6.267	0.140	6.407
21	5746	11256	6205	6149	252821	45023	297844	3.425	0.610	4.035
22	6795	11032	6963	6992	496066	33096	529162	6.721	0.448	7.169
23	8032	10215	8294	7905	176705	30644	207349	2.394	0.415	2.809
24	7882	11725	8473	8891	173400	46900	220300	2.349	0.635	2.985
25	7505	10745	9567	9951	30021	75217	105238	0.407	1.019	1.426
26	8500	14793	14203	11089	25500	429000	454500	0.345	5.812	6.158
27	5618	21394	16135	12307	22473	171148	193621	0.304	2.319	2.623
28		14548	14548	13607		378243	378243	0.000	5.124	5.124
29	8301	14677	13260	14992	16602	102737	119339	0.225	1.392	1.617
30	8450	20812	20125	16463	16900	707594	724494	0.229	9.587	9.816
31		15660	15660	18023		438487	438487		5.941	5.941
32		21849	21849	19674		262189	262189		3.552	3.552
33		19051	19051	21419		723946	723946		9.808	9.808
34		23980	23980	23259		407667	407667		5.523	5.523
35		30264	30264	25197		484224	484224		6.560	6.560
36		44026	44026	27235		132079	132079		1.789	1.789
37				29376					0.000	0.000
38		31365	31365	31620		94094	94094		1.275	1.275
39										
40										
41										
42										
43										
44										
45										
TOTAL					2808516	4572588	7381104	38.050	61.950	100.000

Overall, the smoothed deadweights are believed to be "representative", and their use will avoid aberrations in channel deepening benefits (or negative benefits) using actual average sizes in the world fleet.

PORT FLEET SIZE DISTRIBUTION

The actual distribution of vessel sizes at a port is unlikely to resemble the distribution of vessel sizes in the world fleet. The actual range of sizes will be limited on the upper end by channel size, and on the lower end by the higher cost of transportation in smaller vessel sizes. Within the actual range, the distribution of sizes will reflect a combination of factors more-or-less unique to each port. The actual size range for a port can be determined from statistics, and the upper end can be estimated with reasonable accuracy based on channel depths, the indicated use of tides, and the maximum lightloading that provides competitive costs. The port's upper and lower size limits can be used to truncate the world fleet, to produce a size distribution useful for certain purposes. The same basic procedure can be used for fleet forecasts are not port-specific.

<u>World Fleet Segment</u>. In order to avoid double counting the most efficient ships and the potential benefits of improvements at competing ports, a proportional share of the world fleet has been the expedient. It is only applicable to those types of vessels that are subject to redeployment worldwide over time. However, that includes most tankers and bulkers, and many containerships and other ship types. Proportional port fleets are simply segments of the larger world or forecast fleets, truncated for the channel limits at the port with- and without-project. The proportional fleets are to that extent sensitive to changes in channel dimensions, but they may understate (or overstate) the use of efficient ships because vessel employment is not the same as fleet capacity. Superficially, proportional fleets treat all ports equally. For that reason, they have been looked upon favorably by some review agencies.

<u>Forecast Fleet Segment</u>. Typically, a world fleet segment is produced from a size distribution by draft, for all vessels of a particular type. Truncation

of a fleet forecast will be more complicated if its size distributions are for deadweight ranges, and vessel populations within the size ranges change with forecast intervals. Tables V-11 and V-12 show tanker fleet segments for the world and for the U.S. South Pacific coast, truncated for the 35-foot channel at Richmond, California. The South Pacific coast fleet mix is the baseline fleet shown in <u>Fleet forecasts for the United States to 2020</u>, and both tables use the size ranges used in the forecast. Absent statistics showing actual deadweights of tankers calling at Richmond, the largest size was estimated to be 41 feet design draft, based on two feet for safety clearance, three feet of usable tide, and five feet lightloaded. Smallest size was set arbitrarily at 18 feet. The capacity of all small tankers unaffected by channel constraints could be combined to simplify calculation of transportation costs.

Tables V-11 and V-12 are an intermediate step in using the fleet forecast. Forecasts are stated in total deadweight by size range. The deadweight capacities must be converted to percent deadweight by size range and applied to the world fleet size distribution (forecast range %/world fleet range % * world fleet deadweight or percent capacity in that range). The percentage distribution of capacity within the truncated port fleet is recalculated to allocate port commerce to vessels by draft. The forecasts and related percentages used to produce Table V-12 are shown in Table V-10.

TABLE V-10
TANKER FORECAST FOR U.S. SOUTH PACIFIC COAST, ALL TRADE ROUTES

Forecast	Deadweight Distribution (000) by Size Ranges							
Years	<10K	10-40K	40-80K	80-100K	100-175K	175-250K	>250K	Total
1987	157	2567	8983	1106	0	0	0	12813
1995	95	2006	4503	1843	183	0	0	8630
2000	114	2090	4410	2082	210	0	0	8906
2010	130	1957	4077	2818	294	0	0	9276
2020	164	2030	4706	4520	488	0	0	11908
								51533
Forecast	Capacity Distribution (%) by Size Ranges							
Years	<10K	10-40K	40-80K	80-100K	100-175K	175-250K	>250K	Total
1987	1.225	20.034	70.108	8.632	0.000	0.000	0.000	100.000
1995	1.101	23.244	52.178	21.356	2.121	0.000	0.000	100.000
2000	1.280	23.467	49.517	23.377	2.358	0.000	0.000	100.000
2010	1.401	21.097	43.952	30.379	3.169	0.000	0.000	100.000
2020	1.377	17.047	39.520	37.958	4.098	0.000	0.000	100.000

TABLE V-11
TANKER SIZE DISTRIBUTION FOR RICHMOND, CALIFORNIA - WORLD FLEET SEGMENT

Max	Actual World Capacity Distribution (%) by Size Ranges							Total
Draft	<10K	10-40K	40-80K	80-100K	100-175K	175-250K	>250K	All Sizes
<18	0.717							0.717
18	0.152							0.152
19	0.175							0.175
20	0.129							0.129
21	0.167							0.167
22	0.319	0.008						0.328
23	0.176	0.142						0.318
24	0.098	0.088						0.186
25	0.023	0.077						0.100
26	0.051	0.221						0.272
27	0.011	0.092						0.103
28		0.385						0.385
29		0.275						0.275
30		0.476	0.072					0.548
31		1.117	0.021					1.138
32		0.772						0.772
33		0.616	0.293					0.909
34		1.086	0.164					1.250
35		1.382	0.128					1.510
36		2.797	0.307					3.104
37		1.508	0.617					2.125
38		0.684	0.590		0.044			1.318
39		0.147	1.177	0.031	0.044			1.400
40		0.106	1.506	2.543	0.044			4.199
41			1.270	0.466	0.000			1.736
>41	0.000	0.000	3.551	9.448	16.581	11.191	35.912	76.683
World %	2.018	11.979	9.698	12.489	16.713	11.191	35.912	100.000
Port %	1.302	11.979	6.147	3.041	0.132	0.000	0.000	22.600

(ratio to convert 18'-41'percentages for port cargo distribution is 100.0/22.6)

TABLE V-12
TANKER SIZE DISTRIBUTION FOR RICHMOND, CALIFORNIA - FORECAST FLEET SEGMENT

Max	Forecast Base Year Capacity Distribution (%) by Size Ranges							Total
Draft	<10K	10-40K	40-80K	80-100K	100-175K	175-250K	>250K	All Sizes
<18	0.435							0.435
18	0.093							0.093
19	0.106							0.106
20	0.079							0.079
21	0.101							0.101
22	0.194	0.014						0.208
23	0.107	0.237						0.344
24	0.060	0.147						0.207
25	0.014	0.129						0.143
26	0.031	0.370						0.401
27	0.007	0.155						0.161
28		0.643						0.643
29		0.460						0.460
30		0.796	0.522					1.318
31		1.869	0.152					2.021
32		1.291						1.291
33		1.030	2.120					3.150
34		1.816	1.186					3.002
35		2.311	0.925					3.236
36		4.677	2.221					6.899
37		2.522	4.460					6.982
38		1.144	4.267					5.410
39		0.246	8.510	0.022				8.778
40		0.178	10.889	1.758				12.825
41			9.183	0.322				9.505
>41			25.669	6.530				32.199
Coast %	1.226	20.035	70.105	8.632	0.000	0.000	0.000	99.997
Port %	0.790	20.035	44.435	2.102	0.000	0.000	0.000	67.362

(ratio to convert 18'-41'percentages for port cargo distribution is 99+/67+)

Fleet Forecast Disaggregation. Inspection of statistics for the project port will show whether the truncated world fleet or forecast fleet is realistic. Draft statistics in Waterborne Commerce of the United States show most tanker drafts at Richmond to be either 30 feet, or less than 23. The hourglass shape of the statistics shows the limitations of using fleet segments, and the need for actual vessel information to determine the largest vessels calling the port. At least, there is an apparent need for deepening. The basic ways to produce a more realistic port fleet size distribution, and relate it to forecasts, are described below in the section called "Fleet Forecast Disaggregation". The common starting point for those procedures is good baseline information on the present port fleet.

To relate forecasts to the port, it is necessary to compare the forecast baseline fleet with the actual port fleet at a common point in time--or as close to it as possible. It is desirable to identify the forecast that will be used and its baseline year during baseline information acquisition. The baseline year for Fleet Forecasts for the United States to 2020 is 1987.

FLEET FORECASTING METHODS

The underlying presumption in almost all fleet forecasts is that vessels will grow in size over time. Economies of scale apply because construction and operating costs increase proportional to vessel length, more or less, while capacity increases exponentially. Roughly, a vessel twice as long will cost 2 to 3 times more, but will carry about 8 times more cargo. Over time, the maximum size of individual vessels has grown, and also the share of big ships in the world fleets. The challenge in forecasting is to determine the technological and economic limits on size increases, and to produce a credible estimate of rate of change.

The rate of change in the composition of any fleet is controlled by the ability and need to replace old or inefficient vessels with newer or more efficient vessels. At the port level, there may be potential for rapid change because chartered vessels in world trade can be redeployed. However, there is no way to forecast that port fleet, because the vessels are part of a larger fleet. A true forecast has to consider all vessels in the relevant universe (such as all bulkers in the world, in the case of coal carriers). A port fleet forecast that does not account for all redeployment opportunities of its vessels is, at best, a projection. There are three basic ways to produce a fleet forecast or projection, and a combination of all three may be used.

DEMAND-SUPPLY ANALYSIS

Capital investments are generally made in anticipation of profit opportunities, hence shipbuilding for the world fleet has been subject to wild fluctuations. Demand-supply analyses rely on trade or traffic forecasts to determine the amount of shipping that will be needed, and estimate the new ships required after accounting for vessel retirements (scrappage) and current oversupply. This analysis can produce the best product in terms of rate of change, with future fleet composition and maximum sizes of vessels that reflect trade route practices and constraints. Considerable effort is required to analyze the world fleet. It may be reasonably easy to do for a segment of the domestic fleet.

It is essential to match the trade or traffic forecasts with the appropriate universe of vessels. Bulk carriers in world trade may alternate between coal, grain, ore and other trades, and the maximum amount of trade routes and vessels are involved. Bulk carriers in the U.S. domestic trades might be the other extreme. Vessel ages, as well as sizes for the relevant fleet, are needed to estimate retirements. Comparable statistics on actual trade and fleet capacity are needed to determine current vessel utilization.

Most analyses assume vessels will be retired at the end of their economic life. Individual owners may trade up or down, but the vessels will stay in the fleet until then. Economic life is generally assumed to be 20 years, but it can change for numerous reasons. In order to compare trade route tonnages with fleet capacity, it is necessary to convert both to ton-miles, and account for the disparate speeds of vessels and the unproductive time they incur on loaded voyages and empty backhauls. Merchant Fleet Forecast of Vessels in U.S. Foreign Trade, May 1978 explains the considerations involved. Comparison of capacity supply and demand will usually show an oversupply of vessels, and a judgement call is needed for the oversupply that will prevail in the future. Finally, when demand exceeds effective supply, expert judgement is required to estimate the sizes of new vessels. Some forecasts have used the assumption that new vessels will be 15 percent larger than the vessels they replace.

TREND ANALYSIS

Fleet trend analysis uses the net result of actual fleet additions and retirements, but requires judgement as to how long trends will continue. Similar to any other statistics-based analysis, it is appropriate only when there is a large enough population of vessels. Since actual additions to the fleet and retirements reflect intermittent periods of optimism, it is also limited to vessel types where statistics are available for a long period of years. For most purposes, trend analysis is limited to the vessel types shown in Lloyd's Annual Statistical Tables.

There are options for analyzing historic trends, including software programs. Projections of trends are likely to require some adjustment to rate of change, and a cap on maximum vessel sizes. Some amount of demand-supply analysis and the consensus of experts will help. The experts who produced Fleet Forecasts for the United States to 2020 believe the maximum sizes for all types of vessels have now reached optimum size for trade route port depths, and freight available; further increases in maximum sizes will occur only if higher shipbuilding costs force owners to buy larger vessels. This assumption is supported by Lloyd's vessel age distribution statistics, which show a plateauing of maximum vessel drafts in the past 15 years. (In the meantime, average vessel sizes have grown.)

CONSENSUS OF EXPERTS

The two preceding methods require some degree of expert judgement. The most useful references for identifying technological developments and shipping trends are trade periodicals such as Fairplay. The publications may also cite relevant studies and technical papers. Most textbooks are behind the learning curve. Research using periodicals, papers and study reports can be time consuming, and any forecast or projection based thereon should be supported by multiple references. The services of experts can be contracted for, but if their forecasts or projections are not supported by analyses, they are opinions.

The opinions of experts will be most useful for port fleet forecasts where a limited number of vessels are involved. Disaggregating a few vessels from a large universe of vessels involves a lot of work and conjecture. With a limited amount of vessels, it should be possible to identify and interview the vessel owners and shippers to determine their vessel replacement plans. Their plans, if any, will seldom go beyond the next generation of replacements, but they are the experts. Interviewing people at the docks is unlikely to produce a valid projection or forecast, because those people are not involved in investment decisions.

DISAGGREGATING FLEET FORECASTS

The difficulty of producing a valid forecast or projection is the reason why it is best to use a forecast prepared by experts. Available forecasts have to be related to the actual fleet at the project port. There are three basic ways to do that. Integration assumes that the port fleet will resemble a proportional segment of the forecast fleet at some future time. Historical and optimized shares of the forecast fleet rely on the fact that there has always been a surplus of ships in the world, and the port fleet will reflect the ability of the port and ships to compete for cargos.

INTEGRATED PORT FLEETS

Basically, this is an arithmetic exercise that merges the actual baseline fleet at the project port into the forecast fleets over time. An example is shown in Table V-13. Table V-13 shows the actual mix of containerships at Port Newark in 1982, and the merging of that fleet into a world containership fleet projection produced "in-house," using trend analysis and Lloyd's Annual

TABLE V-13
PORT FLEET FORECAST PRODUCED FROM WORLD FLEET PROJECTION

WORLD CONTAINERSHIP FLEET PROJECTION BASED ON GRT SIZE TRENDS
Source: Lloyd's Annual Statistical Tables, 1972-1983

Size Range (000 GRT)	Actual 1982	.Percent Distribution Fleet Gross Registered Tonnage. 1995	2005	2015	2025	2035	2045
<10	8.36	7.42	6.67	5.92	5.18	4.43	3.69
10/15	8.39	7.31	6.45	5.60	4.74	3.88	3.04
15/20	14.14	12.08	10.46	8.84	7.23	5.62	4.00
20/30	30.34	31.29	31.94	32.60	33.25	33.92	34.56
30/40	16.51	21.67	25.58	29.50	33.41	37.34	41.24
40/50	6.91	6.55	6.34	6.09	5.84	5.57	5.33
50/60	15.35	13.43	11.90	10.38	8.87	7.36	5.84
>60	0.00	0.25	0.66	1.07	1.48	1.88	2.30
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

WORLD CONTAINERSHIP FLEET CAPACITY DISTRIBUTION IN 1982
(Deadweight Distribution Adjusted for Vessel Speeds)

Design Draft	...........Percent Fleet Capacity by GRT Size Ranges........... <10	10/15	15/20	20/30	30/40	40/50	50/60	All Sizes
<28	5.78	0.80	1.26					7.84
28	0.13	0.44						0.57
29	0.00	0.65	0.77				0.43	1.85
30	0.03	2.46	3.67	0.18				6.34
31	0.02	1.30	1.64	2.23				5.19
32		1.01	2.32	5.01				8.34
33		0.58	2.14	2.41	0.28			5.41
34			0.77	8.47	0.69	2.50		12.43
35			0.59	4.64	0.69	1.07	0.43	7.42
36				2.41	3.57	0.35		6.33
37			0.09	4.08	5.38		0.44	9.99
38			0.09	1.30	3.30		1.30	5.99
39				0.19	1.65	2.14	3.90	7.88
40					0.14			0.14
41					1.23		2.17	3.40
42					0.28	1.43	6.50	8.21
43						0.36	2.17	2.53
>43					0.14			0.14
Total	5.96	7.24	13.34	30.92	17.35	7.85	17.34	100.00

NEWARK CONTAINERSHIP FLEET FORECAST - % DISTRIBUTION CAPACITY IN DWT
(1982 Port Fleet Integrated Into World Fleet Projection)

Design Draft	Actual 1982	..................Forecast Years.................. 1995	2005	2015	2025	2035	2045
<28	7.88	4.42	4.12	3.81	3.5	3.2	2.88
28	0	0.02	0.05	0.08	0.11	0.12	0.17
29	0	0.04	0.13	0.21	0.29	0.38	0.46
30	3.83	2.17	2.11	2.03	1.95	1.87	1.8
31	5.96	3.44	3.42	3.37	3.34	3.3	3.26
32	3.46	2.38	3.11	3.85	4.57	5.3	6.02
33	6.87	4.82	4.69	4.55	4.39	4.25	4.1
34	12.16	7.56	8.61	9.62	10.65	11.66	12.68
35	1.34	1.38	2.59	3.79	4.98	6.18	7.38
36	26.18	28.71	25.73	22.67	19.61	16.57	13.53
37	0.89	2	4.99	7.97	10.94	13.91	16.86
38	19.96	33.32	29.18	24.96	20.74	16.53	12.34
39	5.25	3.39	4.09	4.79	5.48	6.17	6.85
40	0	0.03	0.09	0.15	0.2	0.26	0.32
41	4.16	2.53	2.77	3	3.24	3.48	3.7
42	0	0.32	0.96	1.6	2.24	2.88	3.51
43	2.06	3.47	3.02	2.56	2.11	1.64	1.19
44	0	0	0.04	0.11	0.18	0.25	0.32
45	0	0	0.04	0.11	0.19	0.26	0.33
46	0	0	0.04	0.11	0.19	0.26	0.33
>46	0	0	0.22	0.66	1.1	1.53	1.97
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Statistical Tables, 1972-1983. Port data was in deadweight capacity by draft. Lloyd's statistics and the trend analyses used GRT size ranges. The size ranges were converted to capacity by draft, by stratifying the actual world fleet of containerships. The 1982 deadweight/draft distribution was adjusted to world fleet mix after 2000, and interpolated for integration between 1990 and 2000. Integration may be most appropriate for liner vessels that routinely call at a range of ports regardless of port channel depths. If the forecast baseline fleet does not resemble the port fleet, port competition or channel depths may be a factor. In that case, use of historical or optimized fleet share would be indicated.

HISTORICAL SHARE PORT FLEETS

Conceptually, historical share is the reverse of integration. It overlays the historical distribution of vessel sizes on the forecast fleets. In its simplest form it involves: (1) stratifying the historic port fleets (two or more years to eliminate aberrations) into the size categories used in the forecast, and calculating the percentage of port fleet capacity by size range; and (2) determining the percentage of fleet capacity by size range in the forecast baseline fleet, and calculating the percentage by which the port fleet size range capacity shares are greater or less than the size range shares in the forecast baseline fleet. Provided the port size shares do not exceed the forecast size shares by more than the percentage of excess fleet capacity (usually shown somewhere in the forecast), the port percentages can be used to modify the forecast percentages for size share.

If the historical port fleet size distribution shows size categories with shares that exceed the actual distribution in the forecast baseline fleet plus excess capacity, some explanation of where the vessels will come from is needed. It will be necessary to analyze the supply of ships available in the size categories involved. If the forecast baseline fleet is at the trade route or coastal level, it may help to look at the larger world fleet. Alternately, if the forecast baseline fleet is at that level, it may pay to disaggregate to the trade route or coastal range to show that a disproportionate percentage of vessels serve that trade or range, and the port has a disproportionate share of those vessels. Absent some reasonable explanation, historic port share is limited to the forecast percentage plus oversupply.

Historical port share can account for the fact that some ports are more attractive than others to vessel owners because of the availability of backhaul cargos or port facilities. However, it is relatively insensitive to impacts of deepening. Impacts will be reflected only in the truncation of the fleet for limiting channel dimensions with- and without-project. On the other hand, historical port share is also insensitive to port improvements elsewhere.

OPTIMIZED SHARE PORT FLEETS

Optimized share is a variation of historical share that attempts to capture the impact of port improvements. In lieu of historical statistics, it uses the calculated cost of transportation in various vessel sizes, and distributes port traffic among those sizes in proportion to relative efficiency up to the amount of available ships in those sizes. The amount of available ships (as in historical port share) is limited to the world or hopefully, a smaller universe provided in the forecast. The optimized share has to account for the relative attractiveness of all the ports that share trade routes with the project port; hence, it is only practical if the world fleet has been disaggregated to the level of competing ports by some simpler procedure.

To determine optimized share, each port's traffic is assigned to the most efficient vessels (not necessarily the largest size) up to the amount of capacity in that size category in the forecast. The surplus is then assigned to the next most efficient size category, and on, until the port's projected traffic is distributed. Unlike historical port share, which deals in percentages, optimal share uses tons of cargo and deadweight capacity. The initial distribution for all ports sharing a trade route is then added, the totals compared with available capacity in the forecast, and excess cargos are redistributed proportionately across the fleets until the supply of more desirable ships meets demand.

A large number of calculations are required, and a computer program is being developed. Trade route cargoes have to be distributed and redistributed among competing ports for each forecast interval twice, to capture the effect of with- and without-project fleets at the project port. Additional calculations are required if the effect of deepening at a competing port is to be assessed. (Port depths at the overseas ports are assumed to be reflected in the disaggregation to the trade route level.) The available shipping capacity used can be either the amount in the forecast size range, or (as in historical share) forecast capacity plus surplus. However, use of the surplus adds another layer of complexity and conjecture to the product.

The offset for all this work is that it may be useful in multiport analysis. Although the calculations assume a fixed share of trade route traffic for each of the competing ports, the comparative transportation costs with- and without-project can be used to estimate cargo routing shift because of the project(s). The optimized port share approach has been tested, but it has not undergone the scrutiny of multiple review agencies. Presumably, if the optimized fleet bears no resemblance to the actual port fleet, it will be in trouble.

PORT FLEET PROJECTIONS

Because of the unavailability of relevant or recent fleet forecasts, most Corps studies have used the actual port fleet composition and projected change over time, or change because of the project, using some elements of the three basic forecasting methods. Projections that involved large numbers of vessels usually relied on the assumption that all replacements would be incrementally bigger. That assumption can produce rational fleets, and generally the projections have been questioned only when the maximum size exceeded anything afloat. Projections for small fleets have relied heavily on specific vessel replacements, with- and without-project, identified by people at the port. People at that level may not be aware of all vessel supply and demand factors, and tend to overestimate the impact of the project.

TRADITIONAL PROJECTION METHODS

In addition to the approaches described above, some studies have assumed no change in fleet over time or due to the project. All three approaches can provide acceptable projections in given circumstances. These are described below.

Growing the Fleet. A gradual shift in fleet capacity to larger sizes has logic and can be supported by world fleet statistics. It has more logic if a large number of vessels are involved. If the port has a relatively few vessels that are part of a large fleet for which no forecast is available (vehicle carriers might be a case), the port fleet can be grown based on the assumption that there will be redeployments. If the port fleet has relatively few vessels that are part of a small universe (for example, Great Lakes ore carriers, or coastal products tankers), the port fleet may be actually or effectively dedicated vessels. In that case, identification of replacements is in order. A forecast for that small universe should be doable if one is not available. If the port fleet is large and consists of vessels for which world forecasts are available, forecast disaggregation is the way to go.

In effect, growing the port fleet applies a trend observed elsewhere. It is unlikely that any port will have statistics or enough vessels over enough time periods to provide a valid trend analysis. It is necessary to pick an appropriate trend, and (as noted in forecasting methods) determine the rational limits of trend extrapolation. It is also necessary to identify the actual and potential size of the universe from which the port fleet comes, in order to provide a rationality test. Absent forecasts, the actual world fleet composition can be extracted from Fairplay or Lloyd's data bases.

Identified Replacements. A small fleet may be more affected by individual vessel owner or shipper decisions than any other factor. The point is to talk to the right people, and do some amount of supply-demand analysis to verify that their answers are rational.

Static Fleets. When there is no good basis for projecting change in the port fleet, don't. In some port fleets, such as fishing or barges, vessel replacements may be same sizes. Alternately, if no replacements are contemplated until the present vessels run out their economic lives, the present worth of conjecture beyond then may not be worthwhile. The same vessel fleets with- and without-project and over the period of analysis are acceptable. If they are incurring delays or damage, or cannot load fully, project benefits will still apply.

OPTIMIZED PORT FLEET

Use of a hypothetical port fleet with only the most efficient sizes is unacceptable because it is unrelated to reality. One way to add reality is to modify the optimum distribution to spread port traffic over less efficient sizes in the world fleet, in proportion to the relative cost advantage of the optimum sizes. This is more-or-less comparable to forecast disaggregation by optimized share. The disaggregation uses tons of traffic and ship capacity to produce a distribution. The "bottom up" approach uses percentage cost relationships and percent fleet capacity, and may not produce rational results. They have to be tested against actual fleet capacity to determine if there are enough vessels, and the percentages for propensity to use less desirable sizes may have to be adjusted.

An alternate version of this approach has been used and survived review. It is more or less comparable to forecast disaggregation by historic share. The propensity to use efficient sizes is derived from analysis of port statistics, and incorporated into a computer model that accounts for vessel constraints and traffic volume. A model was developed by Phillip Thorpe, a Corps economist, and submitted as a Masters thesis at Rutgers University in October 1987. He developed his model using statistics for coal vessels serving Norfolk, and his model was used subsequently to estimate benefits of Delaware River improvements. It does not produce a port fleet, per se, but distributes port tonnage by size vessel. The model does not determine if there will be enough actual ships of the right sizes, and that has to be verified separately.

DEDICATED VESSELS

The term "dedicated" is commonly used to identify vessels that are committed to haul certain types of cargo or serve certain ports over a long period of time. The commitment may be subject to cargo availability, but where vessels are purpose-built to fit a specific port or port range, they may have limited employment opportunities elsewhere. Dedicated vessels should be accounted for as a preliminary to forecast disaggregations or port fleet projections.

Baseline information should identify the vessels that repeatedly call at the port. Inquiry at the port should identify the individuals who are in a position to state authoritatively if vessels are dedicated to serving the port, how long their commitment may last, and whether other vessels may be dedicated based on with-project conditions. Great Lakes bulk carriers and coastal products tankers are effectively dedicated to serving distinct sets of ports. The large, shallow draft ore carrier built to serve one Australian port is a true dedicated vessel.

SPECIAL PURPOSE VESSELS

Vessels built to minimize draft or maximize maneuverability usually have cost disadvantages when they have to compete with conventional vessels. For that reason, they are almost always built for use in a dedicated service. The fact that there are such vessels, is evidence that they can be a cost-effective solution in certain cimcumstances. The Great Lakes and Australian ore carriers cited above are also examples of "non-structural" alternatives. Such special purpose vessels may or may not be present in the port fleet now, but the appropriate time to consider them is in fleet analysis.

RESTRICTED DRAFT VESSELS

Restricted draft vessels have less draft and wider beams than conventional vessels of the same deadweight capacity. The approximate proportions of a conventional bulk carrier are 7:1 length to beam, 1.8:1 beam to depth, 1.2:1 depth to draft. Freeboard for tankers is less, and their draft is a higher percentage of depth. Ships deeper than conventional can be more economical to build, but channel depths may limit employment opportunities. Ships shallower than conventional are more expensive to build, because extra steel is needed to compensate for suboptimal geometry. The term "restricted draft" is generally applied to ships with drafts 10 percent or more shallower than conventional. A 15 percent reduction is about the practical maximum for oceangoing ships. Great Lakes ore carriers, at about 30 percent shallower, approach the theoretical limit.

The restricted draft vessel is a way to capture some of the economies of greater ship size for a given channel depth. It may or may not be a viable alternative depending on whether it has to compete with conventional vessels of comparable capacity. In the usual range of restricted drafts for oceangoing vessels, construction costs increase roughly proportional to draft reduction (a 15 percent cost increase for a 15 percent draft reduction), and propulsion may be less efficient. Such vessels have a permanent disadvantage in the competitive world charter market, and a small advantage compared with larger conventional vessels lightloaded to the same draft. Comparative costs from one port study were as follows (transportation cost per ton):

- Restricted draft 150,000 dwt. tanker (48-foot loaded)
  5 percent lower than 100,000 dwt. conventional tanker (48-foot loaded)
  13 percent higher than 150,000 dwt. conventional tanker (55-foot loaded)

- Conventional 150,000 dwt. tanker, lightloaded 7-foot
  2.5 percent lower than 100,000 dwt. conventional tanker (48-foot)
  2.5 percent higher than 150,000 dwt. restricted draft tanker (48-foot)

In some cases, such as U.S. coastal and Great Lakes trades and some remote foreign ports, the restricted draft vessel will have no effective competition from conventional vessels. The small net saving from restricted draft will be a permanent advantage, and may be enhanced by other special features such as high maneuverability (the Australian ore carrier) or self-unloading capability (Great Lakes vessels). Comparative costs will show whether a restricted draft vessel may be an alternative. If a serious investigation appears warranted, proceed as with dedicated vessels.

ENHANCED MANEUVERABILITY

Ships that spend most of their time at sea usually depend on tug assistance for docking, undocking and negotiating constrained channels. Ships that have a high number of port calls, such as containerships and other liners, often have maneuverability enhanced with bow thrusters--and in some cases bow and stern thrusters. The extent to which vessels are designed for maneuverability, and have devices for that purpose, will depend on their usual employment. Enhanced maneuverability is a way to capture most of the economies of greater ship size in places with narrow or winding channels, or restrictive bridges. Many Great Lakes ports have all of those problems. For the vessel types that usually rely on tug assistance, enhanced maneuverability has advantages and disadvantages similar to restricted draft.

The two basic ways to enhance maneuverability are tunnel thrusters at one or both ends of the ship, and twin propellers. Most thruster installations range from 500 to 3000 horsepower, with multiple units used for higher power requirements. Costs range from $50 to $250 per horsepower plus 20 to 30 percent for installation. Most vessels can be retrofitted with thrusters at minimal cost penalty versus new building. Horsepower requirements are determined with formulae based on the amount of ship area immersed and above the waterline. Power requirements can be approximated from the tug power that would otherwise be required. Twin propellers are not an option after the vessel is built. Most vessels are "single screw" because one propeller on the centerline is the most efficient location for conventional vessels. Twin screws on restricted draft vessels are not uncommon because water flow to a single propeller would be impaired.

Enhanced maneuverability is a distinct advantage in narrow channels, because the alternative of tug assistance requires more lateral clearance than the ship itself. In wider channels, the safety of tugs alongside limits the ship's speed. In some places, enhanced maneuverability may be an alternative already in use. In that case, a widening or bend easing project may open the port to a greater variety of efficient ships. As an alternative to the project, comparative costs will indicate whether contact with vessel operators and shippers is warranted.

TRANSSHIPMENT VESSELS

The two most commonly used "non-structural" project alternatives are use of transshipment ports and lightering in the vicinity of the project port. They are likely to be the preferred alternatives in lieu of purpose-built vessels of restricted draft or enhanced maneuverability, provided suitable transshipment or lighterage vessels are available. Evaluation of transshipment and lighterage alternatives was covered in Chapter IV. The point in considering them again in connection with fleet analysis is that the feasibility of those alternatives is dependent on the availability of suitable vessels. The point in doing so after describing purpose-built vessels is to emphasize the distinction in vessel requirements.

One reason for the predominance of transshipment and lighterage as alternatives is that both can avoid the need for long term commitments. Very few ports have been built for transshipment purposes, and even fewer ships have been built specifically for lightering or shuttle service. Implementation of these alternatives therefore relies on short term employment of more-or-less conventional vessels. Barges have been the usual solution when operations have been in U.S. coastal waters. In order to access the world fleet, a foreign transshipment port must be used, or lightering performed offshore in international waters. Because of cargo transfer costs and the double-handling involved, the readily available vessels suitable for these alternatives are almost exclusively tank vessels.

Self-unloading capability is the conventional solution for drybulk vessels operating on short routes. The added capability imposes some cost advantages and disadvantages similar to other purpose-built ships. In effect, the economics of self-unloaders involves trading off reduced capacity for quicker port turnaround and investment in port facilities. The economics are unrelated to potential use in project alternatives, and availability will depend on trade conditions.

UNCONVENTIONAL VESSELS

Unconventional vessels include catamarans, multi-hulls, surface effect and other exotic craft. Some of these have special qualities that have commercial applications. However, virtually all commercial cargo transportation is provided by vessels with conventional proportions because those vessels are more economical. Innovative thinking has produced some expedients to cope with channel constraints, such as flotation devices to temporarily reduce vessel draft, but they have few practical uses. Most innovations in commercial vessel design have centered on facilitating cargo loading and discharge. This has produced the containership and specialty vessels such as car carriers and heavy lifters. In some cases, improved efficiency in cargo handling has been at the expense of poor controllability or increased channel requirements. The barges carried by LASH or Seabee-type vessels have the ability to enter shallow ports or penetrate inland rivers, but the mothership requires deep water in a protected location for its loading/unloading operations. Ocean-going barges of various types (conventional and integrated tug-barge units) are usually expedients to cut crew and investment costs. Their operating costs are unique, but they have conventional channel requirements.

VESSELS AS NON-STRUCTURAL PROJECT ALTERNATIVES

The P&G require consideration of non-structural alternatives that may reduce or replace the need for project investment. Certain types of vessels are candidates to be non-structural alternatives. Considering them after the determination of the port's future fleets is common practice, but the orderly way to handle such vessels is as part of fleet analysis. The special purpose vessels that have been described are the candidates, and there is no need to search for more alternatives. If they provide a sensible solution and there is a prospect that they will serve the port, they can be treated as part of the port fleet and not an alternative to it. Fleet analysis is also the appropriate time to identify any vessels with extraordinary channel needs or operating costs that do or will serve the port. Those vessels may provide additional benefits for the improvement project.

CHAPTER VI

COMMODITY ANALYSIS AND PROJECTIONS

The objective of this chapter is to identify future commodity movements and hinterlands. The chapter includes two sections: (1) logic of commodity flow analysis; and, (2) projection of traffic generated in the economic study area.

LOGIC OF COMMODITY FLOW ANALYSIS

The logic of commodity flow analysis is presented in Figure VI-1. Commodity projections begin with current and relevant historical baseline data (Chapter IV). The objective of commodity flow analysis is to identify the volume of benefited traffic that will be handled through the port during the life of the project. The methodologies for traffic projections are conceptually clear; however, forecasts must be made within an analytical framework. Figure VI-1 is intended to illustrate the major decisions and problems that the planner must consider.

PROJECTIONS FOR WITHOUT-PROJECT CONDITIONS

Beginning with the baseline information, the planner must determine whether to forecast all traffic or only benefited traffic. Benefited traffic consists of existing commodity flows, diverted or induced traffic affected by lower transportation costs resulting from the project. Traffic forecasts are based on aggregating past commodity trends ("bottom-up" projections) or disaggregating future forecasts of commodities for multiple ports or hinterlands to the specific project port or affected hinterland ("top-down" projections).

Trend analysis of existing flows requires identification of hinterlands and important production or consumption variables and constraints. Where domestic hinterland production or consumption is market-driven, comprehensive economic indicators such as OBERS projections can be used. Foreign trade areas that

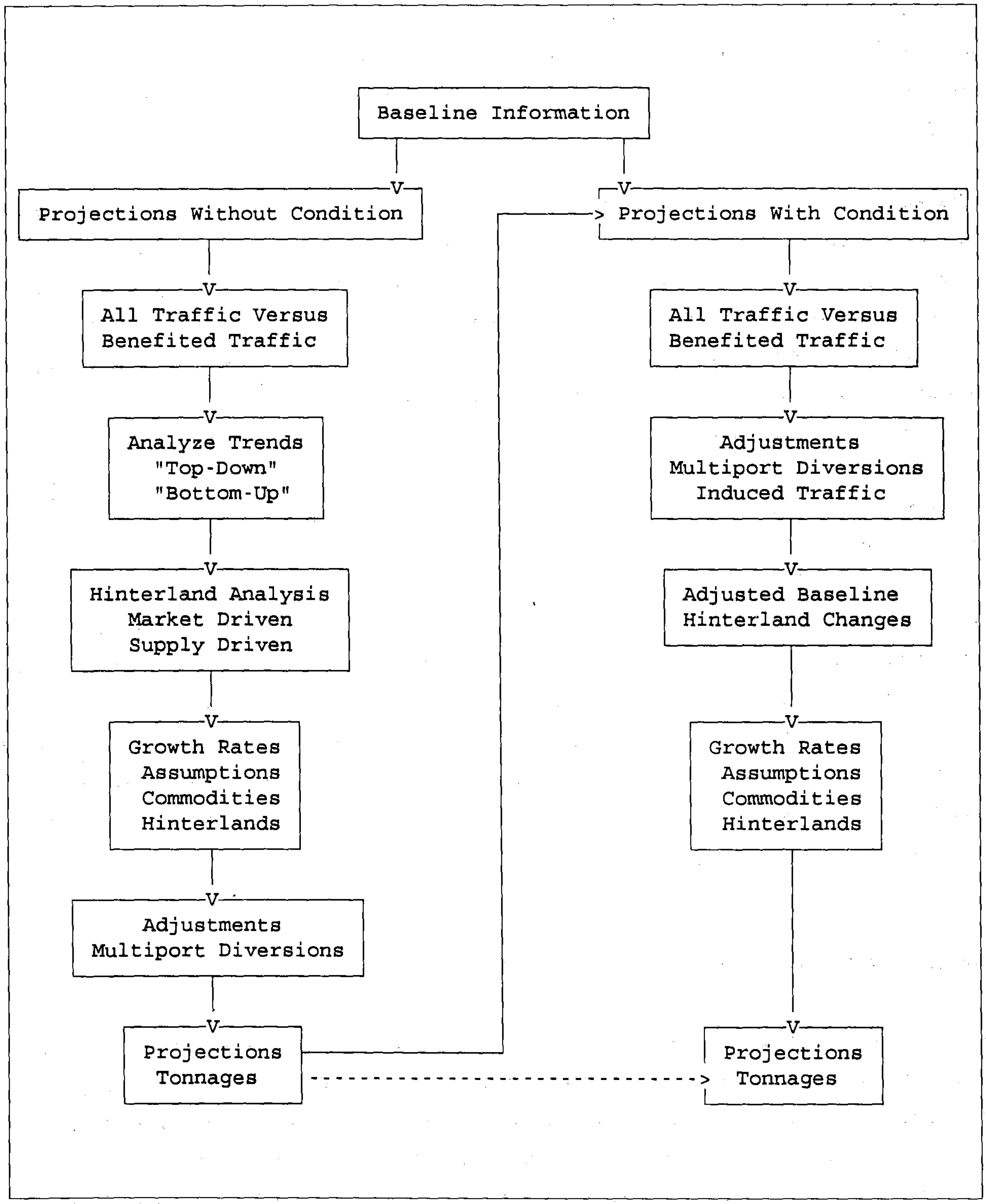


FIGURE VI-1. LOGIC OF COMMODITY FLOW ANALYSIS AND PROJECTIONS are market-driven will usually require disaggregation of top-down macro economic forecasts such as Department of Energy export coal projections or Department of Agriculture grain export projections. Supply-driven hinterlands will be affected by the life of the resources and development of alternative supply sources.

The analyst must address growth rates conditioned on assumptions about major, uncontrollable factors affecting traffic demand. Growth rates should be commodity- and hinterland-specific unless this is impractical, such as with general cargo or containerized cargo that is composed of a wide variety of miscellaneous consumer goods. Growth rates can be derived from trend analysis ("bottom-up") if the past can be assumed to be representative of the future. Growth rates can also be disaggregated from existing "top-down" forecasts for broad ranges of ports or hinterlands. The projections should be reasonable relative to the particular supply and demand characteristics of the port hinterland.

Adjustments to the without-project condition forecast should include potential diversions to other projects (multiport analysis). Unless there is a one time complete loss of traffic of a particular commodity flow the diversion will have to be projected. Incorporating diversions into the baseline results in a series of commodity/hinterland tonnage projections for the without-project condition. This forecast is an input to developing similar projections for the with-project condition.

PROJECTIONS FOR THE WITH-PROJECT CONDITIONS

Conceptually, it is assumed that the analyst knows the impact categories of the with-project condition to identify benefited traffic. The with-project projections begin with examining how without-project projections would be affected by lower transportation costs. If the planner assumes that there are no hinterland changes as a result of the project, diverted and induced traffic are unimportant. Multiport analysis is still required, however, to ascertain whether the existing project will affect competitive hinterlands and divert traffic from other ports. Diverted or induced traffic will require growth rates and underlying assumptions for commodity/hinterland projections. Incorporating projections of diverted or induced traffic into the without-project adjusted baseline will result in a series of commodity/hinterland tonnages by benefit category (existing, diverted or induced) and benefit type (e.g., deeper draft vessels, reduced lightloading, and reduced delays).

PROJECTING ECONOMIC STUDY AREA TRAFFIC

One of the most difficult tasks that the planner must execute is a forecast of future traffic for the with-project condition. Technically, forecasting is not difficult; however, the choice of specific tools, data and assumptions about future conditions affecting demand for the port is often subjective. Forecasting is neither a science nor an art. It is a mixture of both objective and subjective elements. One of the dilemmas for the analyst is to recognize the distinction between the objective and subjective components of forecasting and the sensitivity of the results to changes in the components.

ASSUMPTIONS

There is no perfectly objective forecast. All forecasts of future demand are conditioned on assumptions about uncontrollable environments. If planners knew future economic conditions influencing demand with certainty, they would have perfect knowledge of the future. Forecasting traffic generated in the economic study area must be done because of uncertainty about the behavior of major, uncontrollable determinants of demand.

All forecasts are based on premises about major factors affecting demand. The analyst must make explicit or implicit assumptions about the major factors affecting demand in the economic study area. Forecasting models must consider both economic and government factors. Economic factors can be disaggregated into four levels: international; regional; market; and enterprise.

International Factors. International factors pertain to the effect of general economic conditions on demand. Economic factors for coastal port commodity projections pertain to rates of growth of world trade expressed for specific regions, trade routes, nations, industries, and/or commodity flows. Economic factors are divided into short-run and long-run. Short-run factors include premises about business cycles (full employment/recession/depression) for particular regions or commodities. Long-run factors pertain to trends extending beyond projected business cycles.

Regional Factors. Regional factors pertain to forces affecting demand in the economic study area. Regional factors include population premises, where demand for commodity flow through the port is a function of growth and trends in hinterland population characteristics. Premises about social and cultural attitudes unique to the region and forces that affect hinterland traffic should include tastes and preferences that affect demand for exported and imported goods, for example foreign cars in the United States.

Market Factors. Market factors reflect assumptions about the competitive position of industries and firms, for example coal versus oil. In some instances, where project demand is limited to a few large firms, premises about the position of the hinterland firms in the industry relative to other firms are needed, for example U. S. steam coal exporters competing with Australian steam coal exporters. Technological assumptions also affect the demand for new goods (induced production) or decrease demand for existing outputs through obsolescence. Important technological premises in forecasting demand for coastal ports have involved changes in vessel fleets due to modernization and increased size of ships (Chapter V, Fleet Analysis and Forecasts).

Enterprise Factors. Enterprise factors are assumptions about particular firms. Enterprise factors may be needed if demand for the project is concentrated in a few commodities and firms. Enterprise premises include assumptions about the firm's output, including product type and quality, price and distribution. Enterprise factors are important if the port has large amounts of hinterland cargo attributed to a specific firm. This is often particularly important for smaller projects.

Government Factors. Government factors pertain to future laws, regulations and fiscal or monetary policies that may influence economic activity related to the port hinterland such as tariffs and subsidies. Government factors should reflect potential changes or stability of existing domestic and international policies such as embargoes and foreign aid programs. Assumptions about ethical forces and law include the impacts of institutional changes such as intermodalism incentives and pricing practices under the Shipping Act of 1984.

GUIDELINES FOR ASSUMPTIONS

The number and kind of parameters that are necessary to forecast traffic may be distinctly different for current traffic compared to diverted and induced traffic. Analysts should distinguish between forecasting parameters pertaining to existing traffic and parameters applicable to forecasts of diverted or induced traffic. Failure to distinguish between different parameters and assumptions associated with different benefit categories (existing, diverted and induced traffic) can impair forecasts of diverted and induced traffic.

A common mistake made by analysts is to arbitrarily accept certain assumptions without acknowledging the sensitivity of the forecast to changes in the assumptions on which the forecast is based. This is particularly important in using top-down projections. Sensitivity analysis (Chapter X) pertaining to commodity forecasts is based on changes in assumptions about major, uncontrollable environments. Variability of commodity projections can be attributed to the degree of uncertainty of forecast premises and the underlying sensitivity of the forecast to changes in the premises. Commodity projection sensitivity analysis begins with changes in the underlying forecast premises. Important forecast parameters should be selected for sensitivity analysis before the forecast is initially made. Sensitivity analysis should be explicitly incorporated into the forecast process rather than being conducted as a residual at the end of the forecast.

One of the biggest problems facing analysts is that assumptions have to be made for the duration of the forecast, typically 50 years. Conventional wisdom stipulates that the longer the time span of the forecast, the lower the accuracy and higher the probability of forecast error. Technically, the time span of forecast accuracy is a function of the validity of the assumptions about major uncontrollable environments. A forecast that is based on a set of assumptions which prove to be incorrect within a short period of time will no longer be accurate. Conversely, if major uncontrollable environments are stable for a long period of time, correct assumptions will enable the forecast to be accurate for an indefinite length of time.

The validity of assumptions with respect to time and degree of stability in major, uncontrollable environments is another important aspect that has to be explicitly incorporated into sensitivity analysis before the forecast is made. The analyst has to realize that sensitivity analysis begins with the specification of forecast assumptions, rather than with speculative adjustments to the forecast projections at the end of the process. The accuracy of the entire forecast is only as good as the validity of the assumptions on which the forecast is based, other things equal.

PROJECTION METHODS

For purposes of this report, traffic projection methodologies can be classified as analytical or subjective. Analytical methods use mathematical and statistical tools to project future traffic from primary data. Subjective forecast methods may use primary or secondary data, including reports, expert opinions and surveys, to project traffic. Analytical methods, such as regression, are sometimes regarded as more objective compared to the greater amount of intuition that characterizes subjective methods. However, both types of projection methodologies are inherently subjective because assumptions about uncontrollable environments are explicitly or implicitly required.

ANALYTICAL METHODS

The primary advantage of analytical methods is that mathematical and statistical techniques can be used to reduce subjectivity and determine confidence limits for error and sensitivity testing. The impact of different parameters on the forecast can be analyzed by explicitly incorporating changes in assumptions into the forecast. Analytical techniques permit the analyst to modify assumptions and to identify sensitive assumptions.

The basis for all analytical techniques is historical data on commodity movements. Analytical techniques are particularly appropriate where accurate commodity flow data exists for current and diverted movements. Where no commodity flow data exists, such as for induced movements, subjective techniques are usually more appropriate.

The primary mechanism for projecting historical commodity flow data is time series analysis. Time series analysis is based on a premise that what is being forecast does not remain stagnant because a trend exists. The objective of time series analysis is to identify the relevant historical trend which can be extrapolated into the future.

Moving Averages. Trends can be identified by averaging past data. Moving averages of past data are used when a discernable trend exists. The purpose of moving averages of past data to project future data is to smooth out the trend as close to the true value as possible. Data can be analyzed by a number of different averaging processes: moving average; weighted moving average; and exponential smoothing. The number of time periods, used to project the trend, and the degree of importance given to different time periods is a function of trial and error. The analyst will experiment with different numbers of time periods and different weights for these time periods until satisfactory results are achieved.

The problems associated with the moving average form of time series analysis are the number of time periods to incorporate in the model and how much weight should be assigned to different periods. Generally, if there is little fluctuation between data for past periods, then a larger number of periods is desirable to smooth out the true trend. However, if considerable fluctuation exists among levels of past data, fewer periods should be used to give more significance to more recent data. Generally, where wide fluctuations in the data exist across time, the averaging approach is less accurate than other time series techniques. Averaging past data to project the future will lag any upward or downward trend in the data across time. Consequently, averaging methods usually incorporate weights, either arithmetic or exponential, to correct the lag between the actual and forecast values. How much weight and the form of the weights, arithmetic or exponential, to assign to more recent data is a problem of trial and error for the analyst.

Averaging techniques are seldom used in long-run commodity projections. The simplicity of the technique cannot incorporate the complex number of uncontrollable variables and multiple trends that usually characterize commodity flows. In addition, the use of averaging methods across a long-run forecast period, potentially spanning 50 years, assumes that no change in the past trend will occur. Averaging techniques are generally not applicable to long-run time periods when many variables are subject to change. The analyst who uses averaging methods for long-run trend projections must explicitly or implicitly assume that the major determinants of past traffic volume will remain stable in the future. Generally, this leads to unacceptable results over a long period of time. Averaging techniques are primarily useful for relatively short periods of time wherein the past trend can be reasonably assumed to remain valid.

Causal Models. The most popular time series analytical technique for long-run commodity projections is causal models. Causal models assume that there is a trend or trends which characterize the changes in traffic demand over time. Historical traffic demand can be classified into one or more trends as follows: (1) secular changes; (2) seasonal changes; (3) cyclical changes; and, (4) random changes.

Causal models use regression analysis to infer a relationship between the dependent variable, commodity volume, and one or more independent variables. The most basic causal model is simple linear regression analysis where commodity flows are assumed to be a continuous function of one or more variables. The most basic regression trend assumes that commodity flow is a constant function of time where the volume of the commodity flow, Y, in any future period of time, t, would be equal to: $y = a + b(x)$; where a is the y axis intercept when x equals zero; x is the future value of the independent variable in period t; and b is the slope or the rate of change in y with respect to change in x.

Most commodity flow projections do not use this simple model where traffic demand is assumed to be a linear function of one variable such as time. Such a model assumes that all past indirect relationships between demand and time are entirely applicable in the future. Several classical long-term forecasts have had erroneous results using this premise about an inferred relationship between demand and time. For example, the U. S. electric utility industry experienced an average annual growth rate in demand of approximately seven to eight percent a year between 1950 and the mid 1960s. Major long-term shortages in generating capacity were forecast using regression where demand for electricity was projected based on past stable trends over time. The industry initiated major capacity expansions to meet large forecast increases in demand based on the premise that the factors that affected demand for electricity in the period 1950 to the mid 1960s would continue unabated; primarily, cheap oil prices; expanding industrial growth; continued growth in suburban households; and, growth in the use of electrical appliances. Unfortunately, however, none of the major underlying factors influencing past trends continued unchanged after 1970. Major increases in oil prices, recession, de-industrialization, appliance saturation and weak housing markets all contributed to a much slower growth in demand for electricity after 1970.

The most common form of causal models is multiple regression where two or more independent explanatory variables are used to infer a relationship with demand. The relationship between the independent and dependent variables may be linear or non-linear. The form of the relationship, linear or non-linear, and the number of causal variables is up to the judgment of the analyst to determine by trial and error. Regardless of the form of the model, the analyst should be aware that any trend analysis which relies entirely on past relationships between the variables reflects a premise that these relationships will remain unchanged in the future. This is a very important assumption whenever uncertainty exists about uncontrollable environments affecting the relationship between the variables over a long period of time;

for example, cheap oil prices in 1969 and demand for electricity after the formation of the Organization of Petroleum Exporting Countries (OPEC) in 1972.

Secular Trends. Time series analysis with causal models permits the analyst to disaggregate historical trend into different components. The secular component reflects the underlying stable average long-term trend in the series.

Seasonal Trends. The seasonal component reflects regular, reoccurring short-run patterns of high and low values in the series which affect the average trend. Seasonal changes may not necessarily be related to climate. Seasonal adjustments to the underlying long-term secular trend can be ignored if the purpose of the forecast is to project average long-run commodity volumes.

Cyclical Trends. Cyclical trends are irregular, reoccurring patterns of high and low values of demand. Cyclical trends are commonly regarded as business cycles; however, other variables such as effects of drought on agriculture are also cyclical components affecting demand or supply. While the analyst can theoretically forecast the long-term trend and regular seasonal fluctuations with accuracy, cyclical fluctuations cannot be reliably forecast based on past trend analysis. The analyst must either ignore cyclical trends or incorporate these irregular cycles into the forecast based on such factors as judgment or leading indicators. Consequently, most long-term commodity projections exclude cyclical factors except in the short-run where the analyst can comfortably make subjective assessments about the likelihood of cyclical shifts in demand.

Random Trends. Random trends are residuals which cannot be explained by seasonal or cyclical variations in the secular demand trend. True random trends reflect unusual, unforeseen and non-reoccurring variations due to weather, natural disasters, or other conditions. The objective of the analyst is to identify such unusual, non-representative fluctuations in demand and remove their influence on the true underlying trend by smoothing the data to reflect normal circumstances. Random trends represent noise in the data set which should be removed to better depict the clarity of the underlying relationships between the independent and dependent variables.

SUBJECTIVE METHODS

Subjective forecasting methodologies are used to project hinterland traffic primarily when accurate historical commodity flow data are not available or applicable to the impacts of the project on users and other ports. Such techniques reflect subjective judgment and intuition. The primary disadvantage of subjective forecasts is that the premises which constitute the projections cannot usually be explicitly identified; therefore, sensitivity testing of the projections is difficult. Subjective forecasts also do not permit the analyst to independently compute statistical confidence intervals to estimate forecast reliability. Consequently, subjective forecasts of current or diverted hinterland commodity flows are usually avoided unless substantial uncertainty exists. These forecasts are used primarily to infer the potential of significant changes in existing traffic, or large diversions in induced traffic.

The user oriented subjectivity of subjective forecasts does not mean that these techniques are necessarily less accurate than analytical methodologies. The use of such techniques reflects different forecasting circumstances confronting the analyst. Whenever the with-project condition affects diversion of existing commodity flows or could induce new traffic, subjective forecasting techniques will usually be required. Subjective forecasts are based on expert opinion or user surveys. Expert opinion is usually the simplest and most convenient way to project diverted traffic or to identify induced traffic.

The primary problem associated with expert opinion projections is subjectivity. The forecast is heavily influenced by personal opinions and unsupported by historical data that can be verified. Conflicting expert opinions regarding projections of diverted or induced traffic in the hinterland can only be reconciled if all the assumptions or conditions of the experts are identified. Generally, the assumptions that constitute or qualify expert opinions are not stipulated or explicitly linked to the projection in such a manner as to facilitate sensitivity testing. Therefore, analysts have considerable difficulty weighing the reliability of different expert projections.

User surveys can be employed to supplement expert opinions. User surveys have been a popular means for Corps planners to identify changes in traffic in response to the with-project condition. Properly administered and interpreted, user surveys can be invaluable, especially when no accurate commodity flow data exist or the project is contemplated to have significant impacts on the redistribution of existing commodity flows in the hinterland.

Field questionnaire research has a number of potential problems that can affect the validity of the results. Any traffic survey requires a carefully designed methodology for soliciting information from a reliable sample. Where hinterland shippers or carriers are relatively few in number, a complete survey of all users is desirable to maximize representativeness of the results. If a large number of shippers or carriers exists, the survey should be stratified to proportionately reflect the different distributions of commodity flow characteristics of the hinterland population. Unless the survey is representative of different users (beneficiaries) from the criteria of response to with-project condition, the results cannot be accurately generalized to the hinterland population of project beneficiaries. Non-representative project hinterland user surveys cannot be used other than on a case study basis. The analyst will have to rely heavily on intuition to generalize different case study responses which has significant implications for sensitivity testing (Chapter X).

User surveys properly designed and administered may not generate accurate or reliable information. Analysts should be cautious about respondent attitudes such as optimism or other personal characteristics or competitive circumstances that could bias the information collected. Surveys should be cross-checked for internal validity and consistency among similar categories of respondents. Where significant differences exist between the consistency of individual responses, the analyst should be careful not to infer true or correct information without allowance for sensitivity testing of different interpretations of the data. If inconsistencies exist in the survey data, the analyst should seek to clarify whether conflicting data are based on survey design, administration or user circumstances.

User surveys provide invaluable insight into potential for diverted and induced traffic; however, at the same time survey data cannot be directly verified. Therefore, survey data must be used cautiously, and if at all possible, verified indirectly through consistency checking of the survey process and survey results or by independent expert opinion.

MEASURING ACCURACY OF PROJECTIONS

Although the choice and application of forecasting techniques is subject to judgment and trial and error, the degree of accuracy of the selected approaches can be objectively measured. The best way to measure forecast accuracy is to compare historical demand with what would have been forecast. There are different measurements of forecast accuracy, primarily residuals analysis and statistical measures of goodness of fit between actual and forecast results.

RESIDUALS ANALYSIS

This is a popular tool to depict the accuracy of time series trend analysis and identify different components of demand trends. Residuals analysis is a plot of the difference between actual and forecast commodity volumes over time. A residuals analysis between actual and forecast long term trends may indicate regular, reoccurring differences between actual and forecast demand which indicate that seasonality exists in the historical data. After the long-term trend is adjusted to incorporate seasonal fluctuations by either an additive or multiplicative component, further residuals analysis may indicate sporadic differences between actual and forecast data consisting of irregular, reoccurring differences between actual and forecast values. Unusual, non-reoccurring differences between actual and forecast data reflect random outliers which should be removed from the data set and replaced by adjusted or smoothed data based on observed secular and seasonal trends.

Irregular, reoccurring differences between actual and forecast data indicate cyclical patterns which should be removed by the analyst, unless these trends are to be subjectively incorporated into the forecast of future periods or used to measure overall forecast accuracy and sensitivity to uncontrollable variables over the duration of the forecast. If the analyst can safely assume that cyclical fluctuations will tend to cancel out over a long period of time, they can be removed from the data set and replaced by smoothed data.

Residuals analysis of the differences between actual and forecast values is not only useful to infer whether seasonal, cyclical, and random trends exist, but it can also depict overall forecast accuracy. A forecast with all elements of seasonal, cyclical and random trends removed should closely correspond with actual data. Residuals analysis is one way to depict the overall accuracy of the smoothed forecast.

STATISTICAL MEASURES OF ACCURACY

Other methods to indicate the accuracy of the forecast include the coefficient of determination (R^2) and standard deviation statistics. The coefficient of determination statistic is the proportion of total variation for the dependent variable explained by the independent variables. Ideally an R^2 of 1.00 is desired, indicating that changes in the independent variables account for 100 percent of the changes in the dependent variable. As the R^2 statistic decreases, the amount of variation in the dependent variable directly associated with the independent variables decreases.

The standard error of the forecast is a measure of the dispersion between the forecast and corresponding actual data. If the standard error is large, the amount of confidence in the accuracy of the forecast will be low. One way to express confidence in the forecast is to determine the probability that the forecast will be within an upper and lower limit, using the standard deviation of the forecast. If forecast errors are assumed to be normally distributed --

that is the distribution of high and low forecast values versus actual data is essentially equal -- the normal distribution can be used to compute a confidence interval. If the forecast for period t is 100 and the standard deviation of the forecast is 1, the analyst can be 95 percent confident (subject to the assumption of normal distribution of forecast errors) that the true forecast will be within the range of the mean, 100, plus or minus the standard deviation, 1, multiplied by 1.96, or between 98.04 to 101.96. If the standard deviation is large relative to the mean, the confidence interval will be proportionately greater. For example, if the standard deviation is 20, the analyst can predict that actual demand will fall within the range of 60.8 to 139.2 units 95 percent of the time.

The use of the standard error statistic permits the analyst to determine the sensitivity of the forecast to unexplained variability in the trend (R^2 is less than 1.00). Residuals analysis is important to identify non-representative data and smooth the forecast. As non-representative data (random and cyclical trends) are removed, the true trend becomes clearer and the standard error decreases (R^2 increases). As the standard error decreases more confidence can be placed in the forecast relative to the range of high and low limits. The smaller the standard deviation of the forecast the more accurate the long-run projection, other factors being equal.

USING "TOP-DOWN" FORECASTS

Top-down forecasts are technically a form of expert opinion. The top-down forecasts typically used in port studies represent volatile bulk commodity markets such as energy and agriculture. Top-down forecasts usually reflect broad geographic areas such as national coal export projections developed by the Department of Energy. A primary problem with top-down forecasts is that someone else's projections have to be disaggregated for a broad geographic area or commodity markets to a particular port hinterland. In some instances, the top-down forecasts have focused on domestic trends and the foreign sector has to be inferred. Disaggregating a "fair share" of an aggregated forecast to an individual port requires considerable judgment and subjectivity. If top-down forecasts have been used, the planner should show the reasonableness of the forecast in terms of the allocations of traffic among competing ports.

Top-down forecasts are usually based on macroeconomic trade projections or input-output mathematical models of regional demand. These top-down approaches usually are highly aggregated both for commodity type and hinterland region. More specific disaggregated macroeconomic trade forecasts are primarily short-run in nature, generally less than five years, compared to up to fifty year projection time frames used by Corps planners. Short-run macroeconomic trade forecasts resemble business cycle projections. Attempts to extrapolate short-run projections into long run forecasts usually produce sterile results. It is not uncommon to see, in top-down forecasts, detailed five-year macroeconomic trade forecasts for commodities, trade routes, and nations followed by a long-term trend extrapolation over the remaining forty-five years. Considering that world trade has historically averaged three percent real growth a year, it is not unusual to see detailed macroeconomic trends for the first five years containing various short-run intuitive adjustments for cyclical components followed by steady state projections distinctly reflecting an annual growth rate of approximately three percent.

SELECTING THE APPROPRIATE FORECAST METHOD

The best forecast methodology is generally a combination of techniques. The choice of appropriate forecast techniques will largely be determined by the character of the hinterland commodity flow information available to the planner. Where commodity flows are primarily heterogeneous, freight-of-all-kinds (FAK), such as containerized manufactured goods, commodity projections will reflect historical time series data adjusted by macroeconomic projections for future growth of independent variables. Homogeneous commodity flows of bulk materials will be more susceptible to user surveys to identify diverted or induced traffic projections.

Caution should be exercised when aggregating or combining different forecasting techniques so that the planner does not bias the results from using different methodologies to obtain the most optimistic forecast.

Projections of changes to the current hinterland traffic should be analyzed across different forecasting methods to insure that the variables used are reasonable representations of the different techniques and applications, instead of merely aggregations of optimistic scenarios most attractive to the planner or the project. One of the purposes of sensitivity analysis (Chapter X) is to ascertain the robustness of traffic projections relative to different forecasting scenarios.

Forecasts of the volume of hinterland commodity flows should reflect not only current traffic, diverted traffic, and induced traffic for different commodities, but should identify benefit category, vessel type and trade route associated with each projection. Each commodity flow projection should identify the potential for diversion to other ports as a result of other projects. This data base and projection will be the primary input to multiport analysis (Chapter VII).

PROJECTING PROJECT PORT TRAFFIC

All projections begin with current traffic subject to adjustment based on diversions identified in multiport analysis. Base year traffic subject to projection does not include all commerce through the port net of multiport diversions analysis. Projections are relevant only for benefited traffic, consisting of all cargo affected by reduced transportation costs from the project. In instances of port deepening, some categories of vessels and commodities may not be affected, for example relatively shallow draft pure auto carrier vessels. A forecast of local and non-benefited cargo is not needed unless port capacity constraints exist.

BENEFITED TRAFFIC

Projections of benefited traffic volumes comprise one-half of the basis of benefit estimation. The other element of benefit estimation is cost reduction. Benefits from with-project conditions can be attributed to any change that reduces cargo costs. Traffic projection benefits should be specific to project impacts such as delay reduction, larger vessels, risk reduction, different vessel itineraries resulting in shorter voyages, and reduced inventory. The type of benefits that exist for the with-project condition should determine the structure of the commodity flow forecast. Base year commodity flows affected by the project should be forecast by type of benefit category. Failure to assign base year commodity flows to different project impacts relegates benefits analysis to obscurity. Unless the analyst identifies specific commodity flow benefits for base year traffic, no objective basis for computation of benefits over the life of the project will exist. Failure to specifically disaggregate commodity flows with respect to project benefit categories usually characterizes improper conceptual project planning and results in benefit estimates with the analyst quantifying benefited cargo based on subjective assessment of the merit of the project.

Improper planning for commodity projection relative to benefit impacts ultimately results in planners' perceptions that not all benefits have been delineated. With improper traffic projections, benefit analysis is characterized by a trial and error analysis to find and quantify elusive benefits that the planner intuitively believes remain undiscovered; however, no framework exists to objectively link benefits with commodity projections. In projects of this type, planners spend most of their time seeking to discover benefits rather than analyzing the interface of benefit estimation consisting of traffic projections by benefit category.

Analysts who intuitively know that there are additional benefits have not linked commodity flow characteristics and projections with benefit estimation (Chapter VIII). The purpose of NED analysis is to identify commodity flow impacts of the project. NED benefit analysis explicitly focuses on commodity impacts consisting of existing, diverted and induced traffic. Assuming base-year commodity flow projections and benefit categories are explicitly connected in an analytical framework, the next step in traffic projections is to repeat the linkage of commodity flows and benefit categories for adjustments to the base year forecast. Diverted and induced movements constitute adjustments to the base year benefit projection.

ADJUSTMENTS

Commodity projection adjustments to future base traffic result from the with-project condition, including interaction with fleet changes (Chapter V), capacity changes, and other projects (multi-port analysis). At this stage in the analysis, the planner will include any projected commodity flows associated with the project as a result of diversions or induced traffic. The timing of the adjustments of base traffic to incorporate future benefited traffic will be a function of the staging of the project with respect to realization of different benefits necessary to divert or induce traffic. Timing for incorporation of existing, diverted and induced traffic projections should include all user related investments or non-structural institutional changes necessary to divert or stimulate the traffic. If uncertainty of the timing exists, adjustments to future base traffic should be subjected to sensitivity analysis (Chapter X).

INDUCED TRAFFIC

Induced traffic is an increase in production or consumption because of lower transportation costs from port investments. Induced traffic can be inferred by interviews and statistical analysis. If price elasticities of demand or supply exist, it is possible to infer the effect of cost reduction on increased consumption or production. Price elasticities for some commodities, such as export grain, are available from USDA Extension Service, Purdue University, Lafayette, Indiana.

Price elasticities for commodities where the U.S. is a high cost producer, or not price-competitive (such as steam coal), may not exist. Induced traffic in the absence of elasticities could be estimated by inferring changes in market share based on changes in price from production and market data. For example, changes in U. S. export coal could be inferred from a market share analysis of U. S. steam coal consumption in response to relative differences in world coal prices (delivered), other things being equal.

FORECAST INTERVAL

There is no specific forecast time period for traffic projections over the project life. A 50-year period is legislated for benefit cost analysis; however, for purposes of commodity projection a shorter period of time may be used. For example, traffic may be projected over a 20-year period if no growth is envisioned beyond that period because of capacity constraints. The length of the forecast period is determined by the composition and character of the commodity flows and capacity. Fifty year projections would not be needed if the project life or commodity flow was less than this period. Fifty year projections would be desirable if the commodity projections indicated an unstable or declining trend; for example, resource depletion or alternative sources of supply.

In some instances, commodity projections may be so uncertain or modest beyond the initial adjustments to the base year traffic (diverted and induced traffic) that further projections are not necessary or feasible. Although benefits and costs are discounted over a 50-year project life, there is no mandate for detailed commodity projections over the entire period. The effect of discounting on future benefits makes modest commodity projections beyond adjustments to the base traffic forecast relatively insignificant after 20 years at current discount rates exceeding eight percent.

The diminishing returns of long-range growth projections should be regarded as a signal that the analyst should focus on accurately quantifying benefited cargo and projected adjustments to the base traffic early in the life of the project, particularly diverted and induced traffic and multiport analysis. Instead of being preoccupied with a 50-year forecast, the analyst should focus on the short-run realities of the commodity flows immediately affected by the project or shortly after the project is completed. If these realities can only be projected for 25 years, with no growth foreseen beyond, the analyst then will have captured over one-half of the net discounted benefits in the first ten years (present value of one dollar received in year ten at eight percent compounded interest is $0.46319 compared to the present value of one dollar received 25 years later which is $0.14602).

The forecast intervals will be determined by the character of the projection and the effect of diminishing returns from discounting benefits over time. There is no desirable forecast interval or frequency of time periods at which traffic is projected and benefits estimated. The interval between forecasts will be determined by the character of traffic projections. If traffic is relatively constant, the forecast interval will span the entire 50 years; however, for purposes of benefit estimation, the last 30 years have relatively little contribution to net benefits. If traffic is projected to increase at a steady rate, the frequency of projection should be sufficiently adequate to delineate the constant trend, relative to diminishing returns from discounted benefits beyond 20 or 30 years. If traffic projections exhibit instability because of cyclical (short-run) trends, adjustments to base traffic by the timing of diverted or induced traffic, or other traffic shifts because of fleet changes, capacity constraints, and multiport analysis, then the forecast interval should be shorter to clearly reflect shifts in the trend and resulting impacts on net benefits.

The selected forecast interval will be a product of integrating vessel fleet forecasts and commodity projections. The dynamics of both forecasts, together with multiport analysis, will indicate changes in the overall trends for base year traffic adjusted by diverted and induced traffic. It is important that the forecast intervals and other projections such as fleet changes, capacity, commodity base year benefited traffic flows and adjustments, be congruent in two respects: forecast timing and forecast integration. Timing of the forecasts is important if commodity flows are significantly impacted by fleet changes, capacity changes and adjustments for diverted and induced traffic. A planner with a commodity flow forecast based on five year intervals and a vessel fleet forecast based on ten year intervals that projects major fleet changes will have difficulty integrating the two projections and incorporating adjustments (diverted and induced traffic).

FORECAST INTEGRATION

The technical forecasts of commodity flow, vessel fleet and adjustments for diverted and induced traffic are usually done independently of each other.

The role of the planner is to integrate the separate elements, which should be compatible, based on similar time frames and forecast intervals. Integrating different forecasts can be especially subjective where the commodity projections are not linked to benefit categories affected by fleet forecasts. Benefit estimation under these circumstances becomes a subjective exercise that can tax the imagination of project planners and subsequent reviewers.

Benefit estimation (Chapter IX) assumes that the planner has explicitly linked the commodity projections to forecasts of benefit categories resulting from fleet projections, capacity projections and multiport analyses. Without the integration of the different forecast elements, the analyst has a futile task of assessing project benefits unless obvious benefits can be inferred to specific cargoes, trade routes and vessels. Where multiple categories of benefits apply to broad groups of commodities, trade routes and vessels, the integration of the different forecasts will determine the relative feasibility of different project alternatives (Chapter VIII).

CHAPTER VII

MULTIPORT ANALYSIS

The purpose of this chapter is to outline the major study steps in a multiport analysis. Many of the study steps are redundant if the analyst has closely followed the P&G for other parts of the study. Readers familiar with the application of the P&G outlined in other chapters of this Manual should be able to skip some portions of this chapter. The chapter is written to present a conceptual and practical view of an entire multiport analysis from the perspective of a planner who is not familiar with the topic and has not prepared previous study steps in conformity to the P&G.

Multiport analysis is a systematic assessment of the effects of the with-project condition on other ports. It includes the effects of authorized projects at other ports on the with- and without-project conditions. Conceptually, multiport port analysis is an adjustment to NED benefits that includes systems analysis of port competition. In actual practice, multiport analysis is a systematic comparison of alternative transportation costs for cargoes that could use the project port or be handled through alternative ports.

The objective of multiport analysis is to allow the planner to adjust the traffic forecast for shifts of cargoes among alternative ports in response to the with-project condition at the port of study as well as other authorized projects with local cooperation agreements at alternative ports. Since the purpose of multiport analysis is to account for changes in the with-project condition traffic forecast, only commodities affecting NED benefits and handled by alternative ports for competitive hinterlands must be analyzed. The entire universe of cargoes handled by the project port is seldom subject to a multiport analysis. Only those commodities that could be affected by projects at the port, or at alternative ports which would affect the traffic forecast and benefits, should be considered. Therefore, the purpose and scope of multiport analysis is usually much more limited and well defined than what the topic "multiport analysis" suggests.

Unless all benefited cargo is completely captive to the project port, a systems analysis of competitive ports and hinterlands should be conducted to be in conformity with the P&G. Multiport analysis is essential whenever projects could divert traffic from other ports, which effectively results in a change in hinterlands.

The necessity for a systems analysis of multiproject impacts on competing ports is specifically recognized in the P&G. The P&G indicates that this procedure calls for a systematic determination of alternative routing possibilities, regional port analyses, and intermodal networks that may require the use of computer modeling techniques. The data needed for such a determination are often difficult to obtain; therefore, interviews with knowledgeable experts will often be needed.

Multiport analysis is based on diversion of traffic from competing ports and the impacts of authorized projects with local cooperation assistance (LCA) at competing ports on the project port. Unless the analyst can demonstrate that no port competition exists in the with- and without-project conditions, multiport analysis is mandatory.

CONCEPTUAL PROCEDURES IN MULTIPORT ANALYSIS

Multiport analysis consists of a series of sequential steps. Figure VII-1, Flowchart of Deep-Draft Navigation Benefit Evaluation Procedure (Multiport Analysis), is an application of the P&G's nine-steps to multiport analysis. Conceptually, multiport analysis entails an extension of the study scope to include other ports. Multiport analysis consists of analysis of commodity flows in competitive (overlapping) port hinterlands.

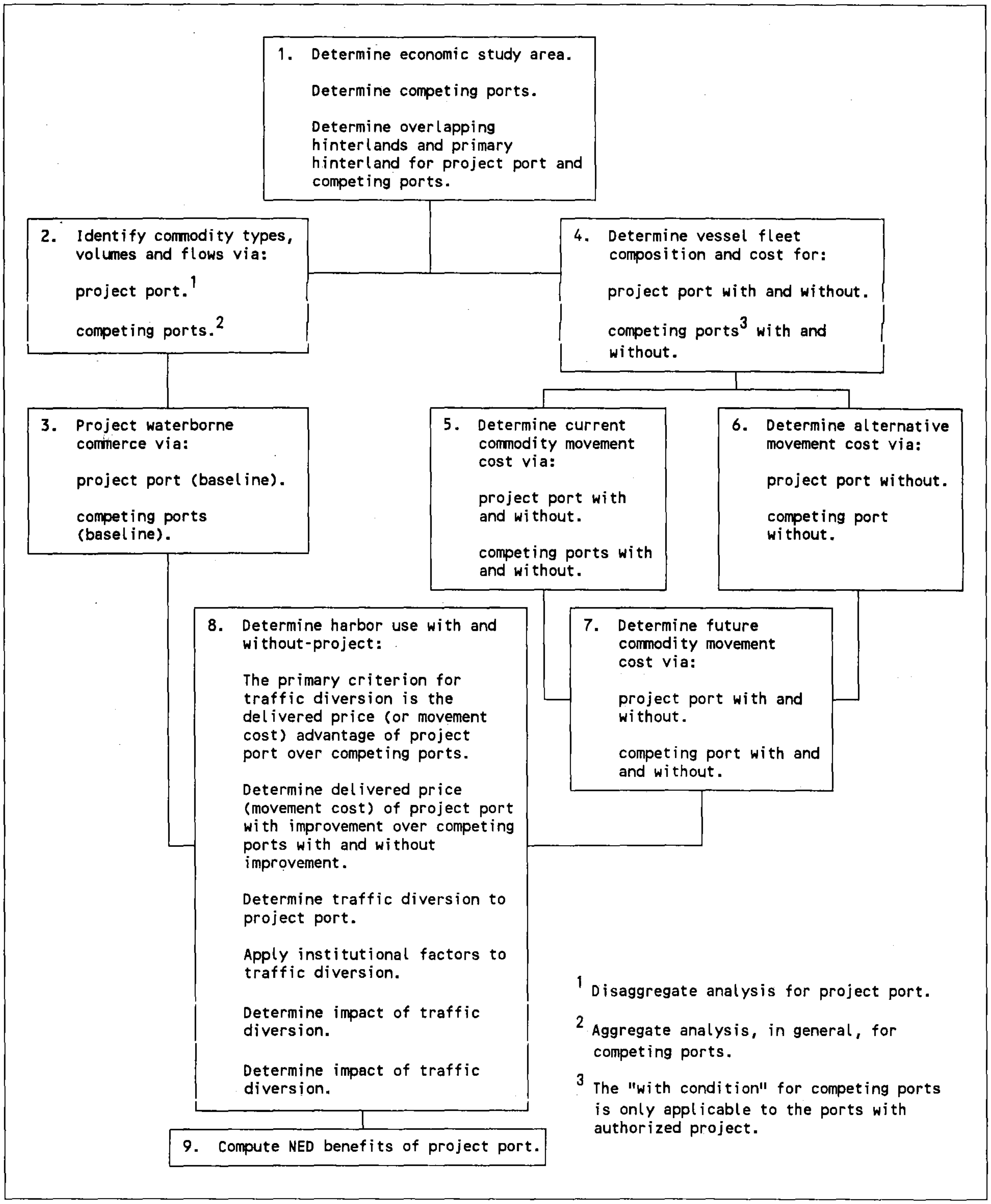


FIGURE VII-1. FLOWCHART OF DEEP-DRAFT NAVIGATION BENEFIT EVALUATION PROCEDURES (Multiport Analysis)

The concept of multiport analysis is identification of traffic diversions in response to harbor improvements. Figure VII-2, Conceptual Framework of Traffic Diversion in Multiport Analysis, indicates two levels of analysis that are needed: (1) project port; and, (2) competing ports. Figure VII-2 is conceptually similar to Figure VII-1. The P&G study steps in Figure VII-2 are applied in a disaggregated level of analysis to the project port and an aggregated level of analysis to competing ports.

LEVEL OF EFFORT

The level of effort to be devoted to a multiport analysis will vary by: (1) type of study; (2) level of disaggregation of commodity flow data required; and, (3) characteristics of competitive hinterlands.

TYPE OF STUDY

Multiport analysis is conducted on a more aggregated level of analysis for a reconnaissance study than for a feasibility study. Table VII-1 summarizes the implementation of the P&G study steps for multiport analysis in reconnaissance and feasibility studies. The steps of execution are the same; however, the level of detail and analysis is greater for a feasibility study. The difference between the two types of studies is the disaggregated level of application of the P&G to multiport analysis.

LEVEL OF ANALYSIS

Multiport analysis does not require analysis of all commodity flows through all competing ports. Multiport analysis is only concerned with competitive commodity flows which are affected by projects at the local port and other ports. The analyst should begin with commodity flows for which benefits exist at the project port and geographically extend the scope of the study to encompass similar flows through competing ports. Competing ports will be identified on the basis of similar commodity flows and hinterlands that overlap the project port. For example, if the project port has commodity flow type A in hinterland location B, the analyst would search for other ports with commodity flow type A that could be associated with hinterland location B.

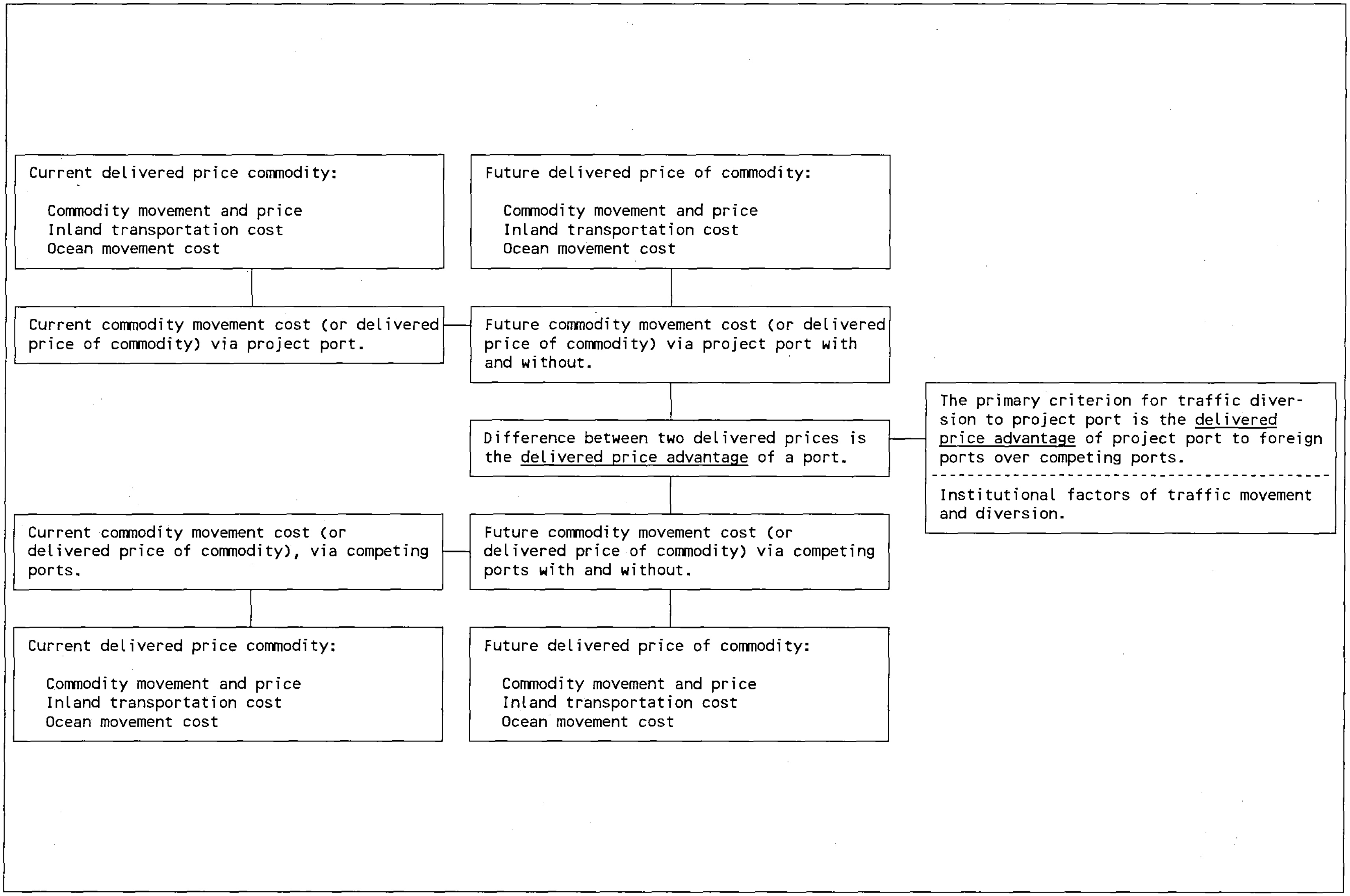


FIGURE VII-2. CONCEPTUAL FRAMEWORK OF TRAFFIC DIVERSION IN MULTIPORT ANALYSIS

TABLE VII-1
MULTIPORT ANALYSIS - SUMMARY OF P&G APPLICATION

STEP	RECONNAISSANCE	FEASIBILITY
1. Determine economic study area.	1. Determine project port and hinterland based on historic and current traffic data. 2. Determine primary competitive ports and their hinterlands. 3. This step may be conducted simultaneously with Step 2 below.	1. Determine overlapping commodity hinterlands serving competing ports, as well as primary hinterland serving only the project port. 2. Locate production/consumption sources by commodity in the hinterlands. 3. This step may be conducted simultaneously with Step 2 below.
2. Identify types and volume of commodity flow.	1. Determine aggregate flows by full O-D (to the extent possible), modes and commodity for project port and competitive ports or coasts. 2. Use existing data on inland water, rail, truck and ocean movements	1. Determine the production/consumption and demand/supply characteristics by key commodities in the hinterlands serving the project port and competitive ports. 2. Use disaggregate flows for project port. 3. Determine aggregate flows for competing ports. 4. Detailed origin-destination studies for project port. 5. Extensive interviews of shippers/receivers/carriers.
3. Project waterborne commerce.	Use aggregate projections by key commodity for project port and potential competitive ports.	1. Determine projected market share of project port and competing ports (or coasts) by key commodities. 2. Determine projected trade route share by commodities. 3. Conduct sensitivity analysis of key variables. 4. Provide high, medium and low projections. 5. Determine disaggregate flows for project port and aggregate flows for competitive ports or coasts.

STEP	RECONNAISSANCE	FEASIBILITY
4. Determine vessel fleet composition and cost.	Use aggregate fleet characteristics for project-port and competitive ports with and without improvement.	1. Use disaggregate fleet characteristics for project port with- and without-project. 2. Determine aggregate fleet characteristics for competitive ports or coasts with- and without-project.
5. Determine current cost of commodity movements.	1. Determine aggregate cost of origin-destination movement by modes for project-port with- and without-project and competitive ports without-project. 2. Use published rates and costs.	1. Determine the current delivered price to foreign ports by key commodities through project port and competitive ports with- and without-projects. 2. Disaggregate cost or price for project-port and aggregate cost or price for competitive ports or coasts.
6. Determine current cost of alternative movement.	Determine aggregate cost of alternative movement for project port and competitive ports by key commodity and full O-D.	1. Determine current delivered price to foreign ports by alternative movements via project-port and competitive ports. 2. Determine disaggregate delivered prices (or costs) for project-port and aggregate delivered prices (or costs) for competitive ports.
7. Determine future cost of commodity movements.	Determine aggregate shipping costs for project port with-project and competitive ports without-project by key commodities.	1. Determine the projected delivered price of commodity for (a) with- and without-project conditions for the project-port and (b) with and without conditions for potential competitive ports. 2. Disaggregate delivered price or cost for project-port and aggregate delivered price or cost for competitive ports or coasts.

STEP	RECONNAISSANCE	FEASIBILITY
8. Determine use of harbor and channel with and without-project.	1. Determine delivered price advantage of project port with improvement over competitive ports without improvement. 2. Determine potential diversion by key commodities based on delivered price advantage.	1. Determine the delivered price advantage of project-port with improvement over competitive ports with and without improvement. 2. Determine potential diversion by key commodities to project-port based on the delivered price advantage of project-port over potential competing ports enumerated in Item 1 above. Correlation between reduced delivered price and potential traffic diversion for project-port should be established. 3. Determine any institutional/service/non-cost related factors that may influence the traffic diversion and incorporate them into traffic diversion analysis. 4. Conduct sensitivity analysis of key variables. 5. Determine potential impacts of traffic diversion on ports involved.
9. Compute NED benefits.	Benefits based on: 1. Transportation cost reduction. 2. Shift of origin. 3. Shift of destination.	Benefits based on: 1. Transportation cost reduction. 2. Shift of origin. 3. Shift of destination.

Multiport analysis begins with the planner identifying competing port hinterlands from interviews, commodity production and consumption data, and traffic statistics. When port competition exists, the planner should only analyze commodities which are subject to diversion through different ports. The level of analysis will be a function of the character of the hinterland.

HINTERLAND ANALYSIS

The geographic scope of multiport analysis will be determined by the size of port hinterlands for different commodities. Port hinterlands can be broadly classified as captive or competitive. Captive hinterlands may exist in the case of bulk commodities which originate from an exclusively localized source, such as phosphate in south Florida shipped in bulk through Tampa. Captive hinterlands also reflect commodities that are terminated in the local hinterland, such as imported cement for local construction or petroleum refined into asphalt for local consumption.

Port hinterlands may be regional or national in scope, thereby overlapping with other ports. For example, most large container ports have handled at least one container originating or terminating in almost every state in the nation. Representatives of these ports frequently describe the port hinterland as "national" or encompassing substantial portions of the nation. Effectively, however, a majority of most ports' containerized commerce is associated with a relatively well defined hinterland.

Hinterlands can be determined by production and distribution costs in the absence of institutional constraints. Multiport studies have used different criteria to stratify competitive hinterlands to avoid incorporating unique isolated movements that are not representative of the relevant economic area of the ports. Hinterland strata range from captive to competitive to marginal. Multiport analysis is not needed for captive hinterlands and is relatively unimportant for marginal hinterlands, unless the nature of the project significantly alters the scope of traditional captive or marginal hinterlands. Multiport analysis should only focus on competitive hinterlands, where traffic can be diverted to or from ports.

Competitive hinterlands, trade routes and ports usually are determined on the basis of delivered cost unless important institutional factors exist, such as inventory in transit, or domestic transportation routes. Shipper interviews and market analysis can provide the planner with appropriate criteria, including institutional factors, to delineate competitive hinterlands and trade routes as part of a least total cost framework.

The planner must decide the appropriate level of effort to expend compiling all relevant origin-to-destination costs. Planners should allocate their time to the most important cost components and variables affecting differences in origin-to-destination costs. The primary determinant of port competition is differences in delivered transportation costs for many commodities with similar production and consumption characteristics. Port handling and miscellaneous costs are usually, but not always, of lesser importance both as a percent of total cost and in level of variability among ports.

The objective of multiport cost analysis is to develop production and distribution cost differentials between competing hinterland flows and ports. Planners should seek to identify those transportation cost components where the greatest differentials exist. Tradeoffs may exist in hinterland trade route flows between economies of scale of larger vessels and increased distances between the origin/destination and port. Shifts in container flows between ports have been analyzed based on delivered cost differences per container as a function of different networks of vessel routings, ports and hinterland flows.

Least total cost analysis enables the planner to classify commodity flows as "captive" or "diverted". If non-price aspects of port competition exist, traffic may not be classified into mutually exclusive categories of captive or diverted. Usually non-price competition results in sharing traffic within a range of cost differences between competing ports. Container traffic, for example, is normally handled by ports other than the least total cost port within a range of transportation cost differentials per ton or TEU/FEU. Competitive cost differentials represent a zone of indifference between exclusively "captive" and exclusively "diverted" traffic classifications in circumstances of non-price competition. When traffic is shared because of non-price competition, the planner has to allocate the flows among competing ports on a historical market share basis or on non-price service characteristics such as frequency, and reliability.

Multiport studies typically use the lowest least cost criterion as the basis for diversion. The lowest least cost basis for diversion is most applicable for bulk commodities. Least total cost has the advantage of objectivity if all relevant costs are properly defined and measured. For bulk commodities, the zone of indifference between captive and diverted traffic is usually zero. Least total cost analysis may not completely explain container movements when cost differentials between alternative ports are small. Differences in service, such as first port of call for imports and last port of call for exports, interact with varieties of vessel deployments and load center locations, including mini, micro and macro-bridge rail/water substitution possibilities for container movements, to create large overlapping hinterlands. Container hinterlands have to be broadly defined both in geographic scope and in terms of port substitution possibilities to accommodate different patterns of vessel deployments, load centering and rail/water alternatives.

Least total cost criteria to define port competition will result in changing hinterlands in response to cost changes. Typically, the with-project condition at the port or authorized improvements at other ports will affect cost and hinterland boundaries. Analytical procedures to define hinterlands should be sufficiently flexible to accommodate changes in the costs of production and distribution in response to with-project conditions at competing ports.

ANALYTICAL PROCEDURES IN MULTIPORT ANALYSIS

Table VII-2 compares the application of the nine P&G study steps to multiport analysis at the reconnaissance and feasibility levels of study. This assumes that the planner is conducting only a multiport analysis. Consequently, the approach to multiport analysis illustrated in Table VII-2 is much more comprehensive than when multiport analysis is performed as part of an existing study.

The following discussion of Table VII-2 assumes that the each P&G step has been followed for the project port. The only new work for the planner performing multiport analysis is to extend existing study steps to analyze the impact of the project on other ports as well as the impact of authorized projects at other ports on the project port. For example, the discussion assumes that commodity and vessel fleet characteristics, costs and forecasts have been developed for the project port. These basic inputs will normally be sufficient to analyze competing hinterlands. Each study step is reviewed in the following sections to focus on incorporating multiport analysis into an existing feasibility study framework. The emphasis is on the use of existing data already available to the planner from the with- and without-project analysis.

DETERMINE ECONOMIC STUDY AREA

Conceptually, the planner has already done this step for the project-port. What remains to be done is to extend the analysis of port commodity flows to an analysis of similar flows at other ports to identify overlapping commodity hinterlands. The interrelationships between assessment of the economic study area and commodity flows usually results in a combination of P&G study steps one and two.

If the planner has followed the P&G for the project port, the available data base should include the production, consumption and distribution characteristics of benefited commodities. The planner should use representative origin/destination nodes to map the commodity hinterlands of the principal benefited commodities which are not captive to the project-port. Commodity flow characteristics will ultimately determine overlapping hinterlands of competitive ports. Competitive ports can be conceptually determined based on interviews with port officials, shippers and carriers. The planner's objective is to develop a conceptual map of competing port

TABLE VII-2
MULTIPORT ANALYSIS - ANALYTICAL PROCEDURES

P&G STEPS	RECONNAISSANCE	FEASIBILITY
1. Determine economic study area.	Determine project-port hinterland based on historical and current traffic data.	A. <u>Determine the competing ports and hinterland</u>. 1. Two characteristics determine the competing ports and hinterlands: a. Full O-D characteristics for a given commodity. (Conduct this analysis in Step 2 below.) b. Production/consumption and demand/supply characteristics of a given commodity. (Conduct this analysis in Step 2 below.) 2. The hinterland of a given port is not fixed. It contracts and expands depending on changes in several factors. Therefore, it may be necessary to redefine the hinterland when some of the factors change; a reiteration would be needed. 3. The fluid nature of hinterland boundaries influence the competitive posture of ports. 4. Determination of competing ports and hinterlands can best be conducted simultaneously with Step 2 below. B. <u>The results of analysis in Step 2 should present the following for Step 1:</u> 1. For a set of given commodities, the full O-D characteristics determine the competing ports through which the commodities move and the shares thereof, as well as the hinterland which the ports serve. 2. For a set of given commodities, demand/supply and production/consumption characteristics determine the volumes and competing ports which feed the demand/supply characteristics and also the hinterland where the production/consumption take place. 3. Hinterland may be defined and classified in two categories or more, if desired. Boundaries of hinterlands are not always fixed and can be fluid depending on changing conditions. a. Primary hinterland: The area which primarily feeds a given port. b. Overlapping (or competitive) hinterland: The area from where two or more ports derive their cargoes and a given commodity could flow to any port depending on rate, service and other characteristics.

P&G STEPS	RECONNAISSANCE	FEASIBILITY
2. Identify types and volumes of commodity flow.	A. Determine aggregate flows by full O-D (to extent feasible), modes and key commodities for project port and competitive ports or coasts. B. Use existing data on inland water, rail, truck and ocean movements.	A. <u>Analyze the historical and baseline commodity movement characteristics of key or major commodities (export and import) through the project-port and competing ports.</u> 1. Two major characteristics are to be highlighted. a. Traffic (or tonnage) through the project-port and competing ports. b. Foreign trade patterns of the project-port and competing ports. 2. Disaggregate analysis on project-port and an aggregate level of data and analysis on competing ports. B. <u>Determine production/consumption and demand/supply characteristics of key or major commodities for the project-port and competing port.</u> 1. Determine production and supply characteristics of key commodities for export in the hinterland of the project port and competing ports. 2. Determine demand and consumption characteristics of key commodities for import in the hinterland of the project port and competing ports. C. <u>The results of analysis:</u> 1. Foreign trade patterns by key commodities of project-port and competing ports, especially the competitive aspects between the ports or coasts for a given commodity. 2. Relationship of trade patterns and commodity flows of project-port and competing ports with production/consumption and demand/supply characteristics by key commodities of hinterlands.
3. Project waterborne commerce.	A. Determine aggregate projections by key commodities for project port and potential competing ports. (No improvement of project-port or competing ports.) B. Determine high, medium and low forecasts for the Item 1 above.	A. <u>Apply baseline forecasts of export/import by key or major commodities for the project-port and potential competitive ports.</u> (No improvement of project-port or competing ports is assumed.) 1. Baseline trade forecasts are based on existing channel depth. These forecasts are needed so that any other forecasts based on improved channel conditions can be compared with, and the effects of, improvement assessed. 2. Conduct disaggregate analysis for project-port and aggregate analysis for competitive ports. B. <u>Determine projected market share of the project-port (and major competing ports) by key commodities.</u>

P&G STEPS	RECONNAISSANCE	FEASIBILITY
		1. Project the port share, based on port trade by commodity, for selected years using any of several projection methods. 2. Port authorities have short-term projections. 3. Coastal shares are desirable before determining the competing ports' shares. A common assumption used is the same coastal shares in the future as the baseline share. 4. Assume the competing ports' shares based on a set of assumptions and an aggregate analysis, such as same share as the baseline share. C. Conduct the sensitivity analysis of the key variables of baseline forecasts. D. Determine any institutional/non-rate related factors. 1. Modify the baseline forecasts with institutional/service/non-rate related factors, if any. E. The results of analysis: 1. Projected high, medium and low foreign trade patterns by key commodities of project-port on disaggregate level and of potential competitive ports on aggregate level. 2. Potential shares by project-port and competitive ports. 3. Relationship of commodity flows and foreign trade patterns of the ports involved with potential production/consumption and demand/supply characteristics by key commodity of hinterland and world.
4. Determine vessel fleet composition and cost.	Use aggregate fleet characteristics for project-port and competitive ports, both with and without improvements.	A. Use disaggregate vessel fleet characteristics, current and projected, of the project-port with- and without-project. B. Determine aggregate vessel fleet characteristics, current and projected if authorized, of competitive ports with- and without-project. C. The results of analysis: 1. Vessel fleet characteristics, current and projected, of project port and competitive ports, both with and without improvement. 2. Comparative ocean shipping costs, current and projected, of project port and competitive ports.

P&G STEPS	RECONNAISSANCE	FEASIBILITY
5. Determine current cost of commodity movements.	A. Determine aggregate cost of movement by key commodity for full O-D and modes for project-port with- and without-project. B. Determine aggregate cost of movement by key commodity for full O-D and all modes for competitive ports without-project. C. Use published rates and costs.	A. <u>Determine delivered price (or cost) of commodity</u> with and without improvement and competing ports without improvement disaggregated by the segments of inland, terminal, port and ocean to foreign ports or delivered price to U.S. inland destination for import. 1. Delivered price is the sum of commodity price at the production source and transportation cost to foreign ports. Use the weighted average delivered price for a commodity. 2. Inland transportation costs or rates. 3. Terminal charges and other charges. 4. Port charges. 5. Ocean movement costs. 6. Prices of commodities are readily available from many sources. B. <u>Results of Analysis</u>: 1. Comparative current costs of commodity movement via project-port and competitive ports, both with or without conditions. 2. Lower cost of commodity movement via project-port with improvement over other ports serves as the criterion for potential traffic diversion.
6. Determine current cost of alternative movements.	Determine current aggregate cost of alternative movement by commodity and full O-D for project-port and competitive ports, both without improvements.	<u>Determine current alternative movement of commodity</u> to foreign port destinations via project-port and competitive ports, both without improvement for commodity determined in Step 2. Describe the alternatives assumed.
7. Determine future cost of commodity movements.	A. Determine aggregate shipping costs by key commodities for project-port with- and without-project and competitive ports without-project. B. Use published rates or costs.	A. <u>Determine projected delivered price (or cost)</u> to Europe and Pacific Rim through project-port and competitive ports both with- and without-project. 1. Disaggregate delivered price is composed of commodity price, inland transport cost, terminal costs, port loading/unloading costs, ocean freight cost any other accessory or service charges. 2. Base future commodity price and transportation costs on the price and operating costs prevailing at the time of study. 3. Comparative future cost of commodity movement through project-port and competitive ports is the criterion of traffic diversion.

P&G STEPS

8. Determine use of channel with- and without-project.

RECONNAISSANCE

A. Determine traffic diversion. The criterion of traffic diversion is delivered price (or cost) of a commodity via project-port with improvement. Another factor to be considered is institutional/non-rate related factors in traffic diversion.

B. Determine delivered price (or cost) advantage of project-port with improvement over competitive ports with and without improvement.

1. Aggregate delivered prices via project-port and competitive ports, both with- and without-project, are determined in Steps 5, 6 & 7 above.

2. Take the difference of delivered prices via competitive ports and that via project-port; the difference is the delivered price advantage of project-port, which is the criterion of traffic diversion.

C. Determine potential traffic diversion by key commodities to project-port based on delivered price advantage.

1. The method for traffic diversion is not well established except for cost-based determination.

FEASIBILITY

A. Forecast the potential diversion by key or major commodities to the project-port with its improvement, assuming (a) no improvement of competing ports and (b) improvement of competing ports.

1. Two types of information are needed to estimate potential traffic diversion:

a. Delivered price advantage of the project-port by commodity over competitive ports.

b. Traffic diversion model or method (based on delivered price advantage and/or institutional/service factors).

2. Sensitivity analysis of key variables is required.

3. High, medium and low forecasts are required.

B. Calculate the delivered price advantage of the project-port by key or major commodities with improvement over the competing ports (with and without improvements). Describe assumed vessel characteristics and alternative improvements.

1. Delivered price advantage of project-port is the difference between the delivered price via the competing port and the delivered price via project-port for a given commodity at various channel depth improvement. Delivered price via the project-port and competing ports both with and without improvement were analyzed in Steps 5, 6 & 7 above.

2. A sample table is given below:

Average Transportation Cost ($/ton)

Production Source Region	Via Project-Port	Via Competitive Ports	Delivered Price Advantage
-	-	-	-
-	-	-	-
-	-	-	-

C. Establish correlation between the decrease in delivered price due to the use of deeper draft vessels at the project-port (and competitive ports) and the potential change in the market share of the project-port (or traffic diversion to the project).

P&G STEPS	RECONNAISSANCE	FEASIBILITY

2. For recon level analysis, simple delivered price advantage may be adequate to determine the volume of traffic subject to diversion rather than resorting to any correlation method.

1. The correlation may be established in the form of market share elasticity or in any other forms usable or available to the project-port (or District). It is noted, however, that the correlation methodologies are not well established.

2. Market share elasticity measures the percentage change in market share of the project-port due to percentage change in relative shipping costs for a given commodity vis-a-vis competing ports.

3. The concept of market share elasticity may apply to grains, coal and container cargoes, but not so much to crude petroleum.

4. For grains, separate diversion models are needed for corn, soybeans and wheat. For example, conduct a correlation analysis between monthly grain export loadings by coast and relative ocean transportation costs (reported charter fixtures) during the past few years. U.S. Department of Agriculture, Office of Transportation maintains the data.

5. For coal, as an example, a statistical correlation may be established between month-to-month delivered cost of coal via the competing ports and the project-port market share. Note this method is not well established.

6. The above relationship may be used to predict the potential traffic diversion as a function of reduced shipping cost (or delivered price) resulting from channel depth improvement.

   A sample table is shown below:

   Potential Diversion

Channel Depth	Average Transportation Cost Savings	Percent Increase In Tonnage
d_1	-	-
d_2	-	-
d_3	-	-

7. In case of any undue complexity of correlation establishment, use a simpler method if applicable.

D. Estimate the redistributed traffic pattern for the project-port and competing port by commodity as the result of the traffic diversion.

P&G STEPS	RECONNAISSANCE	FEASIBILITY
		1. After determining the potential traffic diversion to the project-port, estimate the shift in port or coastal shares for a commodity. 2. Describe inland traffic pattern changes in volume and costs due to traffic diversion. E. <u>Institutional/service factors, if any, should be incorporated in estimating the traffic diversions after technical factors have been analyzed.</u> Technical factor (i.e., delivered price advantage) for traffic diversion to the project-port is analyzed above. However, depending on the commodity and region, the institutional/service factors could influence the traffic pattern and diversion. Institutional and/or service factors, which may be incongruent with technical factors, should be introduced to modify traffic diversion derived from technical factors. F. <u>Determine the significance of traffic diversion</u> for the ports involved in terms of tonnage gained or lost, port market share change, impact on production/consumption sources in the hinterlands, potential impact on port area economy, etc. G. <u>Analyze selected variables rather than the whole set</u>. Some of the variables are world demand and consumption by commodity, U.S. market share, port market share, etc. H. <u>Organize and present the analysis of potential diversion by commodity to the project-port.</u> The results of analysis should present the following: 1. Potential diversion to the project-port with improvement from the competing ports with and without improvements in terms of tonnage and commodity. 2. Sensitivity analysis of key variables and their effects on traffic diversion. 3. Potential impact of the diversion on the ports involved.
9. Compute NED benefits.	Calculate benefits based on (same as specified in P&G): 1. Transportation cost reduction 2. Shift of Origin 3. Shift of Destination	Calculate benefits based on (same as specified in P&G): 1. Transportation cost reduction 2. Shift of Origin 3. Shift of Destination

hinterlands to define the ranges of port tributaries prior to more detailed assessment of commodity specific port substitution possibilities.

The planner should be careful to distinguish between different commodities in terms of production, consumption and distribution characteristics that affect port competition. For example, port substitution possibilities are generally abundant for corn compared to wheat. Both are grains, but each has distinct production, consumption and distribution characteristics. Steam coal has a lower heat content than metallurgical (met) coal. Met coal may be used in place of steam coal, but steam coal cannot normally be used to supplant met coal, unless it is blended with high grade met coal.

The hinterland map of representative origins/destinations prepared by the planner varies among commodities. Grains usually have a wider scope of origins and destinations than coal. Iron and alumina ore imports are for specific facilities generally contiguous to the local port. The planner should remember that there is no specific hinterland per se. Port hinterlands vary by commodity, trade route, and, in some circumstances, by seasonal commodity production or consumption and cyclical variations in world trade. The number of commodities to analyze in multiport studies are a function of port competition and commodity characteristics. The commodity should be well defined, for example, corn, rather than grains, and commodities analyzed should constitute a substantial portion of the NED benefits at the project-port. For most ports, a few well-defined commodities encompass the scope of multiport analysis, rather than an extensive list of commodities.

IDENTIFY TYPES AND VOLUMES OF COMMODITY FLOWS

The planner needs to identify relevant, competing port trade flows based on analysis of trade routes and domestic and foreign origins and destinations. Commodity movements to or from competitive hinterlands to or from the same world trade areas are candidates for detailed analysis. Where the commodities are not identical, such as wheat versus corn, or the trade routes are distinct, such as plywood exports to different world areas, the opportunities for diversion are low. The planner is looking to identify similar movements, characterized by close substitutes, such as corn from location A1 through port

X to world area B and corn from location A2 through port Y to world area B. Similar movements do not necessarily overlap at both origin and destination. Competitive movements include market or product competition such as steam coal from Alabama to Japan via Mobile and steam coal from West Virginia to Japan via Norfolk or Baltimore.

Once the planner has determined overlapping commodity flows that are structurally similar at origin and/or destination, specific analysis of these flows is required to identify volume and cost for each port of transshipment. The planner needs to know the complete origin to destination production and distribution costs for each port. Extending the analysis to competing ports should incorporate the same methodology and data sources described in detail in Chapter IV and reviewed in Table VII-2.

PROJECT WATERBORNE COMMERCE

The volume of competitive traffic is projected in the without-project condition for all competing ports to establish a baseline to determine diversions in the with-project condition (step 8). The planner should use the forecasts already developed for the port for the without-project conditions. In most instances, competitive traffic should have the same forecast level of growth for different ports, except where capacity constraints exist. New forecasts of competing port traffic are necessary only if diversion results in new markets to the project-port.

DETERMINE FLEET COMPOSITION AND COST

Fleet forecasts should be made for both the without- and with-project conditions at competing ports. Fleet composition and trends at competing ports can be identified from **Waterborne Commerce Statistics** and other sources identified in Chapter V. The existing fleet forecast trend analysis for the project-port can be applied to movements through competitive ports if the coastal or trade route fleets are similar. Multiport analyses have typically assumed a relevant world, coastal or trade route fleet for the without-project condition. The planner should prepare a separate fleet forecast for competing ports only if the fleets are structurally different and assignable causes can be attributed to the observed distinctions.

When differences in fleets exist among competing ports, the planner needs to convert vessel characteristics into costs for relevant commodity trade routes. If the differences between fleet characteristics are constant (port A movement uses ship size X and port B movement uses ship size Y: X<Y), fleet cost differences are obvious. When different distributions of fleet size characteristics or vessel utilization exist at competing ports, the planner has to calculate a weighted average fleet cost for each port commodity trade route to reflect the different composition of vessel characteristics.

DETERMINE CURRENT COST OF COMMODITY MOVEMENTS

Step 5 assumes that the planner has fleet and commodity flow characteristics, including production costs and all relevant origin to destination distribution costs for inland, port, and ocean segments for competitive hinterland movements. Step 5 integrates commodity and vessel cost characteristics identified from steps 2 and 4 for the without- and with-project conditions. The objective is to develop the total delivered costs of current commodity movements through different ports for competitive hinterlands. The planner's output is a vector of current costs for different port routing alternatives in the with- and without-project condition at the local port and without-project condition at competitive ports.

DETERMINE CURRENT COST OF ALTERNATIVE MOVEMENTS

Step 6 is an extension of step 5 that incorporates alternatives analysis into a multiport framework. In step 6, the planner determines the total origin to destination costs as in step 5 for alternative vessels, and other project alternatives, and for both relevant structural and non-structural alternatives.

DETERMINE FUTURE COST OF COMMODITY MOVEMENTS

Step 7 is the integration of forecast commodity flows and associated vessel fleet forecasts for the project-port and competing ports. This step should have already been performed for the project-port. The only additional work for the planner is to integrate commodity forecasts and fleet forecasts for competitive ports. Future costs include changes in fleet composition and other impacts of the project on production and distribution costs. Since port improvements primarily impact vessel costs, the with-project fleet costs are particularly important to hinterland impacts.

DETERMINE USE OF CHANNEL WITH- AND WITHOUT-PROJECT

In step 8, the planner uses diversion criteria, usually least total cost, to assess traffic shifts to and from the project-port in response to with- and without-project conditions at the port and at other ports. Diversion criteria which are not cost-based should be clearly identified, supported by interviews, literature or other empirical studies, and subjected to sensitivity analysis. Diversion criteria usually are based on delivered price advantages, other things being equal.

Diversion analysis based on least total cost is conceptually clear; however, the planner should investigate local production, consumption, or distribution characteristics that would mitigate diversion. For example, competitive hinterlands may be served by different railways which do not interchange traffic, except at prohibitive penalties, thereby negating port shifts. Some bulk commodities may not be divertible due to local consumption. For example, the Delaware River multiport study identified large volumes of crude oil that could be refined at New York or Philadelphia; however, much of the oil shipped to New York was determined to be captive since it was refined into asphalt for local consumption. The study determined that it would be cost prohibitive to divert oil to Philadelphia for conversion to asphalt which is then shipped to New York. These details of diversions analysis represent extensions of previous steps which, if not properly done, could result in unreasonable diversions of cargoes which are captive on a cost or institutional basis.

Multiport analysis does not tell the planner how to treat the effects of authorized projects at other ports which meet the local cooperation assistance (LCA) requirement. If the project-port is observed to divert cargo that would subsequently be diverted by another project, this traffic should be excluded from computation of NED benefits. The planner should assume that a long-run equilibrium exists with respect to multiple diversions of traffic among ports based on different project completion dates.

The results of step 8 should be a table of traffic diversions for the project port in the without- and with-condition as affected by with- and without-project conditions at competitive ports. The results should be presented in terms of volumes and savings for different channel depths. Where traffic diversions are substantial, the changes in port market share and percent of port tonnages affected by diversion should be indicated.

The results of step 8 are as follows: (1) potential diversion of traffic to or from the project-port with and without improvements at competing ports; (2) potential changes in trade routes; (3) potential changes in production/consumption sources; (4) sensitivity analysis of key variables and effects on traffic diversion; and, (5) potential impact of diversion on the ports involved.

Finally, in step 9, the planner calculates the NED benefits based on transportation cost reduction, shifts in origin and/or shifts in destination. These steps are specified in the P&G.

CHAPTER VIII

DEFINING THE WITH- AND WITHOUT-PROJECT CONDITIONS

At this stage of the evaluation a large data base of information has been generated describing possible future economic conditions within which the project could be implemented. The information has only limited reference to specific project alternatives, project implementation or economic evaluation. This chapter discusses how the technical (engineering) alternatives are transformed into economic alternatives providing a more complete description of the expected effects of each alternative.

ECONOMIC ALTERNATIVES

The purpose of explicitly structuring economic alternatives is to provide a basis for measuring incremental benefits and costs associated with each technical alternative. At a conceptual level, an economic alternative matches future states-of-the-world with possible project solutions. An economic alternative consists of three major components: (1) a description of project costs and implementation; (2) a description of future commodity flows; and, (3) a specification of relative transportation costs for each commodity flow based on project implementation. These major components are not determined in a vacuum. By implication, each economic alternative also includes the data, analysis and assumptions underlying each of these components as developed in Chapters IV through VII.

As a practical matter, there are usually several futures that might be associated with any project alternative due to uncertainties in the evaluation process. For example, actions by competing ports may be difficult to associate with specific project alternatives. Typically, these uncertainties can be addressed in one of two ways, either by structuring sub-alternatives or through the sensitivity analysis discussed in Chapter X. Because of these uncertainties, it is expected that much of the analysis discussed in this chapter will be undertaken interactively with previous analytical efforts. Of particular concern in this regard is the relationship between the multiport analysis and the alternatives analysis. It is imperative that the multiport and alternatives analyses provide sufficient information to explicitly set forth the level of commerce, the expected fleet composition and costs by transport alternative for each technical alternative that is under consideration.

EXISTING AND BASELINE CONDITIONS

The first step in structuring the economic alternatives is to clearly delineate between the existing and baseline conditions and their conceptual difference from the without-project and with-project conditions. The existing condition simply describes the project area based on the most currently available information. The baseline condition represents a scenario from which other impacts are to be measured. For example, the baseline condition might be a projected continuation of the existing condition, or it may incorporate known changes such as facility closures that would represent a sharp break with the past. Effectively, the baseline condition is simply a "point of reference" and what it should incorporate depends on the nature and expected magnitude of the impacts to be measured.

The with- and without-project conditions represent future states-of-the-world that can be directly associated with-project implementation. These two conditions specify the assumptions that are to be associated with the future in the case when a project is not implemented and in the case(s) when a project is implemented. For computational purposes it is frequently convenient to structure the baseline and without-project conditions to be identical. This is not required, and when conditions in the future are likely to reflect a broad mix of factors that are not easily associated with any particular alternative, it may be more reasonable to distinguish between the baseline and without-project conditions. For example, when certain private sector actions are expected only if the project is implemented, it may be computationally convenient to include these actions in the baseline condition, but not in the without-project condition.

There are no explicit rules on the factors that might lead to differences between the baseline and without-project conditions. Typically, factors which are expected to occur in most of the scenarios and alternatives considered in the economic analysis should be included in the baseline condition. To the extent these factors are expected to occur in the without-project condition, they should be included in describing the without-project condition. Again, it must be stressed that differences between these conditions are largely determined for computational and tractability purposes. It is not unreasonable to adjust both of these conditions as the analysis proceeds to reflect better information generated during the analysis.

INTEGRATION OF MULTIPORT AND ALTERNATIVES ANALYSES

The second step in structuring the economic alternatives is to assess the impacts of the multiport analysis on the commodity flows and relative transportation costs associated with each of the technical alternatives. The importance of the multiport analysis is its explicit consideration of substitution between ports. This concept is illustrated in Figure VIII-1. Typically, demand for a deep draft project is thought of as perfectly inelastic at Q_e, the level of traffic currently using the project. That is, changes in the quantity of traffic using the project are viewed as relatively insensitive to changes in the cost (price) of using the project. While this may be a reasonable assumption when analyzing traffic for all deep draft projects or when changes are quite small, it is unreasonable when examining most projects.

The reason for this difference is that when considering all projects, for example all ports, traffic has to move through one of the ports. In this sense, movements are completely price inelastic as shown in Figure VIII-1, i.e. demand curve D_{nmp}. For the individual project, there is the possibility of substituting between ports. As the cost of using a port increases, it is to be expected that some traffic will shift to another port. Similarly, as the cost of using a port declines, it is to expected that traffic currently routed through a competing port will shift to the port in question. This price effect is shown by the demand curve D_e. Given S_e, the supply curve for existing movements, a cost of P_e is obtained for using the project, the same price that is obtained if demand is assumed perfectly inelastic.

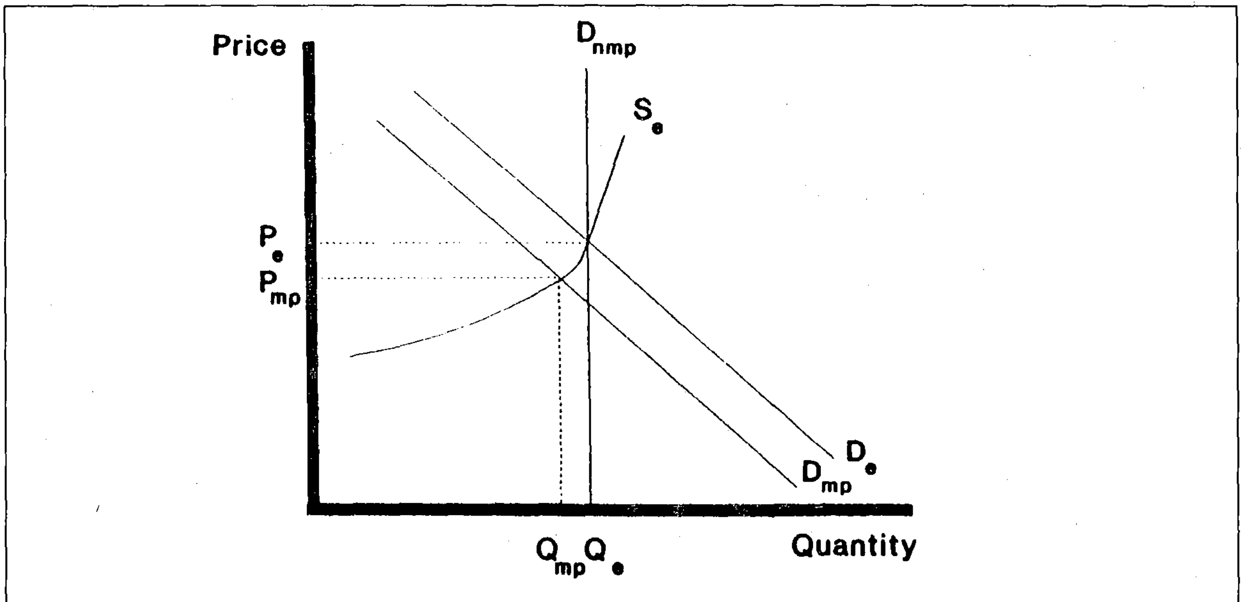


FIGURE VIII-1. DEMAND IMPACTS OF MULTIPORT ANALYSIS

The demand for the project is typically derived as the difference between the two least cost transportation routings. When port substitution possibilities are ignored, i.e. no multiport analysis is completed, the difference between the two demand curves shown in Figure VIII-1 is immaterial. This follows from the fact that in the absence of port substitution, all traffic routed through the existing project will also be routed through the proposed new project. The only transportation costs of any interest are the costs of using the existing project and the costs associated with using the proposed project. Effectively, demand would be inelastic, as ignoring port substitution possibilities assumes an infinitely high price for using competing ports.

The problem that arises is not simply that the two demand curves are different, but that their position is determined by different factors. For some projects or some types of commodity flows, an assumption of price insensitivity may be a reasonable approximation. For others, it can be conceptually demonstrated that the assumption is likely to be unreasonable.

While the position of D_e largely reflects transportation costs via different routings, these differences will reflect assumed conditions at competing ports. To the extent that future conditions at competing ports will differ from existing conditions, the effects on relative transportation costs and demand for the proposed project must be computed. As shown in Figure VIII-1 by demand D_{mp}, if the multiport analysis lowers transportation costs via competing routes, then demand for the proposed project shifts leftward. This results in a decline in traffic and in a decline in the relative price of using the project under consideration (Pmp).

For each technical alternative, the scenarios and results of the multiport analysis must be explicitly addressed and accepted or rejected as adjustments which should properly be reflected in the baseline condition, the without-project condition, or perhaps in the sensitivity analysis. There are few a priori rules for the treatment of specific components of the multiport analysis. Certainly a multiport scenario that includes authorized projects, and any facilities currently under construction at competing projects, should be included in both the baseline and without-project conditions. The manner in which other results of the multiport analysis are reflected in the analysis must be determined by examining the interdependency of projects between competing ports, the likelihood with which the multiport scenarios will occur, and quantitative measures of impacts such as changes in traffic levels and transportation costs.

TRAFFIC DIVERSION DUE TO PORT SHIFTS

Information generated in the multiport analysis should provide critical insights into the competitive position of the proposed project. The competitive position of the project, determined by characteristics of competing ports/traffic routings, will influence possible commodity flow routings, the least cost alternative transport routing, and transportation cost savings for some flows. As relative transportation costs change, it is possible that some commodity flows will shift between projects, altering both the level of commerce and possibly transport costs at which commerce moves on the proposed project.

The importance of integrating the multiport analysis into the economic alternatives can be illustrated with a simple example. Suppose there is an current movement from Point A to Point B that utilizes the existing project. It is reasonable to assume that the current routing represents the least cost total distribution costs, C^*, associated with this movement at the present time. The important analytical question is, however, what will be the least cost routing in the future? As conditions at competing projects change, will the existing routing maintain its current transport cost advantage? If not, which alternative routing becomes least cost and what are the new relative transportation costs of each routing?

As a general proposition, it should not be expected that developments at competing projects will result in large-scale traffic shifts between projects, unless projects are close substitutes such as the ports of Savannah and Charleston. There are, however, two other important exceptions to this generalization. First, some types of distribution systems facilitate rapid changes in traffic routing, for example, container load center ports, or containerizable cargo that is not currently containerized. Typically, these systems are relatively sensitive to variations in transport and physical distribution costs. Second, certain types of distribution systems are subject to heavy competitive pressures at the margin, for example grain shipments. In both instances, rather substantial levels of traffic may be involved, depending on the traffic characteristics of the project. Because of the importance of containers and/or bulk cargoes in the justification of most deep draft projects, the results of the multiport analysis may affect both project justification, scale and timing, even when only a limited number of commodity flows are involved.

Two important phenomena must be considered in the multiport analysis as it relates to the development of economic alternatives: (1) identification of the affected commodity flows and their implications with respect to traffic levels; and, (2) determination of how changes in commodity flows might affect the fleet composition associated with the project and any implications on transportation costs.

It should be stressed that the importance of both these factors is their ability to alter relative transportation costs. To the extent that transport (or physical distribution) costs of the least cost alternative are unaffected, the multiport analysis will not impact the economic evaluation.

DIVERSIONS FROM PROPOSED PROJECT

For each of the technical alternatives, the effects of each multiport analysis scenario are likely to be different. The first step is the determination of which commodity flows are affected in the absence of the proposed project. As appropriate, the commodity flow forecasts and associated transportation costs for the proposed project should be reduced for each combination of the baseline condition and multiport scenario. It should be stressed that, at this stage of the evaluation, no decision is being made as to the relevancy of adjusting the baseline condition of the without- or with-project conditions for a particular multiport scenario.

The adjustments to commodity flow levels and transportation costs described in the following paragraphs should be viewed as conditional rather than final adjustments to any of the data. For example, at this stage in the evaluation, the commodity flows and transportation costs of the baseline are conditional in the absence of any multiport scenarios. Now the analysis generates "modified" baselines which are conditional on specific multiport scenarios occurring. These "modified" baselines are neither accepted nor rejected initially, but simply form part of a broad database of information from which the without- and with-project conditions will be specified.

The logical flow of the determination of these impacts for a given commodity flow and year is shown in Figure VIII-2. From the analysis and forecast of commodity flows (Chapter VI), the analysis of the fleet composition (Chapter V) and the estimated transportation costs, each commodity movement in the baseline condition has an associated tonnage level, T_0, and an associated transportation cost, C_0.

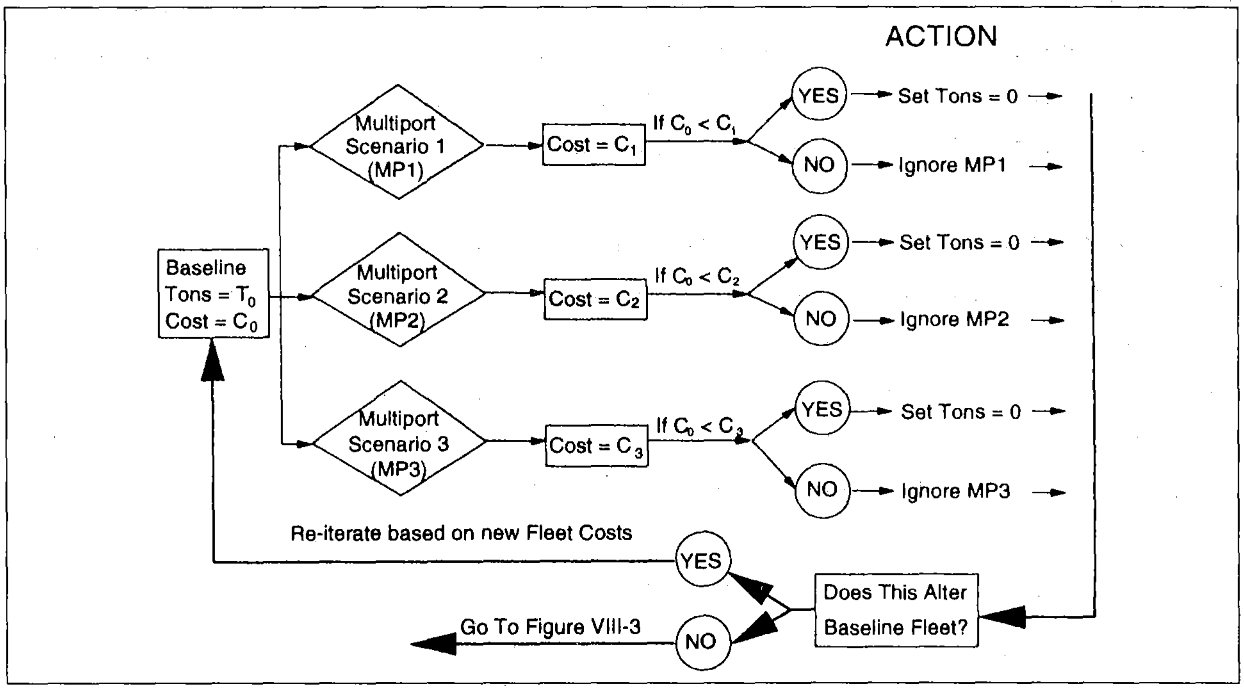


FIGURE VIII-2. ADJUSTING FOR MULTIPORT ANALYSIS

For each of the multiport scenarios in Figure VIII-2, every movement will have an associated least cost transportation routing C_i. The cost of moving via the existing project, C_0, is compared with the cost of moving via each of the multiport scenarios, C_i. If $C_0 < C_i$, then the commodity flow is not affected by multiport scenario i. If this is true for all of the multiport scenarios, then the specific commodity flow is not directly affected by the multiport analysis. That is, transportation costs via the existing project are less costly than via competing projects, irrespective of additional improvements that may be implemented at competing projects. If this is true for all movements using a given vessel type, for example all general cargo vessels, then the multiport port analysis would not influence the level of commodity flows or fleet composition for that portion of the project fleet. If this were true for all movements, that scenario i is irrelevant to the economic evaluation and need not be further considered.

If $C_0 > C_i$ for some multiport alternative i, then the specific commodity flow should be expected to divert to an alternative project for multiport scenario i. When this is the case, then the least costly routing in "modified" baseline i would reflect this routing, and tonnage via the existing project for this scenario would be set to zero. This process would be repeated for all commodity flows in the original baseline to determine their least cost routing in each of the multiport scenarios.

Once the change in traffic flows has been computed, it then is necessary to re-evaluate the project fleet to determine if traffic diversions are sufficiently large to alter project fleet composition and hence estimated transportation costs via the project. Following the process described above for each multiport scenario i effectively divides baseline traffic into two sets of traffic, conditional on a specific multiport scenario:

$T^{O} = \{T_{0j} | C_{0j} < C_{ij}\}$; the set of nondiverted commodities,

$T^{*} = \{T_{0j} | C_{0j} > C_{ij}\}$; the set of diverted commodities.

Given the "modified" baseline traffic (T^0), which is the tonnage level for the nondiverted commodities, the baseline fleet should be re-evaluated to determine if the fleet associated with T^0 differs from the composition of the baseline fleet. If the fleet composition is different, then new transportation costs reflecting the new fleet composition should be computed for all movements and the comparative transportation cost process repeated. The re-evaluation of the fleet also should include movements not originally diverted at transportation costs based on the baseline fleet. This process should be continued until changes in the commodity mix do not alter the fleet composition, and hence do not alter relative transportation costs.

If the cost of moving some commodities from the project port to destination j (C_{0j}) is greater than the cost of moving those commodities from some alternative port i (C_{ij}), then T* represents that set of diverted commodities. The importance of the iterative procedure is that the baseline reflects transportation costs derived from some consistent fleet composition. If sufficient traffic is diverted from the project to alter the fleet composition, then the impact on transportation costs must be assessed and the process continued until the estimated new traffic levels, fleet composition, and transportation costs are consistent. Again, it must be stressed that this process does not result in a new baseline, but in a baseline conditional on a specific multiport scenario. This entire process should be completed for each year in the period of analysis to estimate commodity flow and fleet composition impacts over the project life. When this process is completed, each baseline/multiport combination will be described by: (1) two sets of commodities (T^o and T^*); (2) a "modified" baseline fleet that incorporates the new project traffic (T^0); and, (3) transportation costs that reflect the new fleet and traffic levels for the entire period of analysis.

DIVERSIONS TO PROPOSED PROJECT

In a similar manner to that described for diversions from the project, account must be taken of the potential that traffic may shift to the proposed project from other projects. For each of the project alternatives, possible increases in projected traffic should be identified following the same process as outlined above. The logical flow for computing traffic increases is shown in Figure VIII-3. For each movement in each multiport scenario the baseline least cost routing must be compared with transportation costs for each project alternative. It must be noted that Figure VIII-3 represents a continuation of Figure VIII-2 for a specific multiport scenario. Thus, the logic of Figure VIII-3 would be completed separately for each multiport scenario. For purposes of clarity, this discussion is restricted to a single multiport scenario.

As before, Figure VIII-3 would be completed for each individual commodity movement. For commodity flows that do not divert from the project for a baseline/multiport scenario combination, it is only necessary to compute transportation costs via the project for each project alternative. That is, these movements utilize the project for all alternatives and no further comparison with any multiport scenario is necessary. For those movements having a lower transportation cost via some alternative project, i.e. $T_o=0$ from Figure VIII-2, it is necessary to compare the new least cost transportation routing with transportation costs via each project alternative.

From the analysis completed in previous chapters, transportation costs (AS_i) will be available for each project alternative. If $AS_i > C_i$, this traffic would be permanently diverted to a competing project if alternative i is implemented, and tonnage for this movement is set to zero. If $AS_i < C_i$, this traffic would divert back to the project under alternative i, and tonnage for the movement would be set to T_0^*. Typically $T_0^*=T_0$, that is the tonnage diverted from competing projects when project alternative i is implemented will be equal to the tonnage lost in the multiport analysis. There will be selected instances where additional tonnage will be diverted from competing projects, i.e. $T_0^*>T_0$. In these cases, the additional tonnage can be obtained from the multiport analysis following the logic of Figure VIII-2, i.e. reverse the analytic positions of the various projects.[1]

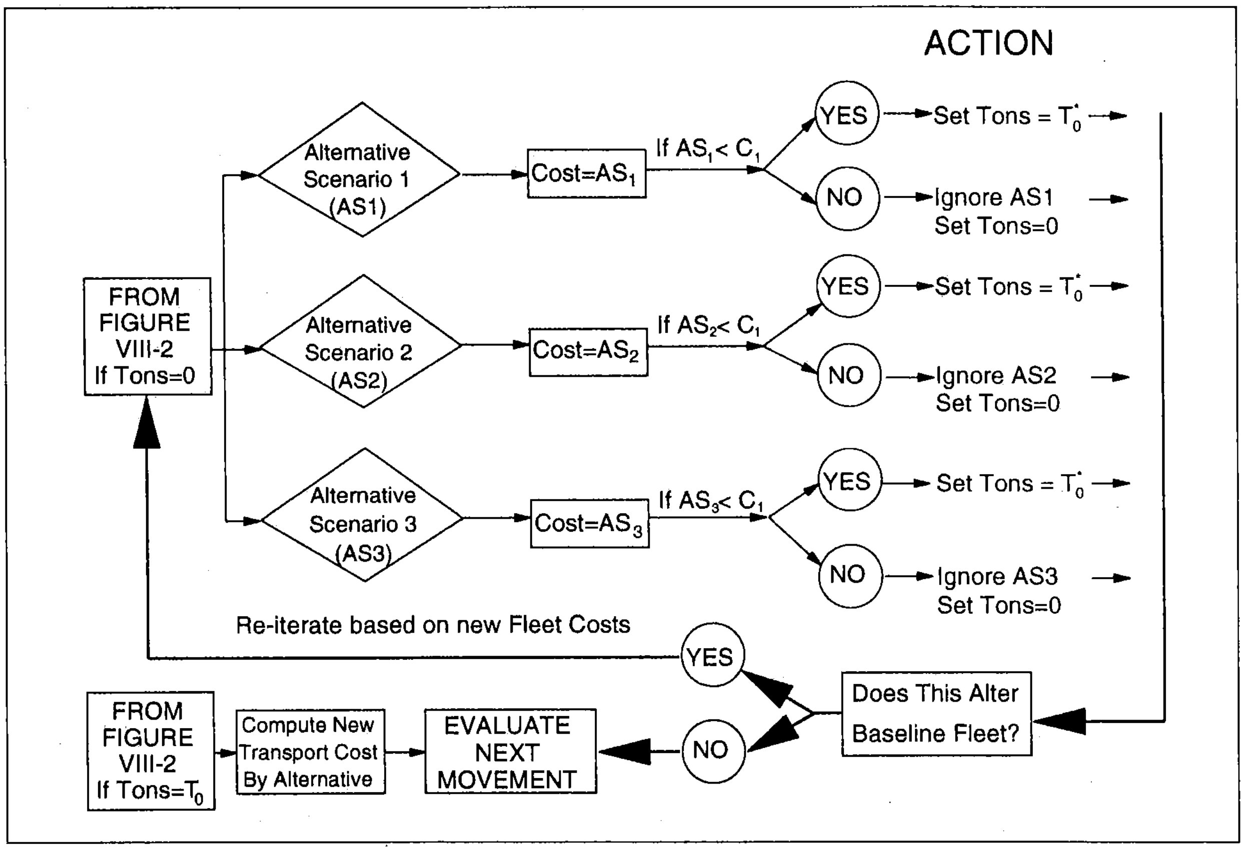


FIGURE VIII-3. ADJUSTING FOR WITH-PROJECT ALTERNATIVES

[1] Conceptually, multiport scenario i would serve as the baseline and project alternatives would serve in place of the multiport scenarios, thus computing diversions from competing projects to the proposed project under multiport scenario i and various project alternatives.

Once the comparative transportation costing analysis has been completed for all movements, the fleet composition for the specific project alternative must be reassessed for consistency with the new traffic levels. If changes in the forecasted traffic levels alter the fleet composition, then transportation costs via the project for the specific project alternative should be recomputed. This process will continue until the new traffic levels, project fleet and estimated transportation costs for the project port are consistent.

STRUCTURAL AND NON-STRUCTURAL ALTERNATIVES

Concurrent with the multiport analysis, several other factors must be integrated into the analysis and structure of economic alternatives. Conceptually, these factors may cover a broad range, but as a practical matter are generally limited to standard operating practices and project implementation strategies. Like the multiport analysis, these factors may alter transport costs directly or through their influence on fleet composition. In fact, as a conceptual problem for generating data to define the without- and with-project conditions, it is useful to view these factors in the same logical manner as the multiport analysis as illustrated in Figures VIII-2 and VIII-3. The critical issues are how these factors might affect transportation costs and commodity flows associated with the project, and how these factors might influence study recommendations. Three specific areas must be addressed due to their potential impact on commodity flows and relative transportation costs: (1) structural alternatives implemented by project users; (2) operational practices; and, (3) any temporal or geographic segmentation associated with-project implementation.

<u>Structural Alternatives Implemented by Project Users</u>. Structural alternatives implementable by project users would include such things as construction of special vessels, piers or wharves. The importance of addressing user-implemented structural alternatives is their potential direct effect on project costs or their direct or indirect effect on estimated transportation costs. In some cases, user implemented alternatives would simply be reflected in project costs as associated costs. In these instances, the analyst must consider the alternatives to the user, that is, facilities at competing

projects. For example, the user may have alternative facilities with excess capacity or which better facilitate capacity expansion in response to increased traffic levels. Of course, the reverse may also be true, with facilities at the proposed project having excess capacity or which better facilitate facility expansion.

In other cases, user-implemented alternatives will affect the transportation (distribution) costs at which traffic moves through the project. For example, utilizing a deeper channel typically requires deeper berths at the project, as well as deeper berths at overseas destinations. For some shippers, the lack of adequate overseas facilities may limit their need for greater depths at their berths which would limit full utilization of the new channel depth. The ability of this shipper to benefit from the project is predicated on the willingness to deepen berths at project facilities. In either case, those aspects of the project that would be implemented by users must be specified for each multiport/project alternative combination. A determination must then be made as to which alternative implementation the user is most likely to take for each multiport/project alternative combination. The analyst should then identify any impacts on project scope and costs (including associated costs), modify the commodity flows and project fleet composition and compute new transportation costs.

<u>Operational Practices</u>. Non-structural alternatives, primarily operational practices such as tide-riding or lightering, should be identified and a determination made as to their applicability in the baseline, and each of the multiport/project alternative combinations that are being evaluated. Two important issues must be specifically addressed in relation to operational practices. The first issue is whether these practices are currently in use. If so, then care must be taken to determine the degree to which these practices are currently reflected in transport costs. For example, lightering is a common practice for petroleum shippers and will frequently be reflected in the baseline transportation costs.

For operational practices not currently in use, a determination must be made as to their economic feasibility now and in the future. It must be stressed that non-standard operating practices are observed at numerous places throughout the world. If such practices are not used at the project in question, it should be concluded that these practices have been evaluated by shippers and carriers and were found to be not economical under existing conditions. The analyst must then determine which of the following best describes the absence of these practices for the project: (1) information deficiencies, for example lack of real time channel depth information; (2) the practice is uneconomical given the particular physical and institutional setting of the project; or, (3) insufficient traffic levels. Particular reasons for the absence of an operational practice must usually be obtained from shippers and carriers currently utilizing the project.

Of concern at this stage of the evaluation is the possibility that certain practices are not currently used due to insufficient traffic levels.[2] If this is the case, the level of traffic where these practices might be implemented should be determined. When the projected commodity flow exceeds this level of traffic, then the analyst should assume that the practice will be implemented and transportation costs via the project altered to reflect the practice.

Temporal or Geographic Segmentation. Certain aspects of each project alternative, for example phased construction or project segmentation, must be contemplated as integral components of a specific project implementation. At this stage of the evaluation, the importance of segmentation (either temporally or geographically) is its possible impact on alternative transport routings and costs over time. The analyst should identify the timing of implementation and associated changes in the fleet composition and commodity forecast when applicable. It is important to take into consideration the possible interrelationships between user implemented actions and project segmentation or phased construction. It is unlikely at this stage of the analysis that the most appropriate (temporal or geographic) segmentation of

[2] An associated problem is that informational deficiencies may be related to insufficient traffic levels currently experiencing problems on the project. This would be addressed in the same manner as operational practices not currently implemented due to insufffficient traffic levels.

project alternatives can be fully resolved. Nonetheless, basic information on project segmentation and its relation to project alternatives will be generated, providing guidance for further analysis.

As noted above, the logic involved in addressing these factors is much the same as for the multiport analysis shown in Figures VIII-2 and VIII-3. Each of these factors may influence commodity flows or the transportation costs at which traffic moves. These effects may be present for the entire period of analysis, or they may appear or disappear at some point in the future, which may or may not be directly related to project implementation. Each of the factors should be evaluated to determine any impacts on transportation costs, commodity flows and the project fleet. Like the multiport analysis, evaluation of theses factors provides information for defining the without- and with-project conditions.

Summary. On completion of the integration of the multiport and non-structural alternatives analysis, it should be possible to structure a matrix which relates commodity flow levels and transportation costs for each multiport/project alternative combination. Following the logical steps in Figures VIII-2 and VIII-3 for each commodity flow, a traffic level and associated transportation cost can be estimated for each possible multiport/project alternative combination.

IDENTIFICATION OF WITHOUT AND WITH-PROJECT CONDITIONS

The above analysis will generate a broad range of information specifying commodity flows and relative transportation costs conditional on characteristics of competing projects and actions related to the project being evaluated. At this point, it is necessary to decide which components of the above analysis are to be included in the without and with-project conditions. Information not specifically incorporated in the without- or with-project conditions is not discarded but should be relegated to the sensitivity analysis discussed in Chapter X.

WITHOUT-PROJECT CONDITIONS

The without-project condition consists of those future conditions most likely to prevail in the absence of the proposed project. The without condition is sometimes referred to as the baseline, but is conceptually different. As noted earlier, a study is frequently structured so that the baseline and without-project conditions are identical. This is simply a computational convenience, although a very handy one for tractability purposes. Depending on the complexity of an analysis, it may be desirable to distinguish between the point of reference for measuring impacts (the baseline), and the point of reference for measuring project benefits and costs (the without-project condition.)[3]

In a very real sense, the issue to be decided in defining the without-project condition is the likelihood that the factors discussed previously in this chapter will occur, and are of sufficient importance to make a contribution to the decision making process. There are no explicit rules which provide guidance on the specifics which the without-project condition must reflect, it simply represents the analyst's best intuition about the future. As a general rule, however, specifying the without-project condition should revolve around the following concepts: (1) tractability; (2) resolved issues; (3) critical issues; (4) commodity flows; and, (5) fleet composition.

<u>Tractability</u>. As has been repeatedly stressed, the purpose of the economic analysis is not to be precise,[4] but to recommend a course of action. In

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[3] The decision to differentiate between the baseline and without-project conditions will be determined largely by changes that are expected to take place between the time the analysis is conducted and the time the project is implemented. If significant changes are expected, it may be desirable to distinguish between the effects of these changes and changes which can be directly related to the proposed project.

[4] The analyst must constantly be aware of estimating the "gnat's eyelash"--dedicating study resources to precisely estimate some parameter ("within a gnat's eyelash") which is then combined with some other parameter that cannot be precisely estimated. The precision with which any parameter is estimated must constantly be judged in relation to how it improves the analysis. Dictums about always obtaining the most precise information possible are simply false.

reaching this recommendation, it is imperative that the logic upon which the recommendation is based be presented in a straightforward manner. This is not to deny that the analysis may be complex, but simply to state that the process of problem resolution follows a linear path. Each decision, assumption or parameter estimate associated with any baseline/multiport combination is predicated on previous decisions, assumptions or parameter estimates. The analyst must decide which assumptions, estimates and conditions best contribute to understanding the logical flow which leads to the recommended course of action. Effectively, the process of problem resolution follows a "branch and cut" strategy. At various stages of the analysis numerous branches will be generated which the analyst may follow. The analyst will "cut" all but one branch and proceed with the analysis along that branch. The flow along the uncut branches represents the definition of the without-project condition. Subject to the two factors discussed below, the without-project condition should follow the path which allows for the clearest explanation of the analysis.[5]

Resolved Issues. The analysis completed at this point will also resolve some issues, that is, identify what should be termed non-issues with respect to the project. It should be recalled that the factors which have been evaluated in this chapter are largely derived from technical and conceptual considerations related to deep-draft projects generally. Past analysis and experience have indicated these factors may influence project justification, scale or timing. There is no reason to suspect that any one of these factors will influence justification for a specific project. The purpose of the multiport and alternatives analysis is to determine how the competitive position of the project is altered by actions at the project and/or at competing projects. It is possible that some of these actions will not affect the estimated project commodity flow levels or relative transportation costs. If this is the case, these factors should be considered resolved (non-) issues. They should simply

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[5] Perhaps a more functional method for understanding this concept is the distinction between generating results (the analysis) and presenting the results. Do not clutter the presentation of the analytical results with a broad discussion of all the analytical details and iterative procedures supporting the logical flow that led to the results.

be incorporated into the without-project condition. This will assist reviewers in identifying those factors critical in reaching the recommended course of action.

Critical Issues. The most difficult aspect of specifying the without-project condition revolves around what are termed critical issues. These are the factors which cause relatively large changes in commodity flows or transportation costs. At this stage of the analysis, the analyst must abandon reliance on objective criteria and make a judgment as to which future conditions are most likely to prevail and include them as part of the definition of the without-project condition. The analyst should avoid the common trap of accepting certain events as part of the without-project condition because they represent "conservative" assumptions. Whether or not an assumption is "conservative" will vary, depending on the specific situation, and can only be determined once the economic analysis is completed.

The only guidance available to the analyst in assessing critical issues is information generated during the data collection and data analysis phases of the study. During the data collection phase, information will be obtained from shippers and carriers that provides a basis for determining the likelihood that certain actions will be implemented relative to each project alternative. Selecting other aspects of the without-project condition requires judgment.

Commodity Flows. While it is analytically useful to discuss and evaluate commodity flows disaggregated by commodity group, trade route and benefit category throughout an economic evaluation, this disaggregation also contributes to defining the without-project condition. As discussed in Chapter VI, disaggregation should be at a level where the ability to forecast trade flows or further distinguish between transportation costs is largely absent. Conceptually, generating the without-project condition commodity flows is a linear decision that begins with the baseline traffic, then proceeds through the transportation cost and multiport analyses, resulting in estimated project commerce adjusted for each study year (or time interval), conditional on some multiport/project alternative combination. The analyst must decide which of the conditional factors best represents the future.

The first step in addressing critical factors is incorporating commodity flow information into the without-project condition. The analyst should examine differences between commodity flows in the baseline and the conditional commodity flows derived from Figure VIII-2. Based on this comparison, differences in the level of commodity flows between various baseline/ multiport/alterative combinations provide one of the best indicators for specifying the without-project condition. Each combination reflects a variety of factors that results in adjustments to projected commodity flows, including diversions to and from alternative ports, and any new developments along the project that will yield additional commodity flows.

It is unlikely that examining differences in commodity flows will resolve all judgments related to defining the without-project condition. Nonetheless, it provides a basis for determining the "robustness" of any particular factor. A factor is robust if it significantly affects most commodity flows for a given scenario or if it significantly alters traffic levels for most scenarios. Unless a factor is known to occur with virtual certainty, for example, current deepening at a competing port, it should only be included as part of the without-project condition if it is robust. By examining the disaggregate commodity flows, it is possible to determine if a factor has a robust (widespread) impact on traffic or is limited to a small number of origin-destination pairs or scenarios. In either instance, the factor or scenarios(s) should generally be addressed as part of the sensitivity analysis.

As with defining the without-project condition, the definition of a robust factor is arbitrary. As a rule-of-thumb, any factor or multiport scenario that alters traffic less than 10 percent should initially be considered as not robust. While this is an arbitrary rule, it must be recalled that some aspects of the without-project condition have been specified. Thus, factors which alter commodity flows by less than 10 percent will typically represent small variations and should be addressed in the sensitivity analysis. The 10 percent criteria will change as the level of study resources and analytic detail changes, an effect normally reflected in the number of multiport scenarios and project alternatives considered during the study. The greater the level of detail of the study, the lower the variance associated with parameter estimates and hence the 10 percent criteria should be lowered.[6]

Fleet Composition. Delineating the fleet composition for the without-project condition follows much the same logic flow as the adjustments to the commodity flows described above.[7] The current fleet reflects a mix of current cargo types; primarily drybulk, liquid, breakbulk and containers. As the commodity mix changes, for whatever reason, the fleet will be adjusted to reflect these changes throughout the project life. The fleet composition will also reflect any operational considerations, practices or constraints existing at the project, as well as any effects of user implemented projects.

How the fleet changes in response to various conditions will also provide information that will assist in defining the without-project condition. The basic concepts are similar to those applied to the commodity flow assessment. Factors which do not have a broad impact on the fleet composition, that is they are not robust, are best addressed in the sensitivity analysis. Factors which do have a broad impact on the fleet composition should be assessed in terms of their likelihood of occurrence and included in the without-project condition as appropriate.

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[6] The basic idea in this discussion is related to Type I and Type II errors in hypothesis testing. If the analyst can assign probabilities to each scenario, the proper criteria for robustness could be determined. This simply continues an infinite regression process since the probabilities are also arbitrary.

[7] In this discussion, it is assumed that the project in question is not so important to international trade that it significantly alters the world fleet. If the project is important to international trade, then both the fleet and commodity forecasts must be completed simultaneously with specification of alternative conditions.

WITH-PROJECT CONDITIONS

The with-project condition(s) consists of those future conditions the analyst believes most likely to prevail for each project implementation. To compare each of the technical alternatives to the without-project condition, it is necessary to construct an economic alternative for each technical alternative. For each alternative, it is necessary to specify the commodity flow and associated transport costs for each project year. Defining the with-project condition will follow the same logical flow as defining the without-project condition. First, determine certain aspects of the without-project condition based on tractability of results and issue resolution, then address the critical factors. Differences in the with- and without-project conditions must arise from factors which can be identified with some specific project alternative. Typically, differences between the conditions should arise from direct or indirect changes in the less costly transport routing alternative.

Commodity Flows. For purposes of clarity, it is useful to distinguish between three types of commodity flows in the with-project condition. The first type would represent a continuation of without-project commerce, that is, traffic that does not divert to alternative ports in any of the multiport scenarios. The second category of commodity flows are those diverted from alternate projects to the proposed project. This would include both traffic diverted from the project in without-project condition, as well as traffic diverted from competing projects for a given project alternative. The third category of commodity flows is induced traffic and traffic with a shift of origin or destination.

There are two major reasons for evaluating disaggregated commodity flows in this manner. First, as in the definition of the without-project condition, estimated commodity flows for each project alternative should be examined to determine which factors have the largest impact on estimated flows. Those factors which are robust should be included as part of the with-project condition, with other factors addressed in the sensitivity analysis. Second, it assists in identifying the likely major beneficiaries of the project. Beneficiaries are defined in a broad sense and might include specific shippers and/or carriers, particular commodity types or specific origin-destination commodity flows. Those factors which lead to major changes in the beneficiaries are likely to be critical factors. The analyst must decide which description of that factor best represents the future and include this in the with-project condition for each alternative.

Fleet Composition. Differences between the fleet composition in the with- and without-project conditions arise from two sources: (1) uneven growth in commodity types; and, (2) changes in project characteristics, for example, a deeper channel. The current fleet mix should be modified over time to reflect the reduction or elimination of constraints on vessel size due to channel dimensions at the project port and other ports of call. It must be noted that the fleet composition does not necessary change in response to project implementation. For example, few projects are likely to alter the composition of the general cargo or autocarrier fleets; only the number of vessel calls will change. Since fleet composition is derived from the commodity flows, any factor not altering the fleet composition is unlikely to be critical in relation to project justification.

It should be noted that there are a multitude of considerations that will influence the specification of the without- and with-project conditions. The two factors focused on in this discussion--commodity flow levels and fleet composition--are likely to have the most direct impact on project justification. In most instances, any factor not influencing commodity flows or transportation costs will not influence project justification.[8] It should not be concluded, however, that other factors are of less importance than commodity flows and fleet composition, as these other factors can influence commodity flows and fleet composition and thus indirectly project justification. Assumptions, conditions at competing projects and other factors that describe the project setting are important and should be assessed for their possible impact on commodity flows and fleet composition.

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[8] There are a limited number of exceptions to this generalization, for example, military preparedness, safety and risk.

DESCRIPTION OF PROJECT USE WITH- AND WITHOUT-PROJECT

At this stage of the evaluation, it should be possible to set forth a fairly complete description of project use in the with- and without-project conditions. Much of this information has been developed in previous chapters, augmented by the efforts of this chapter to describe competition between projects and shipper/carrier behavioral responses to a project. Of particular concern is highlighting the differences between the various conditions and the reasons these differences arise. If the analysis has been conducted correctly, it should be a straightforward matter to set forth the differences in both textual and tabular form. For example, there should be no difficulty in presenting some "tables" showing changes in commodity flows as a result of the multiport analysis and the various technical alternatives as shown in Table VIII-2.

As a check on completeness of the without- and with-project conditions, it should be possible to specify the following information for each movement. Let CM_{ab} be a specific movement of a commodity between Points A and B. If the analysis is complete to this point then the movement can be described by:

$CM_{ab} = f\{T_{W/O}, C_{W/O}, T_{W1}, C_{W1}, \ldots T_{Wn}, C_{Wn}\}$; where

- $T_{W/O}$ Tonnage moved through project in without-project condition;
- $C_{W/O}$ Lowest transportation costs for shipping $T_{W/O}$;
- T_{Wi} Tonnage for least cost transport routing in condition i;
- C_{Wi} Lowest transportation costs for shipping T_{Wi};

That is, the movement can be described as a vector of tonnages and associated least cost transportation routings for each baseline/multiport/alternative combination. The subscripts W/O or Wi indicate the conditions associated with each tonnage level or transportation cost estimate, and are a function of assumptions made during the analysis. Thus:

$W/O = g_{W/O}\{A_{W/O}, MP, PS_{W/O}\}$, and $W_i = g_i\{A_i, MP, PS_i\}$; where

- A_i general assumptions of the analysis as they relate to project condition i;
- MP multiport impacts; and
- PS_i project specific assumptions.

As a result, any specific commodity flow would be described quantitatively by tonnage and transportation costs, and qualitatively by the assumptions and conditions underlying the quantitative estimates. A similar set of specifications can be developed for scenarios not included in the without- or with-project conditions, and would be used in the sensitivity analysis.

CHAPTER IX

CALCULATION OF BENEFITS AND COSTS

The last analytical step in the feasibility cycle is an evaluation of project alternatives to establish the trade-offs that exist between the various project objectives and alternatives. The conceptual framework for assessing these trade-offs is benefit-cost analysis. The fundamental idea of benefit-cost analysis is the existence of a baseline condition against which alternative project incremental benefits and costs can be measured. Efforts completed in the previous chapters provide the necessary data for computing alternative project benefits and costs and for assessing project feasibility, as well as a description of conditions expected to prevail for each project alternative. This chapter addresses the procedures and methods for integrating previous results into a framework that provides a basis for deriving a recommended solution that best meets project objectives.

NED COSTS

The first step in completing the feasibility analysis is the generation of a complete cost stream associated with each alternative over the project life. Three types of costs must be assessed: (1) project implementation (construction) costs; (2) operation and maintenance (O&M) costs associated with the project; and, (3) interest during construction. The role of the analyst in assessing these costs is to insure that estimated costs include everything necessary to achieve the estimated benefit or traffic levels, and that sufficiently detailed information is available for defining and evaluating prospective project segmentation and phasing.

CONSTRUCTION COSTS

The major implementation costs for deep-draft projects are typically federal and non-federal construction costs. These costs are the value of resources that must be committed in implementing each project alternative prior to the generation of project benefits. From an NED perspective, the distinction between Federal and non-Federal costs is unimportant. If resources are committed to the project implementation, they should be reflected as NED costs.

OPERATION AND MAINTENANCE (O&M) COSTS

O&M costs are the on-going claims on resources over the project life. The conceptual difference between these costs is that construction costs are incurred one time when the project is implemented, while O&M costs are incurred annually over the project life. Construction and O&M costs are typically derived using standard engineering cost-estimating techniques.

INTEREST COSTS

Interest during construction reflects the fact that project construction costs are not incurred in one lump sum, but as a flow over the construction period. Interest during construction is frequently computed based on the assumption that construction expenditures are incurred at a constant rate over the construction period. For many deep-draft projects this yields a good approximation of interest during construction, although when more detailed information on the construction schedule is available it should be used. This is particularly important if projects are constructed over a long period of time or in phases (segments.)

Interest during construction can be computed as follows. Let B be the project base year, that is, the year in which the construction costs end and the project begins to derive benefits. Then, the total cost incurred during construction, including actual expenditures and implicit interest payments, is the equivalent lump-sum expenditure in the base year, C_B, which is computed as:

$$C_B = \sum_{i=1}^{t} C_i (1+r)^{t-1}; \text{ where}$$

C_i construction expenditures in period i;
r per unit interest rate; and
t number of construction periods up to baseline year

If all costs have correctly been accounted for, an NED cost stream of the form (C_B, O_1, O_2,...,O_n) will be generated for each project alternative, where C_B represents the total construction costs up to year 1 (baseline year) and the O_i are the O&M costs in project year i from year 1 (baseline year) to and of the project life. This cost stream will represent the resource costs associated with each project alternative over its life necessary to achieve estimated benefits or traffic levels for that project alternative.

ASSOCIATED COSTS

The major problem that arises in specifying project implementation costs is the presence of associated costs. These are any public or private non-federal expenditures on general navigation features necessary to achieve estimated benefits or traffic levels for each project alternative. Associated costs are typically incurred by project users as part of an on-going transportation or logistics process. They may represent fixed costs of doing business, fixed costs of project implementation, or variable costs of the transportation process. Examples of associated costs would be facility enhancements necessary to accommodate larger vessels or larger loads per vessel such as expanded storage areas or deeper side channels to wharves and piers.

The issue to be resolved by the analyst is the manner in which associated costs are addressed in the analysis. Certain types of associated costs, for example, pipeline relocation, are typically included as project implementation costs. In most cases, these costs are unrelated to project throughput, but are required to implement a project alternative at the estimated benefit or traffic levels. The major problem related to associated costs is the frequent assumption that certain types of associated costs are self-liquidating. These costs are typically related to project throughput, either explicitly or implicitly.

The basis of this assumption is that certain associated costs can be provided at constant per unit average costs and are accounted for in other aspects of the benefit-cost analysis. For example, increased storage area for additional containers could be provided at the same per unit cost as existing storage area. If this were the case, the associated cost of increased storage area would be reflected in the transportation costing analysis. The cost would be self-liquidating and would not need to be specifically reflected in project implementation costs.

The analyst must assess two aspects of associated costs: (1) associated costs must be fully identified and accounted for in some manner in the analysis; and (2) whether associated costs should be reflected in project implementation costs or in the comparative transportation costs. There is little general guidance on the best manner to account for associated costs. When an associated cost can be identified with project throughput, it is usually desirable to address it in the comparative transportation cost analysis. Otherwise, it should be reflected as a lump-sum cost of project implementation.

A concept related to associated costs that arises on occasion is the idea of off-setting benefits and costs. Sometimes, it is difficult to determine that a private sector action will be taken in response to a proposed project. For example, will larger container vessels require the purchase of larger cranes? Largely, this is a question of economic or technological obsolescence. The problem arises because most deep-draft projects have an existing infrastructure. The question is whether alterations in the project actually require alterations to certain portions of the existing infrastructure. When the alteration is required, for example, deeper side channels to facilities, then the cost would be addressed as an associated cost. Unfortunately, it is not always clear that an alteration in the infrastructure is required. When it cannot be determined that a cost is required, it is typically assumed that the cost has an off-setting benefit of equal magnitude. In effect, off-setting benefits and costs are assumed to be self-liquidating.[1]

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[1] The distinction being drawn may not always be readily apparent. Associated costs can always be directly related to achieving some level of benefits. Off-setting benefits and costs are difficult to directly relate to benefits of specific alternatives.

NED BENEFITS

At this point in the evaluation, the analyst will have generated a comprehensive description of project commerce. Calculation of transportation costs was covered in Chapter IV. Identification of existing and future vessel fleets was discussed in Chapter V. Estimation of future traffic levels by alternatives was developed in Chapter VI. An evaluation linking estimated transportation costs and forecasted traffic levels by project alternative was completed in Chapter VIII. To illustrate how benefits are computed, it is conceptually useful to initially restrict the following discussion to the base year, and to view each alternative not as a physical configuration of the project, but as a data base describing the relevant transportation characteristics of things, for example, commodity movements or vessels, which benefit from each alternative.

The first condition is simply a notational convenience at this point. The procedures for computing benefits will be the same for each year of the project life, only the data used to estimate benefits will change. The second condition is an important conceptualization of the efforts completed up to this point and how specific study efforts relate to estimating project benefits. The transportation characteristics developed in Chapters IV through VIII, which form the basis for benefit estimates, reflect all relevant information on physical project characteristics. In effect, project characteristics have been transformed into project user-characteristics, and it is the user-characteristics that determine benefits. Hence, it is possible at this point in the evaluation to describe each alternative without reference to any of the physical characteristics of that alternative.

For each movement under each project alternative, a total transportation cost was computed in Chapter VIII. Transportation savings are the difference in transportation costs between the baseline condition and the conditions most likely to prevail for each alternative. The savings in the base year of a project for a specific movement and project alternative is the difference between $TC_{W/O}$ and TC_{W}, the transportation costs for the baseline and alternative project conditions. For discussion purposes, it is useful conceptually to classify transportation costs savings into two general categories: (1) those movements which use the project under all alternatives (cost reduction benefits); and, (2) those movements which use the project under some, but not all, of the alternatives (increased traffic benefits). Based on this distinction and the difference in transportation costs between alternatives, transportation benefits can be estimated as described below.

COST REDUCTION BENEFITS

Cost reduction benefits result from a decrease in the cost of shipping commodities that reflect the same origin-destination pattern and harbor in all project conditions. Cost reduction benefits will generally take one of three forms depending on the specific project formulation: (1) enhanced vessel maneuverability and delay reduction; (2) increased loads for existing vessels; and, (3) use of larger vessels. As the scale of the project increases, it is likely that all three forms of cost savings will be present. It should be noted that only the latter two benefit types are mutually exclusive for a given movement.

Enhanced Maneuverability and Delay Reduction. For most deep-draft projects, it should be expected that changes in the physical characteristics of the existing project may alter vessel maneuverability. For example, an expanded turning basin or an increase in the number of passing lanes could decrease channel transit time for all vessels. Some or all of the large vessels using tides to transit the channel will no longer be tide-dependent. Benefits attributed to enhanced vessel maneuverability or delay reduction are usually computed as a time savings multiplied by some per unit cost.

Conceptually, computation of these benefits follows the same general logic as described below for increased loads or larger vessels. The first step is to determine the number of vessels that benefit from enhanced maneuverability. The next step is to determine the time savings for each vessel (or class of vessels) associated with the particular enhancement. The time savings would be multiplied by per time unit costs of the vessel to determine cost savings per vessel. The cost savings per vessel are then summed over all vessels to estimate total cost savings arising from enhanced maneuverability and/or tide delay and weather delay reduction for a given project year.

Increased Loads for Existing Vessels. For any given operating draft, a larger DWT vessel carries a larger load than a smaller DWT vessel. The larger vessel may provide lower transportation costs, even though it is not fully loaded. As a result, there is an incentive to use oversize vessels for any given channel depth. That portion of the fleet which does not change in response to project implementation is likely to include some oversize vessels that can load more fully because of channel deepening.

Benefits arising from increased loads per vessel can be computed as follows. Let D be the project depth for the baseline condition, and $D_{MAX,i,j}$ be the maximum operating draft of vessels moving commodity i to or from point j via the project. Then,

(1) if $(D \geq D_{MAX,i,j})$, $TC_{W/O}=TC_W$; and

(2) if $(D<D_{MAX,i,j})$ then $TC_{W/O} \geq TC_W$,

where $TC_{W/O}$ and TC_W represent the transportation costs of the movement associated with particular without- and with-project conditions. It should be noted that D and $D_{MAX,i,j}$, as well as estimated transportation costs would reflect adjustments for squat, trim, and other operational characteristics.

Stated less formally, the above conditions simply divide traffic into two classes; those movements which do not benefit from the project and those movements which do. Condition (1) indicates that movements on vessels which are not constrained by the existing project will not benefit from any proposed project. As a result, the movement has the same estimated transportation costs in both the with- and without-project conditions. Condition (2) indicates that movements which are constrained by the existing project may benefit from some proposed alternatives. Condition (2) represents the difference between $TC_{W/O}$ and TC_W. When multiplied by the vessel load, $Q_{W/O}$, this yields the total transportation cost savings for the movement. This difference would be computed for all movements which satisfy condition (2), then summed to obtain total cost savings for the base year.

Larger Vessels. Depending on the characteristics of the proposed project, carriers may have an incentive to use larger, draft-constrained vessels with a resulting increase in average load per vessel. This will be reflected as a shift in the fleet forecast between the baseline and with-project alternative fleets. The conceptual distinction between benefits derived from loading vessels more fully, and benefits derived from the use of larger vessels, is that the latter reflects changes in fleet composition between alternatives, while the former reflects better utilization of that portion of the fleet which does not change in response to various project alternatives.

Cost reduction benefits resulting from the use of larger vessels can be computed as follows. Let D be the project depth for the baseline alternative, and $D_{ALT,i,j}$ be the maximum operating draft of vessels (or a class of vessels) moving commodity i to or from point j via the project for some alternative. Then,

(1) if $(D \geq D_{ALT,i,j})$, $TC_{W/O} = TC_W$; and

(2) if $(D < D_{ALT,i,j})$ then $TC_{W/O} \geq TC_W$,

where $TC_{W/O}$ and TC_W represent the transportation costs of the movement associated with particular without- and with-project conditions.

Stated less formally, the above conditions again divide traffic into two classes; those movements which do not benefit from the project and those movements which do. Condition (1) indicates that movements on vessels which are not constrained by the existing or alternative projects will not benefit from any proposed project. Condition (2) indicates that movements which are constrained by the existing project will benefit from some proposed alternatives. Condition (2) represents the difference between $TC_{W/O}$ and TC_W. When multiplied by the vessel load, $Q_{W/O}$, this yields the total transportation cost savings for the movement. This difference would be computed for all movements which satisfy condition (2), then summed to obtain total cost savings for the base year.

INCREASED TRAFFIC BENEFITS

In addition to the decreased transportation costs for existing movements, the proposed project also may increase the level of traffic as a result of decreasing transportation costs. This is represented by $Q_W - Q_{W/O}$. The increase in traffic may result from any of the following reasons: (1) shift of origin; (2) shift of destination; or, (3) induced movements. It is important to note that this traffic does not represent growth over time, but differences in traffic levels between alternative futures at any point in time.

Shift of origin- and destination-benefits reflect the results of the multiport analysis. Induced movement benefits represent an increase in trade resulting from a sufficient decline in relative transportation costs to and from the region for a particular commodity. In the former case, benefits are based on comparative transportation costs via the project and alternate ports using the results of the multiport analysis as described in the previous chapter. The only difference in computing benefits is that $TC_{W/O}$, baseline transportation costs, reflect transportation costs via an alternative port which is not the existing project. The estimated benefit is still the difference between transportation costs in the with- and without-project conditions.

In the case of induced (new) movements, benefits should conceptually be based on changes in net income to the commodity producer or user. Unfortunately, this change in net income is not easily estimated. Typically, these benefits are estimated as one-half of the difference in the maximum and minimum transportation costs for each alternative. A problem with using this rule-of-thumb is that prior to accepting induced traffic, the analyst may have generated detailed information on the traffic that provides a better basis for estimating benefits. When better or more detailed information is available, it should be used for estimating benefits; otherwise the rule-of-thumb is acceptable.

COMPUTE BENEFIT STREAM OVER PROJECT LIFE

For each movement, the analyst should compute the difference in transportation costs between the with- and without-project condition for each project alternative, and each time period of the project life. Differences in transportation costs for each year are computed in the same manner as described above for the base year. The analyst then will sum the savings for each time period of the project life to obtain total benefits for each project. This will yield a benefit stream over time for each alternative of the form (B_{1i}, B_{2i},..., B_{ni}), where n is the project life and i represents an index of project alternatives.

RECAP OF BENEFIT ESTIMATES

Due to the conceptual differences in estimating the types of benefits cited above, it is instructive to reconsider exactly what has been accomplished and why it is useful to view each alternative as a data base. Consider a single movement, corn shipped from Indiana to Rotterdam, which will be denoted as M_B in the baseline condition and M_A for some alternative. Based on the analysis of Chapters IV through VIII, we can fully describe the movement for each alternative with respect to estimating benefits by:

$M_i \approx (T_i, V_i, R_i, C_i)$, where

- $\approx$ a descriptive operator relating the movement to its characteristics;
- T_i tonnage of the movement under alternative i;
- C_i the cost for shipping T_i on vessel type V_i via routing R_i;
- V_i vessel identifier (such as vessel type or capacity) for the movement under alternative i; and
- R_i routing identifier (such as export harbor) for the movement under alternative i.

So that the notation of the benefit equation is clear, we have described the movement of corn from Indiana to Rotterdam under the baseline, B, and alterative A by:

$M_B \approx (T_B, V_B, R_B, C_B)$ and

$M_A \approx (T_A, V_A, R_A, C_A)$.

The transportation benefit for this movement is computed as:

$$(C_B-C_A)T_B - ½(C_B-C_A)(T_A-T_B),$$

where the righthand term is the savings imputed to new traffic and the lefthand term is the savings for existing traffic regardless of whether or not it used the project in the without-project condition. This is true for each of the benefit types described above.

Note that neither the vessel or routing characteristics directly enter the benefit estimation equation. They do, however, influence the manner in which we classified benefits earlier in this section. For example, when $T_A=T_B$, the righthand term is zero and this describes the condition applicable to cost reduction benefits--same traffic through the same harbor under both project conditions. When $V_A=V_B$, this is the case where traffic moves on the same vessel type in both conditions, i.e. a TPI benefit, while when $V_A \neq V_B$, this represents use of a larger vessel.

What is being pointed out is a structural lapse in the P&G. P&G does not define benefits; it specifies how to classify benefits based on vessel and routing characteristics, and how the benefit associated with each class can be computed. If the analysis of Chapters IV through VIII (steps 2 through 8 of P&G) is complete, the disaggregation of benefits as described above and in step 9 of P&G is a matter of presentation, not computation.

DISCOUNTED BENEFITS

To properly compare the benefit and cost streams associated with each project alternative, benefits and costs must reflect a common time standard. This is accomplished through discounting, a procedure which adjusts the value of a stream of benefits or costs to reflect the time value of money. Discounting converts a stream of payments into an equivalent lump-sum payment at some point in time, typically the base year for project studies. This lump-sum payment is called the present value of the payment stream discounted at interest rate r. The present value, PV_B, of a stream of payments (P_1, P_2,..., P_n) can be calculated as:

$$P_1/(1+r) + P_2/(1+r)^2 +...+ P_n/(1+r)^n$$

$$= \sum_{t=1}^{n} [P_t/(1+r)^t] \; ;$$

where r is the discount rate, t is the project year, and n is the project life.

The net present value of an alternative is defined as the excess of benefits over costs discounted to reflect the time value of money. Using the cost stream (C_B, O_1, O_2,..., O_n), and the benefit stream (B_1, B_2,..., B_n), the net present value (NPV) can be computed as:

$$NPV = \sum_{t=1}^{n} [(B_t-O_t)/(1+r)t] - C_B,$$

where n, t, and r are as defined above. The NPV for each alternative must be computed as this is the basis for comparing the value of alternatives. The appropriate discount rate for water resources studies is determined annually based on the average yield of marketable U.S. securities having a date to maturity exceeding 15 years. It is distributed annually by the Office, Chief of Engineers in the Fiscal Reference Handbook.

AVERAGE ANNUAL EQUIVALENT BENEFITS AND COSTS

An alternative, but equivalent method[2] of expressing benefits and costs in a common time frame is the use of average annual equivalent benefits and costs. This is a discounting technique that converts a stream of unequal payments into an equivalent stream of equal payments in each time period. The average annual equivalent of a stream of payments (P_1, P_2,...,P_n) is a stream of constant payments, P, where the discounted value of both streams are equal. The primary use of average annual equivalents is as a scaling factor in discussing or presenting benefits and costs.

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[2] Strictly speaking, this is true only for projects with the same economic life--a condition largely fulfilled for deep draft projects.

Other frequently computed measures of the value of a project, which make use of the discounting process, are the internal rate of return (IRR), payback period and benefit-cost ratio (BCR). The IRR is the discount rate yielding an NPV=0. The payback period is the shortest project life yielding an NPV=0 at the current discount rate. The BCR is the ratio of the discounted benefits to discounted costs.

INCREMENTAL BENEFITS BY PROJECT SEGMENT

When a proposed project can be divided into segments, the economic criteria for project justification require that each project segment be either independently or conditionally justified. Appropriate general methods for properly defining project segments are largely absent, as segmentation is primarily a function of project-specific characteristics. In most instances, project segments will be defined by the analyst based on physical and cost differences that can be observed and appear to be significant.

A segment might initially be defined based on facility density or the distribution of project costs. Any of the parameters developed in the previous chapters for computing benefits or costs could potentially provide a basis for defining project segments.[3] The only real guide for the analyst in defining segments is that the available data be sufficiently refined to support project segmentation. That is, there should be some obvious characteristic that differentiates the segments.

In terms of benefit estimation, the manner in which segments are defined is irrelevant. They simply represent components of a project alternative to which benefits and costs must be allocated. The procedures for estimating costs and benefits are the same as those described previously in this chapter. The conceptual difference is that each of the steps previously completed in this chapter would need to be completed for each individual project segment.

[3] When possible each project segment or component should be justified on its own merits, i.e. independently justified. This is not always possible, as justification of some segments may be conditional on justification of other segments or project components.

Total project benefits and costs are then the sum of the benefits and costs of the individual segments.

COMPARISON OF ALTERNATIVES

Upon completion of the previous tasks in this chapter, the analyst should construct a tabular summary of benefits and costs. An example is shown below.

Alternative	Present Value of Costs	Present Value of Benefits	Net Present Value of Alternative
Baseline	$1,000	$1,500	$ 500
Alternative 1	2,000	2,600	600
Alternative 2	3,000	3,750	750

This identifies the feasibility of each alternative and determines the need for any additional analysis of the alternative. It will also facilitate specification of parameter variation in the sensitivity analysis.

CHAPTER X

REPORT PRESENTATION AND CONCLUSIONS

The concluding stage in the benefit-cost evaluation is the identification of the alternative plan that best meets project objectives. The first step in this stage is sensitivity analysis to identify the various critical parameters and their threshold values that would significantly impact the acceptability of each alternative. Considering all information related to project feasibility, the recommended alternative plan is then selected. Study conclusions should be presented in a concise, well defined manner, in the form of a "best" alternative and associated alternative strategies, with appropriate supporting documentation. This chapter describes sensitivity analysis, selection of the recommended alternative, and report preparation.

SENSITIVITY ANALYSIS

Economic analysis is typically conducted as if all necessary parameters and variables can be estimated accurately. While this may be true for certain aspects of the baseline condition, it is certainly not true for estimated future conditions. The large number of tasks that must be completed in a deep-draft study makes uncertainty inherent in the data, principal assumptions, and projections that will be completed in the study components. Regardless of the care taken in data collection and analysis, there is always the possibility that the results will be misleading.

In conducting a feasibility analysis, the analyst must constantly trade-off broad-based analysis against in-depth analysis. For example, the fewer alternatives that are addressed, the greater the level of detail at which each alternative can be addressed. This trade-off is reflected in the assumptions and parameter estimates of the analysis. Due to the complexity of the analysis, it is frequently unclear how various assumptions and estimates affect the results. Problems are likely to arise from two distinct sources: (1) estimates of future conditions or decisions; and, (2) decisions made to simplify the analytical process, for example, estimated traffic levels, versus assumptions on possible alternative routings.

Sensitivity analysis is designed to identify those factors that most heavily influence each alternative; for example, forecasts and their influence on project benefits and costs. This includes both aspects of the analysis for which subjective criteria are difficult to develop (future states of the world), and for which objective criteria are subject to estimation errors (transportation costs). A sensitivity analysis of the parameters influencing each alternative must be conducted: (1) to identify all critical parameters underlying the justification of each alternative; and, (2) to determine the range of conditions under which each alternative is justified.
The sensitivity analysis will assist in identifying parameters which are critical to only a few alternatives and those which are critical to all alternatives. It assesses the likelihood of each of the estimated impacts, the degree of importance that should be attached to parameter estimates, and the acceptability of impacts resulting from each alternative in developing the recommendation of the best alternative.

In conducting the sensitivity analysis, the analyst should distinguish between external and internal parameters. External parameters are those factors which occur independently of project implementation, for example, customs fees. Internal parameters are those factors directly related to project implementation, for example, commodity flows using the project for each alternative. The sensitivity analysis does not change based on the use of external or internal parameters, but this distinction will assist in relating the sensitivity analysis to specific project alternatives and future conditions.

There are no explicit rules as to how the sensitivity analysis should be conducted. One source of guidance is the net benefits by alternative that were computed at the end of Chapter IX. This provides a general indication of the variation in parameter values under which each alternative should be evaluated. Specific areas that might be addressed in the sensitivity analysis are discussed below.

UNCERTAINTY IN COMMODITY FORECASTS

For the typical deep-draft project, commodity forecasts are one of the two prime determinants of project benefits. As such, in most cases, some sensitivity analysis related to variations in forecast traffic levels using the project should be conducted. Variations in demand are usually evaluated in two ways: (1) changes in the overall growth rate of commodities; and, (2) changes in the growth rate of specific commodity (or, alternatively, changes in the composition of commodity flows).

Changes in the level of demand require the analyst to evaluate the broader forces affecting the growth in traffic flows, that is to forecast growth in world trade. The easiest method to assess uncertainty in demand is to parametrically alter the level of demand. For example, the analyst might examine the effect on the net incremental benefits of each alternative given a ± 5 percent change in traffic levels. Once the new level of traffic is specified, the analyst should determine how this will affect vessel calls and fleet composition, repeat the comparative transportation cost analysis and compute benefits.

Changes in the growth rate of specific commodities will assess the sensitivity of assumptions related to individual commodity types. For example, certain commodity flows will be more susceptible to alternative supply sources than other commodity types. Which commodity types should be subjected to a detailed sensitivity analysis will be determined by information gathered during the commodity flow analysis and from the benefit-cost analysis. Once the specific commodity types are determined, the analyst could proceed along the same lines as described above--parametrically alter the level of demand for the specific commodity types and repeat the economic evaluation. Alternatively, certain specific commodity flows might be entirely eliminated. The analysis would then proceed as above, with new benefit levels estimated for each alternative.

VARIATION IN FLEET COMPOSITION

Fleet composition is the other major determinant of project benefits. Due to the many parameters involved in evaluating deep-draft projects which may influence the fleet composition, it also should be addressed in the sensitivity analysis. From the benefit analysis, the vessel sizes most likely to benefit from each alternative can be identified. The analyst should vary the fleet composition to reflect greater and lesser numbers of these vessel types, reallocate commodity flows among vessel sizes, then compute new transportation costs and benefits for each alternative.

DISCOUNT RATE

Although the appropriate interest rate for discounting benefits and costs is set by law, it is instructive to consider how variations in the discount rate might influence the recommendation. This can be accomplished by computing the internal rate of return (IRR) for each alternative and then discounting benefits and costs for each alternative at a variety of interest rates between zero and the IRR. The results can be graphically displayed to illustrate changes in net present value between alternatives as the discount rate changes. A similar type of graph could be prepared for commodity flows and fleet forecasts, using average growth rates or average vessel size rather than the discount rate.

DEVELOPMENT OF TRANSPORT ALTERNATIVES

In specifying transport alternatives, the analyst usually (implicitly) distinguishes between technically feasible and economically feasible alternatives based on limited analysis. For example, certain modes and/or routing combinations may be rejected as economically infeasible based on general knowledge about the transportation industry. In an abstract sense, this is an issue of how the analyst defines various alternative transport system conditions, including those in the multiport analysis.

The only direct method for assessing the sensitivity of transport alternatives is to alter the set of possible transport alternatives and then conduct a complete benefit analysis. As a practical matter, the sensitivity of transport alternatives can usually be derived from the sensitivity of transport costs discussed below. This will indicate those movements where estimated benefits are potentially sensitive to alternative transport systems. The analyst should then focus on transport alternatives for these specific movements and how consideration of additional transport alternatives will affect relative transport costs and estimated benefits for each alternative.

SENSITIVITY OF TRANSPORTATION COSTS

Estimated transportation costs represent the combining of information on commodity flows, fleet composition and commodity/vessel routings. Although it is frequently easy to identify the sensitivity of project justification to changes in transportation costs, it is much more difficult to relate these changes to changes in the underlying parameters that determine transportation costs.

Although not obvious, the effect of altering transportation costs by some percentage is little different than altering overall demand by the same percentage. Effectively, any broad changes in estimated transportation costs will be reflected in the sensitivity of commodity flows and fleet composition. In assessing the sensitivity of transportation costs, the analyst should focus on their component parts--inland distribution costs, port (user) charges, vessel itineraries, and possible physical distribution adjustments by shippers and/or carriers.

As in the case of commodity flows, the simplest method of addressing the sensitivity of the component parts is a parametric change in each of the component parameters. For vessel itineraries, this means computing transport costs for specific movements by altering the number of port calls for certain classes of vessels. Because each component change affects only part of total transportation costs, these changes will differentially impact relative transportation costs for each alternative. Using the new transport costs, benefits should be recomputed for each alternative.

SUMMARIZE SENSITIVITY ANALYSIS

Once the sensitivity analysis is completed, its results should be summarized for each project alternative. For the parameters cited above, it is suggested that a table be constructed that allows easy comparison of the results of the analysis. This assists both the analyst and reviewers in assessing the importance of specific study parameters. An example of such a table is given below for commodity flows and fleet composition.[1]

TABLE X-1
NET PRESENT VALUE OF BENEFITS BY ALTERNATIVE

Alternative	Base Case	Commodity Flow -5%	Commodity Flow +5%	Small Fleet	Large Fleet
Baseline	$500	$450	$535	$475	$557
Alternative 1	600	585	625	575	657
Alternative 2	750	610	789	725	807

The analyst should then reassess the assumptions of the without- and with-project conditions to eliminate any possibly contentious, but non-critical assumptions. In Table X-I, the specification of the fleet is largely unimportant--it affects the absolute level of benefits, but not incremental benefits between the alternatives. Thus, any "heroic" assumptions related to fleet forecasts should be modified. In the case of commodity flows, the growth rate significantly alters the relative level of incremental benefits for Alternatives 1 and 2. Presuming the baseline represents the analyst's best projection about the future, there is little that can be done about the commodity flow assumptions. They should simply be cited as critical assumptions and/or parameters.

[1] In most sensitivity analyses, the analyst will also assess combinations of the various factors. In Table X-1 this would include combinations of changing the commodity flows with changes in the fleet composition.

Although the numbers in Table X-1 are arbitrary, they illustrate an important concept related to the economic analysis. There is a tendency for most analysts to identify decreasing commodity growth by 5 percent as a "conservative" assumption of the analysis. Of course, if one examines the table, it is clear that it is not a conservative assumption if Alternative 1 is the recommended project for whatever reason. The reason is that the change in commodity growth largely impacts the net benefits of the Baseline and Alternative 2. The issue here is a warning to analysts--do not feel overly confident about the economic evaluation because it is based on seemingly conservative assumptions. There is simply too much interaction between variables to conclude that "conservative" assumptions lead to a conservative recommendation.[2]

CONCLUSIONS OF ANALYSIS

The objective of the analysis is preparation of information for decision-making. This section focuses on the presentation of information which leads to and supports the recommended course of action, including statement of objective, recommended course of action, assumptions, alternative courses of action, and a concise summary of the results of the economic analysis. Appropriate citations/documentation of all results must be presented. Based upon all the available data and the results of the feasibility analysis, the best alternative will be selected.

The selection of the recommended alternative is based on a comparison of the effects of each alternative and their relative degree of success in fulfilling project objectives. Formally, the best (NED) alternative maximizes net project benefits, where net benefits are defined to include all project

[2] It is worth restating that the goal of the economic evaluation is to reach the best decision, not the most conservative decision. There is no rationale for the conservative conclusion to be either the best or most defensible recommendation.

impacts and acceptable levels of risk.[3] Net benefits are computed as the difference between the present value of benefits and present value of costs for each alternative. The recommendations should be supported by a detailed assessment of the advantages and disadvantages of each alternative with a clear justification and explanation of the rationale for selection of the recommended alternative. Economic impacts of each alternative, with associated effects of the sensitivity analysis, will provide a basis for the critique of each alternative and selection of the best alternative.

In discussing the selection of the recommended alternative, three general features of the analysis should be set forth: (1) there should be a clear statement identifying the most likely scenario, that is, the assumptions and future conditions underlying the analysis that led to the selection; (2) possible phased implementation of the recommended alternative should be presented; and, (3) the critical parameters underlying the recommended alternative must be set forth. The important concept in this discussion of selecting the recommended alternative is that it should serve a guide for reviewers. It need not fully recount the steps of the economic analysis, but it must provide an understanding of the important decisions and results of the economic analysis.

IDENTIFY THE MOST LIKELY SCENARIO

As should be obvious from the previous chapters, a high level of effort may be necessary to properly complete a deep-draft evaluation. If the conclusions of the evaluation are to be acceptable, it is necessary that the analyst identify those future conditions believed most likely to prevail. The analyst must make a "best projection" about the future, which is typically called the most likely scenario. While certain aspects of this "best projection" may seem eminently plausible, they are still estimates of the future. A discussion of the most likely scenario and its relationship to the with- and without-project

[3] A complete discussion of risk and uncertainty is beyond the scope of this manual. Also, not all impacts can be quantified for explicit inclusion in the NED evaluation. Typically these facets of the problem are addressed through policy or by heuristic tools such as simulation.

conditions should be presented. While it may seem trivial, the selection of a recommended alternative is simultaneously an acceptance of a set of future conditions, and these conditions should be made explicit.

This last step is often a critical omission in planning studies. The problem is not a total absence of discussion relating the most likely scenario with various project conditions, but that this discussion is typically scattered throughout a report. A brief description, and perhaps a tabular display, delineating the major characteristics of the most likely scenario and its relationship to the with- and without-project conditions will provide the reviewer (and analyst) with a more focused understanding of the evaluation process. This is largely an issue of presentation, but an important issue if study results are to be understood and accepted.

Included in this discussion should be the major assumptions of the analysis. Economic analysis deals with evaluating processes that involve elements of uncertainty. Some of this uncertainty is addressed by making explicit and implicit assumptions. To present an accurate picture of the analysis underlying the recommendation, a brief summary of major assumptions underlying the analysis is needed. To support the recommendations, a summary table of net and incremental benefits by project alternative and condition should be presented.

PHASED IMPLEMENTATION

The nature of most deep-draft projects make them prime candidates for segmentation and phased construction. Unlike most civil works projects, there are economies-of-scale in construction for deep-draft projects, and benefits are typically related to the geographic scope of construction. The evaluation must assess the timing and phasing of construction of the recommended alternative, and develop the optimal investment schedule for implementation of each segment of the recommended alternative. This should be accomplished by determining the first year in which each segment achieves a benefit-cost ratio exceeding 1.0. Where there are significant differences in the timing of the justification for the various segments, a phased implementation should be included in the recommended alternative.

In conducting the evaluation of phased implementation, two important points must be considered. First, it is quite possible that phased implementation will increase construction expenditures, for example, increased mobilization costs. These should be reflected in new cost estimates. Second, this analysis is subject to the same constraints and limitations that apply to the economic evaluation generally. For this reason, it is unusual to fully optimize the construction schedule based solely on economic criteria unless the phased implementation yields significant construction delays.

RE-EVALUATION DURING PROCESSING OF THE PLANNING REPORT

It is imperative that the analyst realize that the purpose of the analysis and report is rational decision making, and is not to obtain specific answers to questions supporting the decision. It is unlikely that any analysis will completely resolve all areas of concern. It is not reasonable to dedicate resources to efforts which do not lead to better decision making. It is to be expected that certain problems and issues will be resolved at later stages in the planning process. Some of these factors will be identified in the sensitivity analysis. These critical economic parameters should be summarized in terms of how they impact the recommendation and offer possible suggestions for further refinement if additional economic studies are to be performed in the future. The analyst must resist the temptation to rationalize these critical factors as unimportant or unlikely.

REPORT PRESENTATION

The purpose of a feasibility report is to summarize the extent of the navigation problem, present possible solutions to the problem, and justify the basis for a recommended action or a no-project alternative. In presenting the project evaluation, there must be sufficient detail for a reviewer to ascertain the existing and future conditions underlying the analysis and make an independent determination as to the validity of the recommendation. The report should present the project alternatives and any screening methods or procedures used to limit the number of alternatives. The report should clearly describe the methodology and procedures employed in the assessment of alternatives, without undue emphasis on the specific methods/data underlying results. Guidelines for the contents of reports can be found in ER 1105-2-60, Planning Reports, 22 November 1985.

There are several general observations that are of some assistance in structuring a report. Completion of the evaluation described in the earlier chapters represents a rather extensive analytical effort. Whether this effort should be included in the main text or appendices of the report depends on the nature of the project and the problem it resolves. In either case, the report must contain a chapter which clearly and succinctly sets forth the conclusions of the analysis and their underlying rationale.

The (Draft) Final Economic Report can conceptually be divided into four general sections, each of which is likely to consist of several chapters:

- Study Orientation
- Specification of Alternatives
- Benefit-Cost Analysis
- Conclusions and Recommendations

Study orientation is the "boilerplate" of the report, i.e. the non-analytical introductory sections of the report. It includes such items as the statement of the problem, review of past studies and pertinent legislation.

Specification of alternatives should set forth the methods for determining the various project alternatives. An impartial evaluation of a project requires an assessment of the total environment within which the project will operate to ensure the analysis is accurate and appropriate. Therefore, this section must address non-structural solutions such as current operating practices which may affect the viability or timing of a particular alternative.

Benefit-Cost Analysis should present the analytical methods and results. The benefits of each alternative plan should be displayed in current dollars for existing conditions and for conditions expected during the base year, and in ten-year increments through 50 years beyond the base year. Benefits for all years beyond the base year should be discounted by the administratively established discount rate.

Conclusions and Recommendations should succinctly summarize the economic analysis and recommend a course of action. It should contain a brief description and summary of NED Benefits, indicating major differences between conditions/alternatives, for each project alternative carried through the entire feasibility report. In presenting conclusions, only "critical" differences between project alternatives should be presented. All documentation should be readily available and referenced where applicable.

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GLOSSARY

Associated Costs - Any public or private non-Federal expenditures on general navigation features necessary to achieve estimated benefits or traffic levels for each project alternative.

Average Annual Equivalent - A discounting technique that converts a stream of unequal payments into an equivalent stream of equal payments, where both streams have the same present value.

Baseline Condition - A scenario from which project impacts can be measured, i.e. a point of reference. The baseline may coincide with the without-project condition.

Benefit-Cost Analysis - An analytical method for comparing the positive (benefits) and negative (costs) impacts of an action.

Benefit-Cost Ratio (BCR) - The ratio of discounted project benefits to discounted project costs.

Bulk Carriers - Ships designed to carry dry bulk cargo. Category includes: ore/bulk/oil carriers (OBO) and other combination bulk/oil and ore/oil carriers.

Cabotage - Domestic water transport. Can be coastwise, intercoastal, interisland or through inland waterways.

Container Vessels - Ships equipped with permanent container cells, may be full containerships or partial containerships.

Cost Reduction Benefits - Project benefits which result from a decrease in the cost of shipping commodities that reflect the same origin-destination pattern and harbor in all project conditions.

Critical Parameters - Those analytical factors that are the major determinants of the level of project benefits and costs.

Discount Rate - The interest rate used to convert a flow (benefits or costs) into an equivalent stock (Present Value).

Discounting - A procedure which adjusts the value of a stream of benefits or costs to reflect the time value of money. Discounting converts a flow into an equivalent stock at some point in time. This stock is called the present value of the flow discounted at interest rate r.

DWT - Deadweight Tonnage. The carrying capacity of a vessel in tons (most references now show metric tons). It is the difference between the light and loaded displacement (weight of the ship itself vs. ship plus cargo, fuel, stores and water).

Existing Condition - A description of the project setting based on present conditions; it simply describes "what is" at the time the analysis is undertaken.

FEU - Forty-foot-equivalent-unit. This is a 8 by 8 by 40 foot dry cargo intermodal container used as a measurement of container volume. See also TEU, twenty-foot-equivalent-unit. One FEU equals two TEU.

Freighter Vessel - General cargo carrier, full containerships, partial containerships, breakbulk carriers, roll-on/roll-off (RORO) ships and barge carriers.

GRT - Gross Registered Tons. Internal cubic capacity of the ship expressed in tons on the basis of 100 cubic feet per ton.

Handymax Ships - Vessels between 20,000 to 40,000 DWT.

Hinterland - The geographic areas where port commerce originates and terminates.

Increased Traffic Benefits - Project benefits which can be attributed to increased traffic levels as a result of decreasing transportation costs. The increase in traffic may result from any of the following reasons: shift of origin, shift of destination, or induced movements.

Incremental Benefits (Costs) - The difference in benefits (costs) between two Project Alternatives.

Induced Movement (Traffic) Benefits - Project benefits that result from an increase in commodity flows relative to the without-project condition and which do not reflect a change in origins or destinations.

Internal Rate of Return (IRR) - The interest rate which discounts the benefit and cost streams so that they yield a Net Present Value of zero.

LASH - Lighter Aboard Ship. The ship carries barges in special compartments analogous to cellular (container) vessels.

Load Center - A high volume container port effectively reducing vessel port calls by concentrating intermodal sea-land transfers at a few large ports rather than spreading them out among a larger number of small ports.

Macro-Bridge - Also known as "landbridge". It is the same as mini-bridge, except that it involves substitution of land transportation across the United States in place of water service, for traffic that originates and terminates outside of the United States.

Micro-Bridge - Interior point intermodal service similar to mini-bridge, except that cargo originates or terminates at an inland city rather than another port city. The cargo moves on a single ocean bill of lading to and from the interior point and the port.

Mini-Bridge - Substitution of rail or truck service for water transportation between two U. S. port cities for cargo originating or terminating in a port city.

Most Likely Scenario - Those future conditions the analyst believes most likely to prevail.

NED Benefits - The complete benefit stream associated with implementation of a project alternative over the project life that is obtained when the project alternative is implemented.

NED Costs - The complete cost stream associated with implementation of a project alternative over the project life that is necessary to achieve the estimated benefit or traffic levels.

Net Present Value - The excess of inflows (benefits) over outflows (costs) discounted to reflect the time value of money.

Non-structural Alternatives - A project alternative which does not alter the physical characteristics associated with the existing condition. Non-structural alternatives would include operational and management practices, and minor structural improvements that enhance utilization of the existing project.

OBERS - Acronym for the Office of Business Economics of the U. S. Department of Commerce, and the Economic Research Service of the U. S. Department of Agriculture. OBERS is the short title for projections of economic activity and population now produced by the Bureau of Economic Analysis (BEA) in Commerce. Originally they were a cooperative effort under the Water Resources Council, and part of the water resources planning program.

Panamax Vessel - Ships built to maximize capacity within the Panama Canal lock size limits of 950 feet long, 106 feet wide. Design draft is usually deeper than the 39.5 feet Canal limit, with deadweights up to 80,000 tons.

Payback Period - The shortest project life yielding a Net Present Value of zero at the current discount rate.

Phased Construction - An implementation strategy whereby the project is constructed in discrete segments with benefits and costs assigned to each individual segment.

Project Segmentation - The practice of dividing a project alternative into discrete components which can be individually evaluated and implemented.

RORO - Roll-On/Roll-Off Vessels. Ships which are especially designed to carry wheeled containers or trailers, and only use the roll-on/roll-off method of loading and unloading. Containers and trailers are usually stowed onboard on their chassis.

Screening Methods or Procedures - Any qualitative or heuristic processes used to limit the number of cases that would be analyzed. Cases would include project alternatives or various with- and without-project condition scenarios.

Self-Liquidating Costs - A type of Associated Cost whose corresponding revenues (or benefits or inflows) are reflected in some aspect of the benefit analysis for each alternative in which the cost is incurred.

Sensitivity Analysis - An analytical technique designed to identify those factors that are the major determinants of the level of project benefits and costs. The sensitivity analysis will assist in identifying critical study parameters.

Shift of Origin (Destination) Benefits - Project benefits that result from changes in the origins or destinations of traffic movements due to project implementation.

Structural Alternatives - A project alternative which significantly alters the physical characteristics of the project area associated with the Existing Condition.

Tank Vessel - Ships which carry liquid products, such as crude petroleum, petroleum product, chemicals, liquid natural gas, and molasses.

TEU - Twenty-foot-equivalent-unit. A dry cargo container unit measuring 8 by 8 by 20 feet used as a measure of container capacity.

TPI - Tons Per Inch. Measure of vessel capacity equal to the weight of displaced water if vessel draft were to change by one inch.

Traffic Diversion - Any commodity flow which ceases to use the project under some project alternative or scenario.

ULCC - Ultra-Large Crude Carrier. Crude petroleum vessel exceeding 300,000 DWT.

VLCC - Very-Large Crude Carrier. Crude petroleum vessel exceeding 150,000 DWT but less than 300,000 DWT.

With-Project Condition - The set of future conditions the analyst believes most likely to prevail for each project implementation over the planning horizon. These conditions may vary for each project alternative.

Without-Project Condition - The set of future conditions most likely to prevail in the absence of the proposed project. It does not describe conditions as they exist at the time of the study, but describes the conditions that are expected to prevail over the planning horizon in the absence of a project.

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