Volume IV of V

U.S. DEEPWATER PORT STUDY

THE ENVIRONMENTAL AND ECOLOGICAL ASPECTS OF DEEPWATER PORTS

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13. ABSTRACT

This report provides an overall appraisal of deep port needs for the United States by means of identification of the factors critical to U. S. deepwater port decision; development of criteria appropriate to the evaluation of engineering, economic and environmental aspects of deep port needs and policies, analysis of the development options available at this time and the critical issues surrounding each and the identification of critical issues which need further analysis. The study emphasizes port requirements for bulk commodities.

Volume I contains the Summary Report
Volume II contains Commodity Studies and Projections
Volume III contains Physical Coast and Port Characteristics, and Selected Deepwater Port Alternatives
Volume IV contains The Environmental and Ecological Aspects of Deepwater Ports
Volume V contains Transport of Bulk Commodities and Benefit-Cost Relationships

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Volume IV of V

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CONTENTS

INTRODUCTION

The environmental portion of the Deepwater Port Study was undertaken with three principal objectives:

1. To develop background information about the environmental and ecological effects of deepwater port development and operation to aid in identifying the significant elements of any port alternative

2. To develop an analytical framework within which the environmental effects of the various alternative proposals for deepwater ports can be identified, analyzed, and evaluated

3. To conduct a preliminary analysis of a selected set of alternatives to highlight the major environmental and ecological problems associated with each.

Toward this end an extensive information collection activity was undertaken utilizing readily available data as well as the opinions of people familiar with the various activities and areas involved in the analysis. The results of these activities as presented in this report represent the authors' interpretation of this data and information. No formal analyses of basic data or field studies were undertaken.

The following report includes discussions of several general considerations involved in port development: dredging, spoil disposal, ship operations, shore development and offshore development. In addition, commodities of concern in this study are discussed in terms of their environmental effects, with particular emphasis on petroleum.

The conceptual approach, requirements and procedural steps for the analysis and evaluation of the implications of deepwater port development in any area are extensively discussed (chapter IV). Finally, in part II, several alternatives are reviewed based on this procedure. With regard to part II, it should be noted that the evaluation done in this current study is only preliminary and cannot be used as the basis for a decision on actual site selection.

PART I. STUDY BACKGROUND AND DESIGN

I. THE GENERAL NATURE OF THE COASTAL ZONE

The coastal zone is broadly defined as the area extending seaward to the limit of territorial space (3 miles) and landward a distance which includes all land areas harboring activities directly dependent upon or influenced by the water.

In the United States this coastal zone contains about half of the nation's population and most of the major cities. There are over 80,000 miles of shoreline in the U.S. coastal zone, and many biologically important estuaries and wetlands.

The shoreline is the interface of water and land. Its physical characteristics vary greatly from one part of the coast to another. Some areas have steep and rocky shores with near-shore deep water. Other areas have broad, sandy beaches backed by shallow bays and wetlands, and with relatively shallow offshore waters. The shoreline is an area of constant change, which is particularly noticeable along the sandy reaches. Under the influence of winds, waves, tides and currents from the ocean side and under the influence of freshwater inflow and sediment from the land side, the shoreline erodes and regresses in some areas while it accretes in others.

Estuaries, defined as semienclosed water bodies having free connection with the open sea and within which the sea water is measurably diluted by fresh water from the land, are important parts of the coastal environment. They contain most of the coastal wetlands which play a vital role in marine ecology.

Estuaries have a highly complex ecological structure. They contain a wide variety of flora and fauna. Much of the energy requirement of living marine organisms is generated in the estuarine zone through the photosynthetic conversion of the sun's energy into forms usable by higher marine organisms and, eventually, by man. Estuaries are nursery and rearing grounds for many marine species. There are literally hundreds of species of shellfish and other invertebrates and of finfish that are dependent upon the estuarine environment during some part of their life cycle. The wetlands themselves contain the primary energy-producing plants; provide nesting, feeding and resting areas for waterfowl and other wildlife; and, in some cases, provide buffers which absorb and dissipate the energy of waves and storms.

All in all, the coastal zone is an area of highly complex physical interaction and processes where the sea meets the land and where the saline ocean water meets the inland fresh water. And the biological interactions and processes in the coastal zone are no less complex than the physical ones.

Man uses the resources of the coastal zone in many ways. The uses fall into the following categories [2]:

1. Waste disposal (municipal sewage, industrial wastes)

2. Shoreline development (industry, housing, parks, etc.)

3. Exploitation of living resources (fisheries)

4. Recreation (swimming, boating, sport fishing)

5. Water resources (municipal and industrial supplies)

6. Transportation (shipping, waterways, harbors)

7. Exploitation of nonliving resources (oil, gas, gravel, etc.).

Engineering works have been developed to provide the coastal characteristics which man desires. But imperfect knowledge of the forces involved, and of their behavior, has often defeated the purposes or created unexpected and undesired side effects. Frequently such alterations create substantial conflicts between uses. Use of the waters for waste disposal, resulting in water pollution, directly conflicts with the use of the waters for recreation and fishing. Filling of wetlands for use in residential, industrial and port construction conflicts with wildlife and estuarine preservation, and can conflict with related recreation and fishing. Dredging for navigation can alter salinity and water quality and will frequently conflict with practically all uses except waste disposal and shipping. The list of specific cases of conflicting uses could fill volumes.

The development of deepwater ports in the United States, the subject of this report, will require major modifications to the coastal environment. Many of the large vessels now being planned will require water depths of 70 feet or more. With the exception of Puget Sound, no port on the west coast has a depth exceeding 55 feet. The deepest port on the gulf coast is 40 feet, and on the east coast no port has a water depth of over 45 feet. Therefore, if the draft requirements of these large vessels are to be met, it will require deepening existing ports, creating new onshore or offshore ports, or both. Regardless of how the need is met it will have implications for the coastal zone. This study is an attempt to develop these implications in a way useful for input into planning.

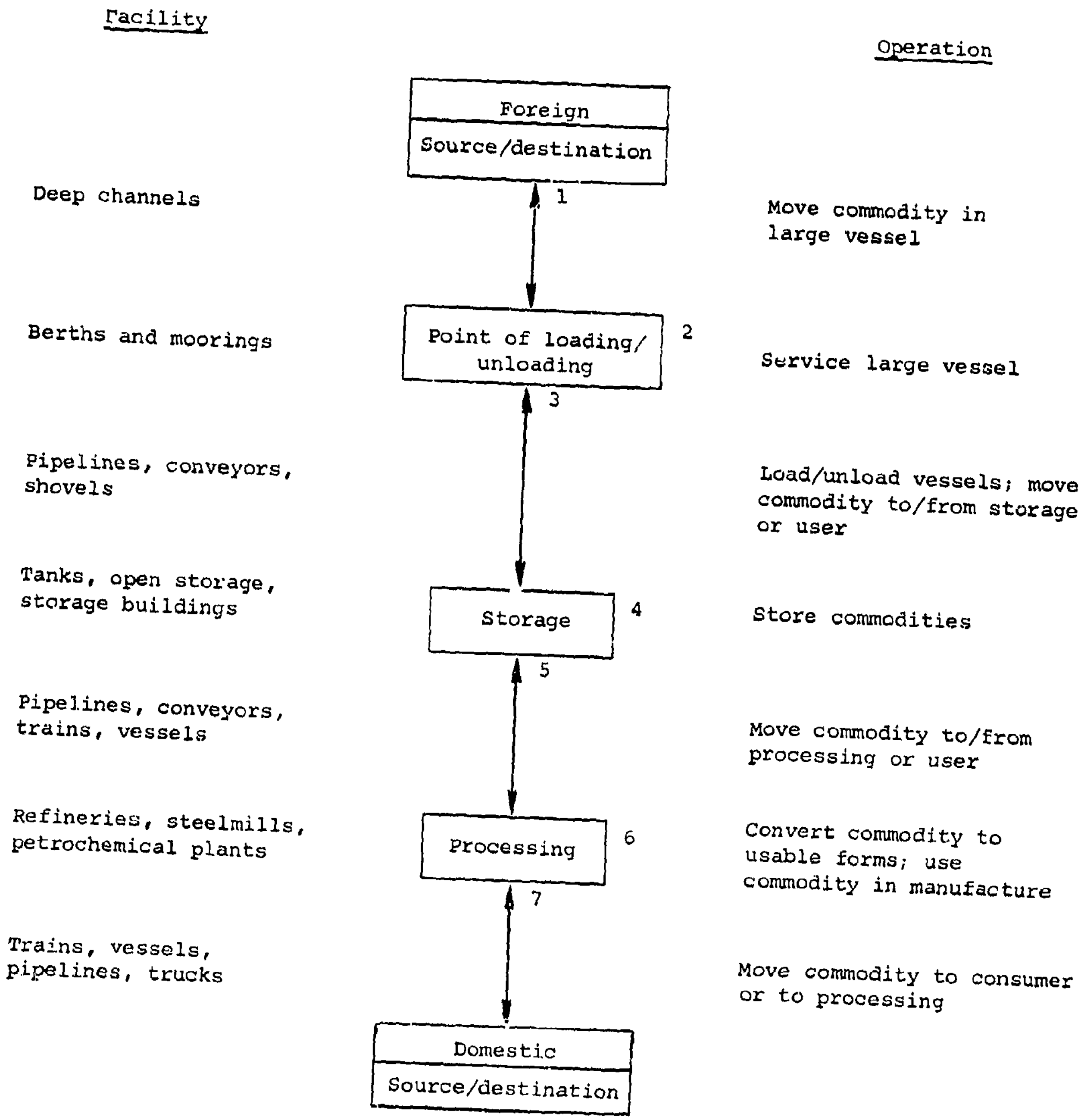
Deepwater Ports and the Coastal Environment

There are several types of deepwater ports and facilities in use, under construction, or planned in various locations throughout the world. These include offshore structures with or without material handling links to shore and onshore or offshore storage, shoreline berths with deep water, and inland ports with natural or artificial harbors.

Each type of deepwater port involves different ecological and environmental considerations depending upon its specific design, the character of its location and the operating procedures instituted. The various aspects of such ports and operations can be described as a deep port delivery system for bulk commodities. The system is comprised of seven components which are identified by the function they perform in moving the commodity from source to destination. Figure 1 depicts the delivery system and its component parts. Each component may influence ecological and environmental conditions. For example, component 1 deals with the operating characteristics and physical requirements of large deep-draft vessels. Thus it will include the effects of dredging and spoil disposal, impacts of vessel movement and the problem of spills resulting from accidental groundings and collisions of large vessels.

In order to evaluate the overall environmental and ecological implications of a number of deepwater port alternatives, information on the delivery system's influence and the nature and behavior of the commodities to be handled must be collected and a systematic approach developed to provide a tool for analyzing, evaluating, and comparing alternatives on a common basis.

Figure 1. Components of a Port Delivery System



II. GENERAL ENVIRONMENTAL CONSIDERATIONS OF DEEPWATER PORTS

In the context of the port deliver system, environmental problems associated with the seven components generally arise from two sources. First, alteration of the physical environment may take place in the establishment of practically every component. The kind and degree of such alteration will depend upon where the development takes place and the particular kind of port that is needed.

Large bulk carriers require more water depth than is naturally available in most existing ports in the United States. Therefore, if the ports are to accommodate deep-draft vessels, they must be deepened, or new ports must be constructed. Deepening through dredging can initiate a large number of changes of an ecological nature. Disposal of the spoil has its own set of effects. The establishment of handling and storage facilities and associated land development will also have a variety of environmental impacts.

The second source of environmental problems is the actual operation of the facility and the handling of commodities, especially bulks. Impacts can arise from movement of vessels, the spill of materials into the water through accidents such as collisions and grounding and equipment failure, and the escape of pollutants into the environment as a result of normal operating procedures.

This chapter contains a comprehensive discussion of these general considerations -- namely, dredging, spoil disposal, ship operations, shore development and offshore development.

Environmental Problems Associated with Dredging

The general areas of environmental concern associated with any dredging activity are those related to basic changes in the water circulation pattern and its implications, interference with ground-water quality and/or quantity, the effects of associated turbidity, and the direct impacts upon resident biota as well as the secondary impacts of physical alterations upon these species. Although the magnitude and duration of any impact are dependent upon the original condition of the water body as well as upon the volume, dimensions and quality of the material removed, some considerations can be enumerated which will generally be applicable to any activity of this kind.

The large-volume dredging activity likely to be associated with the development of a deepwater port at the shoreline or in estuarine areas will undoubtedly affect the speed, volume and direction of both surface and bottom currents. This altered movement may be manifested by changes in tidal exchange, flushing rate, stratification and salinity of the water body. These changes, combined with the resuspension of material removed from the bottom, could significantly alter the general water quality of the area, at least temporarily. Beyond the immediate water region, impacts may occur in tributary freshwater streams where an increased tidal action may alter the position or dimensions of the saltwater wedge extending upriver. On shore, a different circulation pattern may alter the erosion rate of adjacent lands or the salinity content of the soil.

Unfortunately, no generalized model of estuarine circulation exists to adequately predict these changes, and there are only a few site-specific models useful for this purpose. This lack of methodology and the complexity of cause-effect relationships make it difficult to predict changes and to accurately specify corrective action for ameliorating these impacts if they are judged to be adverse. However, beyond the go/no go alternative, some consideration should be given to variations in channel dimensions or the development of additional channels to counteract current changes near the shore or critical water areas caused by the main channel.

In most cases, water circulation pattern change is likely to be the most significant impact of the dredging activity both in terms of duration and ramifications. High priority should be given to the identification of potential changes and their effects because of possible long duration and extensive impacts.

The deepening of near-shore areas offers a potential threat to freshwater aquifers. The decrease in substrate which separates aquifers under estuarine areas from the overlying saline water could allow mixing of the two either within the aquifer or, if fresh water escaped, within the region above. In the former instance, an impact will be felt on the quality and quantity of ground water and, in the latter case, on the salinity regime of deepwater areas and, consequently, their indigenous biota.

Current information on salt-water intrusion and its prevention deals primarily with the overwithdrawal of fresh water from deep wells in inland areas. Ways to prevent intrusion as a result of deep dredging are unknown and may simply require no dredging beyond certain depths. In any case, the significance of these aquifer changes will, to a large extent, be dependent on the aquifer's current or potential use as a source of freshwater supply and upon the ecological changes created by changing salinity. This must be viewed not only in terms of the immediate shoreline area but in terms of upland areas as well.

The turbidity associated with the dredging process affects the environment in many ways. Its immediate and usually short-term impact is to reduce the depth of the euphotic zone, thus decreasing the rate of photosynthesis of surrounding waters. This reduction, often combined with the increased oxygen consumption associated with bacterial activity on the suspended particles, serves to reduce the total amount of dissolved oxygen (D.O.) in surrounding waters. This lowered D.O. can become critical to indigenous biota if prolonged, and thus becomes an important factor to consider if maintenance dredging becomes a near-constant process. Particles suspended during dredging may also clog the feeding apparatus of filter-feeding organisms and increase their mortality rate. In addition, the release of toxic substances from bottom sediments could potentially harm the biota in large areas.

A longer term impact of dredging occurs when the particles begin to settle, possibly covering productive bottom areas and rendering them inimical to later recolonization. Such alteration of spawning areas could be critical to both resident and migratory species. However, it is also recognized that sedimentation may have the opposite impact; i.e., it may promote the development of new productive habitats.

The whole question of the immediate effect as well as the chronic effect of sublethal exposure to turbidity has become the focus of much research. In the face of the uncertainty associated with these questions, steps can and should be taken to ameliorate potential deleterious effects. The first of these involves the selection of dredging techniques which of themselves produce the least amount of turbidity. The second involves the timing, if possible, of dredging to coincide with seasons when the species of the area are likely to be most tolerant of this stress. In addition, since the turbidity is often confined to a relatively limited area surrounding the dredging site, precautions should be taken to avoid areas which are deemed to be most important to the ecosystem of the water body.

The only direct impact of dredging on resident biota is the actual removal of bottom material and the organisms in it. Although in selected instances this may be a very important impact, in general it is less significant than the secondary impacts of dredging which have just been reviewed. Changes in salinity, prolonged turbidity and sedimentation can virtually eliminate a species from an entire area, whereas direct physical removal will be limited to the bottom location which is dredged. Such removal would usually be a problem only in productive shellfish beds. One can only suggest that such areas be avoided where possible when channels are routed.

An analysis of a complex dredging situation in a certain area requires detailed information on the original water depths, current patterns, water quality, and existence of unique areas in terms of biological communities. The susceptibility of the biota to likely changes should also be considered. Data should also be obtained on the location and the extent of aquifers and their present and projected utilization. Since alteration of water movement in the area could affect the area's utilization for waste disposal, the extent of such alteration should also be known. Ideally, sufficient information should be obtained to develop at least a preliminary model of the movement and quality of the water body to help predict the impacts of dredging. Modeling studies should depend upon an early judgment that possible changes would be so significant that the problem warrants the resources and time required to develop and apply the model to predict effects prior to implementation.

Environmental Problems Associated with Spoil Disposal

The deposition of the spoil resulting from dredging, particularly the large volume likely to be associated with deepwater port development, is a major concern both in terms of its problems and its potential uses. Although the uses have traditionally received the greater emphasis, the recent upsurge of environmental concern has served to spotlight the problems.

Three major alternatives exist for the disposal of dredged material: (1) depositing it in relatively nearby underwater sites either alongside the channel or in designated disposal areas; (2) depositing it at onshore locations; and (3) transporting the material to distant ocean disposal areas. The method of disposal chosen will be determined by the physical and chemical characteristics of the spoil, the distances and congestion between dredging site and disposal area, and the use to which the material will be put. However, certain common problems exist in varying degrees regardless of the disposal method, including those associated with general water quality (i.e., turbidity and toxicity) and the burying of existing land.

The extent and duration of turbid conditions associated with spoil disposal can present significant problems to biota in the area of the disposal site. The impact of turbidity from spoil disposal is the same as that from dredging.

The toxicity of dredged sediments has received increased attention recently. Guidelines for the analysis of dredged material have been established by the Environmental Protection Agency [7]. These guidelines are preliminary and include specific limits on the concentrations of volatile solids, chemical oxygen demand, total Kjeldahl nitrogen, oil, grease, mercury, lead and zinc. The exceeding of the stated concentrations for these parameters would preclude open-water disposal of the dredging spoil examined. In addition, other analyses are recommended under certain circumstances to determine the level of total phosphorus, trace metals, sulfides and pesticides. However, no enforcement capability is currently associated with these guidelines.

Nutrient or chemical-rich spoil can have significant effects on a disposal area. These can take the form of an increase in nutrients and a concurrent spurt in area productivity or a destruction of local organisms through the introduction of toxic materials. Such impacts are likely to be extensive in both time and area as these materials are slowly dissolved and spread through the water column. Onshore disposal of spoil can result in a leaching of chemicals into ground-water areas as well as adjacent surface waters, thus having implications for human consumption of these waters.

The burying of biologically productive land, whether off or on shore, is a serious but often avoidable problem. In underwater spoil disposal, the primary concern is for shellfish-producing areas. However, attention must also be given to areas of less obvious benthic richness which may serve as feeding or spawning areas for fish. The long-term effect of such coverage will depend on two principal factors: first, the similarity in terms of physical and chemical characteristics between the spoil and the original bottom material, and, second, the potential for repopulation of the area via the migration of organisms from surrounding areas. If the two conditions are positive, rapid recovery of the disposal area is likely to occur. If these conditions do not exist, a significant alteration of the local ecology will occur. However, under certain conditions the deposition of good-quality spoil offers the potential for creating new productive benthic areas in previously barren regions. Onshore disposal of dredging spoil, particularly in wetland areas, may create land usable for development, but the loss of biologically productive wetlands is an issue of enough importance that prohibition of this activity has occurred in some areas.

Underwater deposition of spoil alongside the channel area can increase shoaling and the need for maintenance dredging. Deep placement of spoil can alter the bottom topography of an estuarine area so as to alter currents, promote shoaling of adjacent areas, and increase the erosion rates of surrounding shorelines. However, by careful engineering, these same factors can have the opposite effect, i.e., promotion of scouring in channel areas and the accretion of local beach areas.

The use of spoil for the construction of an offshore island as part of deepwater port facilities offers an excellent solution to the problem of spoil disposal if the quality and the composition of the dredged materials is amenable to this solution and if proper environmental safeguards are taken. The formation of islands as wetlands and wildlife areas offers potential for the constructive use of dredging spoil. This solution has been tried in some areas with moderate success. The process involves the deposition of suitable material and its subsequent seeding with appropriate vegetation. However, great care must be taken in the construction of such islands so that erosion is minimal and the general hydrography of the area is not impaired.

The onshore disposal of dredging spoil has been a much-discussed topic recently. Traditionally, the use of fill to create new land areas near urban centers has been a lucrative undertaking. However, the recognition of the accompanying loss of thousands of acres of valuable wetland has brought this solution under severe questioning. Future onshore disposal must be carefully regulated with a view not only to this habitat loss and its accompanying ecological effects, but also to the type of development likely to take place in these filled areas and its implications. Constructive onshore disposal can also take place. Examples of this are the development of wetland areas, as mentioned above, and the nourishment of beach areas. Of course, the existence of such alternatives will depend upon the composition of the dredged spoil and the distance between the dredging and spoil areas.

Because of transport costs, ocean disposal of dredging spoil is the most expensive method of disposing of this material. However, the fact that alternative disposal sites are becoming more difficult to find leads to the possibility of the use of this method for the large volume of spoil contemplated in deepwater port development. The ecological effects of such disposal, beyond the problems mentioned above, are mostly unknown. This has prompted the discouragement of such practices, as noted in the recent publication Ocean Dumping: A National Policy [3].

This stand against the ocean disposal of dredging spoil is based on the fact that 80 percent by weight of all ocean dumping falls into this category, and the report further estimates that 34 percent of this material is polluted. No effective measures for the short-term solution to this problem were proposed. Those mentioned were the hauling of the polluted spoil to a point further out to sea to disperse the pollutants and to avoid the more productive near-shore lands, and the diking of polluted spoil disposal areas. The latter is not really effective because of the lack of sufficent land, the aesthetic problems associated with such areas, and the fact that leaching of pollutants will still take place. The long-term solutions suggested include high-temperature incineration, special treatment of the spoil to remove the toxic substances, and the general improvement in water quality to eliminate the pollution of bottom areas.

The analysis of the environmental effects of near-shore or onshore disposal of dredging spoil requires information on the composition (physical and chemical) of the dredging material, the physical and biological characteristics of the disposal area and the purposes for which the area is used.

When spoil is disposed underwater or within a water body, it is also desirable to know the depth of water, the dynamics of circulation and tidal patterns, existing water quality (including turbidity), and the nature of benthic material and organisms to help predict how the spoil deposits will affect water movement, water quality, flushing rates and material transport and deposition.

Environmental Problems Associated with Large Vessels

There are two major aspects of ship operations that are of concern from an environmental standpoint. One deals with the environmental effects of the physical presence and movement of the vessel. The other deals with the effects of operating procedures and the handling of waste materials and spills.

Problems with the Movement of a Vessel

The most significant environmental impacts of vessel movement stem from the motion of the water surrounding the vessel. This motion is set up by the movement of the ship itself, which displaces a large volume of water, and by the actions of the propeller driving the vessel.

The effects of the movement of a large, deep-draft vessel differ from those of a smaller vessel primarily in terms of magnitude rather than type. In small vessels the impacts may be unnoticeably small. The larger and deeper the body of water in relation to the size and speed of the vessel, the smaller will be the impact. Consequently, in the open, deep ocean, any waves or currents generated by vessel movement will generally dissipate without perceptible effects (except upon other vessels very close by). The problems associated with vessel movement are therefore limited to more confined and limited-size channels.

A vessel moving through such a channel can be compared to a piston moving through a cylinder. As the vessel moves forward, the water being displaced at the bow must move away to the sides and under the vessel toward the stern. This tends to set up a current moving toward the stern and bow waves moving off on both sides.

Such currents, turbulence and surface waves can, if of sufficient magnitude, affect the operations and safety of other vessels in the area, particularly of small recreational craft. If the channel is narrow, the currents and waves may cause erosion of the channel's sides and the shoreline. The propellers' turbulent action can add to the erosion as well as cause more complete mixing of the channel waters.

Erosion can create increased turbidity, the effects of which were covered in the dredging discussions. Also, mixing of the waters can alter temperature and salinity regimes within the channel, with effects upon marine organisms.

Ship movement may also significantly alter water temperatures. All ships have power plants for propulsion. Within current technology the efficiency of most propulsion systems does not exceed 35 percent. Consequently, 65 percent of the energy within the fuel is disposed of as waste -- much of it as waste heat. Depending upon the type of system, the waste heat goes directly into the atmosphere or into the surrounding water body.

In summary, the primary environmental concern of large vessel movement is its impact upon currents, turbulence, and surface waves in a restricted-size channel and the resultant impact upon the shoreline, other vessels and marine organisms.

In order to analyze the potential impact of a proposed alternative, a number of items of information must be known: the physical characteristics of the channel (such as depth, width and boundary materials), water circulation, currents, and water quality in the channel. There must be information on the important marine species in the channel and the general structure of the marine ecosystem. Also important to the evaluation is a knowledge of traffic density and type of craft using the channel and the uses made of the adjacent shores.

Finally, if an assessment of the environmental impact of a particular alternative indicates severe problems in the areas discussed above, it is essential to have a knowledge of ways of counteracting or overcoming the problems if they exist. For example, channels may be made wider and deeper than the ships require for navigation to reduce the current problems and erosion; erosion control engineering works may be applied to the shoreline and channel sides; ships may be required to move at slower speeds; the use of the channel may be restricted to the superships only, providing other channels for smaller craft. There are many such alternatives which can be conceived of in the abstract. Not all will be applicable to any one case. Each case must be treated individually.

Problems Associated With Ship Operations

Accidents associated with the operation and movement of a vessel are of major concern not only from the standpoint of safety, but also from that of the possible resulting pollution. Generally, accidents take the form of groundings, collisions with other vessels and ramming of fixed objects.

The huge ships carry a very large cargo volume which could be released into the environment as the result of an accident. This is of special concern in the movement of petroleum. The results of a total spill from a 300,000 d.w.t. tanker could have disastrous effects upon a coastal area and upon the uses of that area. The dry bulk commodities have much less of a potential for causing major environmental damage as a result of an accident, but even so, the spill from so large a vessel can have far more adverse impacts than from small ships.

The Coast Guard compiles and publishes data on oil spills. The most recent information [16] indicates that 3,711 polluting spills were reported in 1970 and totaled over 15 million gallons in U.S. waters. However, these spills are from all sources including onshore facilities (such as refineries, storage tanks and pipelines) as well as from vessel operations. About 9 percent of the total resulted from vessel collisions, groundings and capsizings.

Very large ships have different operating and maneuvering characteristics than smaller vessels. A ship carrying 200,000 tons or more of cargo at a speed of 12 to 15 knots will have a tremendous amount of momentum. Stopping distances under emergency conditions (referred to as a crash stop) can exceed 2 miles. The drafts required by these ships will limit their ability to make emergency turns and to move laterally to avoid collision in channels without adding to the danger of grounding.

There are tradeoffs between the large and smaller vessels, however. Assuming a given amount of the commodity will be shipped regardless of the type of vessel, then, of course, more small vessels would be needed to ship the same volume, and the traffic increase with small vessels could create more of a hazard and potential for spills.

There are management procedures and methods available to reduce the potential for accidents due to collisions and groundings. Traffic separation routes will, and in some cases do, reduce the danger of collision, especially when ships are operating in adverse weather such as heavy fog. In convergence areas at the entrance of harbors, specific traffic control systems could be established similar to air traffic control procedures now in continual use. In addition, advanced scheduling of fewer, larger vessels in and out of the ports, with due regard for weather delays, could contribute significantly to traffic management.

The mandatory use of electronic surveillance equipment such as radar, in conjunction with direct ship-to-ship and ship-to-shore communications, could significantly reduce the hazards. Such systems not only would reduce the hazards of environmental damage, but would also contribute financially by reducing shipping losses.

On a worldwide basis, vessel casualties contribute an estimated 11 percent to the entire ocean oil pollution problem [15]. Even more significant, however, is the estimate that about 34 percent of all oil pollution in the oceans is caused by tank cleaning and bilge wastes along with bunkering and minor leaks. Requirements to hold oily ballast, bilge and washing wastes for shoreside discharge and treatment could alleviate much of this problem, especially in the coastal and estuarine areas near port facilities. But costs in terms of time delays at the dock for pumping ballast and bilges and expansion of shore facilities for treating these wastes are not insignificant problems.

The problems of sanitary wastes are not unique to large vessels or even to tankers. In fact, the larger vessels usually have a smaller crew per ton of cargo and therefore create less of a problem from human waste disposal than do many smaller ships.

One of the main stumbling blocks to the prevention of pollution by the discharge of untreated waste is the difficulty in monitoring and control. This is especially true at sea.

Ship designs can be developed for overcoming many of these problems, but each such shipboard change is an added cost and therefore meets with resistance from an economic standpoint. National and worldwide agreements which would require that vessels be designed to handle wastes in a nonpolluting way (clean ballast systems, sewage treatment systems, etc.) would impose the same cost increases on all operators and would alleviate some of this resistance.

Environmental Problems Associated With Deep Port Shore Facility Development

The environmental implications of shore facility development associated with new deepwater ports deal primarily with land use problems and the large number of "subproblems" which generally accompany significant land use changes. The problems will vary from one alternative to another, depending upon a number of factors. The four principal factors, or dimensions which combine to dictate the impacts, are:

1. Whether the site selected is a new or "virgin" area or an existing port

2. Whether the principal development is on shore or off shore

3. Whether the port is for transfer only or is also planned for processing

4. The type or types of bulk commodity that will move through the port.

Each component of the given port system will have certain design characteristics that will determine how existing and planned land use will be affected. In the context of the delivery system, the shore facility problem starts with the point of loading/unloading and is a factor in each component through the processing. Berths, docks and bulkheads will alter a hitherto undeveloped area substantially, especially where there are important wetlands or beaches. If the area has already been in use as a port, then these changes to accommodate superships may have little or no significant environmental effects or, in fact, may provide substantial improvement in cases where the existing waterfront is in a state of decay.

If the principal berthing for the large ships is off shore (as is generally the case) with some sort of buoy or fixed structure, then the first shore facility impact will likely occur through the development of a pipeline, trestle or some other means of conveying the commodity between the shore and the vessel. An underwater pipeline will have little or no impact on the shore except at the immediate point of entry, and even then the impact may be temporary, occurring only during construction.

Depending upon the type of commodity, large machines are frequently needed to handle material. Equipment such as large shovels, cranes and moveable booms will have an impact, especially on the visual aspects of the shore and near offshore areas. In such a case, oil equipment would likely have the minimum environmental intrusion.

Of major concern in shore facility problems is the need for space and structure for storage of large quantities of bulk commodities. Oil will require large tanks, taking up considerable space and altering the nearby landscape's visual character. Some of the dry bulks (especially grain and phosphate) have to be protected from the weather to maintain their value. Other bulks can be stored outside, but they will still require large areas to accommodate enough volume to satisfy requirements matching the use of superships. Even when the berthing and loading/unloading are located off shore, there is generally the need for onshore storage. The only exception to this is in the development of offshore islands with storage capacity.

If the site is an existing port there will still be a need for expanded storage. In fact, finding the space may be a significant problem in a heavily developed area. It could well mean the displacement of other land uses and will have to be evaluated on an individual basis. The kind of impact on a new area will be different. The site will probably be selected so that space is not the problem. The visual aspects may be very significant. Also, where large surfaces must be paved or otherwise covered, there may be a significant alteration in the behavior of precipitation runoff from these surfaces.

This must be taken into account during the design phase of development. In new development there is also the opportunity to select sites which cause a minimum of environmental intrusion by avoiding ecologically sensitive areas and by placing structures back from the immediate shoreline.

A final element in the analysis of shore facilities is the development of processing facilities and other industry associated with the bulk commodities. This can have a more significant environmental impact than any other component of a deep port system over a long period of time. Processing facilities themselves frequently use large land areas; generate waste products that add to air and water pollution and solid waste disposal problems; create significant intrusion on the visual environment; place demands upon local water supplies; and, if successful, create employment that will tend to increase area population and demand for housing and services such as roads, sewers and schools. If the area of the new deepwater port is already heavily developed, such new growth can create congestion that places severe burdens on existing utilities and services. Development in a new area can take these problems into account through proper site selection, design and planning. But there is no automatic guarantee that it will happen. In fact, it is likely not to happen in a satisfactory way unless effort is put into this aspect of any new port during the planning and design phase of development and is followed by the implementation of enforceable controls.

In an evaluation of the impact of shore facility development, there are two different philosophies which should be recognized and considered. First, there is the point of view that adding new and larger facilities and possible further water, air and visual pollution to a port site now in use and of significantly altered environment will have less of an impact than a new port in a virgin stretch of the coast. On the other hand, there is the argument that existing port areas are too heavily used and congested and that environmental degradation should not be allowed to proceed further and, therefore, that new deepwater port development should look to new areas where adequate planning and regulation can maintain an orderly, environmentally acceptable pattern of growth.

In either case there are alternatives for combating environmental problems. Expansion in existing ports can be designed to improve the area. This is especially true where existing port facilities are old and outdated. Renovation could substantially improve the total environment of the area. In totally new locations, the most modern precautions could be taken to preserve the environment.

There are a number of items of information which are necessary for analyzing the impact of shore facility development upon the environment. Information on the present land uses and level of each should be available. Included in this category of information would be land used for residential and industrial purposes, agriculture (by type), fish and wildlife, recreation and open space. Note should also be made of any area which has unique natural or manmade features.

Planned development for the area will also be important information, especially for ascertaining how the area will develop without the port as compared with the addition of the port, and whether the character of the new port will be in keeping with current development plans.

Present and projected population and the distribution of this population over the area will be of use in analyzing the need for services and housing.

The general visual or aesthetic nature of the area should be provided to give a base upon which to judge the effect of new shore facilities. Present air and water quality should be at least generally characterized. Existing and planned utilities (such as water supply, sewage treatment facilities, transportation links, etc.) should be described in enough detail to allow an analysis of the impact of new port facilities on their utilization.

And, finally, there will be a need for information pertaining to existing statutes, regulations and regulating agencies in the area of land use and associated problems.

Environmental Problems Associated with Offshore Facilities

There are a number of different offshore facilities which may be developed to fill the need for handling deep-draft vessels and their cargoes. Such facilities range from a single point mooring buoy with an underwater pipeline to shore to a large island with protected berths and storage for the commodities. Each will have its own impacts, governed not only by its design, but also by its specific location.

The major potential problems associated with offshore structures deal with their effects upon the movement and flow of the surrounding waters and the direct and indirect effects upon both sessile and mobile marine organisms. There may also be other problems. Offshore structures can obstruct traffic, and the development of processing facilities can generate air and water quality problems.

Impact on Water Movement

A floating buoy-type structure such as a single point mooring will have no appreciable environmental effect. For all practical purposes such a structure will allow passage of all moving waters and will not obstruct wave motion. Consequently, from this standpoint the structure itself should not be of concern.

Structures built on pilings, such as booster stations, through which water may flow serve to alter the movement of swells and waves, especially if the above-water solid portion of the structure is low enough to impede wave movement. If this is the case, and wave movement to the shore is altered, the effects may be significant. If the shoreline is used for beach recreation, the loss of surf may reduce its desirability. The loss of wave action could also significantly alter the movement of sand to and from the beach.

Long structures with an extensive string of pilings may also alter the circulation and flow of water. While little is really known about how circulation and flow will be affected, there appears to be evidence that the bridge tunnel across the Chesapeake Bay has substantially reduced water movement in the upper part of the bay. So this possible effect should not be overlooked.

A solid offshore structure such as a filled island, breakwater or jetty will definitely have an impact on the movement of water. Just what the impact will be depends directly on the location of the structure, its size, and the character of the water movement before construction. Islands can be shaped to minimize their effect on the movement of water. A solid structure which extends above the surface will stop waves from passing through. Prevailing current and water circulation will be altered as a result of the new physical regime. Just how a circulation pattern will be changed is not well understood. Many variables, including the tidal flow and tidal prism, the water depth, size of the water body, and water inflow will all have an influence on how the existing water movement will be altered.

Secondary effects of changes in circulation and wave action may also be important. As previously mentioned, the effect on shoreline surf may be significant. Changes in water flow in partially enclosed bays and estuaries may also alter the salinity and water quality. A decrease in flushing would tend to lower the salinity of a bay's waters while decreasing the rate at which pollutants are removed to the ocean. Such changes in water movement may also significantly alter the way that sand and other solid materials are transported and deposited. Resultant changes can be loss of beach where the sand would normally be deposited and deposition where there ordinarily would be little or none. This can have important implications for other uses such as recreation and shoreline residential use. And it can cause increased sedimentation in the channels, resulting in an increase in maintenance dredging or loss of channel.

Impact on Marine Organisms

The direct impact of offshore structures on marine organisms is generally brought about by the alteration of bottom conditions and by the presence of a structure where there was none previously.

Buoy or floating-type structures will have no significant impact on benthic organisms except in the very limited area of anchorage required to hold the platform in place. It has been noted, however, that many fish tend to congregate around such a structure. This does not indicate an increase in populations, but merely a movement of the individuals from some other location. Such an increased collection of fish may be beneficial to the sport fisherman. In total, the impact of floating platforms on marine species is not of major concern.

The case of solid structures created by diking and filling is a different story. Naturally, a filling operation will cover completely any benthic organisms that are located at the site. If the area to be filled is an important shellfish area, its value for that purpose will be destroyed. Another aspect of this problem is generated by the need for large quantities of sand and fill to construct the island. If the material is dredged from areas where shellfish grow, the problem may be compounded. (This aspect was treated more fully in the discussion of dredging.)

In the case of finfish, an artificial island may create a desirable habitat where none existed before, increasing the concentration of certain species. The face of such a structure, often constructed of rock with holes and irregular surfaces, provides shelter and feeding areas and may be beneficial from an ecological standpoint.

Impact of Material Handling
Links to Shore

Unless the offshore facility is strictly a transshipment facility, there will necessarily be some way to move the commodity from the facility to the shore. Liquids (primarily petroleum) will usually be moved through a pipeline, while dry bulks will usually be moved by a conveyor or trestle of some sort. The technology of moving dry bulks through pipelines by the slurry process has been improving, however, and this method may be used more and more in the future.

Although pipelines may be placed on pilings and kept above the water surface, they are frequently submerged on or in the bottom. Lines which are buried in trenches are protected from the influence of currents and tides and are less susceptible to damage caused by vessel movements and anchors. The laying of a buried pipeline will have temporary effects upon the benthos (see dredging discussion), but once the bottom material readjusts the significance of such effects should disappear.

Pipelines which are <u>on</u> the bottom are more susceptible to damage from physical contacts and currents and have a higher chance of breaks and ruptures and consequent spills. They also may obstruct water circulation, especially in relatively shallow areas near shore.

The use of trestles or conveyors necessarily requires structures to support the apparatus above the water surface. The pilings should have little permanent effect except as was noted earlier and, perhaps, may increase the concentration of fish in the immediate vicinity.

Such above-water structures will create visual changes and, if they are located in an area of high-value recreational or residential shoreline, the visual properties may detract significantly. This will be especially true if the material handling creates noise or significant dust in the immediate area. It has been suggested that such conveyors could be put through tunnels from the offshore structure to shore storage or processing.

Impact of Offshore Operations

The greatest potential for environmental problems with offshore facilities stems from the specific operations conducted rather than from the physical presence of the structure. These impacts are the same as those associated with the operation of shore facilities.

Wastes from vessels -- ballast and other oily wastes and sanitary wastes -- must be contained and treated to prevent water pollution. Facilities for handling such wastes must be part of any development. If the offshore structure has housing and quarters for crew, waste treatment facilities must be included for onsite disposal or transport to other treatment locations.

Storage of commodities may, if not properly planned, cause runoff and accidental spills in surrounding waters.

A major point for consideration in offshore facilities is the safety of the vessel and equipment during operations. Single point moorings with no protective breakwaters have a much higher potential for accidents and spills than do fixed berths with protective breakwaters.

Considerable attention has been given lately to the concept of multiple-use offshore islands to serve a number of purposes, including deepwater ports, airports, and sites for power production. Such uses will have impacts upon the environment. Airports will generate noise, air pollution, and a certain safety hazard. Generating stations discharge large amounts of heated water, air pollution from fossil fuels, and possible radioactivity from nuclear plants. But the siting of these facilities offshore may be far more acceptable than onshore locations.

The information needed to analyze and evaluate the impact of an offshore facility depends directly on what type of a structure is anticipated. For solid structures situated on or in the bottom, the nature of the benthic material and organisms should be known.

For structures which may obstruct water movement, the circulation and tidal movements and their relationship to flushing, material transport and salinity are necessary pieces of information. For structures that protrude above the surface so as to be clearly visible, other activities which could be affected either by physical obstruction or aesthetic intrusion should be known. And, finally, it is important to know what other waterborne traffic may be affected by the presence of an offshore structure from the standpoint of both vessel safety and structure safety.

Public Agency Role in Deepwater Port Development

Many Federal and state agencies would be involved in the approval of any proposal for the development of a deepwater port. At the Federal level, control over such an undertaking resides with the U.S. Army Corps of Engineers. This power stems from their mission to protect and preserve the navigable waters of the United States. In this capacity, they issue permits for any dredging, construction, or discharge into these waters. When such activities are within the boundaries of a state, the approval of any application is coordinated with the state involved.

Other Federal agencies become involved in the decision process through two legal mechanisms. The first of these is the Fish and Wildlife Coordination Act; the second is the National Environmental Policy Act of 1969.

The Fish and Wildlife Coordination Act and the 1967 Memorandum of Understanding between the Corps of Engineers and the Department of the Interior provide for the review of projects which would alter any water body. The goal of such a review is to delineate any anticipated adverse effects on fishery and wildlife resources resulting from the proposed activity. The principal agencies involved in this review are the Bureau of Sport Fisheries and Wildlife of the Department of the Interior, and the National Marine Fisheries Service in the Department of Commerce. Although these agencies can disapprove of any activity reviewed, their objections can be overruled by the Secretary of the Army.

The National Environmental Policy Act of 1969 requires the development of an environmental impact statement for any major Federal activity significantly affecting the quality of the human environment. Such a document is reviewed by all agencies having "jurisdiction by law or special expertise" with respect to any environmental impact involved. The goal of such a review is an informed decision on the advisability of any such activity. However, the mechanism by which such inputs are made a part of the decision-making process is unclear. Further, any review comments carry no legally enforceable power, but are only suggestions. The principal natural resource-oriented agencies which would be involved in such a review and their area of concern include:

1. National Oceanographic and Atmospheric Agency -- the accuracy of statements regarding weather conditions, ocean currents, and ocean bottom condition; the probable impact on any marine or anadromous species and any commercially important freshwater species of fish

2. Bureau of Sport Fisheries and Wildlife -- the impact on any freshwater or estuarine fish species and wildlife resources

3. Bureau of Outdoor Recreation -- the impact on any parks, recreation areas, or wildlife and waterfowl refuges

4. Environmental Protection Agency -- the impact on water and air quality.

Other agencies of the Federal Government would also be involved in the construction and operation of a deepwater port facility. The principal agencies and their pertinent missions include:

1. U.S. Coast Guard -- enforces Federal laws on the high seas and navigable waters, including those applicable to safety standards; establishes and maintains aids to navigation; has responsibility for coordination of oil recovery in the event of a spill

2. Federal Maritime Commission -- administers section of the Water Quality Improvement Act of 1970 with respect to financial responsibility of owners and operators in the event of a spill

3. Federal Power Commission -- issues certificates for construction and operation of interstate pipelines.

State and Local Agencies

State jurisdiction in port development centers around the leasing of riparian rights for such things as pipelines. In some cases, as in Delaware, the state has zoning authority with regard to the establishment of parks and various types of industrial development near the shoreline. In all cases, local government agencies would be involved with the question of land use and zoning for any onshore development. The pertinent agencies in these areas will be briefly discussed in the chapters on specific alternatives.

International Agreements

At the international level, some agreements have been worked out concerning ship design and oil pollution regulations. The principal agency involved here is the Intergovernmental Maritime Consultative Organization, a branch of the United Nations. A discussion of the specific regulations and concerns of this group will be found in the discussion of petroleum in chapter III.

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III. ENVIRONMENTAL EFFECTS OF BULK COMMODITIES

The Environmental Aspects of Petroleum in a Port Delivery System

With regard to a deepwater port delivery system in the United States, crude petroleum is more important than petroleum products in terms of present and projected volumes of waterborne imports and length of ocean haul. In 1967, petroleum tonnage represented 54.5 percent of total world seaborne trade [2]. In the United States, crude petroleum imports totaled 1,324,000 barrels per day in 1970 and are projected to reach 19 million barrels per day by 2000.1/ Thus crude petroleum is a primary commodity with which to attempt to capture the economies associated with supership transport.

This section will be directed primarily toward crude petroleum. Mention will be made of any significant differences in environmental impact as related to product movement where necessary.

An in-depth, definitive treatment of all aspects of a crude petroleum delivery system that can influence the environment is beyond the scope of the present work and, indeed, beyond the current state of the art. For example, no methodology exists for predicting the probability of a spill. We can only highlight the important factors to be considered in reviewing such a system.

1/ Robert R. Nathan Associates, Inc.

Therefore, the following sections will discuss the general nature of crude petroleum in terms of its physical and chemical characteristics and the problems attendant upon an oil spill, including its effects and the mechanisms for its cleanup. Each component of a port delivery system transporting petroleum will then be discussed in terms of its impact on the environment. Finally, questions to be asked and data needed to evaluate the impact of a petroleum delivery system in a specific locality will be enumerated.

Nature and Environmental Impact

General Characteristics

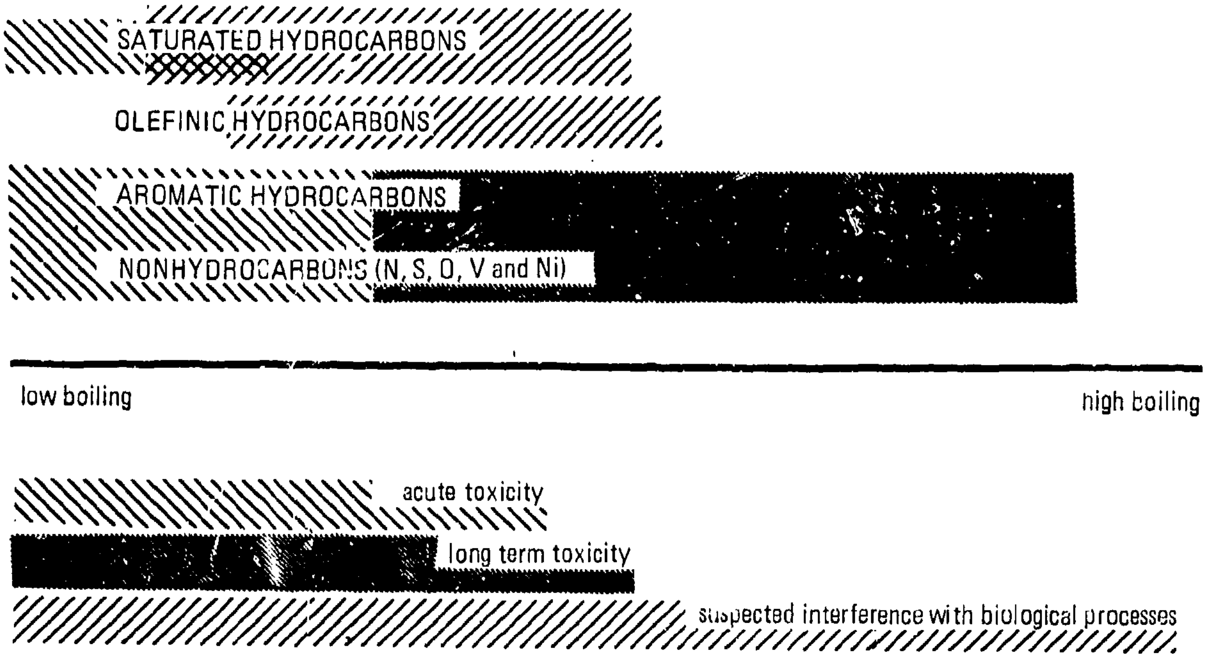
Crude petroleum is a very complex substance whose physical appearance and chemical composition vary widely depending on its source. Variations are found in crude petroleum not only from different parts of the world, but also from different fields in the same area. Thus, crude may appear as a yellowish-brown mobile liquid, a black viscous semisolid, or anything between [21]. Corresponding to this variation in appearance is a similar range in physical/chemical properties such as specific gravity, boiling point, volatility, etc. This variability is caused by the different proportions of the various hydrocarbons contained in the crude, the occurrence of nonhydrocarbons (e.g., sulfur, nitrogen, vanadium, etc.), and the amount of dissolved gas in the oil. These characteristics are important not only in terms of the type of processing to which the crude will be subjected and the number and quality of the products obtained, but also in terms of the commodity's impact on the environment.

Environmental Impact

As a substance, petroleum "under control" impacts on the environment primarily through its volatility and flammability. Although these characteristics are more often associated with petroleum products, they are also important in crude petroleum. The vapors of petroleum can be highly toxic to man and, throughout the port delivery system, present a problem of air pollution. These vapors also have a low flash point and present a constant threat of explosion and fire. This danger has been underlined recently by a series of shipboard explosions, and much attention is currently being directed toward eliminating this hazard. Although these properties often represent significant environmental concerns, the most critical impact of petroleum occurs when it is released "out of control" into the environment. This more important impact is due primarily to petroleum's toxicity and, secondarily, to its "clinging" qualities.

Figure 2 illustrates the relative toxicity of the various components of crude oil as described by Blumer [9]. Low concentrations of the low boiling saturated hydrocarbons have been shown to produce anesthesia, while higher concentrations can produce cell damage and death in some lower animals. From this evidence, Blumer warns that this fraction of crude oil may be especially harmful to the larval and other young forms of marine life. The higher boiling saturated hydrocarbons are not seen to have any direct toxic effect on marine life, although some interference with biological processes may exist. The aromatic hydrocarbons are the most dangerous fraction of the crude petroleum. The low boiling aromatics are acute poisons. It is in this latter category that potential carcinogens are thought to exist. The toxicity of nonhydrocarbons of crude oil is believed to resemble that of the corresponding aromatic compounds. In addition to being toxic, the various hydrocarbons are persistent, which increases their potential harmful effects in the event of a spill.

Conflicting evidence has been cited as to the actual destruction of marine life as a result of a spill. A study of the results of a spill of 650 tons of #2 fuel oil off West Falmouth, Massachusetts, showed that widespread destruction occurred. Many forms of marine life were killed initially, and shellfish within a wide area were so contaminated as to be unfit for human consumption. In addition, 10 months after the spill, pollution in bottom sediments was still discernible and spreading [4]. On the contrary, a study of the spill associated with the Santa Barbara blowout showed a minimum of destruction and a rapid repopulation of affected areas [10].



Note: Olefinic hydrocarbons are not found in crude oil, but do occur extensively in petroleum products. Their effect upon aquatic species in the event of a spill is not known.

Source: Max Blumer, 'Oil Pollution of the Ocean,' in Oil on the Sea, ed. David P. Hoult (New York: Plenum Press, 1969), p. 8.

FIGURE 2. COMPOSITION OF CRUDE OIL AND TOXICITY OF ITS FRACTIONS

This variation in impact can partially be explained on the basis of the materials involved. The spill at West Falmouth involved a product containing a high percentage of highly toxic aromatic hydrocarbons, while the Santa Barbara spill involved crude oil. In the latter case, the percentage of aromatics was much lower and, being highly volatile, tended to evaporate quickly, leaving a much less toxic residue. A further explanation for this disparity may be found in the physical conditions surrounding the respective spills and the extent and detail of subsequent observations.

A resolution to the question of the toxicity of petroleum in the marine environment must be found in more detailed in situ studies. Mere visual observation of petroleum residues and affected areas is not sufficient. Work must be directed toward an understanding of the ultimate disposition of these compounds with regard to their concentration in the food chain and their potential health hazard to man. In addition, long-term studies of affected organisms should be undertaken to determine any changes in population dynamics. These studies should be undertaken in areas of low-level chronic pollution such as harbors, where the long-term effects may have more serious consequences to man than the spectacular vessel spills.

Beyond the chemical toxicity of oil, the mere presence of this clinging substance can become a menace. A notable example of this is the effect on waterfowl which come in contact with an oil slick. The oil reduces the buoyancy of the birds and interferes with the protective layer of trapped air in the plumage, thus leading to death from drowning or exposure. In addition, the aesthetic impact of oil-soaked coastal lands and the subsequent interference with man's recreation and other activities can be significant.

Oil Spills

Occurrence. As petroleum moves through the port delivery system, many circumstances and conditions occur which offer the potential for an oil spill. On a global scale, it has been estimated that 4.9 million metric tons (approximately 1.5 billion gallons) of oil are spilled into the world's oceans annually. Of this amount, some 47.1 percent is estimated to originate from vessels or vessel-related activities; 2.1 percent, from offshore operations; and 50.8 percent, from onshore facilities, including refineries [15].

A slightly different view of sources of oil spills is found in a review of 3,711 spills reported to the U.S. Coast Guard during calendar year 1970 [22]. Of these spills, 32 percent were attributed to vessels, 23.8 percent to offshore facilities, 19.1 percent to onshore facilities, and the remainder (24.3 percent) to miscellaneous or unknown sources. Unfortunately, more than one-half of the spill reports submitted to the Coast Guard did not contain information on the volume spilled. However, it is interesting to note that of the total 15.2 million gallons spilled (identified in 1,352 reports), some two-thirds of this amount was accounted for by four spills. Two of these had their sources on offshore platforms, one at a waste oil reservoir, and the fourth in the collapse of an onshore oil tank. By far the most significant cause of spills was personnel error, which accounted for over one-third of the cases in which a cause was cited.

A more detailed review of the Coast Guard report serves to emphasize the many possible sources and causes of a polluting spill. More discussion of these and of possible preventive measures will be given as each appropriate system component is considered. Once a spill has occurred, however, the main efforts must be directed towards (1) containment, and (2) removal of the spilled material. The ease and degree of success with which these tasks are accomplished and the mechanism chosen to accomplish them will depend on a number of factors. In an aqueous environment, the condition of the water in terms of waves, swells, currents, and temperature will be a determining factor. On land, the texture and moisture content of the contaminated surface will exert an influence. In both areas, atmospheric conditions, the presence of various organisms and the delay between occurrence of the spill and initiation of responsive action will be important.1/

Containment. When oil is spilled upon water it tends to spread rapidly out into a thin film. The containment of the spill in a confined area becomes very important not only to prevent its approach to valuable areas such as beaches and wetlands, but also to expedite its removal by the various methods discussed below. Two principal types of containment apparatus exist, i.e., pneumatic barriers and mechanical booms. Investigations have also been undertaken into various types of chemical barriers.

Pneumatic barriers are perforated tubes that are laid beneath the water's surface. Compressed air is forced through them, thus setting up at the water's surface a current which serves to counteract the spreading tendency of the oil. This countercurrent contains the oil within the boundaries of the barrier. Although such barriers are currently being tested under a variety of conditions, they are severely limited by the amount of power available, thus making them ineffective in strong currents or waves. This limitation, combined with the fact that they are not readily mobile, restricts their area of operation to fixed areas of calm water such as slow-moving river locations.

Mechanical booms consist of floating booms beneath which are hung weighted curtains, often 1 to 2 feet in depth, and above which are affixed "sails" of variable height. These booms can be either permanent fixtures, such as those found about docking and unloading areas,

1/ It has been suggested that under certain circumstances no effort to contain or remove an oil spill should be undertaken. A spill on the high seas, where no coastal lands are threatened, is seen as one circumstance in which the dispersal forces of the ocean's waters can be sufficient to remove a spill. Also, when contaminated coastal lands are either unused rocky lands or unused beach areas (during the winter months for instance), it is felt by some that removal is best left or, more commonly, mobile units which can be towed to the site of an oil spill. Much research has gone into the design of mechanical booms, but unfortunately those currently available seem to be ineffective in currents over 1 knot and waves over 2 feet.1/

Even if water conditions are such that containment is possible, the speed with which the boom is deployed can be critical to its effectiveness. Current research is being directed toward air-deliverable compact systems to solve this problem.

A new approach to oil containment through the use of chemical barriers is now being explored. These would consist of substances which would have the ability either to gel the slick or to spread quickly so as to contain the slick. Little information is available on the effectiveness of such techniques.

Removal. The "removal" of an oil spill upon water may be accomplished through the actual physical removal of the oil -- the preferred method from an environmental viewpoint -- or through the cosmetic removal of the oil from the water's surface. Complete removal can be accomplished by skimming devices, burning, or the application of absorbents. Cosmetic removal is accomplished via dispersants or sinking agents.

Two principal types of skimming devices are currently available. The first relies on the use of settling tanks to separate the oil and water mixture after it has been picked up by a suction or a mechanical device. The second type utilizes a revolving drum or belt

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to the forces of nature. Such a decision can be justified on both economic and aesthetic bases, but the yet-unanswered question of long-term toxicity leaves such a lack of action open to question.

1/ The Coast Guard is currently testing a prototype oil containment barrier designed for 4-foot seas, 2-knot currents, and 20-m.p.h. winds. Preliminary tests were deemed satisfactory, but the boom has not yet been tested under actual conditions.

covered with polyurethane to remove the oil from the water and transfer it to storage tanks. These devices have proved moderately effective, but are hampered by limited capacity and an inability to function in rough water.

The burning of spilled oil and the subsequent removal of a smaller volume of noncombustible, tarry residue has not proved to be a feasible solution to the problem of spill cleanup. The volatile portions of the oil tend to evaporate quickly, and the addition of wicking agents to remove the oil from the cold underlying water and enhance the burning of the more viscous residues has not been satisfactory. Large amounts of wicking agents are needed, and, since they are usually fine powders, much difficulty is encountered in their dispersal in even moderate winds. In addition, considerable air pollution is generated by this method.

A wide variety of substances is available for use as oil spill sorbents. These include either natural or treated minerals such as pumice or perlite, manufactured substances such as polyurethane, or natural vegetable material such as straw or corncobs. A recent study by Dillingham concluded that among these, straw was the best absorbent currently available [6]. Some of the same problems which occur with wicking agents in terms of dispersal are also inherent in the distribution of absorbents, which tend to be very light. In addition, the recovery and disposal of the oil-sorbent mixture can present difficulties. In rough waters, recovery is usually accomplished by the use of special nets. In calmer waters "the use of floating-trash collection vessels, aquatic weed harvesting devices, or manual collection with nets, screens, and pitchforks has been successful" [6]. Disposal is usually accomplished by burning or onshore burial. Some efforts have been directed toward recovering the collected oil, particularly from polyurethane, and 80 percent recovery has been cited in some cases [5]. However, regardless of the problems involved, the use of absorbents is the preferable form of oil spill cleanup from the environmental point of view.

The use of dispersants has been the most common form of oil spill treatment in the past. The aim in using a dispersant is to break up the oil film and to cause the formation of fine oil droplets which are more susceptible to natural degradation. An effective dispersant must do this in such a fashion that the droplets do not reform into a slick. This is accomplished through the use of a surfactant, a substance having both hydrophilic (water-adhering) and lipophilic (oil-adhering) properties. The surfactant is added to a solvent, either a water or petroleum compound.1/ The substance is then applied to the slick and sufficient mixing energy is generated to cause the formation of an emulsion. This mixing energy may be provided by the natural turbulence of rough waters or via that caused by a ship's propellers. A lack of sufficient mixing has been cited as the cause of most ineffective applications of dispersants.

There has been much debate on the effectiveness and environmental impact of using dispersants to treat spilled oil. This controversy arose from the disclosure that in the Torrey Canyon incident, the dispersants used to clean up the oil were several times more toxic than the oil itself. Such evidence has led to complete prohibition of the use of these substances in many areas.

Much work is now being done to develop chemicals which are effective dispersants but which are not toxic to marine organisms. However, the question of the ultimate deposition of petroleum in the marine environment and its potential harmful effects must still be answered before the use of dispersants, as opposed to physical recovery, can be considered as a satisfactory answer, regardless of economies.

The last class of materials used to treat oil spills is sinking agents. These are usually fine-grained substances to which the oil will adhere and

1/ In the case of the Torrey Canyon, an aromatic solvent was held accountable for the toxic effects of the dispersant.

which, because of their density, will then sink to the water bottom. Materials used as sinking agents include sand and a wide variety of treated powders. Two main questions arise with regard to sinking agents: (1) How long will they retain the oil?, and (2) What effect will they have on benthic organisms? Because no firm answers are available to either of these questions, the use of these agents seems to be one of the least environmentally satisfactory ways of dealing with a spill.

Once spilled oil has reached the shore, its removal is very difficult. The placement of absorbent materials on shore and the subsequent manual or mechanical removal of the oil-sorbent mixture is the most effective technique. However, if the oil has become weathered before remedial measures can be undertaken, removal will be difficult if not impossible. If the contaminated substance is sand, removal through the use of earth-moving equipment may be feasible. Burial of the coated sand has also been attempted, but resurfacing of the oil is quite possible. Burning weathered oil has not proved feasible even with the aid of burning promoters. Some success has been achieved with the application of emulsifiers, followed by the use of water jets or waves to wash away the oil. However, this technique has the same problem of toxic effects as is found in the open-water use of dispersants.

Organization for combating spills. A successful attack on spilled oil requires prompt detection, rapid availability of the proper equipment, and sufficient funds for operational support.

The Torrey Canyon incident prompted a flurry of activity directed towards these goals and culminated in the National Oil and Hazardous Materials Pollution Contingency Plan, which was established in June 1970. This plan provides an organization on both national and regional levels designed to respond to a spill in terms of equipment and operational expertise. It also serves to coordinate the efforts of the many agencies having responsibility in this area, including the Departments of Interior; Transportation; Health, Education and Welfare; and the Office of Emergency Preparedness.

The industry has also responded to the pollution threat via such organizations as TOVALOP (Tanker Owners' Voluntary Agreement concerning Liability for Oil Pollution). This scheme, currently involving some 80 percent of the world's tanker tonnage, sets up a mechanism for reimbursing the national Government for cleanup operations which cannot be handled by individual concerns. In several port areas, the industry has also banded together to purchase equipment and set up provisions for removing spilled oil.

New developments for detecting spills involve airplane surveillance of coastal areas and the possibility of detecting offshore spills by weather satellites. As mentioned before, systems are also under development, especially by the Coast Guard, to develop air-deliverable packages of containment and cleanup equipment for rapid response to polluting incidents. Further work along this line will be needed to respond to the potential for large-scale spills associated with supertanker movements.

Petroleum Port Delivery System

Vessel Transport

The first component of the port delivery system is concerned with the movement of tankers from the point of origin to the unloading facility. The number and size of these tankers have increased steadily and will continue to grow to keep pace with the expanding requirements for petroleum. Currently several tankers of over 250,000 deadweight tons (d.w.t.) are in operation, and projections exist for vessels of up to 1 million d.w.t. As with all system components, two primary areas of environmental concern are associated with these mammoth tankers: those resulting from normal operating procedures, and those concerned with accidents which may result in the spillage of large amounts of oil.

Normal operations. The environmental impacts associated with any large vessel in the course of regular operations have been covered elsewhere. Of concern here are those impacts which are particularly applicable to tankers carrying petroleum, i.e., impacts associated with the discharge of oil-contaminated ballast water and washing residues. Although such discharges have been appreciably reduced through the introduction of new techniques and the development of international discharge regulations, it is still estimated that almost 20 percent of the oil pollution of the oceans results from such operations, a total of almost 1 million metric tons annually [15].

A major breakthrough in the problem of oil discharges occurred with the development of the load-on-top (LOT) technique by the oil companies in the early 1960's. This procedure involves the transfer of contaminated water to a slop tank in which the oil and water tend to separate so that the acceptably clean water can be decanted and discharged. New cargo is then loaded on top of this residue,1/ and the mixture is delivered to the refinery where the salt water is removed and the entire cargo is processed. Although the LOT technique reduces the amount of oil discharged to the oceans, some difficulties exist which prevent it from being a final solution to this problem.2/ Visual inspection of the effluent is currently used to determine when the oil content of the water has reached the point at which overboard pumping should be stopped. At night or in rough water, difficulties in determining this point could allow the discharge of considerable amounts of oil. A solution to this problem must be found in the perfection of oil-water interface indicators which can be combined with automatic control of pumps. In conjunction with this, further work needs to be done on mechanical oil and water separators which could be installed on vessels already in operation.

1/ It has proved feasible to utilize this residue on board as fuel, but the equipment to do this is very expensive. It is therefore not currently a practical solution to the problem of oil residues.

2/ Beyond the technical difficulties, LOT has been only partially effective because 25 percent of petroleum carriers do not employ this technique [8]. The reason given for this fact is that some refineries refuse to accept the salt-water-contaminated cargo. In addition, some products being delivered to consumption points are not amenable to this mixing. Returns from such product deliveries may also be of such short duration that sufficient time is not available for the separation of the oil and water mixture to occur.

Although these developments could drastically reduce the oil discharge problem, a complete solution can only be found either in the development of completely clean ballast systems or in an increase in the number of ballast receiving and treating equipment at terminal facilities. The latter has been a long-term goal of the Intergovernmental Maritime Consultative Organization (IMCO), but its realization is doubtful because of the costs involved.

There are two approaches to the provision of clean ballast systems. The first of these involves the construction of shipboard tanks specifically for ballast. Such a system adds appreciably to both the construction and the operational costs of the ship because it decreases cargo space. However, it can offer secondary benefits in terms of safety as when ballast areas are provided in double-hulled bottoms or in wing tanks. A second alternative for a clean ballast system utilizes collapsible containers in the holds. These plastic membranes can act as floating roofs in the tanks. When oil is loaded from the bottom of the tank, the membrane remains folded at the top of the hold. When ballast is required, filling is done through another set of pipes into the top of the hold, causing the membrane to unfold and preventing the water from coming in contact with the oil-covered walls. This technique is still under development and, although it would involve additional costs, it would not be as expensive as the clean ballast construction system.

The recognition of the problem of oily discharges led to the establishment of international agreements on restricted discharge areas and on the quality of discharges. Current regulations prohibit discharges within 100 miles of any shore and restrict the amount of oil in the effluent to 100 parts per million. Amendments that are currently being revised stiffen these requirements somewhat and limit discharges to a rate not to exceed 60 liters per mile of ship travel and the total volume to not more than 1/15,000 of the volumetric cargo capacity of the ship on any ballast voyage. In addition, logs must be kept of the discharges of all ships so that infringements of the regulations can be checked. Such regulations will serve to significantly curtail the operational oil discharges to the sea if sufficient enforcement procedures can be established.

Vessel casualties. A 250,000 d.w.t. tanker can carry over 2 million barrels of petroleum, more than twice the amount involved in the notorious Torrey Canyon incident. The potential effects of an oil spill of this volume resulting from a collision or grounding present the greatest problem with regard to the use of these ships. The probability that any current equipment could effectively handle this type of spill is small because of the present limitations of technology and the great amount of equipment needed. It is difficult to estimate the amount of petroleum that would be released in the event of something less than complete vessel destruction, but a figure in the range of tens of thousands of barrels would seem to be reasonable. Because of the amount of oil that would be spilled during a vessel casualty, and because of the lack of technology to treat such a spill, prevention of such incidences must be a key word with regard to these tankers.

The construction of vessels with double hulls has been proposed as an effective mechanism to prevent large-scale spills in the event of a vessel casualty. A recent paper [15] reviewing three studies on hull penetrations indicated that double bottoms do aid in preventing large spills. However, double side shells of sufficient depth to be effective seem to be impractical. The presence of this space presents both advantages and dangers. When used as a closed clean ballast system, a double-hull design could eliminate the problem of oily discharges at sea. However, the possibility of vapor accumulation and the accompanying danger of explosion within these walls during full cargo voyages must be dealt with. The presence of a gas-inerting system could reduce this danger.

If penetration of cargo tanks does occur as the result of an accident, two conditions can help to limit the amount of oil which is released. The first of these is an arrangement of pipes and pumps such that cargo in the damaged hold can be transferred readily to another hold or to a ship alongside. The second is the size of the hold itself. IMCO is currently working on regulations which would limit the size of holds so that minor collisions could not become major polluting incidents. In terms of a 250,000 d.w.t. vessel, this would mean that wing tanks might be limited to 10,000 cubic meters -- a capacity of 63,000 barrels of oil rather than the capacity of 190,000 barrels of oil that would occur under current practices [7].

Unloading and Transfer Facilities

Several types of facilities exist for the unloading of petroleum imports. Included among these are docks, monobuoys or multiple mooring facilities with pipeline transmission to onshore storage facilities; offshore islands either including storage or with pipeline transmission to onshore storage; and lightering operations with barge transshipment to inland areas. Barge transshipment has also been proposed for petroleum movement from an offshore island outside Delaware Bay [23]. The possible environmental impacts associated with the construction and existence of these various types of facilities has been discussed in chapter II. Once these structures are in place, the primary environmental concern is that associated with any spills occurring during commodity handling operations.

It has been estimated that only 1.4 percent of the oil spilled into the oceans originates in terminal operations [15]. Although the amount is comparatively small, the fact that it occurs in near-shore areas where other activities are likely to be impacted causes it to assume importance out of proportion to the amount of oil spilled. Although major spills are a possibility at these terminal links, it is more likely that spills will be small but frequent enough so that a low level of chronic pollution will result. This is particularly important in shellfish or finfish harvesting areas, which may be near such a facility. In addition, from the public view, oil on the beaches and in boating areas is very undesirable.

Possible sources of a major spill may arise from vessel damage resulting from ramming or grounding during an approach to an unloading point, from pipeline rupture, and from barge casualty. In a recent survey, tanker rammings represented over 15 percent of casualties associated with these ships [15]. One solution to this problem of uncontrolled movement during approaches to a pier or other structure can be found in the use of lateral thrusters to improve ship maneuverability. In addition, care must be taken to assure that offshore buoys provide secure moorings and that a sufficient deep-water area is provided to prevent groundings in the event of an abortive approach.

Pipelines are generally thought to be among the safest means of transporting liquid products. Hazards, however, can be found in stresses imposed by substrate shifts or outside mechanical disturbance. Under water, the latter may occur if the pipeline is snagged by an anchor; on shore, it may occur in excavation activities. Such occurrences can be prevented through the mapping and marking of pipeline routes and adequate burial to prevent interference. Another cause of pipeline failure is the pumping of air into the line during unloading after the hold has become empty. If sufficient buoyancy is achieved, the line can rise and break. This type of casualty can be prevented by good operational procedures and adequate ballasting. In the event of a pipeline rupture, the amount of oil released will be determined by the size of the pipeline, the load it is carrying, and the distance between emergency closing valves. For many pipelines serving offshore terminals, a considerable volume of oil can be released since the distance between valves will be from the terminal to the shore, often a distance of several miles.

The use of barges in a petroleum delivery system can be viewed as one of its weaker links. Statistics for 1970 show a total of 265 polluting incidents, totaling over 1.5 million gallons, involving tank barges [22]. Although barge use provides a more flexible delivery system, the use of pipelines may be preferable if the situation allows it.

The most probable source of polluting incidents at terminals will be those associated with hose ruptures, failure of valves, etc. These incidents are likely to involve relatively small volumes, and can be reduced or eliminated through better operational procedures.

Storage Facilities

Oil storage facilities can be major pollution sources if tanks rupture or collapse. Eight such incidents occurred in 1970, involving a volume of almost 3.5 million gallons [22]. Several precautions are currently being taken to minimize such dangers and to contain the oil in the event of a spill. Of particular importance is the construction of a firm substrate to eliminate differential subsidence and to prevent any spilled oil from soaking into the ground. These factors would present special problems if a tank farm were situated on an offshore island constructed from unconsolidated dredging spoil. Standard practice now dictates that dikes also be constructed around tanks to contain any spilled oil. To protect water quality in the vicinity of a tank farm, it is also desirable to have a runoff water collection and treating system.

Beyond the problem of oil spills, two other environmental impacts are associated with petroleum storage facilities: land use and aesthetics.

The significance of a commitment of land for oil storage depends upon the current utilization of adjacent land, whether urban or rural. However, with the initiation of the precautionary measures mentioned above, such a development would not preclude a wide variety of uses for adjacent land and waters unless the aesthetics of the facility interfered. The experience at Bantry Bay, however, has shown that the appearance of such a facility need not prevent other uses of the area. In that situation, provision was made so that the facility would not mar the landscape. One technique for accomplishing this is to excavate the land so that the tank farm is on a lower level than the surrounding land, with banks to hide the facility. This technique may not be possible, however, if such a farm is located in a wetland area or on an island.

Processing Facilities

Refineries affect the environment in several ways and have particular effects on air and water quality and water consumption. They are often considered one of the more environmentally undesirable industries, although much is being done to ameliorate this situation.

Emissions from refineries can include sulfur compounds, hydrocarbons, particulates, nitrogen oxides and carbon monoxide. Technology is currently available to significantly reduce such air pollutants, and the installation of the required equipment is being undertaken to meet increasingly stringent air quality regulations. As new refineries are built, the costs of such emission control will decrease through incorporation of controls in design and new technology in processing techniques. The efficiency of such systems will also be likely to increase.

Odor is another problem associated with refineries, and can occur as a result of even minor emissions of certain chemicals. New treating techniques and better operational control of leaks can help to alleviate this problem, which is often a source of public complaints.

Water pollution may be the most significant environmental impact associated with refinery operations. Water used in processing becomes contaminated with oil and many highly toxic chemicals. Several water-processing techniques, including biological oxidation, are currently used to maintain effluent water quality within legal limits. Runoff water likely to be contaminated as the result of minor leaks can also be collected, and the oil can be separated from the water before it is discharged. However, although water emanating from refineries is treated and monitored, it still represents some degradation of receiving waters. The significance of such quality reduction must be decided in the context of the original condition of receiving waters and other uses. This becomes a particularly important consideration in the siting of new complexes in relatively virgin areas.

Petroleum processing facilities utilize large quantities of water. For example, some 7 gallons of cooling water are utilized to process 1 gallon of gasoline [24]. However, since approximately 97 percent of the water is used for cooling, the actual consumption of water by these facilities is markedly less. Water recycling and reuse are receiving increased attention in refinery operations, as is the use of brackish water. Such developments will serve to mitigate water quality problems through a reduction of effluent volume, and in addition will open up new areas for plant siting which were formerly undesirable because of limitations on the amount of water available.

Site Analysis

Chapter II of this annex highlighted data needed to make a decision on the advisability of establishing a deepwater port in a given location. When such a facility is designed to serve petroleum, additional information is needed.

Regardless of the amount of operational care taken or the degree of overdesign employed, any petroleum port delivery system will have some oil spills. Therefore, a part of the decision-making process must deal with the susceptibility of the location to these unavoidable occurrences. Data needed would include characteristics of the water body, i.e., its ability to disperse pollutants and its presystem quality; the sensitivity of resident biota to oil contamination; and the extent of present and projected human activities which may be eliminated or curtailed by the presence of some level of oil pollution. Such factors must be considered in conjunction with each component of the system.

The increasing demand for petroleum products will require the expansion of processing facilities, including the building of new refineries. If new refineries are built as a part of a port facility, additional analysis beyond oil spill impacts will be needed. This is due to the fact that refineries, the source of energy and raw materials to many industries, tend to promote more secondary development than do those processing facilities associated with the other commodities discussed in this chapter. Such secondary developments are likely to include members of the petrochemical industries, which are themselves major impactors on the environment. The effects of such industrial expansion could easily be more significant than any environmental considerations of the petroleum delivery system itself.

Environmental Effects of Dry Bulk Commodities

Six dry bulk commodities -- iron ore, coal, grains, phosphate rock, bauxite and alumina -- are being considered in this study. This section will focus on the behavior of these materials during handling and storage. The extraction and/or processing of these materials is by far the area of greatest environmental concern. However, a discussion of these aspects is beyond the scope of this study.

Some of the environmental effects (i.e., aesthetics and land use) of handling and storage are common to all these materials. These effects are discussed in a subsequent general section. Preceding this discussion is a brief description of each of the commodities in terms of current methods of handling and storage and the possible environmental problems associated with them.

Iron Ore

Iron ore is imported either as raw ore or, less frequently, as preprocessed pellets. Ship unloading is accomplished by grabs. The material is loaded onto conveyor belts which lead to the storage area. Storage is in open lots, and placement and retrieval of the iron ore is accomplished by large stacker-reclaimers. Stacking involves dumping the ore from moving belts, while reclaiming is done via a rotating series of scoops with, again, the ore being moved to a new location via conveyor belts. Alternative movements may be by truck or train.

Dust is a problem in iron ore movements during handling operations and while it is stored in open piles. The extent of the problem depends upon the percentage of fines in the ore, which in turn depends upon the ore's source. The use of enclosed conveyor systems during movement and of wetting agents during storage can mitigate the dust problem.

Fine material, carried with the runoff from rain, may go into suspension in nearby waters. Although the material is chemically inert, it will cause increased turbidity and associated secondary ecological effects. The runoff will also impart a bright red color to the surrounding waters, creating an aesthetic problem that can be very significant to other uses of the water.

Coal

Coal for export arrives at terminal facilities by rail. The coal is generally stored in the railcars until shipment, although some open-lot storage is also utilized. At most piers the coal is dumped into bins at the time of shipment, and conveyor belts then transfer the coal into the ship's holds.

Coal has most of the same problems that iron ore has. Stored in open piles, the fines can be blown about, creating a local dust problem. Experience in Norfolk indicates that very little dust occurs if coal is stored in rail cars. The most serious dust problem occurs at the car dumper during unloading. A fine water spray which creates an "umbrella" over the dumper can control this problem.

In open storage, runoff can also create an environmental problem. Unlike iron ore, coal fines in suspension will impart a gray-black color to the adjacent waters. The associated problems of aesthetics and turbidity can be locally significant. Any such runoff will also tend to have a weak acid character, and continual discharges into the nearby waters could have a major impact upon the marine organisms in the area. Storage and neutralization of runoff before release could eliminate that problem.

Grains

Export grains include a wide variety of agricultural products from hard kernel corn to powdery soybean meal. Because of the nature and use of grains, much care must be taken to prevent contamination. Therefore, all transfer and storage areas are enclosed.

Grains are usually delivered to the terminal facility by railway car or barge, and are moved from car to storage and from storage to ship by conveyor belt. The storage facility itself usually consists of a series of tall silos with extensive facilities for drying, humidity control and vermin control by gassing.

Dust control is a major problem at grainery terminals. This control is necessitated by the explosive flammability of suspended dust. The dust also presents a health hazard to some individuals because of its relationship to asthma and many lesser allergic conditions. Control is achieved through the utilization of vacuum suction along conveyor belts and the employment of filtering bags.

Grain spilled into the water during loading operations is a nutrient that will attract fish. However, large quantities will cause a locally adverse impact due to decreased dissolved oxygen. The general quality of the local waters and local populations of marine organisms will be temporarily affected.

Phosphate Rock

Phosphate rock is stored in open piles and enclosed barns. Dust can again be a major problem during storage and transfer. And, again, wetting agents, covered conveyors, and transfer links can be applied to control this problem.

Phosphate rock, like coal, will tend to create a weak acid runoff. Phosphates in solution will increase nutrient levels in nearby waters. With frequent or continual discharges in protected waters, eutrophication may be increased.

Bauxite and Alumina

Bauxite is usually stored in open piles and, consequently, faces the usual potential dust problem.

Alumina, by far the more important of the two commodities, is stored in enclosed structures. Essentially one building design is used for all alumina storage in the United States. The structure is a round, relatively low aluminum dome which is loaded through the top and unloaded at the bottom by conveyor.

Alumina has the consistency of sand. It is inert in the water and will quickly settle to the bottom when dumped into a water body. It does not create any real environmental or ecological problem except for the remote possibility that a sizable spill might obstruct a channel just as shoaling sand would do.

General Dry Bulk Problems

One problem associated with all bulk commodity handling and storage facilities is aesthetics. The presence of open piles, cranes, conveyor belts, and tall storage structures at the water's edge tends to make highly visible changes to the landscape and, furthermore, is very difficult or impossible to camouflage. In addition, the transfer operations are usually accompanied by a high noise level. The seriousness of these problems in any given location will depend on the surrounding land use. If such facilities are located alongside busy navigation areas with already existing development, the environmental impact will not likely be significant. However, if new port facilities are situated in formerly undeveloped areas, their aesthetic aspect will warrant more serious consideration.

Another problem associated with these facilities is related to the sizable land area which they occupy and to the fact that they are not compatible with most other uses of the area. The natural features of the area directly involved will be significantly altered. Former uses such as recreation will be excluded from the immediate area and may be less attractive in adjacent areas because of dust and runoff. Other adjacent uses such as residential development would also be less attractive. Evaluation of the significance of the impact of such facilities must again be based on the original character of the area in terms of other developments and uses.

Summary

The major environmental impacts in the storage and handling of dry bulk commodities are associated with land use, aesthetics, and dust generated during operations. The latter can be extensively curtailed and controlled by existing technology, and the significance of the former two will depend primarily upon the other uses of the area. In general, the environmental impacts of the dry bulk commodities themselves are not significant.

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IV. ANALYTICAL FRAMEWORK FOR PORT ANALYSES

Conceptual Approach to Environmental Evaluation

The primary objective of an analysis of the environmental impact of any proposed activity is to provide information to aid in the decision of whether to undertake the activity. To meet this objective the analysis must determine how the proposed activity will alter the environment and how, in turn, the altered environmental conditions will affect man's activities and objectives as they relate to the use of the natural environment.

Conceptually, this can be depicted as a sequence of cause-effect relationships which starts with the proposed activity and ends with activities and uses of environmental resources. This depicts man as an agent of environmental change and also as a recipient or reactor to the changes to which he has contributed. The focal point between these two views of man is the "natural" environment. The environment can be depicted as a set of physical, chemical and biological conditions which combine to give the environment its characteristics at any given place and time.

If they are to be conducted successfully, all of man's activities and uses of the environment depend upon each of these conditions having a value within a certain range of values. For example, tillage of fields for agriculture requires a slope not in excess of "some" degree. Beyond that degree, tillage becomes impracticable or impossible. A water body must be of a certain quality if it is to be used for swimming, water supply or biological production. Water currents above a certain speed or waves above a certain height will make small boat handling dangerous or impossible.

Theoretically, it should be possible to identify all the environmental conditions which are significantly affected by any proposed activity, and also to identify the environmental conditions necessary to any given activity, to arrive at a network of cause-effect relationships which would provide a useful tool for analysis. With perfect knowledge one could determine exactly how a proposed activity would change a given condition and how, in turn, the new value of the environmental condition would affect planned or existing activities. Although perfect knowledge is impossible, the network of causes and effects can still provide a framework for conducting a systematic and comprehensive analysis and evaluation of a particular environmental problem.

In this study we are dealing with the environmental problems associated with the development and operation of new deepwater ports for bulk commodities. The characteristics, relationships with environmental conditions, and effects of activities associated with each component of a port system have been blocked out in the form of network diagrams to provide guidelines for the analysis in keeping with the discussions in chapters II and III.

The present ability to predict changes is less than perfect, and an element of uncertainty exists in virtually all aspects of the analytic procedure. This is not unusual. All forecasts or predictions contain an element of uncertainty. The degree of uncertainty which exists in any element of the analysis should be explicitly identified and should be an integral part of any decision process.

In an analysis of the environmental impact of any proposed alternative, the relevant measure is the difference in the amount of change in environmental conditions that will take place with and without implementation of the alternative. In addition to determining the changes that may occur in environmental conditions, the analysis must determine the effects of the changes on man's uses of the environment to provide a basis for evaluation. An evaluation can have meaning only when the present and future effects on man's activities, in the broadest sense of human welfare, are determined.1/

Once the expected changes in environmental conditions (the environmental impacts) have been ascertained and their effects on human activities and uses of the environment (environmental effects) delineated, a set of criteria can be used to evaluate the overall environmental implications of the proposal. Some of these criteria are:

1. Uniqueness. If there are any important unique qualities which will be destroyed they should be delineated. These could be sites of historical significance; unique combinations of biological or physical characteristics which have scenic, scientific or other importance; or perhaps unique human activities which will no longer be conducted.

2. Irreversibility. Those changes that will be irreversible and/or require irretrievable commitments of resources (such as the filling of a wetland) should be especially noted for evaluation.

3. Severity of effects on activities. Some impacts will have minor effects on existing or projected uses of the environmental resources. Others will preclude certain uses. The degree of the effect, or severity, should be noted as well as possible within existing knowledge. This could possibly include economic considerations.

4. Health. Any changes which have a significant or potential effect on public health should be identified and described.

1/ In this context, man's activities cover the range from specific resource use activities (such as water use, fishing, transportation, etc.) to the general action of preserving the existing ecosystems, conservation, etc.

5. Safety. Any changes which, while not precluding an activity, tend to create a safety hazard should be explicitly identified.

There is no intent here to imply that the analysis and application of such criteria will expand the analyst's role to include the decision as to which alternative is most acceptable. The role of the analyst is to provide, within the practical limits of present knowledge, a set of potentially significant predicted changes and their impacts upon man. The criteria help him to assure relevance. The decision to reject or accept any or all alternatives remains a social and political one. The assumption here is that, given an objectively presented statement of the potentially significant impacts and effects and a clear statement of the uncertainties involved in the predictions, the decision will be based less upon emotion and more upon the realities of the situation and its alternatives. The analyst must use judgment, however, to sort out the significant effects. Otherwise the decision-maker(s) probably will not make an informed decision.

Requirements for Analysis and Evaluation

In the study of the environmental implications of deepwater ports, the focal point is the delivery system and its components as described in chapter I. Each alternative will contain most of these components in one form or another, depending upon the commodity to be handled and the characteristics of the area in which it is to be located. In fact, all functions except processing will be performed in every alternative. The processing component depends upon the commodity and may be located remote from the deep port and, consequently, may not be part of the delivery system for the purposes of this analysis.

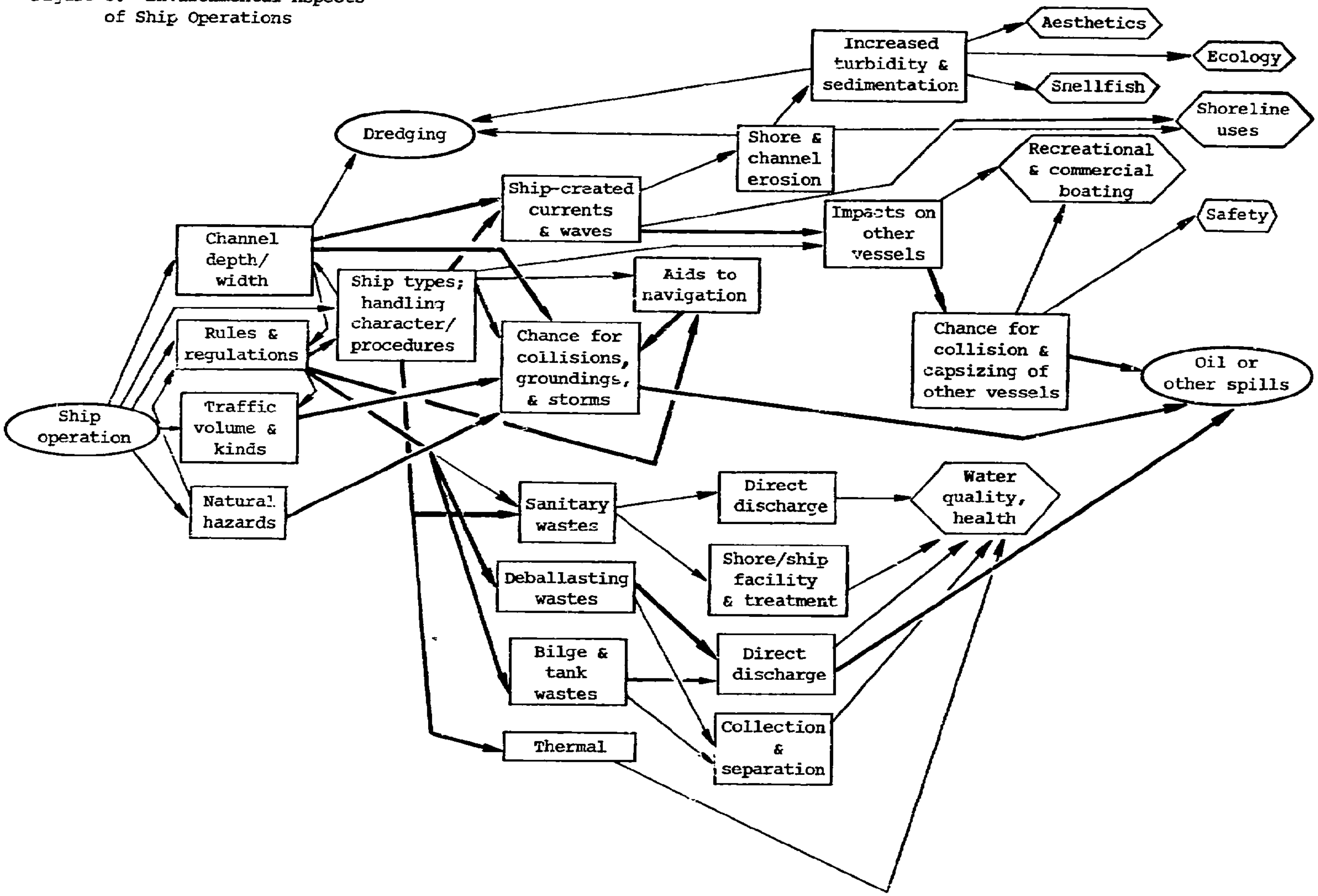
In each component, one or more aspects have possible environmental implications. For example, in component 1, the problem of adequate channel depth and width leads to an analysis of the problems associated with dredging and spoil disposal; the operation of large bulk carriers in heavily traveled channels or in hazardous areas leads to an analysis of the problems of collisions and groundings and associated spills, particularly of oil. For each of these aspects, network diagrams depicting the cause-effect relationships have been developed for use in the analysis of a given alternative.

Figure 3 depicts the environmental aspects of ship operation, including the sequence of cause-effect relationships involved in this component of a deepwater port delivery system. The rectangular boxes represent elements of the system, including the physical characteristics of the area, as well as the planning and operating characteristics of the component (such as waste disposal). Tracing through the networks along the lines which are relevant to a particular port development alternative will eventually lead to either a hexagonal or an oval box. The hexagonal boxes represent the final areas of environmental impact and are the criteria which are used to evaluate a particular alternative. If in the analysis an oval box is reached, it indicates that another diagram has been developed for further analysis and that the analysis should be expanded into that facet. For example, if deeper channels are required for ship operations, then the analysis must proceed into the implication of dredging -- an oval box in figure 3.

This network diagram provides the sequence for analyzing environmental implications of a given system's ship operation. For example, given a port system alternative for oil, the ship operation component is a major potential contributor to oil pollution problems. The diagram identifies the parameters of the port system which will influence the probability that ship operation will contribute to oil pollution, the data necessary to describe these parameters, and the relationship between parameters and intermediate effects up to the point where oil pollution is identified. From that point the analyst can turn to the framework diagram for oil spills to carry on the analysis and evaluate the effects on human activities and ecology.

Tracing back through the diagram from where the oil problem is identified, there are three primary sources of oil pollution from ship operations: (1) discharge of wastes from ships into the adjacent waters; (2) discharge of oil and fuel from collisions and accidents of

Figure 3. Environmental Aspects of Ship Operations



vessels other than tankers, but caused at least indirectly by the movement of large vessels; and (3) the possibility of accidental groundings, collisions or other damage to very large vessels (such as a ship's breaking up due to a severe storm) which can cause major polluting incidents. Each of these can be traced back through the series of cause-effect relationships to the original relevant parameters of the system alternative proposed, so that, in fact, the subsystem of the ship operation component dealing with oil pollution can be identified and isolated. (It is shown on figure 3 by the heavily lined arrows.)

In analyzing a given alternative, one can readily identify the parameters important in ship collisions and groundings (which may contribute to oil spills and pollution). The size of channel, ship types (including handling characteristics and procedures), expected traffic volumes, natural hazards (physical channel obstructions, storms, winds, currents, etc.), and existing regulations pertaining to ship operation all have direct relationships to the probability of a spill caused by ship accidents. If, in the specific analysis, the chance of pollution from such a cause is unacceptably high, the analyst can search back through the parameters to identify changes that could be made to overcome the problem. Perhaps more stringent regulations on traffic movement or enlargement of the channel would alleviate the problem.

During this kind of exercise one must also be alert to the side effects of the changes being investigated. For example, if channel enlargement seems to be the solution for the collision problem, one must address the dredging network and extend the analysis. In addition, the behavior of currents and waves caused by ship movement in the new channel size must be considered if the effects of a change could be significant. The significance can be examined by rapidly following through the diagram to potentially affected activities. If any of these activities are important in the area under consideration, the effects must be dealt with as side effects to the alternative of building a larger channel. (These effects may be beneficial in that a large channel would tend to reduce current velocities caused by ship movement.)

There are a number of data and knowledge requirements which will assist in the conduct of such an analysis. The parameters of the alternative being proposed must be known. The physical and biological characteristics of the port area; natural hazards including storms, winds and waves; and the major land and water uses should be identified. In addition, the cause-effect relationships, such as how the values of the various parameters influence the likelihood of collision and spill or how the size (depth and width) of a channel and the movement of a specified ship combine to create currents and waves, must be understood at least well enough to make judgments. One should also provide an indication of the reliability of the judgment so that the uncertainties inherent in the analysis can be made explicit to the decision-maker.

Ten network diagrams covering the various components of the port delivery system have been developed. Table 1 lists them and indicates the components of the system to which each applies. Figures 3 through 12 contain the diagrams themselves. Application of these diagrams to the specific alternatives will provide systematic analyses performed on a common basis.

It would be impractical to attempt to generalize much beyond these diagrams in terms of data requirements or methods of predicting changes. The specific data requirements will depend directly upon the proposed alternative, and, in fact, each step in data collection will depend upon the results of the last step. It would be inefficient and costly to collect data that would not be used when and if a branch of the network shows up to be insignificant in a given analysis.

Procedural Steps for Analysis and Evaluation

The network diagrams, coupled with the background information contained in chapters II and III and reinforced by the judgment of experts familiar with the particular location (especially with respect to ecology and biological effects) of the port alternative, form the basis for undertaking the analysis. A suggested procedure follows:

Table 1. Relationships of Network Diagrams to Delivery System

Network diagrams	Delivery system components						
	Ship movement	Load/ unload berth	To/from storage	Storage	Move to process	Process	To/from final
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Material spills..	X	X	X	X	X	X	X
Ship movement....	X		X		X		X
Dredging.........	X						
Material transfer	X		X		X		X
Ship berthing....		X					
Offshore structures...........		X		X		X	
Onshore pipelines.......			X		X		X
Offshore pipelines.......			X		X		X
Storage..........		X		X			
Processing.......		X				X	

Figure 9. Environmental Aspects of Onshore Pipelines

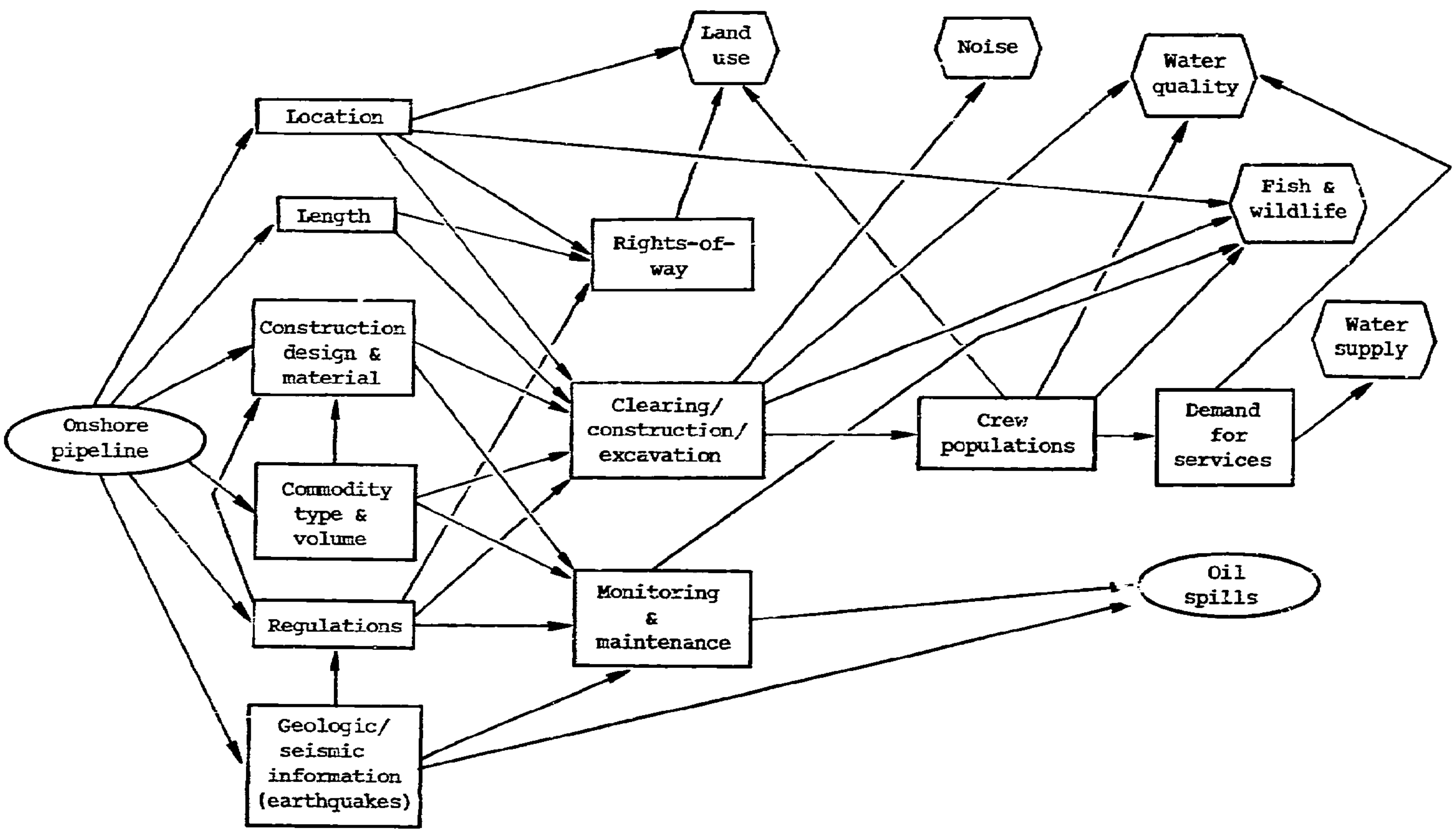


Figure 5. Environmental Aspects of Dredging

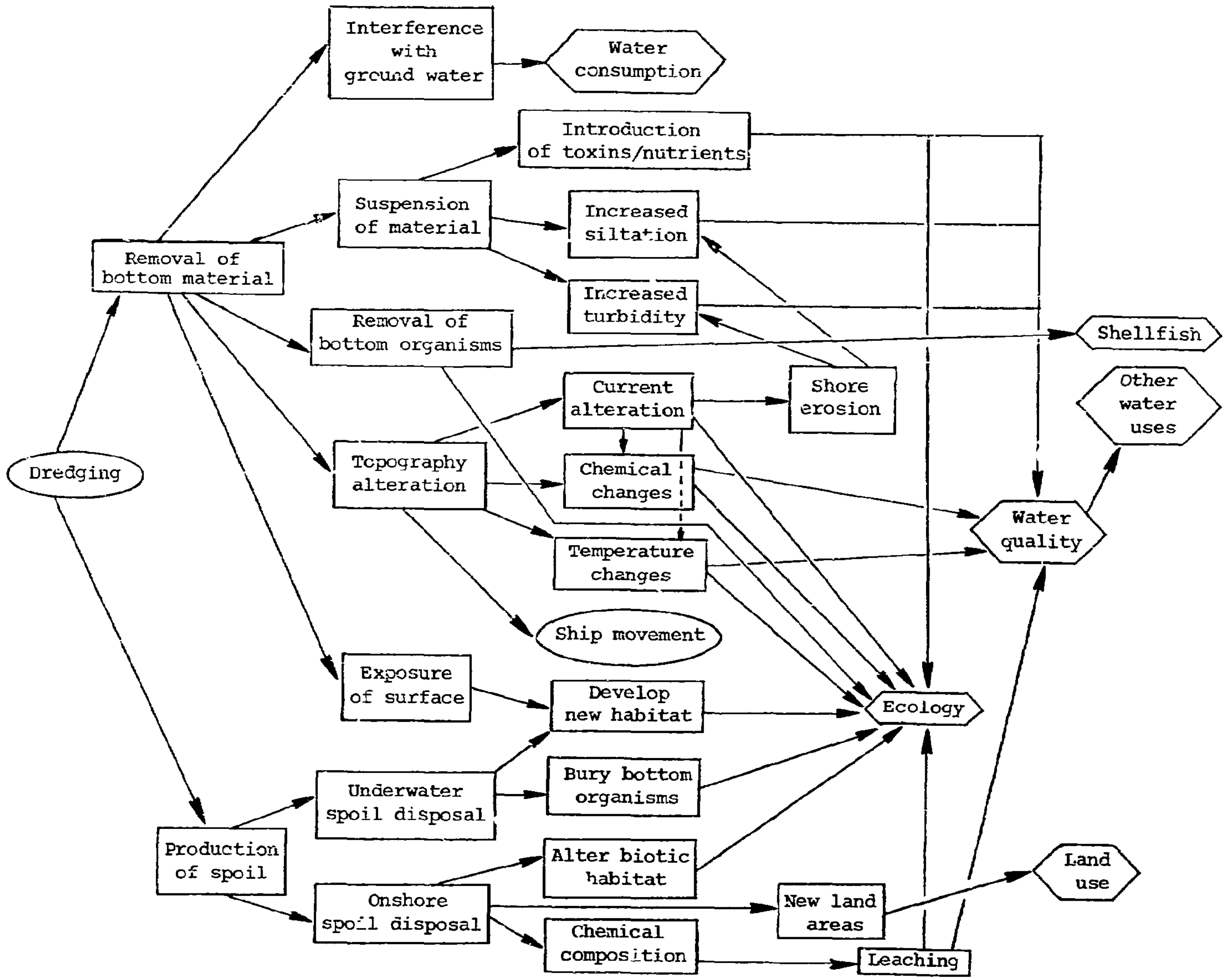


Figure 6. Environmental Aspects of Material Transfer

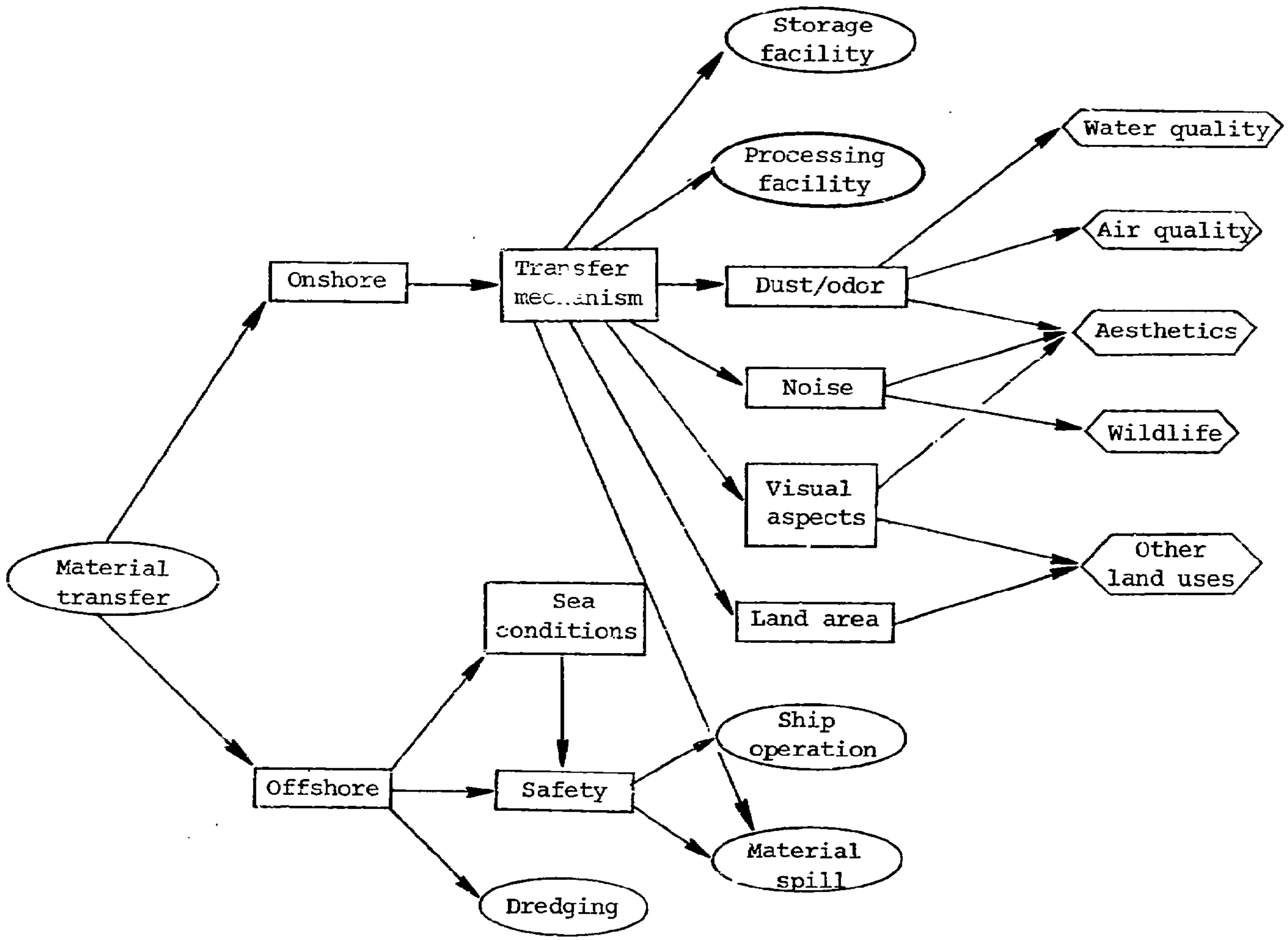
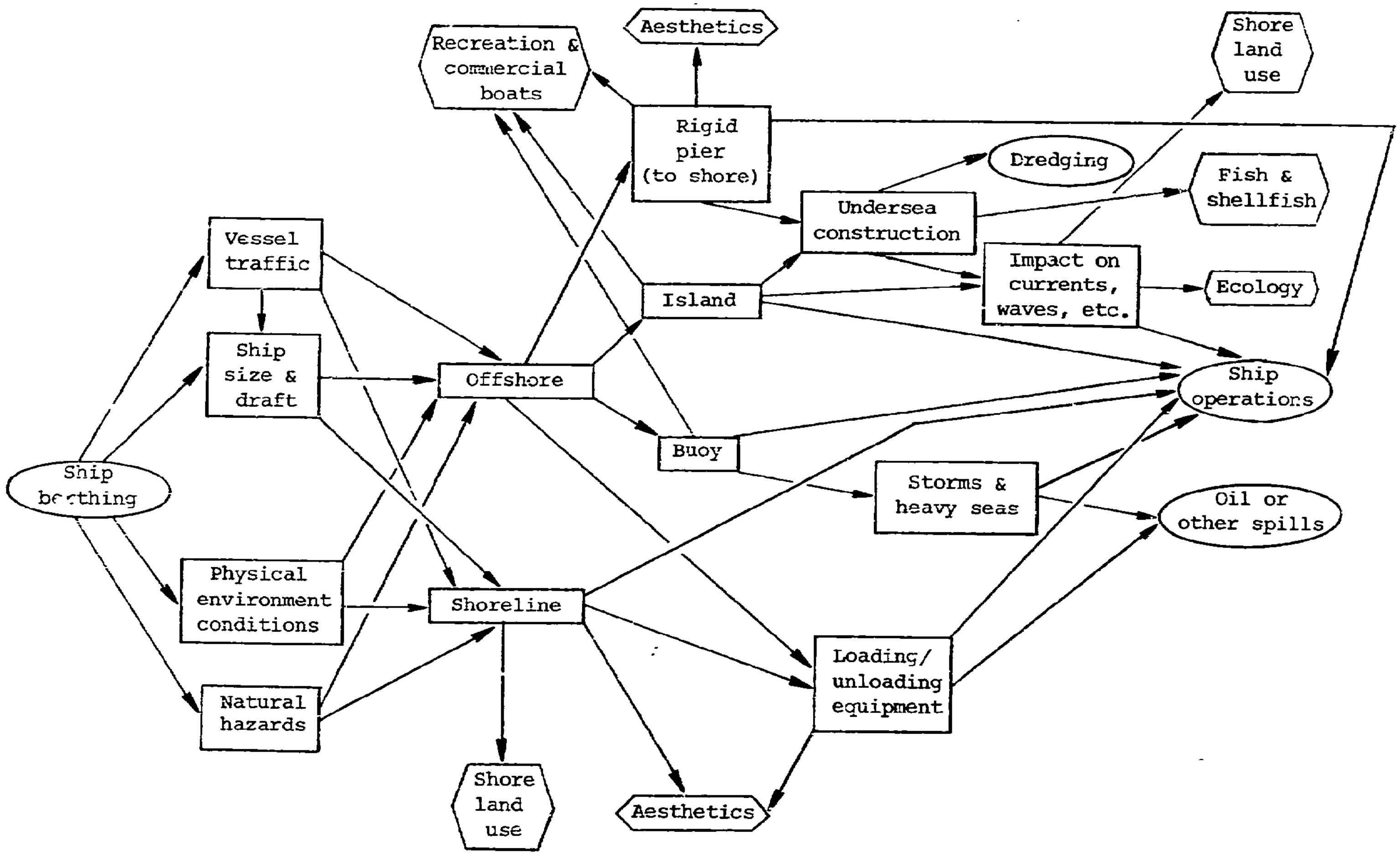


Figure 7. Environmental Aspects of Ship Berthing



81.

Figure 8. Environmental Aspects of Offshore Structures

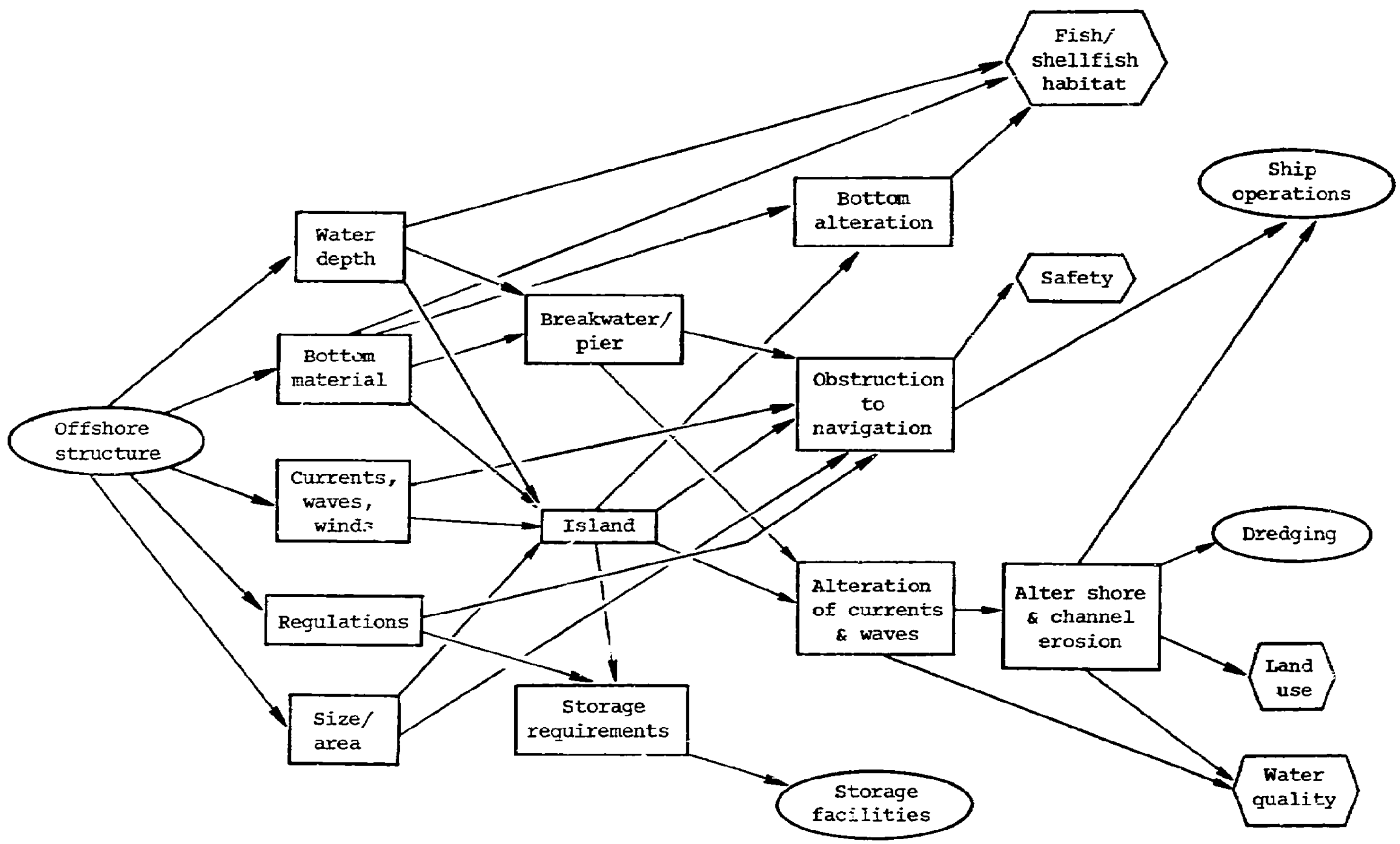


Figure 4. Environmental Aspects of Material Spill

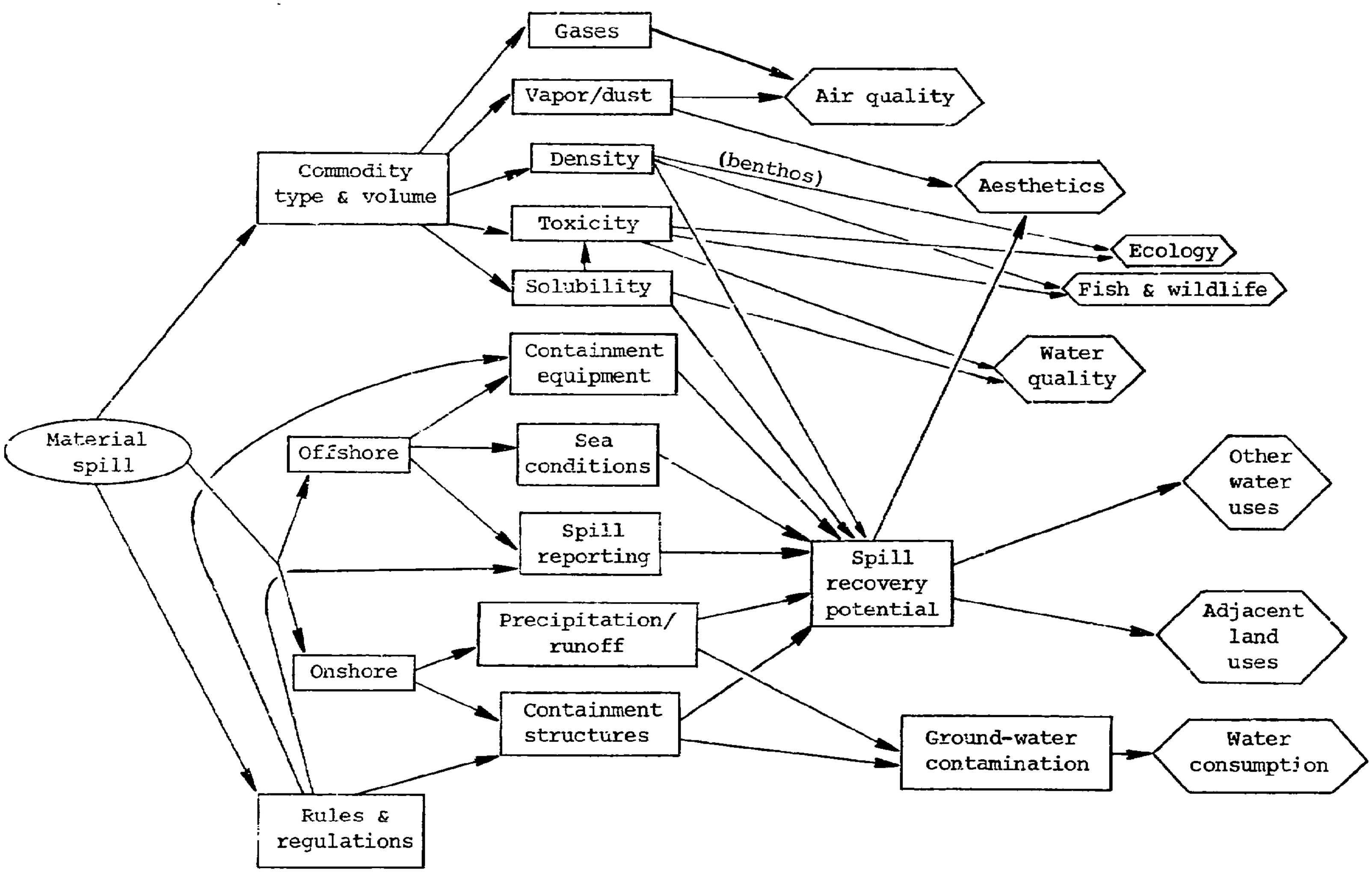


Figure 10. Environmental Aspects of Offshore Pipelines

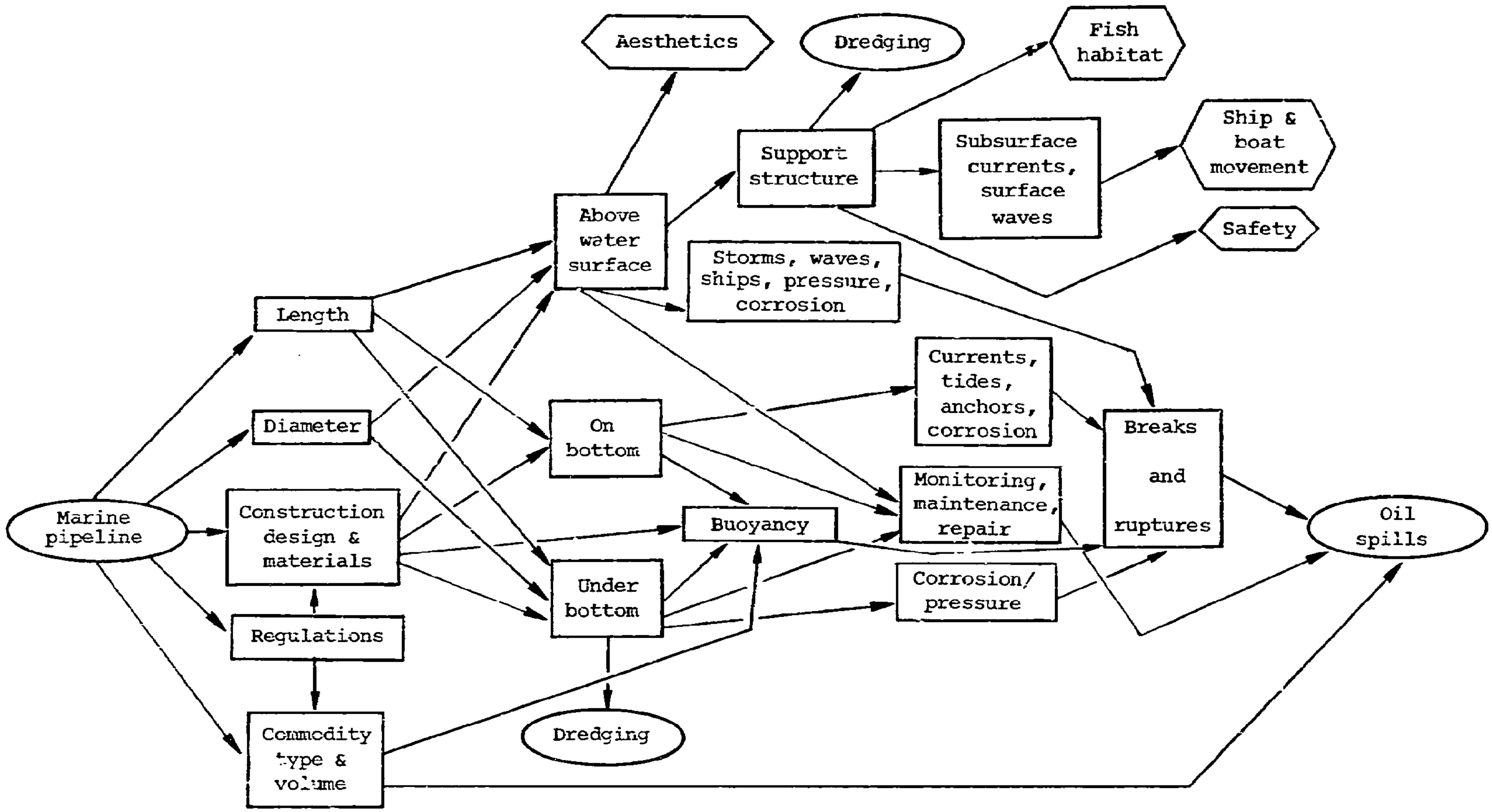


Figure 11. Environmental Aspects of Storage Facilities

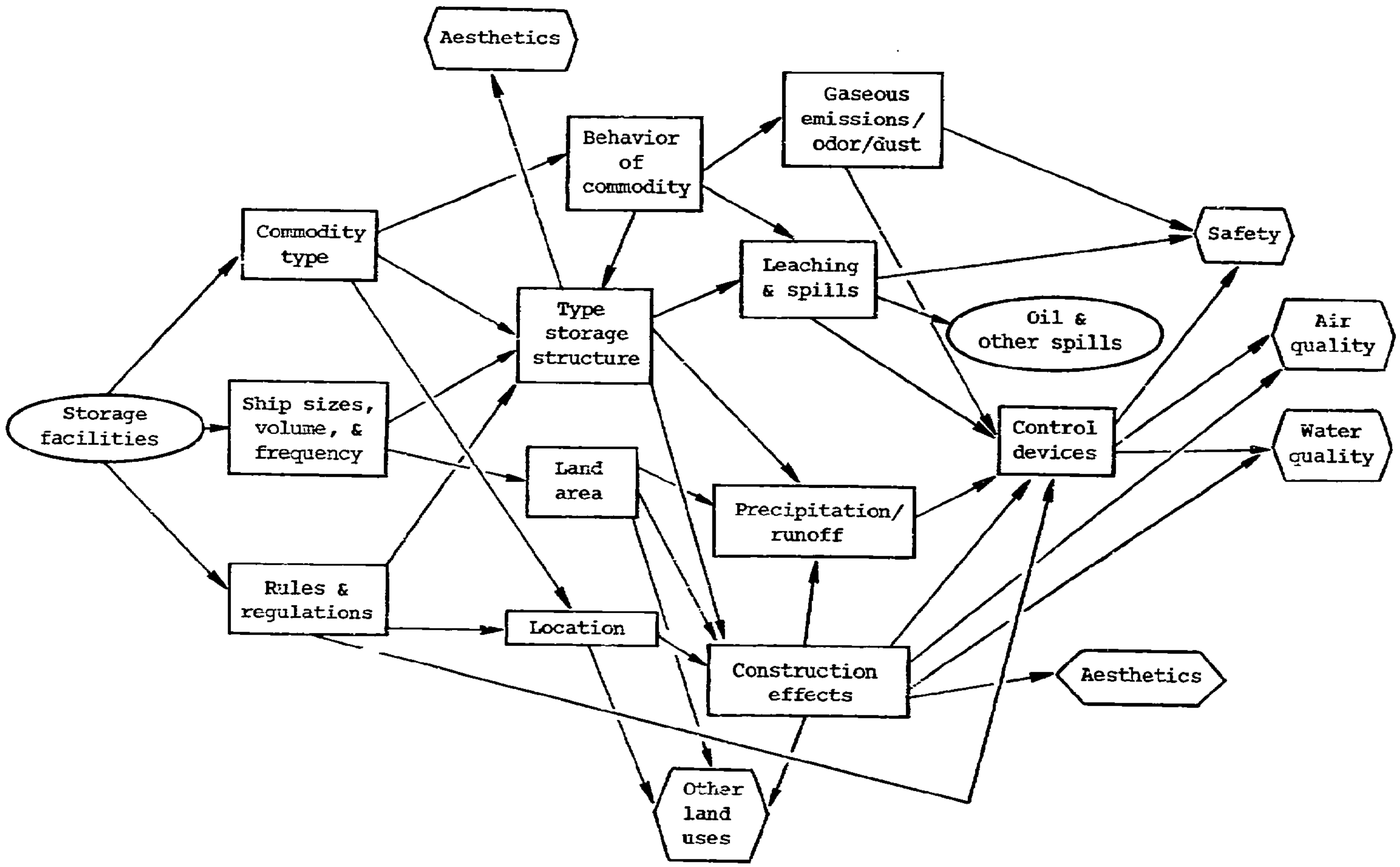
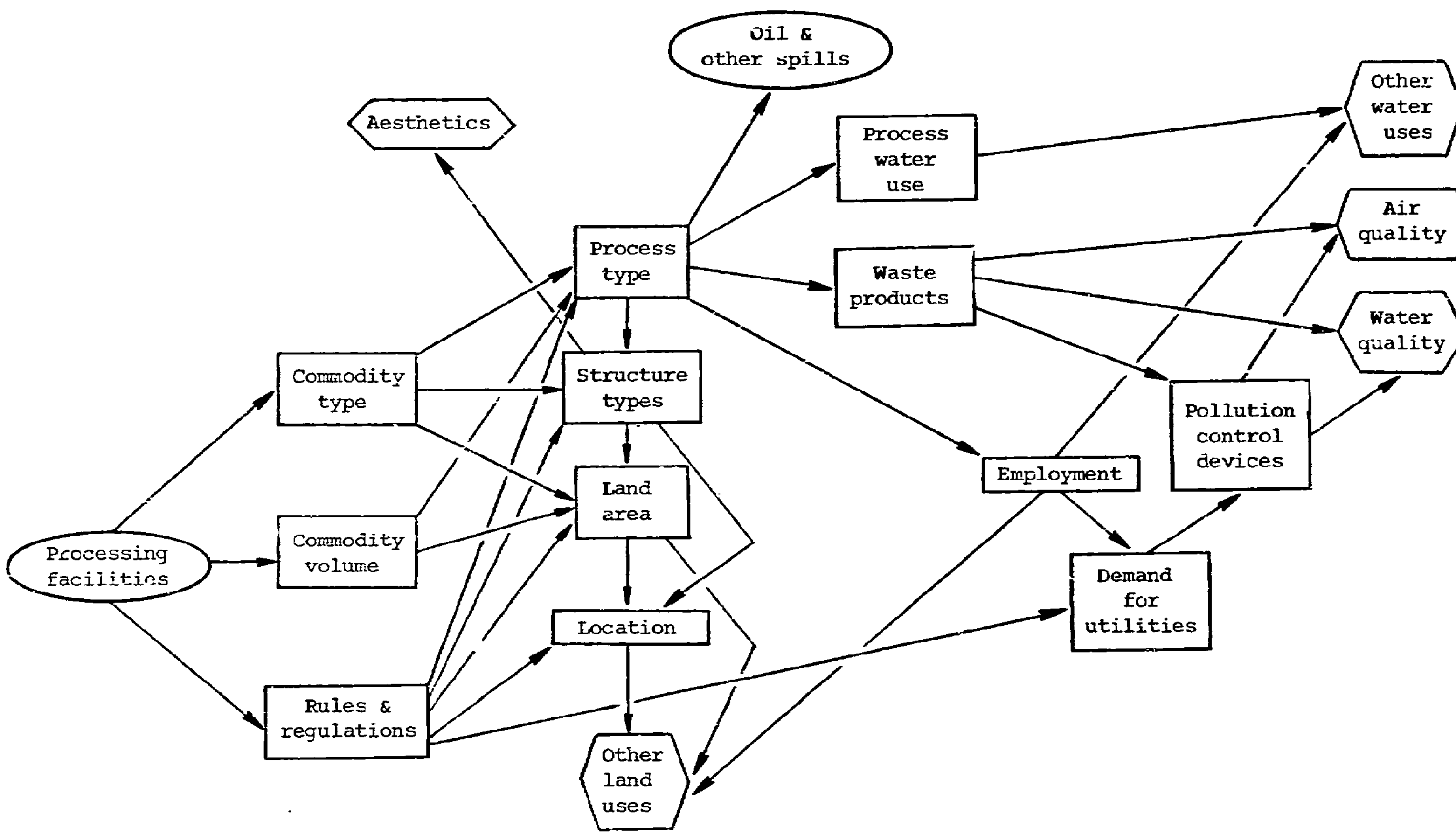


Figure 12. Environmental Aspects of Processing Facilities



1. Describe the proposed development in terms of the delivery system concept. A nearly infinite number of elements can be combined to form the components of a port delivery system alternative. Table 2 contains a listing of the items which will be useful to describe a particular system.

2. Describe what exists at the proposed site(s). This description should be based upon the proposed port delivery system. Care must be taken to insure that all areas which may be affected by the development are identified and included. It is not adequate to concentrate solely on the specific site when it is likely that effects may be more widespread.

In addition to present conditions, it is essential to investigate and describe the expected future conditions of the affected area without the new port, particularly when existing conditions are undergoing rapid change or when plans indicate that significant changes will occur. Table 3 contains a listing of the information items required for this description.

3. Evaluate the existing and projected site(s). It will be helpful during the analysis and evaluation of the effects of an alternative to have at least a judgment as to the "value" of the existing situation and the projected "non-port" situation. The values which should be judged relate to environmental quality, natural and manmade resources, and socioeconomic activities which may be particularly susceptible to changes caused by the implementation of the port system.

Table 4 depicts the items which should be evaluated. This list may be altered as experience is gained in port analysis. These same items will be analyzed when a port system is superimposed upon the present and projected condition of the affected area. This summarized evaluation will, at present, be a highly subjective ranking of the particular elements and will be done only in terms of <u>high</u>, <u>medium</u> or <u>low</u> values. This ranking will be followed by the descriptive information on the site to provide some basis for the judgment. If desirable, the evaluation of these elements can be undertaken by using the judgment of others deemed qualified and knowledgeable in that particular area. This could be particularly helpful when deriving the projected values. With adequate time and resources a modified "Delphi"

Table 2. Information Descriptive of a Delivery System

System component	Specific information
1. Ship movement	Type of vessel: draft, beam, dwt., speed, handling characteristics, onboard navigation equipment, material handling equipment Number of vessels expected and frequency of arrival Shore-based navigation equipment Commodity type and volume Channel engineering to be undertaken
2. Ship berthing	Location Type of mooring Space required Engineering works to be constructed Numbers and sizes of vessels to be accommodated
3. Material handling (load/ unload)	Commodity type and volume Equipment on board Equipmen at the berth and to storage Location and space required Operating procedures
4. Storage	Commodity type and volume Location and space required Type and design of structures Equipment and operating procedures
5. Material handling (to/from processing)	Commodity type and volume Location and space required Equipment and operating procedures
6. Processing	Commodity type and volume Facility type and design Location and space required Operating procedures Waste products generated Water use Power consumption Expected employment

continued--

Table 2. Information Descriptive of a Delivery System continued--

System component	Specific information
7. Material handling (to/from dest.)	Commodity type and volume Equipment Operating procedures Location and space required

Table 3. Information Descriptive of the Existing Situation

System component	Descriptive information
1. Ship movement	Present and projected traffic types and number of vessels Present water characteristics: depth, width of channels, bottom material, currents, waves, water quality, marine biological populations, dredging, hazards, to navigation Operating history: collisions, spills and polluting incidents, general operating spills Present and proposed land uses in affected areas Existing and proposed aids to navigation Existing and proposed rules and regulations pertaining to vessel movement and traffic control
2. Ship berthing	Present and planned area uses: shoreline uses, offshore uses Conditions of the affected area: water quality, visual aspects of shoreline, fish and other marine organisms Natural hazards Existing and proposed regulations
3. Material handling (load/ unload)	Existing and proposed facilities: type, condition, amount of use and associated current environmental problems Present air and water quality (and trends) Present visual aspects Present and projected land and water uses in affected area Natural and manmade hazards Existing and proposed regulations
4. Storage	Present and proposed land use in area affected Present environmental character of the area affected

continued--

Table 3. Information Descriptive of the Existing Situation continued--

System component	Descriptive information
	Visual aspects Air and water quality (and trends) Natural and manmade hazards Existing and proposed regulations
5. Material handling (to/from processing)	See component 3
6. Processing	Current and projected land use Present environmental character of the area affected: air, water quality, visual aspects Present and projected water supply/demand situation Available facilities for waste disposal Population and available labor Transportation links and utilities General nature of the area Existing and proposed regulations
7. Material handling (to/from dest.)	See component 3

Table 4. Form for Presenting Evaluation of ________ Area

	Aesthetics	Water Quality	Air Quality	Uniqueness*	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
Present value																			
Projected value																			

Key:
H = high value, high quality, or high level of use
M = moderate value, moderate quality, or moderate level of use
L = low value, low quality, or low level of use

* Number entered equals number of natural or historic sites in the area of influence.

technique could be applied. During the present study, however, time and resources dictate that the author utilize readily available information and reach a conclusion on the basis of the application of this information to the framework and background provided in this report. Thus, the current study cannot be used as the basis for a decision on site selection, but can only indicate areas of study needed.

4. Analyze proposed system. Each element of the proposed port system should be conceptually superimposed upon the existing and projected situation to identify impacts and effects. Actual implementation of a proposed development can affect the existing situation in several ways. The construction of the elements may create changes (such as the turbidity created by dredging). The physical presence of the structures will have effects. Breakwaters, for example, will change the wave patterns and water circulation and may create improved fish habitats. The operation of the port system may also create changes in the situation. Oil spills may arise from the operation of a system. Other bulk commodities may create dust and air quality problems. And finally, secondary development brought about by the economic advantage of such a deepwater facility may create a number of environmental effects. New industry, increased employment, demands for services, transportation requirements, and water use changes may all have effects upon the existing and projected situation in the area.

Each element of the proposed system should be analyzed with regard to its construction, presence, and operational effects upon the items evaluated for the area. The analysis should attempt to ascertain the degree of effects upon the situation. It is also important to note the direction of the effect; that is, whether it is detrimental or beneficial to the item being considered. Finally, the duration of the effect should be noted. Some effects, most often those related to construction, will be temporary in nature; that is, after a reasonable period of time, the effects will no longer be noticeable. Others will be permanent as long as the facility or its operations exist, but will disappear if the facilities are removed or the operation is stopped. And, finally, other effects will be irreversible; that is, regardless of how long the facility exists, or even if it is removed, these effects will still be discernible.

All these effects should be summarized for the particular system in a table similar to table 5, with a code used to denote degree and duration of effects in each box where a relationship is discerned. Each element which is judged to be significant should then be discussed in a brief text describing the nature of the relationship and the degree of uncertainty which is imbedded in the predicted effects. In some cases, the level of uncertainty and possible significance of a particular effect may be such that it would be meaningless or misleading to enter a summary value in the table. In this case an asterisk should be entered in the appropriate box to denote that this particular relationship is discussed in detail in the text.

The attention to be given to the individual effects will vary according to the scope and depth of the analysis and evaluation. In a broad overview and general comparison between many alternatives, one may deal only with major permanent and moderate irreversible effects on moderate- or high-valued items in the existing character of the area. When attempting to select a particular system for a particular location, one may deal even with minor effects, particularly if they relate to high-valued items in the existing character of the area. For the present study, in-depth analysis accompanies only those entries which are moderate and permanent or more severe.

For those effects which are judged to be significant, the text should include the identification and description of any alternatives which would alleviate the effect.

5. For selected alternatives prepare the resulting information in a format consistent with the requirements of the National Environmental Policy Act, which specifically requires [2]:

a. A description of the proposed action

b. The probable impacts on the environment, including primary and secondary consequences on ecological systems, population patterns, resource use, and others

Table 5. Sample Summary of Effects Table

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
onstruction:																				
Dredging																				
Spoil Disposal																				
Pilings & Berths																				
Artificial Island																				
Breakwater																				
Mooring & Anchors																				
Submarine Pipeline																				
Onshore Pipeline																				
Submarine Storage																				
Onshore Storage																				
resence:																				
Channel																				
Onshore Berths																				
Offshore Berths																				
Offshore Island																				
Breakwater																				
Offshore Mooring																				
Overwater Trestle/Pipe																				
Offshore Storage																				
Submarine Pipeline																				
Onshore Pipeline																				
Onshore Storage																				
Underwater Storage																				
peration:																				
Channel Maintenance																				
Dry Bulk Handling																				
Petroleum Handling																				
Ship Operations																				
Facility Operations																				
Major Oil Spill																				
econdary Development:																				

c. The probable adverse environmental effects which cannot be avoided

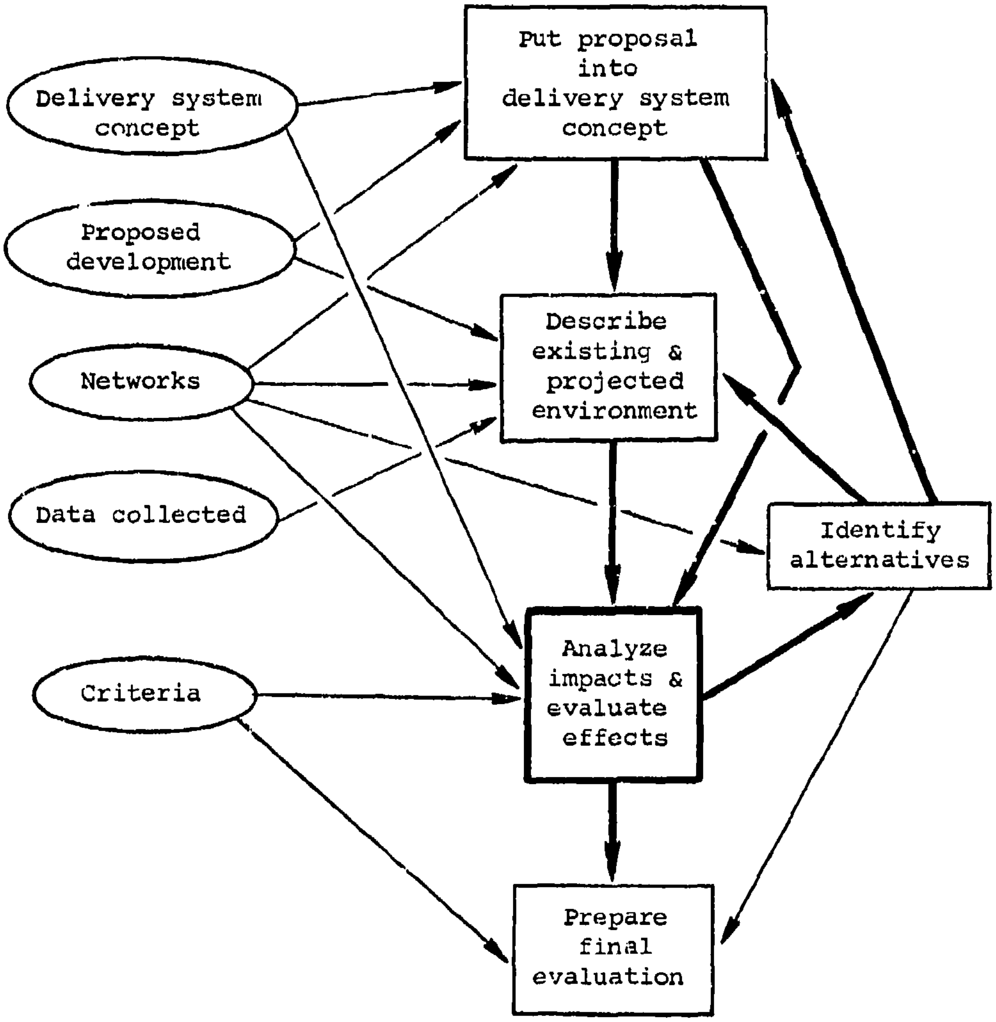
d. Alternatives to the proposed action

e. The relationship between the short-term uses and long-term productivity of the environment

f. Any irreversible and irretrievable commitment of resources which will occur in the proposed action.

Figure 13 depicts this procedure as a sequence of steps and identifies the major inputs to each step. The heavy arrows indicate the flow of the analysis and the dependence of one part upon the results of the previous part. For example, in the description of the existing and projected environment, the kinds of data to be collected depend to a large part on the system being proposed. If a proposed system calls for the construction of an offshore island with no shore-based facilities, there will be no need to collect detailed data on current and projected land use.

Figure 13. Environmental Analysis Procedure



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PART II. ANALYSIS AND EVALUATION OF SPECIFIC ALTERNATIVES

V. INTRODUCTION

The port alternatives proposed for detailed study were selected on the basis of two principles. First, each alternative meets certain real needs. That is, if it were actually implemented it would be used, as hypothesized, by deep-draft vessels carrying the bulk commodity or commodities for which the port was intended. Second, the alternatives selected for detailed analysis cover a wide range of different kinds of ports and facilities. The reason for this was to demonstrate how the approaches to the economic, engineering, and environmental analysis and evaluation could be applied to a variety of very different port concepts.

The environmental analysis and evaluation have been conducted along the lines laid down in chapter IV. The analysis has drawn upon the information collected and contained in chapters II and III. No actual field studies were included in the scope of this project. Therefore, the analysis was conducted within the current state of knowledge and within the limits of readily available data and information. Many parts of the analysis and most of the evaluation, while based on this information, required the use of value judgments, and so are open to comment and criticism.

Eight distinct areas containing one or more port alternatives were selected for analysis. These areas are:

<u>Atlantic coast</u>

- New York/New Jersey
- Delaware Bay
- Norfolk/Newport News

Gulf coast

- Offshore Louisiana
- Freeport, Texas

Pacific coast

- Los Angeles/Long Beach
- San Francisco Bay
- Puget Sound

For each of the eight areas, a general description is given of the relevant environmental and social characteristics of the area. (A characteristic was deemed relevant if it will affect or will be affected by implementation of a port alternative, either directly or indirectly.) The description is followed by a subjective evaluation of the particular quality characteristics, resources, and resource use activities as they now exist and as they are projected to exist without the development of the alternative.

This is followed by an analysis of the impact of each element of the port delivery system alternative on the same set of characteristics, resources and uses. The results of this analysis are presented in a summary table identifying impacts, their severity and duration. Those impacts which are deemed significant are also discussed in the text which accompanies the table. The analysis and evaluation are done for each alternative proposed for that area and, finally, conclude with a summarization and comparison between alternatives for the area.

The symbols on the evaluation tables have the following meaning:

T = Temporary effect: will return to original, or near original, state.

P = Permanent effect: will be discernible as long as facility exists.

I = Irreversible effect: cannot be eliminated once instituted.

+ = Potential or real beneficial effect.

1 = Minor effect: may be discernible but not of consequence (usually).

2 = Moderate effect: is discernible but usually acceptable.

3 = Major effect: will cause important changes in the value or use of the resource.

* = Treated in text, but no evaluation attempted.

In these tables, impacts which warrant some discussion have an entry in the first column indicating the page on which they are covered.

VI. NEW YORK AREA ALTERNATIVES

Introduction

Two sets of alternatives are suggested for the New York area to serve as a local (1-1) or a regional (1-2 and 1-3) solution to the increasing demand for crude petroleum.

Alternatives 1-1 and 1-2 are sited in Lower New York Bay and propose the construction of an island with berthing facilities and a tank farm. Pipelines would deliver the crude petroleum to the refineries along Arthur Kill and Kill Van Kull; in alternative 1-2, pipelines would also extend down to the refinery complexes in the Philadelphia area. Alternative 1-3 proposes the deployment of monobuoys off Long Branch, New Jersey, with pipeline connections to an onshore storage facility in the vicinity of New Shrewsbury, New Jersey. This alternative is proposed only as a regional solution and, thus, pipelines would extend from the tank farm to both the New York and Philadelphia areas.

For clarity, these two sites (Lower New York Bay and Long Branch) will be discussed separately in the following sections. However, it should be recognized that the two alternative sites have some common aspects both in assumptions and in areas of impact. None of the alternatives include the construction of new refinery complexes. Any increase in refining capacity is expected to take place via the expansion or modification of existing facilities. In addition, the establishment of either set of port alternatives will have the same impact in terms of traffic reduction in the upper reaches of New

York Harbor. Both sets of alternatives will also present a similar threat of oil pollution to the recreational beaches of the New Jersey shore.

Lower New York Bay Alternatives

The Waters of the Lower New York Bay Region

Physical Characteristics

When investigating the impact of a deepwater port facility in Lower New York Bay, one must look at the entire water system, which also includes Raritan Bay and Sandy Hook Bay. Taken together, these water bodies form an estuary covering approximately 72 square miles. The major inflow to this area comes from the Hudson River which, combined with the East, Hackensack and Passaic Rivers, flows through the Narrows into the northern portion of the estuary. Other inflows come from the Raritan River, which empties into Raritan Bay on the west, and from the Navesink River, which empties into Sandy Hook Bay on the south. To the northeast, Rockaway Inlet leads to Jamaica Bay. The outflow from the estuary is through a 5.5-mile stretch between Sandy Hook, New Jersey, and Rockaway Point, Long Island.

The water in the bay is generally less than 30 feet deep except in the area of dredged channels and near the Narrows. Extensive shoal areas are found outside these dredged areas.

The mean tidal range in the area is about 5.5 feet. The currents are generally weak, with the exception of the flow down Ambrose Channel and around Sandy Hook, which can reach speeds of about 2 knots. The principal flows are down Ambrose Channel in the eastern portion of the estuary and a large counterclockwise gyre in the western portion.

The prevailing winds in this region are northwest during the winter and southerly during the summer months. Severe winds of gale force occur about 5 percent of the time during the winter months and originate mostly from the northwest and less frequently from the northeast. Storm activity during the summer can be associated with hurricanes or tropical cyclones, but their occurrence is relatively infrequent. Severe local thunderstorms, however, are common during these warmer months.

Biological Characteristics

The waters of the Lower New York Bay area were at one time an extremely productive region for both shellfish and finfish. As recently as 1945, extensive shellfish harvesting and oyster production were carried on in these waters. However, severe pollution and the increased salinity caused by dredging have curtailed these activities [8].

It has been estimated that a standing crop of approximately 5 million bushels of hard clams still exists in the Raritan Bay area, as well as significant numbers of soft clams. However, they cannot be harvested because of the sewage pollution of the waters. Sandy Hook Bay also has a good shellfish population, and some commercial and sport harvesting occurs in this area.

Blue crabs are still an important resource in this area, although this population has experienced wide fluctuations. This species winters in the deeper, more saline areas of the bay (such as Ambrose Channel). Commercial harvesting is done in these deeper waters, and a considerable recreational fishery from shore centers on the blue crab. The deeper waters also serve as a nursery area for lobsters, and some harvesting of these is also done.

The number and variety of finfish in the bay area have decreased in the past 30 years. Currently a limited amount of commercial harvesting of foodfish and menhaden is done, but its value is not significant. On the other hand, sport-fishing activity in these waters is steadily increasing. Principal species caught are striped bass, flounders, weakfish, porgies, and bluefish. The shallow waters of Romers Shoal and Flynn's Knoll are particularly important to the striped bass population.

Although they have been severely modified, the wetlands surrounding the Lower New York Bay area are still important to wildfowl populations. Both resident and migratory species are found here, including many species of ducks, plovers, gulls, hawks, and wading birds such as egrets [8].

Uses of Bay Waters

Besides the sport and commercial fishing mentioned above, the Lower New York Bay area is the site of several other activities including commercial navigation, recreational boating, and waste disposal.

Because of the presence of the port of New York, commercial navigation is the most significant use of the waters. This port area is the largest in the United States in terms of tonnage handled. In 1968 this throughput totaled 167 million tons, and it is expected to continue to increase. Ships carrying bulk cargoes move along Ambrose Channel through the Narrows to docking facilities in Upper New York Bay. Although some oil tankers also utilize this route, the majority tends to pass through Sandy Hook and Raritan Channels toward the refinery complexes along Arthur Kill. The volume of this traffic is staggering. Oil tankers recorded 2,600 arrivals in 1968. The number of vessels in these waters will continue to increase as new containership terminals are completed on Staten Island.

Adding to the congestion in these waters is their increasing utilization by recreational boaters. The protected waters of Sandy Hook and Raritan Bays offer an excellent area for the pursuit of this sport. Much of this boating is associated with fishing activities, but extensive sailing also takes place.

The waters around New York have always functioned as a major depository of waste materials. Wastes from the industrial complexes in the Arthur Kill and Kill Van Kull area and along the Raritan River, along with millions of tons of raw and semitreated sewage, have found their way into these waters. This activity has had a severe impact on other uses of the bay, particularly shellfish harvesting and beach recreation. A great deal of money and effort is currently being expended in attempting to correct this situation. All areas surrounding these waters will be provided with collection facilities and treatment plants which will function with a high degree of secondary treatment. Industrial plants will be required to treat their effluents at a comparable level. Other types of corrective measures are also being suggested, such as the building of a breakwater from Fort Wadsworth out into the bay to divert the waters pouring through the Narrows away from the beach areas on the southeastern coast of Staten Island.

Several suggestions exist for new and extensive uses of this area. Included among these is the idea of building an offshore airport to relieve some of the pressures on Kennedy Airport and Jamaica Bay. The increasing demand for power has also prompted suggestions for the siting of a nuclear power plant in this region. The proximity of this open stretch of water to the large metropolitan area around New York will continue to spawn ideas for its development and utilization. Unfortunately, there does not seem to be enough resources to satisfy all these incompatible demands.

Land Use

Monmouth and Middlesex Counties, New Jersey

The south shores of Raritan and Sandy Hook Bays are part of Monmouth and Middlesex Counties, New Jersey. The terrain of this area is a mixture of high bluffs and low wetland areas. The coastline contains extensive low, narrow beaches of fair to poor quality. To the east of Sandy Hook Bay lies a rapidly growing sandy spit of land known as Sandy Hook. This area contains sand dunes and some wetland areas on its inner protected side.

Sandy Hook is currently occupied by Fort Hancock, a military facility originally developed to protect New York Harbor. This installation is being phased out, and the land will be combined with Sandy Hook State Park on the lower part of the peninsula into a major section of the Gateway National Park [7].

The coastline along Sandy Hook and Raritan Bays is primarily devoted to residential and commercial use. This area was traditionally a summer resort area for New York City. Keansburg is still the area's leading resort. However, current trends are toward the development of year-round homes for retirees and commuters to the city. Little industrial land is found in the Monmouth County portion of this area. However, as one moves closer to the Arthur Kill area through Middlesex County, a marked increase in industrial land use is found, especially around South Amboy and Perth Amboy. The only other significant shoreline use in this area is the large pier which is maintained by the U.S. Navy as part of its ammunition depot.

Recreational utilization of this shoreline area is not as extensive as it could be because of problems of water quality. However, as noted before, recreational fishing and boating are significant activities, and several marinas exist along the coast to service this use.

Staten Island

Staten Island is the third largest borough of New York in land area (57 square miles), but the smallest in population. It contains a great deal of diversity in land form and use. The development of this area has been very rapid since the construction of the Verrazano-Narrows Bridge. Prior to that it was a largely undeveloped area, and some sections still maintain this characteristic.

The southeastern shore of the island, which is the most important in terms of this study, is extensively developed for medium- and high-density residential use in the section close to the Verrazano-Narrows Bridge. However, as one moves down the coast to Tottenville, extensive areas of undeveloped land are encountered. The only industrial use of the shoreline is found in this lower section. Institutional land use occurs on a significant portion of this shoreline.

Two park areas are found along the coast -- Wolfes Pond Park and Great Kills Park. The latter contains the only public marina in this area. Attempts are being made to establish a greenbelt area immediately adjacent to the shoreline from Fort Wadsworth to Great Kills Park. The recreational use of this open space area and of the beaches along the coast is not as extensive as it could be. Again, water quality is the major problem, and the beaches have been periodically closed for this reason.

Extensive plans exist for the development of the southeastern shore of Staten Island. One of the recent proposals was put forth by the Rouse Corporation and involves the development of a city for 450,000 in the South Richmond area [9]. A part of this development would involve the building up of some 3,000 acres of the shallow offshore area to allow for industrial and residential expansion.

South Brooklyn

Although not considered an area that is likely to be impacted by the development of alternatives 1-1 and 1-2, a brief mention of the section of Brooklyn abutting Lower New York Bay will be made in order to give a complete picture of the land use around this area.

The South Brooklyn area is completely developed in high-density residential, commercial, and, to a lesser extent, industrial use. Adjacent to the shoreline is the famous recreational area known as Coney Island, which is currently the object of an extensive urban renewal project. Across Rockaway Inlet from Coney Island lies Breezy Point Park, which is also designated as part of the Gateway National Park development. Behind this area is Jamaica Bay, which has been extensively altered by land fill and the development of Floyd Bennet Field and Kennedy International Airport. Current plans are to develop this entire bay region as a recreational area to serve the huge population in the Metropolitan New York area.

Major Problems and Conflicts

The major problems associated with the Lower New York Bay area involve the need to upgrade water quality and the incompatible demands put on this area from the point of view of development versus recreation.

Brief mention was made above of the efforts being directed toward curtailing waste disposal in this area. Plans call for the upgrading of all the waters of this area, with the exception of those immediately adjacent to the Raritan River and Arthur Kill, to a level which permits all uses including water-contact recreation. The attainment of this goal will do much to lessen the problem of incompatible demands.

Various types of development which preclude recreational uses of some areas will continue to be proposed. Although such facilities as power plants may be economically desirable, they do not represent the best use of this area in view of the burgeoning population. The problem of the wise and equitable allocation of limited resources will exist for the foreseeable future.

A further problem in this area stems from air pollution. The Environmental Protection Agency has designated the Metropolitan New York area as a priority region, indicating that it falls below minimum standards for every air quality criterion. Although the source of this problem is not in the Lower New York Bay area, pollution does significantly impact on the area.

Regulating and Planning Agencies

Several local and regional agencies and groups would be concerned with the development of alternatives 1-1 and 1-2, including the States of New York and New Jersey. Included among these would be:

1. New York Department of Environmental Conservation -- concerned with air and water quality regulations and enforcement

2. New Jersey Department of Conservation and Economic Development -- regulates use of riparian lands and is concerned as well with aspects of environmental quality

3. New York City Planning Commission -- establishes goals for New York City area lands and waters

4. Port of New York Authority -- controls all port activities

5. Tri-State Planning Commission -- plans and reviews major undertakings in the New York, New Jersey, and Connecticut area

6. Interstate Sanitation Commission -- establishes water quality criteria and recommends appropriate actions

7. New York City Environmental Protection Administration -- concerned with all aspects of environmental quality, including air, water, and noise.

Attitudes Toward Port Development

It is difficult to gauge the attitude which would be held towards the development of alternatives 1-1 and 1-2. The New York area has been oriented toward more and bigger development. It is reasonable to assume that this view would also be taken with regard to a deepwater port facility. The fact that this development would reduce traffic in the upper reaches of New York Harbor would add weight to this viewpoint. However, residents along the Monmouth County coast and people taking part in developing Sandy Hook as a major recreational area will undoubtedly object to the project because of the potential for oil spills and the removal of a significant portion of the estuary from recreational use. It is not possible at this point to judge the net result of these opposing views.

Possible Modification to Alternatives 1-1 and 1-2

Although it has not been considered in detail, it is important to recognize a significant possible modification to these alternatives. This involves the site of the storage facility.

Instead of locating the tank farm on an offshore island, it may be more desirable to utilize an onshore site for this facility. One possibility would be to construct the needed storage in the industrially zoned area of Staten Island along Arthur Kill. From an environmental viewpoint, the advantages of such a location would lie in the fact that the size and aesthetic impact of the island would be significantly reduced, and that any major spill associated with the storage facility could be better controlled. Considering the present character of the Arthur Kill area, the adverse environmental impact of such a storage facility on the region would be marginal.

Difficulties likely to be encountered in this location stem from two sources. First, opposition would be voiced to the establishment of a pipeline right-of-way across Staten Island. Although the environmental disruption caused by the construction of this link would be minor and temporary, local feelings against such an undertaking may very well preclude it.

The second source of difficulty lies in the need to dedicate this valuable and limited land resource to more labor-intensive industry. Currently, only 55 percent of the labor force on Staten Island can obtain employment in the immediate area. The rest must go to Manhattan or other areas to work. Planning agencies perceive this problem and are likely to oppose such a non-labor-intensive use of the land.

Analysis and Evaluation

The difference between alternatives 1-1 and 1-2 is primarily one of magnitude, with the exception of the onshore pipeline extension to the Philadelphia area in the latter alternative. Both alternatives involve the development of a new channel paralleling Ambrose Channel and the dredging of a turning basin in Romers Shoal. The island will be about 90 to 105 acres in size for the local alternative and may be up to 170 acres for the regional alternative. Two berths will be required for alternative 1-2. Pipeline connections to shore will follow the same route in both cases and will utilize one 48-inch line per berth.

To obtain an overview of the water and land areas in the immediate vicinity of the proposed alternatives, table 6 was developed to illustrate the value of certain resources and characteristics. The evaluation is based on the analyst's viewpoint after consulting the pertinent literature and talking with people in the area. Table 7 contains an analysis of the probable impact, on these same resources and characteristics, of the construction and operation of the type of deepwater port facility proposed herein. The estimation of extent and seriousness of the impact is solely the author's responsibility.

Dredging

The development of the approach channel and turning basin for these alternatives will involve a considerable amount of dredging -- a maximum of over 80 million cubic yards. This activity will involve some disruption of the area in terms of increased turbidity and interference with navigation, but the impact will be temporary and not very significant. Any permanent physical change in water movement caused by the alteration of the bottom topography may cause local problems with regard to increased currents, but this does not appear to be significant at this time. A beneficial effect may even accrue from this change because the flushing time will be increased in this lower bay area. A resolution to the uncertainty involved in this aspect of the port development may be found in the exercise of the hydraulic model of this area which is now at Vicksburg.

Another concern involved with the dredging activity is related to the site chosen and its current biological characteristics, but again the impact can be both detrimental and advantageous. Currently Romers Shoal is a valuable habitat for striped bass and, consequently, a good recreational fishing area. The deepening of this area as part of the turning basin will destroy its value to this species. However, the development of a new

Table 6. Evaluation of Lower New York Bay Area

	Aesthetics	Water Quality	Air Quality	Uniqueness *	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
Present value	M	L	L		M	L	L	M	L	H	M	L	H	L		L	H	H	H
Projected value	M	M	M		M	L	L	M	M	H	M	M	H	M		L	H	H	H

Key:
H = high value, high quality, or high level of use
M = moderate value, moderate quality, or moderate level of use
L = low value, low quality, or low level of use

* Number entered equals number of natural or historic sites in the area of influence.

Table 7. Evaluation of Deepwater Port Alternatives 1-1 and 1-2, Lower New York Bay

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		M	L	L		M	L	L	M	L	H	M	L	H	L		L	H	H	H
Construction:																				
Dredging	117	1T	1T			1P			2P	1P		2T		2T					2T	
Spoil Disposal	120	1T	2T						1T	1T		1T								
Pilings & Berths																				
Artificial Island	120	2T	1T						2T			2T		2T					2T	
Breakwater																				
Mooring & Anchors																				
Submarine Pipeline		1T	1T						1T	1T		1T		2T					1T	
Onshore Pipeline	121	1T										1T								1T
Submarine Storage																				
Onshore Storage																				
Presence:																				
Channel	117		1P			1P			1P	+				1P					+	
Onshore Berths																				
Offshore Berths		1P				1P			1P			1P		1P					+	
Offshore Island	120	2P				1P			1P			1P		1P					+	
Breakwater																				
Offshore Mooring																				
Overwater Trestle/Pipe																				
Offshore Storage		2P										1P								
Submarine Pipeline																				
Onshore Pipeline	121		1P									1P								
Onshore Storage																				
Underwater Storage																				
Operation:																				
Channel Maintenance	117	1T	1T						1T	1T		1T							1T	
Dry Bulk Handling																				
Petroleum Handling	122		1P	1P								2P								
Ship Operations			1P	1P								1P								
Facility Operations												1P								
Major Oil Spill	122	2T	3T			2T	2I	2T		1T		3T	2T	2T	2T				2T	
Secondary Development:																				

deepwater area may attract more lobsters and blue crab and improve the recreational and commercial pursuits of these species.

Another problem related to the dredging activity, as well as to the island construction, will be the description of already existing structures on the bay bottom. Lower New York Bay is crisscrossed with many pipelines and cables serving the utilities in the area. Any construction activity will likely require the relocation of these links.

Deposition of the spoil developed as a result of the dredging is not viewed as a significant problem since much of it can be used in the construction of the island. Much of it is also likely to be of commercial value. Any valueless material will in all likelihood be dumped at sea, which is the current practice in the area. This practice is not desirable from an environmental point of view because of the impact on the bottom organisms in the area. However, assuming that the amount to be thus disposed of is small and viewing it against the background of other similar activities in the area, the disposal activity associated with these alternatives cannot be considered a significant problem.

Offshore Island

The construction and presence of the offshore island and its storage facilities involve several environmental considerations. The structure will be quite visible from the land and will thus have a significant aesthetic impact. The value placed on this impact will be determined by the viewer. Thus, residents along the coast may consider it undesirable since it will disturb the skyline. However, it may also be judged as a pleasant diversion to tourists who may enjoy seeing the large tankers moving in and out of the area.

The construction of the island will permanently remove the bottom area and water column from other uses such as recreational fishing and boating. Although this fact can be viewed as locally significant, the area thus precluded is not a major consideration in the context of the large expanse of the Lower New York Bay area.

The island will present a navigational hazard to recreational and commercial vessels navigating this congested area, particularly during the construction period. However, once the island is in place, sufficient warning devices such as lights and horns can be established to minimize this hazard.

The most significant impact of the island lies not in its physical presence and associated alteration of the environment, but in the setting of a precedent for uses of the bay waters. The pressure for the development of other structures such as airports or power plants has been mentioned before. Once an area of the bay is relinquished to a use incompatible with the area's natural amenities, the pressure for other forms of development is likely to increase. Further, these other developments may have a more significant and extensive adverse impact on the region as a whole. This possibility will be one of the prime considerations in the decision of whether to implement these alternatives.

Onshore Pipeline

Except for the ever-present threat of rupture, the construction and existence of the onshore pipeline is not of significant environmental concern. The evaluation is based on the fact that the route will coincide with existing rights-of-way, whether railroad or highway. In this manner although some disruption of land transportation may occur, it would not be extensive or long-lasting. The adverse impacts of noise, dust, and increased activity would not be different from those caused by any current construction to which these highly developed areas are commonly subjected, such as that for sewer lines.

The threat posed by the rupture of a pipeline and a resulting oil spill is of some concern, but since this area is fairly stable and since overdesign in terms of protective casings is assumed, it is not viewed as significant. Special care will need to be taken in areas where the pipeline route crosses water bodies, such as the Raritan or Delaware Rivers. A rupture in such an area would cause extensive damage because of the high-intensity use of these waters and because of the fact that a spill occurring in these flowing waters could rapidly get out of control and cover a large area downstream.

Major Oil Spills

A major spill occurring at the offshore facility proposed in these alternatives would have a relatively good chance of being contained and removed. The storage tanks will be surrounded by dikes, and in the event of a rupture the amount of oil entering the water is likely to be small. Any spills occurring in the berthing areas will be in an already partially enclosed water body, and the rapid deployment of booms behind the vessels would offer effective containment.

The major concern will center on accidents involving ships approaching the island along Ambrose Channel and those maneuvering in the turning basin area. The direction taken by an oil slick resulting from any such casualty and the land area affected, if any, will primarily be determined by wind conditions at the time and, secondarily, by currents.

During the winter months, the prevailing northwest wind would tend to drive a slick out to sea, although the tip of Sandy Hook could sustain some damage. Winds from the north or northeast would cause the slick to move toward the beaches along the Monmouth County coast and possibly to penetrate into wetland areas around the Navesink River. A southerly wind would move the slick toward similar areas around Jamaica Bay. If a spill occurred as a result of a casualty involving a vessel approaching the bay area, the two areas susceptible to the pollution would be the recreational beaches along the New Jersey coast or those along the southern coast of Long Island.

In all the cases mentioned, the impact on the areas would be serious but temporary. The most serious impact would occur during the summer months when the recreational use of these areas would be high. More long-lasting damage would occur if such a spill managed to enter the wetland areas, particularly around Jamaica

Bay. The death of a significant number of waterfowl would likely occur in this case.

In summary, the threat of oil pollution must be considered a significant environmental factor in this alternative as in most others.

Maritime Shipping

A significant environmental benefit derived from the implementation of these alternatives would be the reduction of small oil tanker movements into the Arthur Kill and Kill Van Kull areas. A major traffic problem currently exists in this area, and the Lower Newark Bay region where these two water bodies meet is the site of many accidents. As the demand for crude petroleum expands and the number of ships required to move it into this area increases, the situation will become ripe for more accidents and the possibility of some major oil spills. Either the number of ships must be decreased or extensive physical modifications to these areas must be undertaken to widen and straighten channels. The latter would be required to provide more space as well as to remove some hazards to ship movement in these areas.

Summary

The environmental impacts associated with the implementation of alternatives 1-1 and 1-2 are generally of a minor or temporary nature, with three exceptions: the benefits accruing to the Philadelphia area and the upper reaches of New York Harbor; the threat to recreational areas of a major oil spill; and the establishment of a precedent for development in these waters. These exceptions are stated in order of ascending importance. The last is of overriding importance in the long-range view. Too often developments such as those proposed herein have neglected to consider these secondary effects. One of the principal needs in this area is an improvement in the quality of life, attained in part through such mechanisms as more recreational opportunities, more open space, and cleaner air and water.

Offshore Long Branch -- Alternative 1-3

Physical Characteristics

The ocean shoreline of New Jersey extends 125 miles from Sandy Hook in the north to Cape May in the south. The coastline is all beach of generally good to excellent quality, with much of it on barrier islands. Behind the islands are many bays and wetland areas which extend far inland at some points. The entire coast is subject to alternating periods of erosion and accretion, which are of critical proportions along many stretches. Extensive changes are associated with the severe coastal storms and hurricanes to which the area is occasionally subjected [4].

Long Branch lies about 6 miles south of Sandy Hook. There is no barrier island in this immediate area, and the beach fronts directly on the mainland. The beach is of generally fair to poor quality, with only one small stretch considered excellent. Erosion is a severe problem in this area and has necessitated the construction of extensive groin and jetty systems in an attempt to stabilize the shoreline. The littoral drift is northward along the beach, as evidenced by the accretion along the south sides of these structures and the rapid elongation of the spit known as Sandy Hook [4, 10].

The climatic characteristics of this area are not appreciably different from the Lower New York Bay area. During the winter months the prevailing winds are from the north and west. Gale winds are predominately associated with this direction, although they can also originate in the northeast. Summer winds are generally from the south and southwest and are of weaker intensity than those in the colder months. Near-shore fog is frequent in the spring and summer [1].

Land Use

The land area around Long Branch has been extensively developed for a long time. As with the rest of the New Jersey coast, the prime orientation is toward recreation and tourism. Long Branch ranks among the most important recreational centers along the shore.

Land use in this area is almost completely residential and commercial. Traditionally, residential use was primarily seasonal. Although many strictly seasonal dwellings still exist, recent years have seen an increasing development of year-round housing, much of it associated with retirement-age populations. Included in this housing are some new high-rise developments near the coast, as well as the conversion of one-family seasonal dwellings into year-round homes. This changing character of the area has resulted in a mix, where many areas designated as blighted or deteriorating exist alongside large expensive estates, and has directed attention to the need for urban renewal in some areas.

Most of the shoreline in this area is in private ownership, and commercial establishments oriented toward the tourist trade abound. Many private beach clubs exist along this portion of the coast, allowing use of the beach by members only. This has created a severe problem in terms of public access to beach areas, and efforts are currently being directed toward alleviating this problem [4].

Where access is available, high-intensity beach and water-contact recreation exists. Fishing is also an important activity off the coast. The immediate Long Branch area has little in the way of wildlife or wetlands. The nearest area of this type is located up the coast near the Shrewsbury and Navesink Rivers.

As one moves inland from Long Branch, some industrial use of land is found, but it is limited. Along the Garden State Parkway in such towns as New Shrewsbury, the amount of land zoned for this use increases significantly. A major tract of land in the Colts Neck-New Shrewsbury area is utilized by the U.S. Navy's Earle Ammunition Depot. This is the area chosen in this alternative as a possible site for the onshore tank farm.

Population Characteristics

The population of Long Branch in 1970 was 31,774, a 21 percent increase over the 1960 population, reflecting the rapidly changing residential pattern referred to above. During the tourist season the population of this area is significantly higher. New Shrewsbury is a much smaller community with a 1970 population of only 5,925, a 19 percent decrease from the 1960 population level.

State Agencies

Since the monobuoys proposed in this alternative would be located approximately 7.5 miles off shore, the major involvement in the establishment of these facilities would be by Federal agencies such as the Coast Guard. However, the pipeline access to the storage area and the associated use of riparian lands would fall under the jurisdiction of the New Jersey Bureau of Navigation, which leases these areas. This bureau is a part of the Department of Conservation and Economic Development, which would also be concerned with the general environmental impact of such a port system. The New Jersey Department of Public Works and the Highway Department would also be involved due to the utilization of existing roads as a part of the pipeline route.

Attitudes Toward Port Development

It is highly probable that the attitude of the general public in the Long Branch area would be strongly against any deepwater port development off the coast. This opposition would be based primarily on the threat to the beach and its associated tourist industry posed by oil spills associated with such a facility. Such an attitude is likely to exist in all the communities along this coast. This general feeling is reflected in a bill recently put before the New Jersey Legislature. The bill is patterned after the one passed in Delaware and is designed to prohibit all offshore development in New Jersey waters and all links (such as pipelines) from developments in Federal waters off New Jersey. The passage of this bill would preclude the establishment of this alternative.

Analysis and Evaluation

Alternative 1-3 proposes the development of three to five monobuoys in about 80 feet of water at a location some 7.5 miles off Long Branch, New Jersey. A 48-inch pipeline would connect each monobuoy first to a booster station located on a pile-supported platform about 5 miles from the coast and from there to an onshore tank farm located in the vicinity of the U.S. Navy's Earle Ammunition Depot in New Shrewsbury, New Jersey. From this intermediate storage area, pipeline transmission would supply crude oil to the refinery complexes in the New York and Philadelphia areas.

To assess the impact of such a port system on the Long Branch area, an evaluation of certain natural resources and characteristics of the area has been made (table 8). The values presented are based on observation as well as on a review of pertinent literature and conversations with people familiar with the area. The entries represent an evaluation of the general coastal area about Long Branch, not merely of those lands and waters within the city limits.

Table 9 contains an evaluation of the effects of the proposed port system development upon this same set of resources and characteristics. In reviewing table 9, the reader will note the absence of entries under the column entitled "marine transportation." The impact on marine transportation is one of the primary considerations involved in the development of alternative 1-3, but the location of this effect is removed from the Long Branch area. The discussion of this aspect of the alternative will be found on page 131.

It should also be noted that aside from some limited activity associated with the burial of the submarine pipeline, no dredging is involved in this alternative.

Offshore Structures

The monobuoy and booster station located off shore will essentially be invisible from the beach,

Table 8. Evaluation of Long Branch, New Jersey Area

	Aesthetics	Water Quality	Air Quality	Uniqueness *	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
Present value	M	H	M		L	L	L	M	L	H	M	H	M	H		L	H		H
Projected value	M	H	H		L	L	L	M	L	H	M	H	M	H		L	H		H

Key:
H = high value, high quality, or high level of use
M = moderate value, moderate quality, or moderate level of use
L = low value, low quality, or low level of use

* Number entered equals number of natural or historic sites in the area of influence.

Table 9. Evaluation of Deepwater Port Alternative 1-3, Long Branch, New Jersey

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		M	H	M		L	L	L	M	L	H	M	H	M	H		L	H		H
Construction:																				
Dredging																				
Spoil Disposal																				
Pilings	127	1T				1T			1T			1T		1T						
Artificial Island																				
Breakwater																				
Mooring & Anchors	127	1T							1T			1T		1T						
Submarine Pipeline	127	1T	1T			1T			1T			1T		1T						
Onshore Pipeline	130	2T	1T									1T			1T					2T
Submarine Storage																				
Onshore Storage		2T										1T								
Presence:																				
Channel																				
Onshore Berths																				
Offshore Berths																				
Offshore Island																				
Breakwater																				
Offshore Mooring	127	1P				1P			+			1P		1P						
Overwater Trestle/Pipe																				
Offshore Storage																				
Submarine Pipeline	127	1P				1P			+			1P		1P					1P	
Onshore Pipeline			1P									1P								
Onshore Storage	130	2P										1P					1P	1P		
Underwater Storage																				
Operation:																				
Channel Maintenance																				
Dry Bulk Handling																				
Petroleum Handling	131											1P								
Ship Operations		1P										1P		2P						
Facility Operations																				
Major Oil Spill	131	3T	3T			1T	1T	1T		1T		1T	3T	2T	3T					
Secondary Development:																				

and their adverse aesthetic impact would therefore be experienced only by boaters in the area. A second impact upon recreational boaters would be their exclusion from the area of large ship maneuvering and mooring. The moorings and booster station could also be a navigational hazard.

The offshore structures may offer an advantage as fish of sporting value are attracted to the area. This situation can be capitalized upon by sport fishermen in the vicinity of the booster station since the structure will be some 2.5 miles from the maneuvering area and no interference with supertanker movements would occur.

In summary, it is felt that the construction and presence of these offshore structures offer no significant adverse environmental effect.

Onshore Pipeline

The onshore pipeline also does not appear to have a major adverse environmental impact. No significant environmental problem will be associated with placing the pipeline across the beach at Long Branch. Recreational use of the beach will be curtailed during the construction period, but this can be timed to occur during the winter months. Because of the susceptibility of this shoreline to erosion, care will need to be exercised to insure adequate burial and maintenance of the pipeline.

For the major portion of its route, the onshore pipeline will follow existing roads or railroad rights-of-way. Although the construction activity will cause an adverse aesthetic impact and possibly some interference with land transportation, this will be minimal and temporary. A more serious concern will exist where the route crosses water bodies. In this case, a permanent threat of a pipeline rupture and consequent environmental danger exists, but such an occurrence is not necessarily probable. Overdesign of safety features will be required to minimize the possibility of any spills from this source.

Major Oil Spills

The threat of a major oil spill and its effect on the recreational beaches along the New Jersey shore offer the primary environmental concern associated with this alternative. Whether a spill occurring in the unloading area would reach these shores is dependent primarily on the direction and strength of the wind and associated currents at the time. Under the prevailing northwest winds in winter or south and southwest winds in summer, the oil slick would tend to stay off shore. However, in storm conditions associated with northeast or southeast winds, any released oil would be driven onto the beach. It could also impact on some wetland areas if it is driven far enough south to enter one of the inlets through the barrier beaches. Unfortunately, the most likely occurrence of a vessel casualty and an associated spill would be during these storm periods. Under such weather conditions, it would be almost impossible to contain the slick.

The contamination of the beach areas by oil would be a severe but temporary problem. Various mechanisms exist for cleaning beaches, and the natural forces of the waves would help to dissipate the oil. However, minor remnants of weathered oil and the psychological impact of such a spill could have a severe effect on the recreational attractiveness of the beach area.

Marine Transportation

The impact on maritime shipping of an offshore deepwater port handling crude petroleum was discussed previously under the Lower New York Bay alternatives. Briefly, such a development would serve to reduce the heavy traffic of tankers currently navigating in the area of the Arthur Kill and Kill Van Kull in New York Harbor, and in the Delaware River. Such a reduction would lower the probability of accidents and associated oil spills in these areas, and would offer an opportunity for more and safer utilization of these waters by other types of commercial or recreational craft. An added advantage in locating this deepwater port off Long Branch would be the reduction of traffic in the outer approaches to Ambrose Channel, since tankers approaching Long Branch would be removed from this area.

From this point of view, the establishment of alternative 1-3 offers significant environmental benefits.

Summary

The development of alternative 1-3 has relatively few and minor adverse environmental impacts, and these are mostly of a temporary nature. The only significant concern is that associated with a major oil spill. However, even after this potential impact is taken into consideration, an offshore monobuoy facility near Long Branch would create less environmental impact than the island in Lower New York Bay.

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VII. THE DELAWARE BAY ALTERNATIVES

Introduction

The alternatives selected for detailed analysis in Delaware Bay entail a channel 72 feet deep entering the bay at the location of the existing channel, then proceeding northwesterly (but south of the existing channel) to a location 4 to 5 miles off shore from the Big Stone Beach area. The alternatives range from a single-purpose facility with an offshore berth, submarine pipeline and onshore tank farm for the import of crude petroleum to a multipurpose facility with onsite storage for iron ore and coal as well as crude petroleum. The direct influence of the alternatives will be felt primarily in Delaware. The offshore location will be on the Delaware side of the bay, and all shore facilities will be located in Delaware. Therefore, the major effort in investigating the environmental impact of the potential development has been concentrated on the implications for that state.

The Characteristics of the Area

General Nature of the Delaware Bay

Delaware Bay is a large, shallow, muddy estuary that is about 130 miles long, 27 miles wide at its greatest width, and 11 miles wide at its mouth. It has a surface area of about 450 square miles and an average depth of about 23 feet. The New Jersey side is the more shallow. The Delaware side is characterized by shoals interspersed with fingers of deep water, making it more amenable to the development of deep channels.

The Delaware River provides the major inflow of fresh water to the estuary. Many small streams on both sides of the bay also contribute to the inflow, and there is an extensive ground-water regime throughout the area that is related to the stream and the bay itself. The exact nature of the relationship is not well understood at this time.

The water flow and circulation in the bay are generated by river and tidal flow, and are influenced by Coriolis force and meteorological conditions. The general circulation pattern is a counterclockwise motion which causes the waters of flood tides to build up primarily on the New Jersey side and the ebb tides to build on the Delaware side. This pattern tends to increase the salinity on the New Jersey side and lower it on the Delaware side. It also indicates that polluted water flowing down the Delaware River remains close to the Delaware shore.

The normal winds in the bay region tend to come from a northerly to northwesterly direction during the fall, winter, and early spring. Late spring and summer winds more frequently come from a southerly direction. The most frequent wind speeds range between 6 and 10 knots throughout the year, with highest speeds up to 30 to 35 knots.

As would be expected, the wave action follows a similar pattern to wind action, with waves coming from a northerly direction in fall, winter, and early spring, and from a southerly direction in late spring and summer. The most frequent wave heights are from 0 to 2 feet, with normal high waves from 4 to 6 feet.

Of course, exceptions to these normal conditions are generated during storm conditions. Table 10 provides information on the 25-, 50-, and 100-year storm waves and winds. As can be seen, the waters and winds of the bay can reach forceful proportions.

Table 10. Storm Wave and Wind Characteristics of Delaware Bay at 38° 55.9'N, 75° 10.3'W[a/]

Type of storm	Maximum wave height (feet)	Maximum wind gust (m.p.h.)	Maximum sustained wind speed (m.p.h.)
100-year storm....	36.8	165	110
50-year storm....	31.6	129	85
25-year storm....	19.7	90	60

a/ The approximate location proposed for a deepwater terminal in Delaware Bay.

Source: Divcon Engineers, Inc., Cost Study and Design of Marine Transportation Facilities, Delaware Bay Transportation Company, Delaware Bay, June 1968; data provided and analyzed by A.H. Glenn & Associates.

The bay waters have contained a high level of pollution for many years. The bay is subject to pollution from industrial chemicals, oils, insecticides, herbicides, and domestic wastes. This pollution is primarily associated with the heavily populated and industrialized region in the upper estuary and along the Delaware River. The discharge of untreated, or inadequately treated, wastes into the many small streams flowing into the bay has also contributed to the problem. In fact, a number of the streams and bay shore areas have been closed to shellfishing because of pollution.

An extensive pollution control program has been developed and is now being implemented on an interstate basis. The program, while not expected to be complete until 1985, has already improved water quality in some areas of the bay, particularly in its upper reaches.

Delaware has over 18 important species of salt-water fish. Among the most important from a recreational and commercial fisheries' point of view are shad, menhaden, sea trout, striped bass and flounder.

In recent years fishing has been impaired by the low water quality. Commercial finfishing has declined drastically from a value of about $4.5 million annually at the turn of the century to a 1966 value of $14,000 [10]. However, this last summer (1971) provided the best sport fishing in perhaps 45 years. Sea trout were much in evidence, and there were indications of the best menhaden spawning in many years.

Oysters, hard clams and blue crabs are the most prevalent and important shellfish in the bay. Although oysters have experienced a serious decline, the oyster population is recovering, mainly because of the buildup of a strain with natural resistance to the MSX disease. Also, as the coastal creeks are cleaned up, additional valuable oyster beds, now closed, will be added to the resource. Delaware has an extensive oyster program now underway under the Department of Natural Resources and Environmental Control, with a long-range goal of an annual yield of 4 to 5 million bushels. Seed oysters are now raised primarily in the northern parts of the bay, and are then transplanted into growing beds in an area extending southward off of Bowers Beach. Blue crabs, which are found scattered throughout the bay, have also declined in recent years. Hard clams are also quite scattered. Clams are not as important a species, from a commercial standpoint, as oysters, but are frequently taken by recreational fishermen.

Delaware Bay and River are the gateways to the largest import port area in the United States. They have the largest concentration of refineries on the east coast, which require a tremendous amount of crude oil to supply their needs. Small tankers move through the bay directly to the refineries. An extensive amount of lightering is done in the lower bay, where tankers up to 175,000 d.w.t. can enter and transfer a portion of their cargo to barges. The movement of this crude into the bay and river is a major cause of environmental concern. In fact, in sampling runs on the bay in 1970, oil slicks were identified in 33 out of 38 runs. The causes, when identifiable, included disposal of oily bilge waters, leaking and broken hoses, collisions, careless handling and lightering activities [10].

Delaware Bay, then, is at this time a major shipping thoroughfare and an important estuary for wildlife, and has been significantly altered by man. Current management programs in conservation, fish and wildlife and pollution control are designed to preserve and restore it as an estuarine and marine habitat with the potential to satisfy commercial and recreational demands of the surrounding areas.

General Nature of the Delaware Coastal Zone

There are two major parts to the Delaware coastal zone. The Atlantic Ocean shore area extending from Cape Henlopen on the north to the Maryland border on the south consists primarily of wide sand beaches backed by dunes. It is highly valued for beach recreation activities, and a number of resort communities and two state-operated recreation areas are located in the area.

The bay shore is the other major part of the Delaware coastal zone. This area is characterized by narrow beaches backed by extensive wetlands for practically the entire length. Delaware has approximately 120,000 acres of coastal wetlands [5]. Those in the northern portion of the zone have been severely modified by road and bridge development, industrial and residential development, waste and spoil disposal and mosquito control.

The total ecology of the Delaware coastal area is vitally linked to the health of the coastal wetlands.

The contributions of wetlands to marine life have been well documented. They serve as breeding and nursery areas for a number of fish and crustaceans, and they are highly productive of nutrients and provide a major source of such nutrients for marine life.

The Delaware wetlands also serve as nesting areas for waterfowl, and are an important link in the Atlantic flyway from Canada to the Gulf of Mexico. Very large numbers of wildfowl stop here on their annual migrations. In fact, coastal wetlands in Kent County serve as feeding grounds for the Greater Snow Goose, a species in very real danger of extinction.

While the northern marshes, particularly north of the Chesapeake and Delaware Canal, have been severely altered by development, the central wetlands remain nearly in their original condition except for local areas of pollution and some dredging for mosquito control. Further south, in Sussex County, wetland losses are attributable primarily to recreational resort development.

Pressure for actions which tend to destroy the nature and function of wetlands continues in Delaware as it does in nearly all coastal areas. The State Fish and Wildlife Division estimates that the rate of wetlands loss in recent years has been approximately 1 percent per year. To counteract this trend, efforts are continually underway to expand the area of wetlands that is under the protection of the State and Federal Governments [5].

The State of Delaware

Delaware, with a total land area of about 1,983 square miles, has a population of 548,104 (1970 census). The northern part is in the eastern megalopolis, strategically located between Philadelphia and Baltimore. Delaware is bordered on the east by the Delaware River and Delaware Bay, and in the extreme southern part by the Atlantic Ocean.

There are three counties in the state. New Castle County, in the northern part, contains the cities of Wilmington, New Castle, and Delaware City. Kent County, in the central part of the state, and Sussex County, in the southern part, are mostly rural but have a number of small but growing urban areas.

Existing Land Use

Residential

The major concentration of population is located in the urban area of New Castle County, which contains over 70 percent of the state's population. Below the Chesapeake and Delaware Canal, most of the residential land use is located immediately adjacent to the scattered urbanized areas such as Dover and Milford in Kent County, and Bridgeville, Georgetown, and Lewes in Sussex County. The rest of the land below the canal is predominantly rural with scattered residential areas. Very little residential land is located along the Delaware Bay. There are a few small communities on the bay shore, but the residences are mostly seasonal in nature.

Industrial

As with residential land use, the greatest concentration of industry is located in the northern portions of New Castle County, although manufacturing employment has been increasing at a much higher rate in Kent County. Several large oil refineries are located on the Delaware River shore north of the Chesapeake and Delaware Canal. Below the canal there is no major industrial development in the primary coastal zone bordering the bay.

Recreation

Recreation in the coastal areas of Delaware covers the usual range of activities which are normally associated with the shore. Swimming and beach recreation are predominantly located on the Atlantic shore from Cape Henlopen south to the Maryland border. The shore of Delaware Bay is not considered to be of a high enough quality for swimming. In addition to the fact that substantial areas are polluted, the beaches are generally narrow and the bay bottom tends to be muddy. Also, access to the bay shore is limited by the extensive wetland areas and lack of access roads [4].

Recreational boating is conducted quite extensively in Delaware Bay and is frequently undertaken in conjunction with fishing both in the bay and off shore in the Atlantic. There are a few boat-launching sites on the bay, usually located at the small shore communities where good roads lead to the shore.

Recreational fishing, as noted, is also an important activity in the coastal zone of Delaware and has shown substantial improvement in the past several years.

There are three recreational facilities on Delaware's Atlantic coast. Cape Henlopen State Park, formerly Fort Miles, contains 1,641 acres, and offers the broad range of beach recreation activities; Delaware Seashore contains 1,759 acres of the Atlantic shore and offers the same broad range of activities; and Holts Landing State Recreation Area, located on 33 acres on Indian River Bay, offers the usual range of activities.

Conservation

Several fish and wildlife areas under State and Federal administration are located along the shore of Delaware Bay. Bombay Hook National Wildlife Refuge, on the bay shore northeast of Dover, is an important part of the Atlantic flyway. It contains over 16,000 acres and has recreational opportunities for nature study, photography, sightseeing, dog field trials, and limited hunting [4].

Primehook National Wildlife Refuge, located on the bay shore below Slaughter Beach, has been under development for 10 years. It will ultimately contain 10,000 acres of coastal wetlands and will offer nature study, hiking, fishing, boat launching, picnicking, and some controlled hunting.

In addition to the above two refuges, which are under Federal administration, there are outdoor areas for recreation and conservation along the bay shore as well as inland, which are administered by the State Fish and Wildlife Division.

The recreation and conservation areas along the bay serve multiple purposes. In addition to recreation, they help to provide open space and to protect the coastal wetlands, which are so important from a fish and wildlife standpoint.

Unique Qualities

Delaware had a prominent role in early American development and, consequently, has a number of historic sites which can be considered unique and irreplaceable. In the immediate coastal area, however, little early activity was undertaken because of the extensive marshes. Nevertheless, one location, near Bowers, is the site of a prehistoric Indian village, the largest and most significant ever found to date on the peninsula. Called the Island Field site, it is a unique and irreplaceable resource which should undoubtedly be preserved [7].

Present and Projected Population

As mentioned earlier, the 1970 census figures indicated a total state population of 548,104. New Castle County contains 70 percent of that total, while Kent and Sussex share the remainder in about equal proportions. Delaware's population is expected to increase to over 800,000 by 1980. New Castle County will still maintain the lead in population for the state. Kent County will likely have the most rapid rate of population increase, whereas Sussex County will grow more slowly and tend to retain its rural, agricultural nature [7].

Water Supply and Waste Disposal

Delaware's prime source of water is the extensive system of aquifers which underlies the entire area, including the bay itself. In fact, all ground-water reservoirs are near to or at least partially in contact with the bay or the Atlantic Ocean.

The concern with the reservoirs is the fresh-water/salt-water relationship. Excessive withdrawals of fresh water near the coast may cause saline intrusion into the supply. Deep dredging may also cause a fresh/salt exchange. For example, the Chesapeake and Delaware Canal penetrates an outcrop of an aquifer and has caused saline intrusion into the nearby supply.

Of particular interest is an observation by scientists from the College of Marine Studies of the University of Delaware. In their field measurements in the bay, they have observed the phenomenon of cold, saline (dense) water over warm, less saline water in a deep hole just inside the sill of the bay. While it is speculation at this time, it is quite possible that this phenomenon is caused by a bleeding, or outflowing, aquifer which may also help to keep the hole clear. If so, dredging on or near the sill could cause changes in the aquifer.1/

The coastal wetlands of Delaware are underlaid by a water table that is generally less than 10 feet above sea level. The salt-water/freshwater interface moves inland during the summer when precipitation and stream flows are lowest, and back toward the bay in winter. Heavy withdrawals in this area would significantly increase intrusion and let the area of saline encroachment move further inland [2, 12, 13, 14, 20, 21, 22].

Twenty-six communities in Delaware have sewage disposal systems. Not all these systems are adequate for pollution control, however. The state has undertaken an extensive program of upgrading and building new

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1/ Personal communication with Professors Polis, Kupferman, and Sheridan of the College of Marine Studies, University of Delaware.

systems (some regional) to provide a high-level secondary treatment. It is designing major regional collection systems to handle the developing areas and also to treat storm water runoff which now generally goes untreated in overtaxed existing systems [7].

Existing Land Use Planning and Regulation Agencies

Municipal

Many of the towns in Delaware have local zoning ordinances and active planning programs.

County

New Castle and Sussex Counties have control of lands through zoning. Kent County has no such powers at this time.

State

A number of state agencies have the responsibility to conduct planning and resource management programs. The programs of the Delaware State Planning Office and the Delaware Department of Natural Resources and Environmental Control (NREC) are particularly relevant. The State Planning Office has been responsible for the development of the Delaware Comprehensive Outdoor Recreation Plan (1970) [4], the implementation of which has strong implications for the coastal zone, particularly in the preservation of the wetlands and open space. The Planning Office also has the task of constructing the State Comprehensive Development Plan as a strategy for long-range physical development to meet the needs of the people while maintaining the character of the land. The preliminary plan was completed in 1967 and explicitly recognizes the need and desirability of preserving the coastal wetlands as open space for fish and wildlife habitat, conservation, and recreation.

NREC is the principal state agency responsible for programs in natural resource development and conservation, as well as environmental quality control. Within NREC, there are extensive continuing activities leading to the design and development of community and, more importantly, regional sewage collection and treatment systems. NREC expects all areas of population concentration and all areas where significant pollution has been occurring to be sewered and using advanced secondary treatment by 1985.

NREC also has a significant shellfish program underway with the goal of returning the industry to its past prominence. The program is concentrating primarily on oyster production at this time. It has developed a new code for shellfish management practices and has the long-range goal of reaching an annual oyster harvest of 4 to 5 million bushels. The planners believe this goal is readily attainable as long as the schedule for water pollution programs now underway is adhered to and the planned quality is attained.

In addition to these programs, the State of Delaware has also enacted very significant legislation designed to prevent development within the coastal zone which could be detrimental and contrary to the long-range goals of the state. The legislation specifically bans new heavy industry and all bulk transfer facilities (meaning any port or dock facility, and any artificial island) from the coastal zone. The Governor appointed a Task Force on Marine and Coastal Affairs to analyze the problems of the coastal zone and to develop recommendations for its future use. A preliminary report was completed and submitted in February 1971 [10], and a complete final report is now being printed. The report endorses and strengthens the Outdoor Recreation Plan previously mentioned and recommends that legislation be enacted to provide for state zoning in the waters of Delaware Bay, Little Bay, and the Atlantic Ocean, and for enforceable standards for land-use control in the adjoining areas. These standards are to be enforced within the framework of county and municipal planning and zoning. The report further recommends legislation to preserve existing coastal wetlands and to control uses which would cause environmental degradation in these wetlands.

Interstate-Federal

A number of interstate agencies also have some planning and management influence on Delaware Bay, its shores and resources. Some of the more important are:

1. Delaware River Basin Commission -- primarily concerned with the conservation, use, quality control, and management of the waters of the Delaware River Basin, including the bay. (Has Federal representation.)

2. Delaware-New Jersey Fisheries Compact -- has the goal of developing uniform laws for the taking of finfish in Delaware and New Jersey, including the bay.

3. Coastal States Organization -- established for planning the development and preservation of the marine resources of the coastal zone.

4. Delmarva Advisory Council -- established to advocate programs for the economic development of the area.

In summary, current planning and management agencies and programs cover the entire spectrum from local planning and zoning to broad-scale regional programs that are concerned with the broad range of resources available in the region and that have Federal participation.

Outstanding Conflicts in Land and Water Uses in the Coastal Zone

At present, the most outstanding conflicts appear to be between the use of the bay waters for fishing, wildlife, and recreational activities and for receiving waste products. These conflicts are gradually being relieved by the water pollution control program. Industrial development has not occurred to any extent in the coastal zone in the southern two counties. In New Castle County, the major coastal industrial development has existed for a long enough time so that other incompatible uses which could cause conflicts are not extensively pursued.

Other conflicts appear to be more potential than real at this time. Continual growth in population and industry will put pressure upon the existing groundwater supply and may cause the salt/fresh interface to move inland, creating conflicts of major proportions. Also, new port development can create secondary coastal development which would conflict with the other uses of the coastal zone. Adequate planning and control can help to avoid many of these conflicts as Delaware grows.

Public Attitude Toward Port Development

The people of Delaware recognize the need for and the inevitability of growth. However, they also recognize that they can control the changes through adequate planning and management. Delaware is seeking what is commonly called a balanced approach -- an approach that will provide economic stability and growth while maintaining a high quality of life. The state will not accept a headlong rush into developments that may adversely affect this quality, and this caution is reflected in the moratorium on development in the coastal zone. The establishment of the Governor's Task Force on Marine and Coastal Affairs, which is to develop guidelines and recommendations for the management and wise use of the water and land resources of the coastal zone, reflects the desire for a balanced approach.

The Task Force recognizes the following as desirable goals:1/

1. To preserve and improve the quality of life and the quality of the marine and coastal environment for recreation, conservation of natural resources, wildlife areas, aesthetics, and the health and social wellbeing of the people

2. To promote the orderly growth of commerce, industry, and employment in the coastal zone of Delaware which is compatible with item 1

1/ These goals are cited in the Report of the Governor's Task Force on Marine and Coastal Affairs, presently in draft.

3. To increase the opportunities and facilities in Delaware for education, training, science, and research in marine and coastal affairs.

The Delaware Bay Oil Transport Committee was formed in September 1971 and instructed to investigate ways to safely meet the petroleum needs of the refineries in the Delaware River and Bay area. There is naturally a great deal of concern about the effects of the movement and potential spillage of large volumes of petroleum on the marine and coastal environment. Delaware is determined at this time to preserve and protect its coastal and marine environment from the potentially disastrous effects of a "Torrey Canyon" incident within the bay, and from the less spectacular but potentially as disastrous effects of continual small spills. However, its people are seeking ways to meet the needs both of the petroleum refineries and of the environment. Therefore, while the attitude toward deepwater ports and major environmental modifications is understandably negative at this time, the people are willing to investigate ways to accommodate these needs without causing unacceptable conflicts in goals and objectives.

Present and Planned Navigation Activity

Port Activity - Bulk Commodities

All major port development within the Delaware estuary is located in the Delaware River. There are five major terminals. Going upstream, the first of these is located in Delaware at Delaware City just above the Chesapeake and Delaware Canal. The others are located in the Marcus Hook/Philadelphia/Camden area further upstream. Petroleum storage capacity in these port areas is approximately 60 million barrels.

Although petroleum makes up the greatest part of the bulk commodity movement in the Delaware estuary, the Fairless Plant of the U.S. Steel Company, located about 30 miles upstream from Philadelphia, creates a movement of bulk iron ore, the second largest volume bulk commodity to move through the bay.

The port of Philadelphia is also a major port for general cargo. In total, over 120 million tons of general cargo and bulk commodities move through the Delaware Bay and River ports every year. The approximate breakdown is 60 percent petroleum, 10 percent iron ore, and 30 percent other commodities and general cargo.

Traffic Types and Density

During 1966 there were 210,392 waterborne trips in the waters from Trenton to the sea [16]. This total includes passenger vessels; dry cargo carriers; tankers, including barges; and tow and tug boats. Because larger ships (especially tankers) are being used, the depth of the channel is becoming a constraint to movement. To partially counteract this, these larger tankers are now lightering in the Lower Delaware Bay in naturally deep water. The lightering operation there and immediately off shore from the mouth of the bay is becoming a common and extensive activity.

Not only is the tonnage of commerce increasing, but the number of vessels and the draft of the vessels are also increasing. In 1966, there were over 8,000 trips to Philadelphia by vessels with a draft of at least 20 feet, and over 1,600 trips by vessels with drafts over 32 feet.

With respect to accidents involving vessels in the river, the Coast Guard records appear to indicate that there has been no increase in the number of collisions and groundings as a result of the increased traffic.

Channel Development and Maintenance

The natural depth of the Delaware River in the Philadelphia area is 17 feet. The channel from Philadelphia to the sea has been developed and is presently being maintained at a depth of 40 feet. The maintenance of that depth requires repeated dredging in areas where shoaling occurs. Most of the shoaling areas are in the river above the bay. Annual maintenance dredging results in about 7,800,000 cubic yards of spoil material which must be disposed of. The using up of existing spoil areas and the public resistance to new or expanded disposal areas are creating problems. In fact, at the present rate of activity, it is estimated that maintenance dredging alone will use up all presently available disposal sites by 1985. Consequently, any further deepening will require new disposal practices, such as ocean or bay disposal. Bay disposal will undoubtedly cause a large public outcry. Ocean disposal will be costly because of the distance which the material must be moved, and will also cause environmental concerns. The spoil disposal problem is, indeed, significant from the standpoint of growth in vessel size and shipping to the Philadelphia area, especially for bulk commodities.

Scientific Activities Related to Delaware Bay

Organizations

Several publicly funded organizations are actively engaged in environmental and marine-related research in the Delaware area. The University of Delaware has the College of Marine Studies, which has an active and growing interdisciplinary program in Delaware Bay. Other departments within the university also have related programs and joint cooperative programs with the College of Marine Studies. These programs entail field studies and measurements as well as laboratory and analytical studies in biology, physical and chemical oceanography, geology, hydrology, engineering, and systems modeling and resource planning [23, 24].

Past and present programs at the university are sources of extensive amounts of data and information about the bay environment. Current reports, postgraduate student theses, and the staff people themselves can provide up-to-date data. The Water Resources Center at the university has an important collection of information and knowledge particularly related to the Delaware ground-water situation.

The U.S. Geological Survey, which has a cooperative program with the State of Delaware, also has data and information relevant to the water resources of the state.

The Delaware Department of Natural Resources and Environmental Control, with its programs in water quality improvement and shellfish management, also has data, particularly on current water quality and trends. The Department, of course, also has a scientific staff with knowledge about the interrelationships of the bay important to their own programs.

Models

A very large physical hydraulic model of the bay has been built by the Corps of Engineers and is located at the Waterway Experiment Station at Vicksburg, Mississippi. A more limited physical model of a part of the bay has been built at the University of Delaware for experimental study.

Additional activity is underway at the university to develop operationally useful and scientifically sound mathematical models of the physical properties and behavior of the bay waters. It currently has a model for studying wave and flow patterns around large structures in deepwater conditions and is extending it into shallow waters with variable shoreline configurations. It has not yet been verified or checked with physical modeling.

Baseline Study

The College of Marine Studies has developed a plan to conduct a comprehensive baseline study of the Delaware Bay. The purpose of the study is to gather, analyze, and relate extensive amounts of data to gain an understanding of the estuary as a basis for scientific research and the development of predictive models. The actual study is still in the planning phase, with an evaluation of existing information. It is expected that the major field activity will be underway in the near future.

In general, the physical behavior of the bay has been studied far less than its biological nature. Consequently, there are fewer data, less understanding, and less predictive capability in that area at this time.

Analysis and Evaluation of Delaware Bay Alternatives

Fourteen different alternatives are proposed for deepwater ports in Delaware Bay. However, common elements among these alternatives simplify the task of analysis. All alternatives call for a 72-foot channel in the same location, so the implications of dredging such a channel need be analyzed only once. A pipeline to shore storage tanks is proposed in six alternatives, while island storage tanks are proposed in six others. All but two alternatives include a pipeline for crude petroleum from storage to the existing refinery locations. None of the alternatives include the development of shore processing facilities in the area of the port, but rely instead upon the use of already industrially developed land at existing processing facilities. (In the Delaware region, refineries and petrochemical plants are the major processing facilities, all of which are located on the upper estuary and river rather than on the bay shores.)

The major environmental aspects of the area which could be affected by the development of one or more of the alternatives were discussed in the previous section. Table 11 indicates the evaluation, or ranking, of each of the aspects as a result of the analysis. The reader is reminded that this ranking is strictly the result of a subjective judgment by the analyst and does not necessarily reflect the opinions or judgment of anyone in the affected area or in the State of Delaware.

Tables 12 through 16 present the summaries of impacts for the alternatives proposed for the Delaware Bay area. One summary covers several alternatives in those cases where the differences between the alternatives appear to be insignificant with regard to impacts. For example, table 12 contains the summary of impacts for alternatives 2-1 and 2-3. The main difference

Table 11. Evaluation of Delaware Bay Area

	Aesthetics	Water Quality	Air Quality	Uniqueness*	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Poat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
Present value	M	L	M	1H	H	H	H	L-M	L	H	M	L	M	L	H	L	L	H	M
Projected value	M	M	M	1H	H	H	H	M	M-H	M	M	M	H	M	M	L	M	H	M

Key:
H = high value, high quality, or high level of use
M = moderate value, moderate quality, or moderate level of use
L = low value, low quality, or low level of use

* Number entered equals number of natural or historic sites in the area of influence.

Table 12. Evaluation of Deepwater Port Alternatives 2-1 and 2-3, Delaware Bay Area

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		M	L	M	1H	H	H	H	M	L	H	M	L	M	L	H	L	L	H	M
Construction:																				
Dredging	160	1T	2T			1T			1T	1P	*			2T					2T	
Spoil Disposal	162		2T			2I			'T	2I				1T					1T	
Pilings & Berths			1T				2T			1T		1T		2T					2T	
Artificial Island																				
Breakwater																				
Mooring & Anchors																				
Submarine Pipeline	162	1T	2T			1T		2T	1T	2T			2T	2T	1T				2T	
Onshore Pipeline	163	2T	2T	1T	2T	1T	2T	2T			1T	1T			1T	1T	1T	2T		1T
Submarine Storage																				
Onshore Storage	165	1T	2T	1T	*	1T	3T	3T			1T	1T			1T	1T				1T
Presence:																				
Channel	161		2I			1I			1I	1P	*								+	
Onshore Berths																				
Offshore Berths		1P							+	1P		1P		2P	1P				2P	
Offshore Island																				
Breakwater																				
Offshore Mooring																				
Overwater Trestle/Pipe																				
Offshore Storage																				
Submarine Pipeline	162											1P		1P					1P	
Onshore Pipeline	163	1I						1I				1P			1P	1P		2P		1P
Onshore Storage	165	1P	2P		*		2P	3I				2P			2P	1P		1P		1P
Underwater Storage																				
Operation:																				
Channel Maintenance	160	1P	2P			2I			1P	1P	*		1P	2P	1P				1P	
Dry Bulk Handling																				
Petroleum Handling	167	1P	1P	1P			1P	1P		2P		1P	2P	1P	1P					
Ship Operations			1P	1P								1P	1P	2P					1P	
Facility Operations			2P	2P		1I	2P	2I			1I	1P	1P	1P						
Major Oil Spill	167	3T	3T			3T	3I	3T	2T	3I		3T	3T	3T	3T				2T	
Secondary Development:	170	2I	2I	3I	3I	3I	3I	3I	2I	3I	*	2I	1I		3I	3I	+	3I	+	2I

Table 13. Evaluation of Deepwater Port Alternatives 2-2 and 2-4, Delaware Bay Area

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		M	L	M	1H	H	H	H	M	L	H	M	L	M	L	H	L	L	H	M
Construction:																				
Dredging	160	1T	2T			1T			1T	1P	*			2T					2T	
Spoil Disposal	162		2T			2I			1T	2I				1T					1T	
Pilings & Berths			1T				2T			1T		1T		2T					2T	
Artificial Island	171	2T	3T			2T	1T		2T	3P				2T	1T				2T	
Breakwater																				
Mooring & Anchors																				
Submarine Pipeline	162	1T	2T			1T		2T	1T	2T			2T	2T	1T				2T	
Onshore Pipeline	163	2T	2T	1T	2T	1T	2T	2T			1T	1T			1T	1T	1T	2T		1T
Submarine Storage																				
Onshore Storage																				
Presence:																				
Channel	161		2I			1I			1I	1P	*								+	
Onshore Berths																				
Offshore Berths		1P							+			1P		2P					2P	
Offshore Island	171	2P				1I	1P		+	2I		1P		2P					2P	
Breakwater																				
Offshore Mooring																				
Overwater Trestle/Pipe																				
Offshore Storage	171	2P	2P									1P								
Submarine Pipeline	162											1P		1P					1P	
Onshore Pipeline	163	1I						1I				1P			1P	1P		2P		1P
Onshore Storage																				
Underwater Storage																				
Operation:																				
Channel Maintenance	160	1P	2P			2I			1P	1P	*		1P	2P	1P				1P	
Dry Bulk Handling																				
Petroleum Handling	167	1P	1P	1P			1P	1P		2P		1P	2P	1P	1P					
Ship Operations			1P	1P								1P	1P	2P					1P	
Facility Operations			2P	2P		1I	2P	1I			1I	1P	1P	1P						
Major Oil Spill	167	3T	3T			3T	3I	3T	2T	3I		3T	3T	3T	3T				2T	
Secondary Development:	170	3I	3I	3I	3I	3I	3I	3I	2I	3I	*	2I	1I		3I	3I	+	3I	+	2I

Table 14. Evaluation of Deepwater Port Alternatives 2-6 and 2-7, Delaware Bay Area

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		M	L	M	1H	H	H	H	M	L	H	M	L	M	L	H	L	L	H	M
onstruction:																				
Dredging	160	1T	2T			1T			1T	1P	*			2T					2T	
Spoil Disposal	162		2T			2I			1T	2I				1T					1T	
Pilings & Berths			1T				2T			1T		1T		2T					2T	
Artificial Island	171	2T	3T			2T	1T		2T	3P				2T	1T				2T	
Breakwater																				
Mooring & Anchors																				
Submarine Pipeline																				
Onshore Pipeline																				
Submarine Storage																				
Onshore Storage																				
resence:																				
Channel	161		2I			1I			1I	1P	*								+	
Onshore Berths																				
Offshore Berths		1P							+			1P		2P					2P	
Offshore Island	171	2P				1I	1P		+	2I		1P		2P					2P	
Breakwater																				
Offshore Mooring																				
Overwater Trestle/Pipe		1P										1P		2P					2P	
Offshore Storage	171	2P	1P	1P								1P								
Submarine Pipeline																				
Onshore Pipeline																				
Onshore Storage																				
Underwater Storage																				
peration:																				
Channel Maintenance	160	1P	2P			2I			1P	1P	*		1P	2P	1P				1P	
Dry Bulk Handling	174	2P	1P	1P		1P	1P					1P								
Petroleum Handling																				
Ship Operations			1P	1P								1P	1P	2P					1P	
Facility Operations		1P	2P	2P		1I	2P	2I			1I	1P	1P	1P						
Major Oil Spill																				
econdary Development:	170	3I	3I	3I	3I	3I	3I	3I		3I	*	2I	1I		3I	3I	+	3I	+	2I

Table 15. Evaluation of Deepwater Port Alternatives 2-8, 2-9, 2-12, and 2-13, Delaware Bay Area

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		M	L	M	1H	H	H	H	M	L	H	M	L	M	L	H	L	L	H	M
Construction:																				
Dredging	160	1T	2T			1T			1T	1P	*			2T					2T	
Spoil Disposal	162		2T			2I			1T	2I				1T					1T	
Pilings & Berths			1T				2T			1T		1T		2T					2T	
Artificial Island	171	2T	3T			2T	1T		2T	3P				2T	1T				2T	
Breakwater																				
Mooring & Anchors																				
Submarine Pipeline	162	1T	2T			1T		2T	1T	2T			2T	2T	1T				2T	
Onshore Pipeline	163	2T	2T	1T	2T	1T	2T	2T			1T	1T			1T	1T	1T	2T		1T
Submarine Storage																				
Onshore Storage	165	1T	2T	1T	*	1T	3T	3T			1T	1T			1T	1T				1T
Presence:																				
Channel	161		2I			1I			1I	1P	*								+	
Onshore Berths																				
Offshore Berths		1P							+	1P		1P		2P					2P	
Offshore Island	171	2P				1I	1P		+	2I		1P		2P					2P	
Breakwater																				
Offshore Mooring																				
Overwater Trestle/Pipe		1P										1P		2P					2P	
Offshore Storage	171	2P	1P	1P								1P								
Submarine Pipeline	162											1P		1P					1P	
Onshore Pipeline	163	1I						1I				1P			1P	1P		2P		1P
Onshore Storage	165	1P	2P		*		2P	3I				2P			2P	1P		1P		1P
Underwater Storage																				
Operation:																				
Channel Maintenance	160	1P	2P			2I			1P	1P	*		1P	2P	1P				1P	
Dry Bulk Handling	174	2P	1P	1P		1P	1P					1P								
Petroleum Handling	167	1P	1P	1P			1P	1P		2P		1P	2P	1P	1P					
Ship Operations			2P	2P								2P	1P	3P					2P	
Facility Operations		2P	2P	2P		2I	2P	2I			2I	2P	1P	1P						
Major Oil Spill	167	3T	3T			3T	3I	3T	2T	3I		3T	3T	3T	3T				2T	
Secondary Development:	170	3I	3I	3I	3I	3I	3I	3I	2I	3I	*	2I	1I		3I	3I	+	3I	+	2I

Table 16. Evaluation of Deepwater Port Alternatives 2-10, 2-11, 2-14, and 2-15, Delaware Bay Area

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		M	L	M	1H	H	H	H	M	L	H	M	L	M	L	H	L	L	H	M
Construction:																				
Dredging	160	1T	2T			1T			1T	1P	*			2T					2T	
Spoil Disposal	162		2T			2I			1T	2I				1T					1T	
Pilings & Berths			1T				2T			1T		1T		2T					2T	
Artificial Island	171	2T	3T			2T	1T		2T	3P				2T	1T				2T	
Breakwater																				
Mooring & Anchors																				
Submarine Pipeline	162	1T	2T			1T		2T	1T	2T			2T	2T	1T				2T	
Onshore Pipeline	163	2T	2T	1T	2T	1T	2T	2T			1T	1T			1T	1T	1T	2T		1T
Submarine Storage																				
Onshore Storage																				
Presence:																				
Channel	161		2I			1I			1I	1P	*								+	
Onshore Berths																				
Offshore Berths		2P							+	1P		2P		2P					2P	
Offshore Island	171	3P				1I	1P		+	2I		2P		2P					2P	
Breakwater																				
Offshore Mooring																				
Overwater Trestle/Pipe																				
Offshore Storage	171	3P	2P	1P								2P								
Submarine Pipeline	162											1P		1P					1P	
Onshore Pipeline	163	1I						1I				1P			1P	1P		2P		1P
Onshore Storage																				
Underwater Storage																				
Operation:																				
Channel Maintenance	160	1P	2P			2I			1P	1P	*		1P	2P	1P				1P	
Dry Bulk Handling	174	2P	1P	1P		1P	1P					1P								
Petroleum Handling	167	1P	1P	1P			1P	1P		2P		1P	2P	1P	1P					
Ship Operations			2P	2P								2P	1P	3P					2P	
Facility Operations		2P	2P	2P		2I	2P	1I			2I	2P	1P	1P						
Major Oil Spill	167	3T	3T			3T	3I	3T	2T	3I		3T	3T	3T	3T				2T	
Secondary Development:	170	3I	2I	3I	3I	3I	3I	3I	2I	3I	*	2I	1I		3I	3I	+	3I	+	2I

between these alternatives is the volume of crude throughput and, consequently, the amount of storage, the number of berths, and the size of pipelines that are necessary. Although we cannot adequately deal with such differences in this study, their implications are dealt with in the accompanying text wherever possible.

Dredging

The general environmental considerations associated with dredging were discussed in chapter II. All Delaware Bay alternatives require a 72-foot channel from the ocean to the area of Big Stone Beach. The only difference between alternatives occurs in the type of terminal proposed; e.g., an island structure will have different requirements than will offshore berths for tankers. A combination of both will have still a different requirement to accommodate more vessels and differently located turning basins.

A longitudinal cross section of the channel location indicates that dredging will be required at locations about 10 miles outside the mouth of the bay; inside the bay from a point 4 miles in from the mouth to 8 miles inside; and again from 12 miles inside the mouth to the Big Stone Beach site.

The various potential impacts were identified and analyzed with the dredging network diagram used as a guide. One of the more significant potential impacts is the danger of interference with the ground-water situation. As discussed earlier, the Delaware and New Jersey areas near the bay are underlaid by extensive aquifer systems, and practically all water supply requirements are met by ground-water withdrawals. Deep dredging in the bay could expose an aquifer, causing either an inflow of saline bay water or an outflow of fresh water into the bay and a lowering of the head. This would eventually increase the saline intrusion into the current water supply. This problem is unsolved at this time because no observation borings have been conducted to test the depth or flow of aquifers under the bay in the region of required dredging. Even with test holes, however, there will still be uncertainty about the actual impact dredging will have on the ground-water situation. The only way to ascertain the impact is to dredge, monitoring the ground water through test borings both before and after. The general feeling of experts in the field of ground-water hydrology and of the water resource situation in the Delaware Bay area in particular is that dredging to the 72-foot depth (plus required overdepth) may disturb the ground-water situation, but will not likely be significant or even noticeable. Dredging much beyond the 72-foot depth, however, could have a very significant adverse impact on the ground-water situation over a long period of time. Caution would dictate that test observation borings be made and analyzed prior to any deep dredging.

The potential impact of dredging upon the bay's water quality must also be considered. Dredging during construction tends to increase turbidity levels in the immediate area of the dredging activity. The major implication of the increased turbidity is a reduction in the photosynthetic process and primary production. However, the impact is temporary and disappears when dredging stops. It can also be countered to a certain extent by dredging during the winter season when the primary production activity is naturally quite low in the bay waters.

Turbidity will be more of a factor if constant dredging is required to maintain the required channel depth. The Delaware Bay deep channels characteristically contain constantly moving sand waves caused by water currents. Initial dredging should take these waves into consideration because they will very likely reappear after the channel is deepened to 72 feet. If extra depth is provided initially to allow for the buildup of sand waves, then maintenance dredging can be substantially reduced and resulting turbidity conditions will not be a major problem.

Another water quality implication which has to be considered stems from the changes in circulation and flushing which would be expected to occur with substantial deepening of a channel. Increased water exchange could remove polluted waters at a faster rate and, at the same time, increase salinity levels in the upper bay. However, the physical character of the bay and the relatively small amount of dredging required give a reasonable assurance that the dredging will not create a significant impact in this manner.

Consideration also must be given to dredging's physical impact on fish in the area. Dredging has little effect on finfish, for they tend to leave the area during dredging operations and return after completion of the project. The situation is different with shellfish, which do not have this mobility. The two major species in the bay are hard clams and oysters. Dredging for the proposed alternatives would not occur in the important oyster beds, which are located further north in the bay. Hard clams, which are generally scattered throughout the bay, would naturally be removed in the dredged area, but would probably recolonize the channel bottom in a relatively short time. Therefore, it appears that dredging the channel for the proposed alternatives will have a minor impact on the fishery.

The alternatives which include a submarine pipeline to shore will require the additional dredging necessary to bury the pipe in the bottom. Such dredging will likely increase turbidity during construction and will also disturb shellfish and other benthic organisms, but any detrimental effects will be temporary and will disappear rapidly upon completion of the project. Burying the pipeline is much more acceptable than laying it on the bottom (where it would be susceptible to damage from anchors and storm currents) or placing it on a trestle above the water.

A final and very important aspect of dredging is the disposition of the dredged material. If the material is of acceptable quality (which is quite likely, especially in the already deep areas), it will, at least partly, be used in the construction of the offshore island for those alternatives which include that development.

For the material which must be disposed of, there are basically three alternatives. It can be disposed of on shore, deposited in the bay, or barged out to sea and dumped. Onshore disposal would entail filling of wetland areas and/or possibly beach replenishment, with wetlands the likely candidate. The most economic disposal would be in the bay alongside the channel area. Both these alternatives would have impacts upon the ecological and environmental character of the area. Destruction of wetland areas by spoil disposal is not acceptable in the Delaware area (for this reason, the summary table shows no impact on wetlands). Likewise, dumping in the bay would substantially increase the turbidity and would cover a large number of benthic organisms, primarily shellfish.

The only remaining alternative for spoil disposal is ocean dumping. Very little is known about the effects of such disposal, but at this time it appears more acceptable than the other alternatives. If the material was polluted, a very real problem would exist because ocean dumping would be prohibited. Current data and knowledge about the bay, however, indicate that the material is most likely unpolluted. Ocean dumping is the preferred disposal method for the bay alternatives.

In summary, the only major implication of the proposed dredging deals with the long-term disruption of the underlying aquifer system and associated changes in the quantity and quality (salinity) of ground waters available for supply in the vicinity of the bay. Little uncertainty or adverse implications exist elsewhere as long as the actual project follows the proposal. A decision to extend the channel to another area, to deepen it beyond 72 feet, or to dispose of the spoil in some way other than ocean dumping (such as wetland filling or bay dumping) would create a much greater chance of ecological and environmental damage.

Onshore Pipelines

Onshore pipelines from Big Stone Beach to the existing refinery locations have several impacts, the most obvious of which will occur during the actual construction. The use of heavy equipment to move the materials and dig the necessary trenches will require roadways where none now exist. The movement and noise of equipment and the presence of construction crews will have a noticeable, but temporary, effect on wildlife in the area. Such effects may be minimized by limiting activity to the times when the many waterfowl which use the area are nesting or feeding elsewhere.

Construction activity may also generate water quality problems when runoff from the open land carries silt into the area's streams and into the bay itself. Care can be taken, through the use of standard construction techniques, to control runoff and trap sediment before it gets into a nearby water body.

Generally, however, the ecological and environmental impacts of the pipeline construction are temporary. Once the pipeline is in, buried, and regrowth covers the area, the above-mentioned effects will no longer be evident.

The implications of the physical presence of the pipeline and required pumping stations are more permanent. Other land use along the line will be limited. An access strip will be needed for inspection and maintenance activities. If the location is through forested land, farmland, and residential areas, the route of the line will be permanently apparent and considered by some to be a scar on the landscape. This problem can be eliminated if the selected route is coupled with another facility already in use. This might be accomplished along a railroad right-of-way with a minimum of general environmental intrusion. A highway right-of-way could also resolve the long-term problem.

The problems associated with pipeline construction, acquisition of rights-of-way, operation, and presence will be more difficult in those port alternatives which are designed for regional petroleum distribution (2-3, 2-4, and 2-12 through 2-15) because the line will necessarily be much longer than that required for the local distribution alternatives (2-1, 2-2 and 2-8 through 2-11). The regional alternatives will require pipelines extending the additional distance from the Philadelphia area to the New York-New Jersey refinery complex.

No specific routing has been undertaken for this study. Preimplementation activity would require an extensive field survey to select a route that would least disrupt the social and ecological values in the area. Without a specific route and survey it is impossible to evaluate all the implications as far as the locational aspects are concerned.

With respect to the movement of oil through an underground pipeline, the area does not generate many problems. Little seismic activity occurs, and any that would disrupt or break a pipeline is extremely rare. With proper construction, maintenance and monitoring, such a pipeline will cause little or no oil pollution problem.

In summary, the major problems related to the onshore pipeline are the implication for other land uses and the permanent access strip along the line. Oil pollution should be no problem except in the unlikely event of a leak or rupture. With adequate inspection, safety devices, automatic pump shutoffs and check valves, the oil loss during a leak or rupture can be kept small.

The actual site survey and location of the pipeline should attempt to utilize existing utility or transportation rights-of-way. Consideration should be given to selecting a site where multiple uses are possible. In addition, as far as possible, the routes should be kept out of the coastal wetlands which occupy much of the bay shore.

Onshore Storage --
Petroleum

Those alternatives which call for the development of an onshore tank farm for crude petroleum storage (2-1, 2-3, 2-8, 2-9, 2-12, and 2-13) have several implications which can be significant. The effects will depend upon construction methods, exact location, size of storage area, design of storage from a visual and safety standpoint, and operating procedures.

The proposed storage location is in the area of Big Stone Beach. Much of the area behind the narrow shore and dunes is a part of the extensive Delaware shore wetland system, and major construction will have an effect on waterfowl. The presence of construction crews, heavy equipment, and noise will disrupt the use of the area by wildlife. In addition, water quality in the wetlands will be affected locally by construction runoff. These effects of construction should be temporary, disappearing when construction has been completed.

However, the presence of the storage facility will have effects of a permanent nature. Water quality may very well be permanently altered by the runoff which carries with it pollutants from the storage area. There will be permanent changes in the pattern of use by wildlife in the vicinity. Also, with construction in a wetland area, the filling for the storage and access roads will create a permanent and irreversible intrusion on the wetland. Even if the facility were removed in the future it is highly unlikely that the wetland would return to its original state.

Another potential effect should be recognized: the possible safety hazard brought about by the danger of fire. However remote the possibility of a tank fire, such an occurrence could have a major effect upon the surrounding area of wetlands and wildlife habitat. In addition, the rupture or bursting of a large storage tank would create a major oil spill in an area where waterfowl are frequent inhabitants.

Although the area behind Big Stone Beach would not be considered highly scenic by anyone not interested in conservation and wildlife, the presence of the large tank storage facility could be detrimental to the use of the beach for recreation. If the facility is visible from the shore and beach area, it will detract from the scenic qualities of the beach.

In summary, the construction of a tank farm for storage of crude petroleum in the Big Stone Beach area will have temporary detrimental effects on wildlife and water quality. More permanent effects will result from the presence of the facility. It will affect the other land uses of the area, the patterns of wildlife use, and water quality in the area. It will also be a potential safety hazard because of the increased danger of fire and the potential for a major oil spill, and will irreversibly change the area's wetlands.

Consideration should be given to locating the tank farm farther inland, removed from the wetland areas of the bay shore. An underground pipeline through the wetland would be less of a disruption during construction, and its permanent ecological and environmental effects would be minimal.

One final item which should be taken into consideration in the site locations for storage and pipeline is the existence of the Island Field site near Bowers, north of Big Stone Beach. As was previously mentioned, Island Field is the site of a prehistoric Indian burial ground and is the most important archeological find on the Delmarva Peninsula. It should not be disturbed by the port development.

Petroleum Handling and Spills

The handling of petroleum, and the consequent possible oil pollution of the coastal waters, are among the most significant environmental and ecological implications of the deep port development alternatives. All the alternatives except 2-6 and 2-7 include petroleum as a major commodity.

In a port delivery system, there are a number of points at which petroleum can find its way into the environment. (The general nature of these was discussed in chapter II under ship operations, and in chapter III under petroleum.) Accidental collisions and groundings of tankers, hose ruptures, tank overflows, pipeline breaks, and tank failures are the major sources of such spills.

The channel proposed for development to the 72-foot draft is almost completely separate from the existing channel into and through the bay. From the deep ocean to the mouth of the bay, the new channel would be south of the existing one. The channels would coincide for a short distance at the mouth, but would separate again as the new channel branched off south of the existing channel and continued on to the proposed berthing location about 4 miles off Big Stone Beach.

If the 72-foot channel is used only by loaded vessels, a one-way traffic pattern could be established for the "petroleum only" alternatives (2-1 through 2-4), except where the channels come together at the mouth of the bay. In this case, concern about a major oil spill resulting from collision would focus on the mouth of the bay since it would have the highest probability of such an occurrence. This area is relatively exposed to the influence of the open ocean waves, making containment of a spill difficult. With a normal northwesterly wind tending to hold the oil out and the normal circulation tending to bring the oil into the bay, the spill would likely come ashore in the extreme lower bay and on the lower Delaware shore near Lewes and the resort areas around Rehoboth. This would have a very significant effect upon recreation in the area, as well as on waterfowl, shellfish, and the general ecology.

In the alternatives designed to handle coal as well as oil, the one-way traffic lane for loaded vessels no longer applies, because the loaded deep-draft coal carriers would be moving out of the bay rather than into it. Thus the chances of a spill due to collision inside the bay would be increased, and because both vessels would be fully loaded, their momentum would be greater, as would the resulting impact and damage. Therefore the amount of oil spilled could be very large.

In the location of the proposed channel, the bay has normally small waves which would make the spill more amenable to containment. However, the amount of oil to be handled would make it very difficult to contain the entire spill. The natural counterclockwise circulation in the bay and the mormal northwesterly winds would tend to move a spill onto the Delaware shore of the bay between Big Stone Beach and Lewes. This area is bordered with extensive wetlands and waterfowl nesting areas, and the impact of a major oil spill would be very significant and could disrupt the ecology of the area, although the area would likely recover over a long period. Consequently, the impacts on aesthetics, water quality, recreation, and wetlands (among others) are classed as major but temporary. The impact on waterfowl would likely be irreversible. In addition, the psychological impact of a major spill from the standpoint of tourists, recreation, and land values could last well beyond the time normally considered "temporary."

The loading and unloading of vessels is another potential source of oil pollution. In all cases the alternatives call for fixed berths rather than buoy-type moorings. Fixed berths tend to reduce the risk of accidental spills from sudden unexpected vessel movement during oil operations. They also reduce the need for flexible hoses which wear rapidly in a moving sea and which may leak or rupture unexpectedly.

Spills also may occur because of the failure to shut down a pump or switch the flow in time, causing an overflow. Adequate communication between the vessel and the storage area and an alert crew can substantially reduce such accidents. Also, mechanical safety devices can be installed to automatically control flows and practically eliminate the problem.

The impact of frequent small spills can be more significant than one major spill, especially on marine organisms. Frequently a single large spill will dissipate rapidly, allowing affected organisms to survive and recover. With continual spills, the length of exposure to the oil may exceed the tolerance of the organisms and create irreversible ecological changes. Therefore, all the berthing areas must be equipped with oil containment and recovery systems to control the expected continual small oil spills into the water. Containment equipment should be used as a matter of course.

In summary, the problem, or potential problem, of oil pollution due to the unloading of large vessels in Delaware Bay is one that warrants a careful investigation. It is one of the most significant environmental problems of these alternatives. A major spill in Delaware Bay could seriously affect the wetlands and their inhabitants. It could taint shellfish in the exposed area and could seriously detract from all other beneficial uses of the bay. It is significant enough to warrant a detailed analysis of the probability of a spill based upon vessel sizes, numbers of vessels, characteristics of the channels, predictions of direction of movement of a spill, and suggested regulations for governing ship movement and material handling and storage.

Secondary Development

None of the deep port alternatives proposed for Delaware Bay include secondary development provisions. The assumptions are that the refinery capacity expansion necessary to meet the increased demand and to handle the increased imports into the bay will take place at the sites of existing refineries in areas already dedicated to that use. This assumption also applies to the import of iron ore.

However, with the development of the deepwater port, pressures for locating certain industries will naturally increase in the vicinity of the port. If allowed, industrial growth along the shore will exert pressures for more housing for employees and for more and better roads. Localized heavy water use in the coastal area would increase saline intrusion inland to the point where existing local supplies would no longer be usable and new sources would have to be sought. Secondary development in the coastal zone would also place added pressure on the wetlands. Because there is little dry, usable land adjacent to the shore, the pace of wetland filling would tend to increase to provide more land.

With increasing coastal development and increasing local populations, the wildlife habitats would be decreased in size and value, endangering some of the most important nesting areas for wildfowl on the east coast.

In summary, secondary development is not included as a part of deep port development for Delaware Bay. If allowed, it will substantially change the character of the coastal zone in the area of the port. Consideration should be given to instituting land-use planning and well-conceived controls adequate to prevent unwanted secondary development prior to the development of any deep port in the bay.

Artificial Island in Delaware Bay

Alternatives 2-2 and 2-4 through 2-15 specify the development of an artificial island in Delaware Bay approximately 3 miles off shore from Big Stone Beach. Accurate predictions of the impact of the island on sediment transport and circulation require model studies, and model studies, in turn, require an extensive amount of data which have not yet been collected. Because modeling is not within the scope of this study, the estimated effects of the island were arrived at through a composite of expert judgments. The interpretations are solely the responsibility of the author.

The current water depth at the site is less than 10 feet. The sediment in that location is transported down in a southeasterly direction through the deeper finger of water that runs east of the site. It is transported onto the shoal at the site by a turn of the bottom current to the southwest. The development of the island will block the current and prevent the transport of material over the shoal. This will probably result in an accretion of the shoal to the southeast of the island and a loss of material from the southwest side. In neither case will such a change significantly affect operations, as long as the island is so designed that it will not be undermined by the loss.

The impact of the island on the currents and circulation appears to be local and of minor concern, because the amount of water moving over the shoal is already limited by the water depth. Consequently, a noticeable impact on the beach will be unlikely. Again, accurate prediction of the effects could be derived only through model testing. With a model available, the program should include the evaluation of a variety of island shapes and sizes so that a design could be selected on the basis of minimum adverse effect.

The construction of the island will require a large amount of fill material. It is assumed that the source of the fill will be the spoil dredged from the channel. It may require washing to remove fine silty material prior to use. In any case, the handling of the material will cause substantial temporary turbidity in the bay waters and, as the material settles, can bury benthic organisms under a silty layer. The turbidity will also reduce the depth of penetration of sunlight and reduce primary productivity. It might be necessary to halt construction operations during the warmer months when primary production is at its peak, although a preferred alternative would be the use of extra precautions to prevent turbidity at the construction site.

In the specific location of the island all benthos will, naturally, be permanently affected because the bottom will be covered completely. The island is not, however, located in an important shellfish area. The oyster beds are located further up into the bay. Hard clams are scattered throughout the bay, and therefore no one location is preferable to any other with regard to its impact on them.

Finfish will likely find the island an attractive addition to their habitat. As is frequently the case, an increased local population of finfish in the immediate vicinity of the island may be expected once construction activity has been completed.

An island 3 miles off shore from Big Stone Beach will have a substantial visual impact. It will be clearly visible from the shore, and the larger the island and the more structures that it contains, the more impact it will have. The alternatives which provide island storage for coal, iron ore, and petroleum (2-11 and 2-15) will necessarily be the largest, and the single-commodity alternatives (2-2, 2-4 and 2-6) will be the smallest.

Care must be exercised in the design and arrangement of structures to minimize the aesthetic intrusion. The island should be landscaped to camouflage storage tanks and piles and to provide a natural appearance to the island. If properly planned and carried out, there will be no aesthetic loss.

The physical presence of the island has implications for boating and navigation. Large vessels would not be affected because they do not now navigate in this area, for it is shallow and distant from the existing channel. Recreational boating and fishing boats will have to contend with a structure where there is now open water. This will also be the case with offshore berthing structures, which are included in every alternative. Consequently, there will be some increase in navigation obstruction in the bay. The size of the facility, however, will make it difficult to overlook, and extensive aids to navigation will be used to prevent accidents.

In summary, there are three principal concerns for the ecological and environmental consequences of the offshore island in Delaware Bay. First, there is the potential impact of the island on water circulation and material transport in the vicinity and its effects upon shoaling and on the nearby Delaware shore. This is not expected to cause significant problems, but there is a relatively high level of uncertainty about what will actually happen. Model studies would substantially reduce that level of uncertainty (at an undetermined cost).

Second, there is the temporary, but significant, impact of increased turbidity during construction on primary productivity and on filter-feeding organisms.

Construction activities should be designed and controlled to minimize the effects of turbidity over the span of time necessary.

Finally, there is the impact of the physical presence of the island and its facilities on the visual quality of the bay. This, of course, will be a permanent impact as long as the structure is in existence. Care must be taken to ensure that the island and facilities are designed to be aesthetically acceptable. Approval to construct should be contingent on an acceptable design.

Dry Bulk Handling

All the Delaware Bay alternatives except 2-1, 2-2, 2-3, and 2-4 include the transport, storage, and handling of coal or of coal and iron ore.

The main environmental considerations of handling these dry bulk commodities are the potential problems of dust during loading and unloading and when stored in open piles, and the problems of leaching and runoff of precipitation, carrying with it the weak acid wastes associated with the commodities.

Dust problems should not affect adjacent shore areas because normal prevailing winds will tend to keep the dust off shore. Stronger storm winds would blow toward the shore, but would usually be accompanied by precipitation, eliminating blowing dust problems. Wetting down of the storage piles can eliminate the dust during storage, and the use of fine sprays and steam barriers as well as covered conveyors can reduce the problem during handling to insignificance.

The problem of runoff is potentially more significant. If the surface of the island is permeable, the weak acid runoff could conceivably leach through and find its way into the bay. More likely, however, will be the tendency for it to go as surface runoff. If not intercepted, it will go directly into the bay water, causing a pollution problem. However, the problem is relatively easy to solve by collecting the runoff and treating it to remove the pollutants prior to discharge. This definitely should be included as a provision in the engineering design of the facility.

There will also be a visual aspect to consider because of the large piles of coal and iron ore which will be visible from the shore. This impact cannot be eliminated, but adequate landscaping will offset most of the problem.

The Offshore Delaware/Atlantic Alternative

Introduction

As an addition to the alternatives proposed for development within Delaware Bay, alternative 2-5 is proposed as an oil terminal to be located in deep water about 10 miles east of Rehoboth Beach, Delaware.

This alternative entails the construction of an artificial island with berths for tankers with drafts of 70 feet; a tank farm on the island; and berths for transshipment vessels. The plan is to use the island as a transshipment terminal to supply crude oil to the refineries in the New York (Arthur Kill) area and the Delaware River area.

The crude will move up the Delaware in 40,000 d.w.t. barges, and to the Arthur Kill in 30,000 d.w.t. barges, so that existing channel depths will be adequate.

General Nature of the Area

The site for the planned facility is in the open Atlantic about 10 miles east of Rehoboth Beach, Delaware. As such, the site is generally undisturbed from its natural conditions.

Winds

The prevailing winds are northwesterly in direction, with an average velocity of about 12 knots. The strongest winds tend to occur during the winter months. Very strong winds, sometimes reaching hurricane force, accompany the frequent, brief storms as the air masses move rapidly through the area during the winter.

Summer winds tend to be of lower speed except during infrequent but very destructive tropical storms. Maximum winds will reach up to 71 knots on a 5-year recurrence and over 80 knots on a 10-year recurrence. During such storms, the highest winds come from the northeast.

Waves

There is a lack of actual observations of wave heights at the site, but statistically derived estimates indicate an average wave height of 4 feet, with 5-year recurring extremes of 60 feet. The wave directions will generally follow the winds.

Visibility

Visibility around the site is estimated to be less than 5 miles about 10 percent of the time and over 10 miles about 60 percent of the time on an annual basis, with the highest incidence of low visibility occurring during the spring months. Fog signals in the area are operated an average of 475 hours per year.

Potentially Affected Land Areas

The land areas adjacent to the offshore island are the eastern shores of Delaware, Maryland, and Virginia.

The entire Delaware shore, about 25 miles in length, is sandy beach. Some of this is in the form of a barrier beach; the remainder fronts directly on the mainland. About one-half of this shore comprises state parks and conservation areas. Virtually the entire length is heavily used for recreation. Behind the barrier beaches are several large bays with extensive marsh areas. While these bays are of high value for fish and wildlife, the pressure for dredging, filling and development has altered substantial parts of them. The Delaware State Planning Office has recommended in its development plan that the bay shores be retained as open space [7].

The coast of Maryland has nearly continuous barrier beaches backed by shallow bays and marshes. Most of the beach area is publicly owned and dedicated to recreation. Maryland's most popular recreational resort, Ocean City, accommodated nearly 13 million vacationers in 1969 [17]. Projected use for the area is a continued increase in recreational development, both public and private.

The Atlantic shore of Virginia is also fronted by barrier islands and beaches for most of its length. Practically this entire shoreline is undeveloped and receives little use because of a lack of accessibility for recreationists. The bays behind the barrier islands and the marshes are highly productive areas for fish and wildlife. Waterfowl use the area for resting and feeding, and shellfish, particularly oysters, are an important resource of the area.

Offshore Delaware/ Atlantic Analysis

Table 17 contains an evaluation of the environmental characteristics of the proposed site for the offshore island. A number of environmental criteria and resources do not apply to an ocean site, and these have therefore been left blank in the table. It should be noted that this evaluation is for the particular site only and does not include an evaluation of the adjacent shorelines that were described in the previous text.

Table 18 contains an evaluation of the potential effects of the development.

Table 17. Evaluation of Offshore Atlantic (Delaware) Area

	Aesthetics	Water Quality	Air Quality	Uniqueness*	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
Present value		H	H		H		H	H	L		M		M	H				H	
Projected value		H	H		H		H	H	L		M		M	H				H	

Key:
H = high value, high quality, or high level of use
M = moderate value moderate quality, or moderate level of use
L = low value, low quality, or low level of use

* Number entered equals number of natural or historic sites in the area of influence.

Table 18. Evaluation of Deepwater Port Alternative 2-5, Offshore Delaware-Atlantic Area

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
			H	H		H		H	H	L		M		M	H				H	
onstruction:																				
Dredging	180		2T			1T			1T			1T							2T	
Spoil Disposal																				
Pilings & Berths																				
Artificial Island	180		2T			1T			1T			1T							2T	
Breakwater																				
Mooring & Anchors																				
Submarine Pipeline																				
Onshore Pipeline																				
Submarine Storage																				
Onshore Storage																				
esence:																				
Channel																				
Onshore Berths																				
Offshore Berths																				
Offshore Island	180	1P				1P			+			1P							2P	
Breakwater																				
Offshore Mooring																				
Overwater Trestle/Pipe																				
Offshore Storage	180	1P										1P								
Submarine Pipeline																				
Onshore Pipeline																				
Onshore Storage																				
Underwater Storage																				
eration:																				
Channel Maintenance																				
Dry Bulk Handling																				
Petroleum Handling			1P	1P								2P								
Ship Operations	181		1P	1P							1P	2P							2P	
Facility Operations			1P	1P							1P									
Major Oil Spill	182	2T	3T			2T	2I	2T		2T		2T	1T	1T	1T				2T	
econdary Development:																				

Construction

The site of this island has an existing depth of about 55 feet. The loaded tankers will require 81 feet of draft. Consequently, the berthing and turning areas must be dredged. However, the estimated volumes to be dredged closely approximate the amount of fill required for the construction of the island, and there is consequently no problem with spoil disposal. The dredging and island construction will cause turbidity in the area, but the effect will be temporary and not of major importance.

The construction activity and the presence of heavy equipment will cause a hazard to navigation for vessels approaching and leaving the Delaware Bay area. Again, this effect will be temporary, and the risk of accidental collision can be reduced by utilizing navigational aids and issuing warnings of the hazards.

There is also the possibility that the dredging construction will temporarily disrupt the fish in the area. Shellfish are not important there, but finfishing will be affected for the duration of the construction activity as the various fish move out of the turbid areas and away from the activity. This effect will be very localized.

In summary, the environmental effects of the project construction do not appear to be very significant or long lasting.

Presence of Facilities

Upon completion of the project, an island over 100 acres in size, storage tanks for up to 3 million tons, and berths for the large tankers and for the transshipment barges will have been constructed.

The primary impact of these facilities will be as a hazard to the movement of vessels in the area, and adequate navigational aids must be included to minimize the potential risk of collision. The impact of the physical structure on wave action and currents appears to be insignificant. It should have no effect on littoral drift along the mainland and no perceptible effect on wave action at the shore.

From the standpoint of the local fishery, the impact may very well be beneficial. It has been frequently observed that fish tend to congregate around such a structure. The rock face of the breakwater could provide an improved habitat for some species. There is one potential hazard associated with this beneficial effect: the local population of fishing boats in the area may also increase, thereby increasing the potential of collision and accidents.

In summary, while the facility will be a major change to the local environment, its significance from an environmental and ecological viewpoint is not great.

Ship Operations

One aspect of this alternative sets it apart from the others: its reliance on the use of transshipment vessels to move the crude oil into the Delaware River and Arthur Kill refineries.

The estimated annual throughput in millions of tons, based upon the commodity projections, is as follows:

Subalternative	Delaware River		Arthur Kill	
	1980	2000	1980	2000
A and C (low)....	70	115	30	35
B and D (high)...	115	230	35	70

Using transshipment vessels of 40,000 d.w.t. for the Delaware and 30,000 d.w.t. for the Arthur Kill, the annual average numbers of vessels required daily will be as follow:

Subalternative	Delaware River		Arthur Kill	
	1980	2000	1980	2000
A and C (low)....	5	8	3	4
B and D (high)...	8	16	4	7

This traffic will increase the potential for oil spills in Delaware Bay and River and New York Harbor over that which would exist from a pipeline transportation system. Any alternative which increases the traffic load through these heavily traveled channels will have an associated safety hazard because of the added risk of collision.

During the early part of the time period, the number of vessels would most likely not create a significant problem. In the later part of the period, however, when the estimated use rises to 16 vessels per day, the impact on traffic flow and the risk of a major spill would increase very significantly.

Major Oil Spills

The possibility of a major oil spill exists in two areas. Transshipment vessels in heavily traveled channels and very large tankers in the open sea could both create a problem.

A major spill in the vicinity of the island would be difficult to handle. Containment equipment available under today's technology will not be effective under wave conditions which normally prevail at the site. Consequently, the impact of such a spill depends to a large extent on the movement of the oil into coastal waters.

Because the primary force which determines the movement is wind, one would expect the prevailing westerlies to keep the slick off shore. However, the strongest storm winds (which could very well act as a contributing cause of a spill) are easterly. Spills that occurred during a major storm could very well reach the mainland shores. The coasts in the area (primarily Delaware, Maryland, and Virginia, but perhaps also New Jersey) are generally highly valued for recreation, fish, and wildlife.

Summary

In summary, the only significant concern from an environmental standpoint is the possibility of major oil spills. Such spills would be hard to contain and control if they occurred near the site of the island in the Atlantic. While spills from transshipment vessels in protected waters would be easier to contain, there would be much less time to act because of the proximity to the shores where the most significant damage would occur.

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VIII. THE CHESAPEAKE BAY ALTERNATIVE

Introduction

The alternative proposed for Chesapeake Bay entails deepening the existing channels to the coal docks at Norfolk and Newport News. The proposed depth is 55 feet, which is the maximum depth allowed by the Chesapeake Bay Bridge and Tunnel. The project would affect the Thimble Shoal, Hampton Roads, and Lower James River Channels.

The project does not include any major changes to shore facilities, nor does it forecast any major changes in bulk shipping patterns because of the increased depth. Consequently, the environmental and ecological implications of the alternative are limited to the problems of dredging and spoil disposal. For this reason, the following description does not include any major consideration of land-use problems or problems associated with petroleum handling.

General Nature of Chesapeake Bay

The Chesapeake Bay is the largest estuarine system on the east coast. It is almost 3 million acres in area and has 4,600 miles of shoreline, four major rivers, and many tributary streams, both large and small [2].

Waterborne commerce is one of the most important uses of the bay. The port of Baltimore in the north and Hampton Roads in the south have major industrial complexes associated with them. Located on the southern end of the large eastern megalopolis, the bay is within easy reach of a very large population and is receiving increasing demands for the myriad uses to which such a water body can be put.

In addition to being a major waterway and industrial complex, the bay is an important commercial and recreational fishery. About 600 million pounds of fish and shellfish were harvested in 1966, and sport fishing was recently estimated at about 2 million angler-days per year [7].

The bay serves as a nursery area for many of the fish species that frequent the waters from North Carolina to Maine. Among the most important of these is the striped bass, highly prized throughout this coastal area by sport fishermen and commercial fishermen alike. Oysters are the most important shellfish resource in the bay. The James River oyster beds provide most of the seed oysters used in Virginia waters.

The Chesapeake is also an important part of the Atlantic flyway. There are about 300,000 acres of salt marsh in the bay area, about half of which is now managed especially for waterfowl. Wintering waterfowl come from the James and Hudson Bays and even from as far away as Greenland. The coastal wetlands are of major importance to both the wildlife and the offshore fishery.

Recreational use of the bay is increasing as the population of the area increases. This is especially true of recreational boating, but it also holds for swimming and water skiing. (The bay's jellyfish frequently deter water-contact sports, however.)

Water Quality

Pollution is a continuous and increasing threat to Chesapeake Bay. The large metropolitan areas use the bay and its tributaries for the final disposal of their treated water. Even though large and expensive collection and treatment systems are being constructed, the vast quantities of phosphorus and nitrogen entering the bay are not being removed. Because of the area's rapidly growing population, the problem will likely increase. Shipping has contributed to the pollution problem by bilge pumping and accidental oil spillage [6].

The bay is also being subjected to an increasing thermal load from electric generating facilities. There are now 16 plants in existence, and seven more are in various stages of planning and development.

Dredging

Extensive dredging is required in the Chesapeake to maintain the channels for commercial shipping. Upland and shoreline erosion create large volumes of silt, necessitating maintenance dredging in all channels.

Dredging and spoil disposal have caused major modifications within the bay system. Deep channels in otherwise shallow areas have had a profound effect upon water circulation, flushing, and salinity pattern, as well as directly upon shellfish located in the path of the channel. Spoil disposed of in the water has covered oyster beds and caused extensive turbidity in several areas. Deposition of spoil on wetlands, although it has produced some valuable real estate, has destroyed waterfowl habitat [2].

Scientific and Management Activity

The Corps of Engineers has been and is very active in the management of the Chesapeake Bay. Of particular importance is its development of hydraulic models. The Corps is presently developing a model of the main bay, which is not yet operational, and it has developed and is operating a model of the James River.

The Virginia Institute of Marine Sciences (VIMS), with facilities at Gloucester Point, has a scientific staff with the best available knowledge about the environment of the Lower Chesapeake Bay. VIMS is a member of the

Chesapeake Research Council, which also includes the Chesapeake Bay Institute of Johns Hopkins and the Chesapeake Biological Laboratory of the University of Maryland. The council was formed to promote and coordinate research on the bay, and has a large research project underway which is supported by the IRRPOS Program of the National Science Foundation. The project's goal is to provide the basic scientific knowledge necessary to the management of the bay and its resources [1].

Management and control of development and uses of the bay are spread through a large number of agencies and are not fully effective at this time. Only the major metropolitan areas have active zoning programs to control land use. Neither Virginia nor Maryland has any effective control over dredge and fill activity in the bay.

Chesapeake Bay Alternative

This alternative calls for the deepening of the Thimble Shoal, Hampton Roads, and Lower James River Channels to 55 feet to accommodate larger bulk coal carriers at the existing coal docks of the Norfolk and Western Railway in Norfolk and the Chesapeake and Ohio Railway in Newport News.

All of these channels are in the extreme southern part of Chesapeake Bay. The berthing, commodity storage, and land links are now in existence, and implementation will require nothing more than the modification of berths and loading equipment to handle longer and wider vessels.

The only expected environmental modifications are related to dredging and spoil disposal. However, these can be very significant to the existing environment unless they are adequately planned and carried out with environmental protection in mind.

Table 19 provides an evaluation of the existing and projected environment and resources for the entire Chesapeake Bay area. The proposed project will not

Table 19. Evaluation of Chesapeake Bay Area

	Aesthetics	Water Quality	Air Quality	Uniqueness *	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contuct Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
Present value	H	M	M		H	H	M	M	H	H	H	M	H	M	L	H	H	H	M
Projected value	H	M	M		H	H	M	M	H	H	H	M	H	M	L	H	H	H	L

Key:
H = high value, high quality, or high level of use
M = moderate value, moderate quality, or moderate level of use
L = low value, low quality, or low level of use

* Number entered equals number of natural or historic sites in the area of influence.

directly influence many of these factors, but indirectly the influences could be great. Those which appear to be significant are shown in table 20 and are discussed in the following sections.

Dredging and Spoil Disposal

There are two primary concerns with regard to dredging. The first is the impact of dredging on bottom organisms, particularly shellfish. This impact results from their physical disturbance and removal and from the effects of the suspended material and associated turbidity. The suspended material will affect filter feeders, and as it settles out it may also cover and smother shellfish in the area.

The second area of concern is the effect of spoil disposal. The common practice of disposal into the deeper waters has covered a number of shellfish areas, while disposal on shore tends to take place in valuable wetland areas. The ecological effects of ocean disposal are not well understood. The Maritime Administration estimates that the 55-foot channel will require the placing of 180 million cubic yards of spoil -- mostly silt -- for the initial development. In addition, a significant amount of maintenance dredging will be required to prevent the channels from shoaling [5].

The area's primary disposal site is Craney Island, which has been diked for spoil disposal. However, this site has nearly reached its capacity and will not be adequate to handle this project unless its boundaries are extended or the land fill is increased in elevation. From the standpoint of the maintenance of the Chesapeake Bay environment, ocean disposal would be most desirable. As previously mentioned, however, the impact of such a practice is not well known.

In summary, the spoil disposal issue has not yet been resolved for a project of this magnitude in the Lower Chesapeake Bay. For this reason, no evaluation of its impacts and environmental effects can be made.

Table 20. Evaluation of Deepwater Port Alternative 3-1, Chesapeake Area

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		H	M	M		H	H	M	M	H	H	H	M	H	M	L	H	H	H	M
onstruction:																				
Dredging	194	1T	2T			2T			1T	1P		2T		2T					2T	
Spoil Disposal	194	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Pilings & Berths																				
Artificial Island																				
Breakwater																				
Mooring & Anchors																				
Submarine Pipeline																				
Onshore Pipeline																				
Submarine Storage																				
Onshore Storage																				
resence:																				
Channel	196		2P			1P			1P	1P		+		+					+	
Onshore Berths																				
Offshore Berths																				
Offshore Island																				
Breakwater																				
Offshore Mooring																				
Overwater Trestle/Pipe																				
Offshore Storage																				
Submarine Pipeline																				
Onshore Pipeline																				
Onshore Storage																				
Underwater Storage																				
eration:																				
Channel Maintenance		1P	2P			1P			1P	1P		1P		1P					1P	
Dry Bulk Handling																				
Petroleum Handling																				
Ship Operations																				
Facility Operations																				
Major Oil Spill																				

Presence of the Channel

The presence of the deep channel from the Atlantic Ocean into the Lower James River may create significant changes in the ecology of that area and, in fact, throughout the bay. The actual effect is highly uncertain at this time. The increased depth could alter the circulation in the lower bay, increasing the tidal flows and changing the salinity regime over a wide area. Model studies to determine these effects are recommended before such a project is undertaken.

Summary

The environmental and ecological implications of the Chesapeake Bay alternative result primarily from spoil disposal and the potentially increased flows through the deep channels. An analysis of these requires the selection of a site for disposal and a scientific study of how circulation and flushing would be changed.

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IX. MISSISSIPPI RIVER DELTA ALTERNATIVES

Introduction

Six alternatives are proposed for the Mississippi River Delta area (alternatives 4-1 to 4-6). All alternatives involve the construction of an island to be used as a regional transshipment terminal for grain, iron ore, crude petroleum, or some combination of these commodities. The size of the island will depend on the amount of intermediate storage required for the commodity or commodities handled and may vary from 220 to 295 acres. Berthing depths considered range from 66 to 114 feet, corresponding to tankers of 200,000 to 500,000 d.w.t.

The site selected for these alternatives is in the vicinity of Garden Island Bay, which is located between South Pass and Southeast Pass at the tip of the Mississippi Delta. The major environmental impacts of such a deepwater port facility would be confined primarily to this immediate area. However, the possibility of secondary development associated with the terminal facility may extend the affected area to other parts of Plaquemines Parish, Louisiana.

General Character of the Mississippi River Delta

Physical Characteristics

The Mississippi River Delta area today reflects centuries of sediment deposition from the Mississippi

River, which drains approximately 41 percent of the coterminous land mass of the United States, and a much shorter period of extensive human modification of the natural system. The existing birdfoot delta is dominated by the river and, outside the levee-protected areas, contains many ponds, bays, and both natural and manmade channels. The land is marshy lowland with natural elevations of not more than 2 to 3 feet above sea level. The area tends to be subject to periodic overflows of the Mississippi River, with accompanying salinity changes and nutrient flows. However, the natural water movement across the delta region has been severely altered by levee construction, channelization, and the deposition of dredging spoil.

The coastline of the delta is highly irregular and constantly changing. It has been estimated that the land area has advanced seaward an average rate of 300 feet annually [1, 2, 6]. However, this advance is offset by erosion of the shoreline and land subsidence in other areas, so that a net annual loss of land area now occurs. The tides along this coastline have a range of only 1 to 2 feet and can often be obliterated under the influence of wind conditions.

The entire gulf area is susceptible to hurricanes. The two most notable storms in recent years were Hurricane Betsy (1965) and Hurricane Camille (1969). The former is considered to be a once-in-a-100-year storm, while the latter is viewed as a once-in-a-1,000-year storm. Camille all but destroyed the lower portions of the delta, and the communities involved are still recovering from the extensive damage [3].

Biological Characteristics

The 3 1/2 million acres of wetlands in the delta region are biologically very rich and unique in both their breadth and productivity. An estimated 2 billion pounds of protein are produced annually in this area. It is a prime nursery area for commercially harvested shrimp and finfish, and is therefore an integral part of the rich Gulf of Mexico fishery. Extensive oyster beds are also found in the delta region. In 1969, these conditions resulted in Louisiana's being the leading state in the volume of commercial fish landed and the third in terms of value of catch [7].

The Mississippi Delta is the terminus of the Mississippi flyway and is consequently an area rich in many forms of birdlife. Other wildlife is also abundant, including muskrat, nutria, and alligators.

Population Characteristics and Land Use

The Mississippi Delta region is part of Plaquemines Parish, Louisiana, which comprises over 1,000 square miles along both sides of the Lower Mississippi River. According to the 1970 census, the population of this parish was 25,225, an 11.9 percent increase over the 1960 population. Current projections foresee a population of 45,500 in 1980 and 66,000 in 1990. Approximately 85 percent of this population is concentrated on the west bank of the river in the upper portion of the delta region.

The type and amount of land use in this region is primarily determined by the extent of the levee system. In 1970 a land-use survey was conducted in this levee-protected area. At that time residential development occupied only 950 acres. This limited area reflected, in part, the after-effects of Hurricane Camille, since many residents were occupying mobile homes after their permanent dwellings were destroyed. Projections for 1990 estimate residential land use to increase to over 4,000 acres. Commercial land use is estimated to show a similar pattern, with a 1970 acreage of 82 and an expansion to almost 200 acres seen by 1990 [3].

Industry currently occupies some 2,000 acres in this protected area, and is expected to more than double by 1990. A new addition to this area is the Gulf Oil refinery at Alliance. This 672-acre facility has a capacity of 155,000 barrels per day. This area is seen as particularly favorable for new industrial development, although industrial growth is also projected for the lower portions of the parish. These projections are based, in part, on continued expansion of the levee system and new road construction.

Outside the levee system, some 156,527 acres are devoted to mineral-producing uses [3]. These include hundreds of oil and gas wells and a large sulfur mine in the lower delta region. The other major activity in this unprotected area is fishing. Towns in this area, such as Venice, serve primarily as supply centers for the offshore oil production facilities.

In terms of control of land use, no zoning yet exists for this area at either the state or parish level. However, plans for zoning are currently being formulated by the Plaquemines Parish Commission Council. Other controls in the area reside primarily with the Register of State Lands, whose authority encompasses the leasing of submerged lands for oil and gas production.

Garden Island Bay Area

Garden Island Bay is located at the tip of the Mississippi Delta where it approaches the end of the Continental Shelf. It is generally a shallow bay which becomes very deep where it joins the Gulf of Mexico. The bottom is composed of silty mud which, it is thought, becomes coarser at the deeper end.

The bay and its surrounding land are a part of the Pass a Loutre Game and Fish Preserve-State Public Hunting Grounds. The area is used extensively for hunting, fishing, and recreational boating. Mineral extraction is also a major activity around the bay. The Freeport Sulphur Company has facilities in this marshy area, and extensive oil and gas fields are scattered throughout the area.

Attitudes Toward Port Development

The possibility of deepwater port development is currently a much discussed topic in Louisiana. In the spring of 1971, two bids were submitted on offshore tracts in Garden Island Bay by companies wishing to build an offshore port facility. Many legal and environmental questions were raised in response to these plans, and any development is therefore currently in abeyance. However, partly as a result of this situation, many studies are currently being undertaken with regard to port development. A Louisiana Superport Task Force Committee has been established to investigate the implications of and possibilities for the development of a deepwater capability. In addition, Louisiana State University is engaged in two studies directed toward this topic. One is being undertaken for the state, while the other is part of the effort of the Council on Environmental Quality to review the deepwater port question.

Analysis and Evaluation of Mississippi Delta Area Alternatives

Some questions exist regarding the feasibility of constructing an island in Garden Island Bay. These are based on (1) the problems associated with obtaining fill material for an island, and (2) the suitability of the bottom land of this area as a substrate for such a structure because of the depth of the silt layer. Basic data to resolve these questions are not available.

Table 21 contains an evaluation of the current and projected resources and characteristics of the delta area which could be affected by deepwater port development. The evaluation is directed towards the entire Plaquemines Parish area and not just Garden Island Bay. The values depicted are based on the author's estimate of the situation.

Table 22 contains an evaluation of the effects of alternatives 4-1 through 4-6 on these same resources and characteristics.

Table 21. Evaluation of Mississippi River Delta Area

	Aesthetics	Water Quality	Air Quality	Uniqueness *	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
Present value	M	M	H	H	H	M	H	H	H	M	H	L	M-H	L	L	H	L	H	L
Projected value	M	M	H	H	H	M	H	H	H	M	H	L	H	L	L	H	L	H	L

Key:
H = high value, high quality, or high level of use
M = moderate value, moderate quality, or moderate level of use
L = low value, low quality, or low level of use

* Number entered equals number of natural or historic sites in the area of influence.

Table 22. Evaluation of Deepwater Port Alternatives 4-1 through 4-6, Mississippi River Delta Area

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		M	M	H	H	H	M	H	H	H	M	H	L	H	L	L	H	L	H	L
Construction:																				
Dredging	206	1T	1T			1T			1T	1P		1T		1T					1T	
Spoil Disposal	206	1T	2T		1P	1P	1P	2P	1T	2T		1T		1T	1P				1T	
Pilings & Berths	207	1T							1T			1T		1T					1T	
Artificial Island	207	2T							2T	1P		1T		1T					1T	
Breakwater	207	1T							1T	1P		1T		1T					1T	
Mooring & Anchors																				
Submarine Pipeline		1T	1T			1T			1T	1T		1T		1T					1T	
Onshore Pipeline																				
Submarine Storage																				
Onshore Storage																				
Presence:																				
Channel						1P			+	1P				1P					+	
Onshore Berths																				
Offshore Berths	207	1P				1P			+	1P		1P		2P					+	
Offshore Island	207	2P				2P		*	+	2P		1P		2P					+	
Breakwater		1P				1P		*	+	1P		1P		2P					+	
Offshore Mooring																				
Overwater Trestle/Pipe	207	1P							1P	1P		1P		1P						
Offshore Storage	207	1P										1P								
Submarine Pipeline												1P							1P	
Onshore Pipeline																				
Onshore Storage																				
Underwater Storage																				
Operation:																				
Channel Maintenance		1T	1T			1T			1T	1T		1T		1T					1T	
Dry Bulk Handling				1P								1P								
Petroleum Handling												1P								
Ship Operations												1P							+	
Facility Operations		1P		1P								1P							+	
Major Oil Spill	208	3T	3T		2T	2T	3T			2T		3T	3T	2T	1T				2T	
Secondary Development:	208	3P	1P	1P	3P	2P	2P	1P	1P	1P	1P	1P		2P	1P		+	1P	+	1P

Dredging

The first dredging to be encountered in these alternatives involves the removal of the silt layer to reach a coarser, firmer base for the island. Such dredging will involve increased turbidity in the area, but this will be of short duration. Against the background of the natural sediment load carried by these waters, such an increase will be marginal and not of major concern.

Disposal of the dredging spoil could be of more concern. Two methods are presently employed for disposing of silty dredging material. The first involves the pumping of the spoil to diked areas on or near shore. The second involves the open-water disposal of this material at some distance from the dredging site.

Onshore spoil disposal in the delta region has been done extensively in the past, but this is not an environmentally desirable practice. Productive marsh areas are covered and the natural flow of water across the area changed. Even if such disposal areas can be utilized as wildfowl habitat, the result is usually a net loss to the ecology of the area.

The practice of offshore dumping of dredging spoil is currently being questioned. Areas thus covered are changed in character, usually to a less productive state, and the associated turbidity can be quite prolonged. Movement of the bottom silt can also have an impact on areas adjacent to the original dumping site. Mitigation of these adverse conditions must involve a very careful selection of location to insure that particularly productive bottoms are avoided.

Alternatives 4-5 and 4-6, which involve the transshipment of iron ore, will require dredging to provide protected areas for unloading behind the island. Again, disposal of the silty material will be a problem. If coarser material is encountered in dredging to 66 feet, this material could be used as island fill, thereby mitigating the disposal problem.

In summary, the impacts associated with dredging do present a problem in this area. Uncertainty concerning the nature of the bottom material makes an evaluation of the significance of this problem difficult.

Island and Ancillary Structures

In addition to the island, other structures will be required in the transshipment terminal. In alternatives 4-5 and 4-6, which involve iron ore unloading, a breakwater structure will be required to prevent the movement of silt into the dredged area behind the island. Protecting breakwaters will also extend outward from the island to protect this back harbor.

These facilities will occupy a large area of the water column, and will permanently preclude other activities such as bottom trawling or recreational boating. (However, in areas away from the flow of traffic, these structures may serve to attract fish, as do the piled structures off shore.) The presence of these structures may also increase hazards to navigation in the fogs which are often found in this area, and sufficient care must therefore be taken to clearly mark them.

These problems are relatively minor compared with the possible effects of the structures on the currents in this area. As noted before, the bordering lands of Garden Island Bay are a variable area with regard to erosion and accretion. The impacts of these structures on these phenomena are unknown, and, unfortunately, sufficient information is not available to evaluate this problem. The development of a hydraulic model would be required to obtain the information needed for an assessment. However, the potential does exist for severe changes to this area. The uncertainty about what the impacts will be serves as a major argument against the development of these alternatives.

Oil Spills

Both minor and major spills have occurred in the Lower Mississippi Delta. Fortunately, no permanent damage from such occurrences has been noted.

Whether or not a spill occurring in the Garden Island Bay area will affect the valuable wetland areas depends on several conditions. These include the prevailing wind, the pattern of local currents, and the discharge of the Mississippi River system. If these conditions were such that the coastal wetlands were affected, the impact would be severe but temporary.

Secondary Development

The construction of an island to serve only as a transshipment terminal represents a port system which is essentially independent of the surrounding land mass. Although some support facilities in terms of manpower and supplies from the mainland are required, their impact would be minimal. As was pointed out before, some towns in the lower delta region are already oriented toward this type of service for the offshore mineral-producing industries. The extension of this type of service to an offshore terminal would require only a marginal increase in support facilities.

The presence of a deepwater capability in the delta region offers some economic advantages to industry to locate there. Since land availability in this marshy region is dependent on levee construction, pressures for secondary development could have a far greater impact on this region than any other factors previously considered. The ecological value of these wetland areas makes any further alteration unacceptable from an environmental viewpoint. Safeguards against such development should be an integral part of legal controls involving the establishment of a port.

Summary

The disposal of the dredging spoil and the potential for oil spills are areas of environmental concern in the development of the proposed Mississippi River Delta alternatives. However, other uncertainties evidenced in the preceding analysis are more significant from the environmental viewpoint. These are directed primarily toward the subtle physical changes to the water currents and land areas, and to the ability to control any secondary development linked to such a facility. Insufficient care with regard to these factors would modify this valuable and unique marshland to such an extent as to virtually destroy it and the valuable fishery resources which it supports. Such an outcome is so significant that any decision-making process must give considerable weight to the uncertainties involved in these alternatives.

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X. FREEPORT, TEXAS, ALTERNATIVES

Introduction

Freeport, Texas, has been chosen as one of the two gulf coast sites to be considered for deepwater port development in this study. The seven alternatives being considered at this site involve two basic port system concepts: traditional inshore port development and offshore mooring utilizing monobuoys. The principal commodity handled will be crude petroleum, with secondary emphasis given to the export of grain in conjunction with inshore deepwater port development.

The primary area affected by such alternatives will be the land and waters around Freeport, although other adjacent areas may be affected by oil spills. Before pursuing these impacts, it will be helpful to look at Freeport in detail and to put this site in the perspective of the entire Texas coastal zone.

General Character of the Texas Coastal Zone

Physical Characteristics

According to a recent study by the Corps of Engineers [9], the gulf, bay and estuary shores of Texas total some 2,498 miles at the mean high tide line, of which some 378 miles can be considered to be natural beach.1/ Most of this shoreline fronts on a series of

1/ Values for shoreline length vary greatly according to the technique used. Other investigators have cited bays, the most important of which are Galveston Bay, Matagorda Bay, Corpus Christi Bay, San Antonio Bay, and Laguna Madre. These bays are separated from the open gulf by barrier islands and peninsulas. The land behind the shoreline is part of the Coastal Plain Province and is extremely flat for several miles inland. Ten major river systems drain into this coastal area, including the Brazos River at Freeport.

The Continental Shelf off the northeastern portion of the Texas coast near Louisiana slopes gradually to the deeper waters of the gulf. However, near Freeport this slope increases, so that from Freeport to Brownsville the 100-foot contour maintains itself within 40 miles of the shoreline. The near-shore currents in this area flow southwesterly, and in the vicinity of Baffin Bay meet a northeasterly flowing near-shore current which comes up the coast from Brownsville. These currents are fairly constant, although their relative strengths and convergence point vary slightly because of the influence of the prevailing winds. Offshore currents can be quite strong and exhibit a very complex and variable pattern. The tides along the Texas coast are diurnal and have a range of only 1 to 2 feet.

The climate in this area varies from humid subtropical in the eastern to semiarid in the southwestern portions. Average rainfall varies from 55 inches at Sabine Pass to about 26 inches at Brownsville. The summers along the coast are long and hot, while the winters are short and mild. Average annual temperatures range from 70° F. at the Louisiana-Texas border to 74° F. at Brownsville. The entire coastal area is subject to hurricanes and can be expected to have one on the average of once in 2 years. Historically, about two-thirds of the hurricanes have occurred in August and September. Recent hurricanes of note were Beulah in 1967 and Celia in 1970. Damage from such storms results from winds, waves, and extensive flooding over the low-lying coastal lands [5].

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lengths for the Texas shoreline ranging from 600 to 1,850 miles.

Biological Characteristics

The many bays and rivers draining into the coastal area of Texas are the basis for some 760 square miles of wetlands and marshes [5]. These areas are a valuable wildlife habitat and a nursery for the rich bay and offshore fisheries.

Wildlife found in the coastal area includes deer, squirrel, rabbit, and a wide variety of birdlife, including turkey and quail. The eastern portions of the coastline are in the Mississippi flyway, and the rest of the coast is a part of the Central flyway. Therefore, during the spring and fall migration a wide diversity of geese and ducks is found in this area. In addition, some 31 endangered bird species, including the whooping crane and brown pelican, spend at least a portion of their lives in these coastal marshes. Five major national wildlife refuges are found in the Texas coastal zone, totaling some 213 square miles [5].

The marine fisheries are an important component of the Texas coast. Shrimping comprises 90 percent of the total state fishery. Species harvested are primarily the brown, white, and pink shrimp. Other important marine species include menhaden, spotted sea trout, red drum (redfish), and blue crab. The bay areas support the juvenile stages of many species, and there are also sizable oyster beds in many areas [5].

Coastal Development and Uses

More than 50 percent of the residents of Texas are located within a radius of less than 100 miles from the coastline [8]. This area is one of rapid growth, the population of which increased 20 percent between 1960 and 1970. The population is very unevenly distributed along the coast, with major centers at Beaumont-Port Arthur, Houston-Galveston, Freeport, Corpus Christi, and Brownsville. Between these areas are extensive tracts of open, undeveloped land, particularly west of Freeport. Ownership of the coastline is 82 percent private, 15 percent Federal, and the remainder public [9].

The principal uses of the coastal lands and waters are agriculture and ranching, mineral extraction, chemical production, transportation, recreation and fishing. Other less significant activities include dredging for shell in the bay areas, new mariculture developments directed toward catfish and shrimp, and Federal experiments with desalinization.

Agriculture and ranching are the major land-using activities in the coastal zone. The principal agricultural crops are rice and grain sorghums. Cotton cultivation is less extensive but of importance in some localities. Beef ranching occupies extensive areas in the central coastal counties, and grazing occurs on many of the low-lying coastal marshes and on some of the barrier islands such as St. Joseph Island and Matagorda Island.

Mineral extraction has been one of the most important activities in the coastal zone of Texas for many years. Texas accounts for more than 30 percent annually of the total domestic crude oil and condensate production [7], although this production and reserve capacity have declined over the past 20 years. Natural gas production is also extensive along the Texas coast. These mineral industries had sales of more than $972 million in 1969, which make them one of the most valuable uses of the coastal waters [7]. A major refinery complex exists in the Houston-Beaumont-Port Arthur area, and a secondary refinery center exists at Corpus Christi. The 31 refineries located in these areas have a capacity of more than 3 million barrels per day.

Other extractive activities occurring in the coastal area are associated with sulfur, salt, and shell mining. The presence of these raw materials combined with the availability of gas and oil have resulted in attracting petrochemical industries to this area. The Dow Chemical plant at Freeport is the largest petrochemical complex in the world.

Water transportation is a major activity in the Texas coastal zone. Eleven major ports are located in this region: Orange, Beaumont, Port Arthur, Sabine Pass, Houston, Texas City, Galveston, Freeport, Corpus Christi, Port Isabel, and Brownsville. These ports handled over 168 million short tons of cargo in 1967 [5]. The largest of these ports is Houston, which accounted for almost 34 percent of this total. Liquid cargoes, primarily petroleum and chemical products, are by far the largest class of cargo handled. Plans for expansion and improvement exist at almost all ports, none of which have current depths of more than 40 feet.

An important aspect of waterborne shipments from these ports is the presence of the Gulf Intracoastal Waterway, which extends from Brownsville, Texas, to Canabelle, Florida. Total movements along the Texas segment of this waterway amounted to about 55.5 million short tons in 1967, the majority of which were petroleum products [8].

The mild climate of the Texas coast offers year-round recreational opportunities and attracts many seasonal residents from as far as the Middle West. Types of recreational pursuits include water-contact activities (such as surfing and water skiing) as well as camping, hiking, and excellent fishing. The development of the Padre Island National Seashore has given new impetus to the recreational pursuits in this region, but many areas which could also offer good recreational opportunities are as yet untapped. Many barrier islands and their beaches are inaccessible except by water. Even on the peninsulas, poorly developed road systems prevent access except by dune buggy. Plans are being considered to improve this situation through the state purchase of more coastal land for public use.

Fishing is an important recreational and commercial enterprise along the Texas coast. Some indication of the variety of marine life available was given above. In 1970, the value of finfish and shellfish landed along this coast was over $53 million. In addition, it is estimated that over 1 million salt-water anglers spend about $85 million annually in this area. These extensive bay and gulf fisheries offer one of the main attractions of this coast.

Coastal Zone Planning and Regulation

The coastal zone of Texas has been defined to include 36 counties and is two counties deep from the shoreline. This area will be the primary one affected by any marine activities. No comprehensive development or use plan for this region currently exists. However, a significant undertaking directed towards this goal was initiated in 1970 by the establishment of the Coastal Resources Management Program. This organization is part of the Interagency Natural Resources Council, a body made up of members from all state agencies having planning or regulatory interests affecting the state's natural resources [5].

The goal of the Coastal Resources Management Program is to study the resource base of the designated area, identify natural resource problems, and present recommendations to the legislature to deal with these problems. In December 1970, an interim report was presented to the legislature. It included reports from 21 task forces assigned to study a wide variety of pertinent issues from fishery resources to financial institutions. Fifteen major problem areas were identified as the result of this investigation, and efforts are now being directed towards recommending solutions to these problems. A final report is due in December 1972.

The state agencies which are members of the Interagency Natural Resources Council and which have particular interests in the coastal zone include:

1. Texas Parks and Wildlife Department -- responsible for the enforcement of game and fish laws, water safety laws, and trespass laws; administers sale of sand and shell from public waters; conducts marine fisheries research program

2. Texas Water Quality Board -- administers and coordinates all water quality control programs; has undertaken a Coastal Water Quality Monitoring Program; develops comprehensive water quality plans

3. Texas Water Development Board -- plans water supply developments; conducts research on water quality and hydraulic characteristics of coastal bays

4. Texas Water Rights Commission -- issues permits for utilization of public freshwater supplies

5. Texas Air Control Board -- operates the Texas Air Sampling Network; establishes rules and regulations regarding air pollution

6. Texas Railroad Commission -- regulates production of oil and gas, including safety precautions

7. Texas State Department of Health -- determines suitability of coastal waters for the harvesting of shellfish

8. General Land Office -- manages all beaches and submerged lands owned by the state.1/

The only other pertinent mechanism for regulating land use in the coastal zone involves the zoning rights of the cities. This regulatory authority exists not only within the city but also in the land area around the city known as the extraterritorial region.

Research in the Coastal Zone

In addition to the extensive work being done under the Coastal Resources Management Program, many other marine-oriented research activities occur in the coastal zone. One of the most important of these involves the Sea Grant Program at Texas A&M University. Other pertinent activities of this university include the research conducted by the Oceanography Department and the University Marine Laboratory at Galveston. The University of Texas at Austin and several smaller colleges and universities are also involved in studies oriented toward various aspects of the coastal zone.

1/ In Texas, all lands from mean high tide out to 10.3 miles at sea are in the public domain and under the jurisdiction of the state.

Two investigations about to begin at Texas A&M University involve studies of superport development. The first of these is being done through Sea Grant under the auspices of the Council on Environmental Quality. Its goal is an environmental survey of the Texas coastline with a view toward evaluation of the area for superport development. The study commenced April 1, 1972, with a final report expected about October 15, 1972.

The second study is an implementation of the broad study design first put forth by Texas A&M in Work Plan for a Study of the Feasibility of an Offshore Terminal in the Texas Gulf Coast Region. It will be an 18-month study with a total cost of approximately $500,000. Some $350,000 of this will be contributed by the Maritime Administration (MARAD), with the balance coming from diverse sources that include the oil industry. The study will cover economics, legal issues, engineering, and environmental considerations. Its goal is actual selection of a site and preliminary design so that, shortly after its completion, construction and design activities can take place.

The Freeport Area

Population

Freeport is a community of approximately 12,000 people located on the Texas coast about 50 miles south of Houston. Along with the towns of Clute, Lake Jackson, Lake Barbara and Richmond, it forms the area known as Brazosport, a community with a total population of about 50,000.

Natural Characteristics

The Freeport area has a mild and humid climate. Climatic averages for the area include: relative humidity, 80 to 90 percent; January temperature, 55° F.; and August temperature, 82° F. Rainfall amounts to about 50 inches annually and is uniformly distributed throughout the year. Snow is rare and occurs only about once every 5 years. This area, like the rest of the coast, is subject to hurricanes. Between 1940 and 1970, eight hurricane paths covered Freeport, and it has experienced the peripheral effects of many others.

This region is one of the few areas along the Texas coast that does not have a barrier island to protect the mainland. This fact, combined with a high frequency of storms, has necessitated the construction of protective levees which have recently been increased to a height of 18 feet.

The center of Freeport was once the natural channel of the Brazos River, one of the major rivers of the Texas area, but the river was diverted to the west to form a silt-free harbor area. The Brazos has a large but variable flow. It carries a large burden of silt from upland areas and is slightly brackish. It is currently utilized as a source of industrial water, while water for human consumption is obtained from aquifers lying 300 to 400 feet beneath the land surface.

Much of the land around Freeport is marshy lowland, but its value to wildlife is marginal because of the human development in the area. However, some waterfowl do winter in the area which is, as was mentioned before, part of the Mississippi flyway. The rivers and near-shore waters are biologically productive, and the area off the coast is one of the major shrimping areas along the gulf.

Economic Base

The economy of the Freeport area is dominated by the Dow Chemical Company, which occupies two extensive sites adjacent to Freeport Harbor. These plants produce ethylene, chlorine, caustic soda and a number of other chemicals. Several other chemical plants are also located in Freeport, and this industry represents the largest contribution to the local economy.

The fishing industry is the second largest segment of the economy of Freeport. The principal catch is shrimp, as it is along the rest of the Texas coast;

in recent peak years catches valued at $15 million have been landed here.

Tourism is the third major economic activity in Freeport. The Brazosport area has over 40 miles of beach which serve as an attraction to residents of the Houston area. This has resulted in an extensive development of "second homes" along the beach area. The fishing in the area has also proved to be a tourist attraction. Species obtained include redfish, flounder, tarpon, croaker and red snapper. Crabbing and some oystering are also done in inland waters.

Freeport Harbor

The Freeport Navigation District is the second largest in the state, encompassing 1,124 square miles. It is the eighth largest port in the state based on cargo handled, which amounted to almost 4.2 million short tons in 1967, of which 76 percent was liquid cargo.

Attitudes Toward Deepwater Port Development

As noted before, two studies are being conducted on the feasibility of a Texas deepwater port. Because, in part, of the traditional dependence of this coastal region on the petroleum industry, such a possibility is generally viewed in a favorable light by some of the state agencies. However, caution is evinced with regard to the environmental problems associated with such a development, and sufficient safeguards for environmental protection will be required. Hearings were held in April 1972, but the record of these hearings is not available.

In the Freeport area, Dow Chemical is one of the industries supporting the large Texas A&M University study on deepwater port development. Also, the Brazosport Chamber of Commerce is very interested in attracting new industry to the area. Thus, it follows that at least some of the local interests would welcome the development of a deepwater port at this site. If opposition occurs, it is likely to come from the fishing industry and the vacation homeowners in the Surfside area. The extent of such opposition is not yet known.

Analysis and Evaluation of Freeport Area Alternatives

Seven alternatives for development of a deepwater port capability at Freeport, Texas, have been proposed. These can be broken down into two main categories: those based on the traditional inshore port concept and those based on an offshore monobuoy concept.

Traditional Port Concept

Alternatives 5-4 to 5-7 involve the dredging of a channel into a new berthing area, itself dredged out in the vicinity of Swan Lake. The channel lengths and depths would be 12 miles at 66 feet, 24 miles at 81 feet, and 45 miles at 109 feet.1/ The size of petroleum tankers which could thus be served would be 200,000 d.w.t. at the shallowest depths and 500,000 d.w.t. at the maximum depths. A new channel would be dredged from the berthing area to connect with the currently existing lower turning basin of Freeport Harbor. A one-way traffic pattern would therefore be set up, for empty tankers would leave through the present Freeport Harbor channel.

A tank farm would be built adjacent to the berthing area and would cover a maximum of 300 acres. From this site, a pipeline distribution system would be established to deliver crude oil to the refineries at Houston, Baytown, Beaumont, Orange, Lake Charles, Baton Rouge and New Orleans. An additional line could also lead from Beaumont to the Port Arthur area.

Alternative 5-7 attempts to capitalize on such a deepwater capability by handling grain exports in

1/ Jetties 0.7 to 2 miles in length would be constructed alongside the channel.

addition to oil imports at these facilities. This would involve very little alteration of the first three alternatives, with the exception of a marginal increase in berthing and storage facilities and the establishment of two-way traffic in the new channel, since loaded grain carriers would be required to use this channel.

An important consideration in these four alternatives will be the necessity of moving the Gulf Intracoastal Waterway to a more northerly location. This displacement is based on the interference with barge traffic that would exist and the need to obtain enough area to construct the deepwater port.

Offshore Monobuoy Concept

The remaining three alternatives involve the deployment of offshore monobuoys to accommodate the large crude oil carriers. The number of buoys involved in each alternative varies with the size of ship involved and the projected demand. A minimum of three buoys would initially be deployed, and up to 13 buoys may eventually be needed. Each of these buoys would be connected to the offshore storage area by a 48-inch pipeline. The lengths of the pipelines will be approximately 16 miles in alternative 5-1, 22 miles in alternative 5-2, and 34 miles in alternative 5-3.

The capacity of the tank farm will be comparable to that of alternatives 5-4 through 5-6, but its location would be some 3 miles inland on the western side of Freeport. The pipeline route to existing refineries would also be the same with the addition of the link across the Freeport area.

Table 23 contains an evaluation of those resources and characteristics of the Freeport area that could potentially be affected by the development of a deepwater port. The present values are based partly on observations by the analyst and partly on personal communications and available literature. The future values are based on the author's estimate of changes likely to result from current planning and on the extrapolation of present trends.

Table 23. Evaluation of Freeport Area

	Aesthetics	Water Quality	Air Quality	Uniqueness*	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
Present value	M	M	M		M	L	L	H	H	H	H	M	M	M	L	H	M	M	M
Projected value	M	M	M		M	L	L	H	H	H	H	H	M	H	L	H	M	M	M

Key:
H = high value, high quality, or high level of use
M = moderate value, moderate quality, or moderate level of use
L = low value, low quality, or low level of use

* Number entered equals number of natural or historic sites in the area of influence.

Table 24 contains an evaluation of the effects of the proposed traditional port concept development on the same set of resources and characteristics. No distinction is made for the addition of a grain handling capability since the impact would be marginal. Where the impacts are of a different character from petroleum handling and are significant, these differences are noted in the text. Table 25 contains an evaluation of the effects of the proposed offshore monobuoy concept development.

Dredging and Spoil Disposal

The dredging of a channel and berthing area of the size necessary to accommodate supertankers in the inshore area of Freeport will cause an irreversible change in the present characteristics of the area. Swan Lake and its adjacent wetland areas will be completely obliterated by the berthing area. A considerable portion of the beach will be removed to provide the entrance channel. The seacoast highway will be moved to the borders of the new segment of the Gulf Intracoastal Waterway, which itself will be displaced to a more northerly location. This, in turn, will completely change the character of Oyster Creek and its surrounding wetlands. The channel will alter the local current pattern, and its effect on the adjacent shoreline is difficult to predict. However, it may have a beneficial effect on the finfish in the area by providing a new deepwater habitat.

The dredging will also produce a minimum of 75 million cubic yards of spoil. The disposal of this material, a combination of sand and clay, will present a major problem. It is possible that some of this material will be of commercial value and that some can be used in the building up of the harbor area or protection levees, but most of it will have to be dumped.

Three possibilities exist for disposal of this material: onland disposal, offshore dumping, or a combination of the two. Onshore sites likely to be chosen for such disposal are wetland areas, which will involve the loss of wildlife habitat areas.

Table 24. Evaluation of Deepwater Port Alternatives 5-4 through 5-7, Freeport Area

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		M	M	M		M	L	L	H	H	H	H	M	M	M	L	H	M	M	M
onstruction:																				
Dredging	226	2I	3T			2I	1I	2I	2T	2T				2T	1I				1T	1I
Spoil Disposal	226	3I	2T			3I	1I	2I	2T	2T				1T	1I		+	+	2T	
Filings & Berths		2T	1T			1T	1T		1T	1T				1T					1T	1T
Artificial Island																				
Breakwater		2T	1T			1T			1T	1T			1T	2T	1T				2T	1T
Mooring & Anchors																				
Submarine Pipeline																				
Onshore Pipeline	229	2T	1T			1T	2T													1T
Submarine Storage																				
Onshore Storage		2T	1T			1P	1P										1P	1P	1P	1T
resence:																				
Channel	226	1I				2I			+	1I			1P	1P					+	
Onshore Berths		2P				1P			+				1P	1P					+	
Offshore Berths																				
Offshore Island																				
Breakwater		2P				1P			+			1P	1P	2P					2P	
Offshore Mooring																				
Overwater Trestle/Pipe																				
Offshore Storage																				
Submarine Pipeline																				
Onshore Pipeline	229	1P				1I	1I					1P								
Onshore Storage		1P				1P	1P					1P			1P		1P	1P		
Underwater Storage																				
eration:																				
Channel Maintenance		1T	1T			1T			1T	1T				1T					1T	
Dry Bulk Handling		1P		1P								1P				+				
Petroleum Handling	230	1P	1P	1P								1P					+			
Ship Operations		1P	1P			1P			1P					1P					2P	
Facility Operations		1P		1P								1P								
Major Oil Spill	230	3T	3T			2T	3T	3T		1T		3T	3T	3T	3T				2T	
econdary Development:		2P	1P	1P		1P	1P				2P	1P			1P		+	1P	+	1P

Table 25. Evaluation of Deepwater Port Alternatives 5-1 through 5-3, Freeport Area

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		M	M	M		M	L	L	H	H	H	H	M	M	M	L	H	M	M	M
Construction:																				
Dredging	226	1T	1T			1T			1T	1T				1T					1T	
Spoil Disposal	226	1T	1T			1T			1T	1T				1T					1T	
Pilings & Berths						1T			1T	1T		1T		2T					2T	
Artificial Island																				
Breakwater																				
Mooring & Anchors						1T			1T	1T				1T					1T	
Submarine Pipeline		1T	1T			1T			1T	1T				1T					1T	
Onshore Pipeline		2T	1T			1T	2T	1P												1T
Submarine Storage																				
Onshore Storage		2T	1T			1P	1P										1P	1P	1P	1T
Presence:																				
Channel																				
Onshore Berths																				
Offshore Berths																				
Offshore Island																				
Breakwater																				
Offshore Mooring									+					1P					1P	
Overwater Trestle/Pipe																				
Offshore Storage																				
Submarine Pipeline												1P		1P					1P	
Onshore Pipeline	229	1P				1I	1I	1I				1P								
Onshore Storage		1P				1P	1P					1P			1P		1P	1P		
Underwater Storage																				
Operation:																				
Channel Maintenance																				
Dry Bulk Handling																				
Petroleum Handling	230	1P	1P	1P								1P					+			
Ship Operations			1P						1P					1P					2P	
Facility Operations		1P		1P								1P								
Major Oil Spill	230	3T	3T			2T	3T	3T		1T		3T	3T	3T	3T				3T	
Secondary Development:		2P	1P	1P		1P	1P				2P	1P			1P		+	1P	+	1P

The environmental impact of offshore disposal in terms of benthic organisms and secondary effects is likely to be quite extensive because of the volume of material involved and the characteristics of the spoil. The hard parched clay likely to be dumped will not be amenable to rapid recolonization by benthic organisms at dumping sites.

The only dredging associated with the offshore mooring concept will be in conjunction with the burial of the pipeline leading to the tank farm. The impact on the turbidity of the surrounding waters will be minimal and of short duration. Little of the bottom area will be involved, and only a small amount of spoil will be developed since it is assumed that the pipeline trench will be refilled.

In summary, the dredging involved in alternatives 5-4 to 5-7 will have very significant environmental implications. The problem of spoil disposal will also be significant. The offshore alternatives would eliminate these problems.

Onshore Pipeline

In general, the environmental impact associated with the construction and presence of an onshore pipeline as part of these alternatives will be minimal. This evaluation is based on the assumption that such a system would be established along existing rights-of-way in the area, and consequently that no virgin wetland areas would be crossed and no areas with other land uses would be affected. Many suitable routes exist and are controlled by groups that would benefit from the development of a crude pipeline. Thus, the only environmental impacts will be those temporary effects associated with the construction phase.

An exception to this is the onshore portion of the pipeline leading from the offshore moorings in alternatives 5-1 through 5-3. This route will cross beach and wetland areas which, although not unaltered, are undeveloped. The beach area along the route will preclude recreational uses, especially during the construction phase. After construction the area will be much less desirable for recreation if the pipeline is exposed. The route through the wetland areas would be significantly and permanently altered by pipeline construction. Productive bottom land would be destroyed, water movement would be altered and wildlife would be displaced. However, since these areas are considered of only moderate ecological value and are relatively limited in extent, the total impact will not be major. Nevertheless, attempts should be made to minimize these impacts through the selection of already altered land areas wherever possible.

Major Oil Spills

Because of the prevailing winds and near-shore current pattern, a major oil spill in the waters near Freeport would probably be pushed onto the beach area west of Freeport. Although such an occurrence would impact on the currently limited recreational use of this area, it would be temporary and the potential for complete recovery of the area would be very high. However, if such a spill managed to enter Matagorda Bay and reach the wetland areas, its effect would be more widespread and serious.

Plans to prevent and, secondarily, to combat such major spills should include advanced navigation guides, stringent operational procedures, and the immediate availability of advanced oil containment and recovery equipment. In addition, the capability to block oil slicks at the entrance to the more sensitive bay areas is necessary.

The rupture of a submarine pipeline would present essentially the same situation as a vessel casualty. The onshore rupture of pipelines or the collapse of storage tanks also presents difficult problems in containment. The saturation of surrounding land and the seepage into ground-water supplies are principal problems. Little is currently done to provide impermeable beds for pipelines, and mitigation of adverse effects must rely on prompt detection and application of absorbent materials.

Storage tanks should be built with essentially impermeable substrates and containment dikes, the latter of which are currently in common use. Fortunately, the failure of these systems is comparatively rare.

In summary, although large-scale oil spills do represent a threat in these alternatives, their impact is likely to be temporary and their occurrence infrequent.

Summary

The traditional inshore port development concept as proposed in alternatives 5-4 to 5-7 will have a severe and significant impact on the Freeport area. This is primarily a result of the extensive dredging involved in these alternatives. The offshore mooring concept, on the other hand, presents few significant problems beyond the potential for a major oil spill.

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XI. THE LOS ANGELES/LONG BEACH ALTERNATIVES

Introduction

Deepwater port alternatives 6-1 and 6-2 propose deepening the existing channels in Los Angeles and Long Beach Harbors to 81 feet to accommodate the large tankers which will be used in the future movement of petroleum.

These alternatives coincide with existing plans for the ports. Because of this and, also, because of the existing physical characteristics of the ports, no variations in the alternatives are proposed for analysis at this time.

In the following sections describing and analyzing alternatives 6-1 and 6-2, the Los Angeles/Long Beach area is treated as one area except where existing differences make it essential to treat the ports individually. Therefore, discussions of the Los Angeles area refer to the area as a whole.

The Character of the Los Angeles/Long Beach Area

General Nature of the Harbors

Los Angeles and Long Beach Harbors are man made. Three breakwaters were built across most of San Pedro Bay to form the harbor area. The breakwaters lie between 1 and 3 miles off shore and are about 9 miles long.

The San Pedro Breakwater runs from the western shore of the bay at Cabrillo Beach easterly 11,152 feet. The channel to the Los Angeles portion of the harbor is located at the eastern end of the San Pedro Breakwater. The Middle Breakwater continues easterly beyond the Los Angeles Channel for 18,500 feet to the opening for the Long Beach Channel; the Long Beach Breakwater continues beyond the Long Beach Channel for 13,350 feet, leaving an opening at the eastern end of the bay approximately a mile in width [11].

The harbor facilities are primarily concentrated in the western half of the bay and are fully protected by the breakwaters.

There has been extensive modification of the natural character of the bay bottom and bay shore over the years. The Inner Harbor, made up of a number of channels and turning basins around Terminal Island, was formed by extensive dredging and filling of the adjacent wetland areas in what was once the estuary of the Los Angeles River. Also, the harbor has been further improved for shipping and navigation by additional channel dredging and extensive land building by filling.

Two additional causes of modifications to the bay and harbor are rather unusual. First, four 10-acre islands have been built in the eastern portion of the Outer Harbor to serve as petroleum production platforms. They all have currently producing wells. Second, extensive subsidence of the bay bottom and some surrounding shoreland in the area of Terminal Island has been caused by oil extraction from the Wilmington Field. Some areas have subsided as much as 29 feet since production began in 1928 [7]. A water-pumping program is now in effect which requires replacing extracted petroleum with water, thus ending the danger of further subsidence from this cause.

Water Movement and Quality

There are two sources of freshwater drainage into the harbor: the Los Angeles River and the Dominguez

Channel. The Los Angeles River, with an average annual flow of 103,000 acre-feet, carries large volumes of sediment into the eastern part of the harbor. This sediment has been dredged and used extensively by Long Beach to develop land-filled areas in the Outer Harbor. The Dominguez Channel, which empties into the Cerritos Channel in the Inner Harbor, has been lined with concrete and drains the highly urbanized area north of the harbor. Consequently, it carries little sediment with its 16,000 acre-feet of average annual runoff. However, it has been used extensively for waste disposal and has been a major source of pollution in the Inner Harbor.

Over the years the harbor has been the recipient of large amounts of a variety of wastes. Direct discharge of sewage and industrial wastes has been substantial. The wastes, combined with silt and clay, have created a layer of sludge on the harbor floor, primarily in the Inner Harbor area. The depletion of dissolved oxygen by the decay of organic matter in the sludge has caused frequent fish kills and has practically eliminated most life forms in the affected areas. Hydrogen sulfide gas has also been generated in the bottom deposits, creating obnoxious odors and a health hazard.

A substantial amount of oil finds its way into the harbor waters, primarily as a result of ship-loading accidents. Oil has also entered the harbor with brines produced as a byproduct of some oil wells. In addition, large amounts of oil are discharged outside the harbor by arriving and departing ships.

Activities have begun in earnest to clean up the harbor waters. Municipal sewage has been diverted for treatment and discharge, and the discharge of industrial wastes has been reduced. The California Regional Water Quality Control Board intends that all industrial discharges shall be terminated prior to 1973 [8, 9].

Some problems remain, however. Ship wastes generally cannot be put into municipal systems because of their salt-water content. In addition, a large number of foreign flag vessels use the harbor, and little can be done on a local scale to require these vessels to meet city waste disposal standards. Recreational boaters also contribute significantly to the pollution of the harbor by sewage discharge and litter.

Water within the harbor is protected from ocean waves and swells by the breakwaters. Small waves and chops occur in the harbor as a result of strong winds, but they are not of consequence to large vessels. Occasionally a seiche or surge may be generated in the harbor, causing loading problems and damage to ships and shoreline facilities.

Tidal currents reach a maximum speed of about 1 knot and generally follow the lines of the channels. They are important to the flushing of the harbor and the removal of polluting wastes.

Biological Characteristics

A large variety of marine organisms have been identified in a few surveys of the harbor and outer breakwaters. The Inner Harbor area was originally an estuarine and wetland habitat, but this has been completely destroyed. Most of the remaining desirable habitat is in the Outer Harbor. The highest quality habitats are around the breakwaters, particularly the outer areas. The breakwaters themselves form artificial habitats which are desirable to numerous species of fish. The Outer Harbor contains a large population of anchovies, which are very important as bait fish for the sport-fishing industry [10].

Waterfowl use the harbor extensively for feeding and resting, but no significant number of nesting sites exist. Counts made by the Audubon Society show that up to 43 species of waterfowl visit the harbor at some time during the year. The harbor waters are heavily populated by gulls during the winter. The Brown Pelican and the Least Tern, both on the list of endangered species, are known to frequent the area, but they are not limited to the area and do not nest there.

Harbor Uses

Shipping and navigation. Los Angeles/Long Beach Harbors are major ports for both domestic and foreign trade. In addition, naval facilities are extensive in both areas. In 1969, the ports had a combined incoming-vessel traffic load of 5,946 ships [11].
ships [11].

Fishing. As previously mentioned, the harbor contains a major anchovy population which forms the basis for the southern California marine sport fishery. Used as live bait, the anchovies of Los Angeles/Long Beach Harbor are a commercially important resource.

In addition to being the site of anchovy fishing, Los Angeles Harbor is home port for sport and commercial fishing boats which fish well outside the harbor. Sport fishing is also undertaken extensively in the harbor from the wharves and breakwaters as well as from small boats.

Recreation. There are several bathing beaches inside the harbor. At the western end of the San Pedro Breakwater are the two Cabrillo Beaches; one is inside and one is outside the breakwater. Both are about 1/2 mile in length and have seen heavy recreational use. In addition, the inner beach is used for boat launching and training for scouts. The third beach, on the eastern side of the harbor bordering Long Beach, is 4 miles long and also has experienced heavy use.

There are about 20 anchorages for small craft in the harbor with a capacity in excess of 3,500 boats, and harbor improvement plans include the development of marina facilities at Cabrillo Beach and east of the Long Beach dock facilities. It should be noted, however, that small recreation craft are used extensively throughout southern California and are not confined to the protected harbor.

General Nature of the Land Area

Land Use

The land of Los Angeles and Long Beach in the area of the harbor is heavily used for residential, commercial, and industrial purposes. The immediate harbor area is characterized by the heavy concentration of port-oriented industry, including warehousing, fish processing, petroleum storage, shipbuilding and ship repair. The U.S. Navy is also an extensive land user in the immediate port area; its facilities include the Naval Base, Naval Supply Center, Naval Shipyard and Naval Station.

Plans exist to add extensively to the harbor land area by filling in existing inefficiently used or unused water areas. Such expansion will be used to increase the number and size of berthing spaces and the storage area for bulk commodities, containers and general cargo.

Seven refineries are located in the Los Angeles area, all within 8 miles of the harbor. All are now in operation and draw primarily on the local supply of crude oil, although imports of crude are increasing. These refineries are located in industrially zoned areas, according to Los Angeles City Planning Department maps [2].

An extensive network of pipelines runs throughout the area between crude petroleum wells and the refineries, between the port and refineries, and between the area and distant demand points. Most of the existing lines are under 12 inches in diameter.

Little open space is set aside for recreation or aesthetic relief in the inland area. The harbor shoreline east of the port facilities in Long Beach and the Pacific shoreline west of the harbor and northward throughout most of the length of Santa Monica Bay are dedicated to recreation and open space. One significant break in this stretch occurs at El Segundo, just below the Los Angeles International Airport, where an oil refinery is located near the shore and has a loading facility off shore at the same site [2].

Water Resources

There are three major sources of the Los Angeles area's water supply. They are the Colorado River, the ground waters of the San Fernando Valley, and reservoirs in the High Sierras [2].

Freshwater wells along the coast have generally been rendered useless by salt-water intrusion caused by excessive withdrawals inland. Attempts are being made to control the intrusion by injecting fresh water into the aquifer. As the technology improves, reclaimed waste water may be injected for the dual purpose of controlling the intrusion and recycling the water. Plans for expanding the Los Angeles area's supply rely primarily upon a heavier use of the supply available in the High Sierras. Changes in water allocations and high costs reduce the desirability of expanding the use of the Colorado River as a source.

Air Resources

The Los Angeles area is notorious for its air pollution problems [1]. The three most important sources of air pollution are automobiles, power plants, and industry, in that order. In the industrial category, petroleum refining leads the list of sources.

Population

Los Angeles County has over 7 million inhabitants, according to 1970 census data, representing an increase of about 16 percent during the past decade. Recent indications, however, point toward a pronounced slowing of population growth. This is generally attributed to a slowdown in the immigration from other parts of the country and may be related to the economic conditions in the aerospace industry.

Regulating and Planning Agencies

A number of local, regional, and state agencies are concerned with and may influence the growth and development of Los Angeles/Long Beach Harbor. Among the more important are:

1. Board of Harbor Commissioners of the ports of Long Beach and Los Angeles -- concerned with the operation and development of the ports

2. City Planning Departments -- concerned with the orderly and balanced growth of the entire area, of which the ports are important parts

3. Southern California Coastal Water Research Project (SCCWRP) -- established to investigate the impact of and the ways to control waste disposal into the coastal waters

4. California Regional Water Quality Control Board -- established to carry out the Porter-Cologne Water Quality Act, establish standards, and to plan and enforce the implementation of measures to meet the standards

5. Air Resources Board -- established to "restore the atmosphere to the best possible quality in those areas presently suffering from the effects of polluted air and prevent the occurrence of air pollution in other areas through a coordinated state and local effort"

6. California State Department of Navigation and Ocean Development -- established to plan for the development of the California ocean and coastal areas in a manner compatible with the preservation of the character of that area.

Outstanding Conflicts and Attitudes

Up to the present the general attitude of the area's population apparently has been tuned to rapid growth and an apparent willingness to accept the associated consequences of congestion, heavy traffic, air pollution, and loss of nearby open space. The people have traditionally turned to the ocean and its beaches and to the mountains for recreation and open space.

Los Angeles/Long Beach
Analysis and Evaluation

The deepwater port alternatives for Los Angeles and Long Beach Harbors (alternatives 6-1 and 6-2) consist of selected deepening of existing channels for the purpose of crude petroleum imports.

The Los Angeles entrance channel and turning basin would be deepened to 80 feet from their present depths of 47 feet. The terminal facilities would be located on shore between the existing East and West Channels about 1/2 mile east of Cabrillo Beach. The Long Beach Channel would be deepened from its present 62 feet to 80 feet from the entrance to the oil facilities on Terminal Island. Both channels will require some deepening to a distance of about 3 miles outside the breakwater.

Both ports would require expanded berths, onshore storage, and pipelines to the existing refineries. It is assumed that refinery capacity expansion will occur at the site of existing refineries rather than at completely new sites.

Material available from the dredging will be used as land fill to increase the usable land within the ports. In fact, the planned developments will probably require more material than will be available from this dredging project.

Table 26 contains an evaluation of the resources and characteristics of the Los Angeles/Long Beach area which may be affected by the port development. The present values are based partly on observations and partly on personal communications and available literature. The future values are based on existing plans and programs in environmental and resource management which will likely have an effect on the area's characteristics. Table 27 contains an evaluation of the effects of the proposed port development upon the same set of resources and characteristics.

Table 26. Evaluation of the Los Angeles - Long Beach Area

	Aesthetics	Water Quality	Air Quality	Uniqueness *	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
Present value	L	L	L	L	L	L	L	M	L	L	M	M	M	M	L	H	H	H	M
Projected value	M	M	L	L	M	L	L	M	L	L	M	M	M	M	L	H	H	H	H

Key:
H = high value, high quality, or high level of use
M = moderate value, moderate quality, or moderate level of use
L = low value, low quality, or low level of use

* Number entered equals number of natural or historic sites in the area of influence.

Table 27. Evaluation of Deepwater Port Alternatives
6-1 and 6-2, Los Angeles - Long Beach Area

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		L	L	L	L	L	L	L	M	L	L	M	M	M	M	L	H	H	H	M
nstruction:																				
Dredging	246	1T	3T						1T	1I		2T		2T					2T	
Spoil Disposal	246	2I	3T			2P	2I		2I	1I		2T		2P					2P	
Pilings & Berths																				
Artificial Island																				
Breakwater																				
Mooring & Anchors																				
Submarine Pipeline																				
Onshore Pipeline	247	1T																2T		2T
Submarine Storage																				
Onshore Storage	247	1T	1T			1T													2T	
esence:																				
Channel	246		2P			1P			1P										+	
Onshore Berths		1P												2P					1P	
Offshore Berths																				
Offshore Island																				
Breakwater																				
Offshore Mooring																				
Overwater Trestle/Pipe																				
Offshore Storage																				
Submarine Pipeline																				
Onshore Pipeline	247	1P										2P						2P		
Onshore Storage	247	2P					1P					1P								
Underwater Storage																				
eration:																				
Channel Maintenance			2P											2P					2P	
Dry Bulk Handling																				
Petroleum Handling		1P	2P				1P					2P	1P	1P	2P					
Ship Operations			1P	1P							1P			2P					2P	
Facility Operations																				
Major Oil Spill	248	3T	3T			2T	3I			1T		3T	3T	3T	3T				2T	
condary Development:	249	1P	1P	2P							1P						+	1P		

Entries are made only in those rows which are applicable to these alternatives. They are based upon the judgment of the analyst, who is solely responsible for the evaluation. However, a comprehensive analysis of the potential environmental impact of the extensive dredging and filling project already proposed for the two ports has been done by the Corps of Engineers [10]. Although based on existing information, the draft environmental statement covers the subject very well and was the source of a major part of the information used in this evaluation for the harbors. The report does not cover the impacts associated with onshore secondary development such as increased refinery capacity and the installation of additional pipelines. Therefore, this report will concentrate on the latter aspects.

Dredging

The actual deepening will occur in existing dredged channels and consequently will not have a great impact upon the benthic biota. The effects on water quality may stem from two sources. First, some of the material being dredged may go into suspension and cause turbidity to increase in the Outer Harbor. If the material is polluted, which does not appear to be the case (although the Inner Harbor bottom is severely polluted), a serious pollution problem could occur and could last for a substantial time because of the relatively low flushing rate within the harbor. The second source of impact on water quality would be the changes in the hydraulic character of the harbors. Deeper entrance channels would likely increase the rate of flushing and could improve the quality of the harbor water.

Maintenance dredging could cause continuous turbidity problems if the channels are improperly constructed. The bottom material tends to be unstable, and dredging to 80 feet may create steep walls that may crumble. This possibility should be investigated prior to project implementation, and the channel walls should be stabilized if necessary to reduce or eliminate the need for extensive maintenance dredging.

More significant than the dredging itself is the proposal to add substantial land area by filling in parts of the Outer Harbor with the dredged material. The area proposed for the land fill is now used by the large anchovy fishery, and in addition is a resting area for waterfowl. The land fill will not only impact heavily on these uses, but will also destroy any benthic organisms in the area. There will also be changes to the hydraulic characteristics of the harbors.

There is a possibility that the anchovy population will relocate, probably to a more easterly portion of the harbor. Also, new wildlife habitats may be established along the edges of the new land areas.

From an aesthetic standpoint, the land fill will create a very different appearance to the harbor. The western half of the harbor will have much less of an expanse of open water than it has now. This could very well be considered a detriment to the environmental quality of the harbor area.

In summary, the projected land fill area is by far the most significant part of the dredging portion of the project. If the project is planned and carried out properly, the impacts will be significant but generally more acceptable than spoil disposal at sea or in any other area where it would serve no beneficial use.

Onshore Development

The proposed alternatives will require expanded petroleum storage and pipelines to the refineries. The greatest impact of the storage is aesthetic. No way has been devised (or used) to make large storage tanks an asset to the environment of an area. In the Los Angeles area the tanks will have a particular impact, for they will be located not more than 1/2 mile from a heavily used bathing beach (Cabrillo Beach). Low profile should be maintained if possible, or relocation to a less visible site should be considered.

The construction of new pipelines through a very heavily developed area such as Los Angeles can be very difficult, if not impossible. However, as previously mentioned, many lines already exist throughout the area. Although this point has not been investigated, it is assumed that the rights-of-way exist and that the new lines can be placed through them. If so, there may be the temporary disruptions that are created by any construction, but no permanent effects should be noticed.

In summary, onshore storage should be so designed and located as to minimize its aesthetic intrusion, especially at the Los Angeles facility. If this is done and if the pipelines can utilize existing rights-of-way, the impacts cannot be considered serious. However, if the rights-of-way cannot be used, the impact of laying new pipelines could be very significant.

Major Oil Spills

The threat of major oil spills is not new or unknown in this area, a fact attested to by the Santa Barbara incident. As previously mentioned, four oil "islands" are located within the breakwaters of the Los Angeles/Long Beach Harbors, and consequently the possibility of a major spill exists now. The addition of very large tankers will add another element to the existing risk.

A major spill from a collision or grounding outside the breakwater would be difficult to contain. The result could be quite similar to the Santa Barbara incident, with oil coming ashore on beaches south of San Pedro Bay and perhaps on Santa Catalina Island, although the island is far enough offshore that the oil would probably disperse before reaching it.

A major spill inside the breakwater could easily be contained and isolated for cleanup. This could be accomplished even more easily after the development of the planned land fill and port expansion.

Although most of the impacts caused by a major oil spill would be temporary, they could be highly significant from the standpoint of waterfowl, pleasure boating, and beach recreation on Cabrillo Beach and Long Beach.

Plans for combating oil spills in the harbors should therefore include the permanent installation of movable oil barriers to prevent the escape of oil to the beaches or out of the harbors.

In summary, the impact of a major oil spill will always be highly significant, although much less here than in some other areas. The breakwater will make retention and cleanup relatively easy, and controlled access and limited traffic lanes would reduce the risk of major spills.

One other element in the potential for major oil spills must be considered: potential damages caused by a major earthquake. During seismic activity pipelines may rupture and break and storage tanks may also be damaged, causing major leaks and spills. Care must be taken to design facilities to minimize the probability of oil spills from such natural forces.

Secondary Development

Because the Los Angeles/Long Beach area is already heavily developed, a deep-draft harbor for supertankers will not create any significant secondary development beyond what exists or is planned, except for the expansion of existing refineries to meet the growing demand for petroleum products. This may mean an additional burden on the air resources and waste disposal systems of the area, although it is currently claimed that new and expanding refineries can significantly reduce their environmental problems by improved design and operating practices.

In summary, the impact of any secondary development in the Los Angeles/Long Beach alternatives will not be significant.

Summary

In general, the proposed development of a deep port for the import of crude petroleum in Los Angeles/Long Beach Harbors creates little significant environmental intrusion.

However, two aspects are of major concern. First, the harbor alterations will cause severe changes in the present anchovy fishery, a valuable resource and the source of much economic activity in sport fishing throughout southern California. This impact warrants more scientific investigation to ascertain the actual effect of the alterations, and, if the effect is detrimental, the countermeasures that can be applied to assure the maintenance of the fishery. Second, the possibility of a major oil spill will remain regardless of design and engineering. If the spill occurs within the breakwater, it can be controlled. Outside the breakwater, however, a large spill could spread along a long stretch of the southern California beaches.

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XII. THE SAN FRANCISCO BAY ALTERNATIVES

Introduction

Deepwater port alternatives 7-1, 7-2, 7-3, and 7-4 consist of a series of channel deepenings in the San Francisco Bay area for the import of crude oil to supply the bay area's demand. Alternatives 7-1 and 7-3 call for deepening of the channels into the port of Richmond to depths of 50 feet and 60 feet. Alternatives 7-2 and 7-4 include, in addition, deepening of the Pinole Shoal and Carquinez Straits into Benicia and Martinez. Again, the project depths would be 50 feet and 60 feet, respectively.

It is assumed that, under alternatives 7-1 and 7-3, the refineries in Carquinez Strait and Suisun Bay would be supplied with crude by pipeline from the Richmond facilities.

The Character of the San Francisco Bay Area

The general character of the San Francisco Bay area is molded by the very close and continuous interaction of the land and water. This area has a unique combination of natural characteristics, including the bay itself, the hilly terrain, and the climate, which makes it highly scenic, a good port area, and heavily populated.

General Nature of the Bay

What is denoted herein as San Francisco Bay actually consists of several closely connected water bodies. It runs generally in a north-south direction and is separated from the Pacific Ocean by relatively narrow strips of land. The Golden Gate is the only outlet to the ocean from the bay. San Francisco Bay itself forms the water area from the city of Richmond to beyond Redwood City. To the north of this is San Pablo Bay. East of San Pablo Bay is Carquinez Strait, a narrow strip of water which leads into the area called Suisun Bay. The Sacramento River and the San Joaquin River join and enter the bay in this area, providing the major input of fresh water into the bay.

Bay Sediments

The bay is quite shallow, with 70 percent of it having depths of less than 18 feet. The bottom material consists of mud, clay, and sand. The upper channel areas near Carquinez Strait have a high proportion of very fine sediment. The channels in San Pablo Bay (Pinole Shoal) and the Richmond area contain some very fine sediment underlaid by a coarser substrate. The bottom material of the outer bay channel outside the Golden Gate is mostly sand and gravel.

Much of the bottom material in the channel areas is polluted, the result of industrial waste. This is especially true of the upper 2 to 3 feet of sediments in the Richmond and Carquinez Strait areas. The sediments of the outer bay are generally not polluted. The annual sediment inflow is estimated to average about 10 million cubic yards, and the outflow is estimated at 3 million cubic yards [18].

Dredging and Spoil Disposal

Extensive maintenance dredging is required in the existing navigation channels. According to the Corps of Engineers, approximately 11 million cubic yards are dredged annually for this purpose [16].

One of the biggest problems associated with maintenance of the channels is the disposal of spoil. Unpolluted material dredged for maintenance in the bay is deposited in deep water immediately off Alcatraz Island. Several other small disposal areas for clean spoil are located south of Oakland in relatively deep water [18].

The material dredged from Potatopatch Shoal, as the outer bar is called, is redeposited on the bar south of the channel so as not to upset the littoral movement of the sand to the beaches south of San Francisco [16].

The four major maintenance dredging areas and the approximate annual amounts [18] are:

Area	Amount (cubic yards)
Bar Channel.........	990,000
Richmond Channel....	610,000
Pinole Shoal........	630,000
Suisun Bay Channels.	325,000

Polluted material must now be transported to sea and dumped beyond the 100 fathom line (about 23 miles outside the Golden Gate) or placed on a completely contained land fill. Land fills are generally not favored in today's climate of environmental concern.

Studies of the environmental effects of dredging at the bar indicate that there are no severe ecological problems [16]. The sediments continually shift and move, and any organisms there must be adaptable and mobile enough to reestablish themselves. The studies indicate a need for a better understanding of sediment movement on the bar to assure disposal is done in a way that will prevent beach starvation and increased erosion downshore.

Bay Waters

The bay waters contain substantial pollution. Municipal and industrial wastes and agricultural runoff of pesticides and fertilizers are the main causes. Port activities have also contributed to the problem because ships pump bilges and empty ballast waters into the bay [13, 19].

As a result of the water quality, all shellfish areas in the bay are closed. However, the California Regional Water Quality Board is undertaking a program of water quality improvement in the bay. At this time the program is in the planning stages [13].

Incidents of major oil pollution have occurred in the bay area, the most noticeable and recent of which was a collision of two tankers in fog outside the Golden Gate. This created a major spill which, driven by prevailing westerly winds, entered the bay and created a serious problem, especially along the north shore around Sausalito and Tiburon, which are both high-value residential and recreational boating areas.

As previously mentioned, the Sacramento and San Joaquin Rivers provide the major inflow of fresh water into the bay. They are supplemented by a large number of smaller local streams. The source of the flow is primarily snow melt and, as such, peaks in late spring and early summer. The annual average freshwater flow into the bay is estimated at 29,000 cubic feet per second.

Weather

The San Francisco Bay area is especially noted for its climate. One of the key weather elements from a navigational standpoint is the high incidence of fog. Fog is especially prevalent during the summer months, and is most severe in the Golden Gate area. It enters the bay through the Golden Gate and follows the streamline of the bay into Carquinez Strait. Summer fogs are frequently "high"; that is, they do not reach the surface. Consequently, navigation is not too severely hampered except in the Golden Gate area [15]. Winter fogs form to the east of the bay. These tend to flow through the low passes westward into the bay area, and are usually shallow surface fogs that create severe navigational problems.

The prevailing winds in the area are westerly and northwesterly. Peak winds occur during winter storms, but highest average winds occur in summer. The local winds tend to follow the streamlines caused by the topography, generally blowing into the Golden Gate and up Carquinez Strait. Areas more closely contained by surrounding hills, such as Carquinez Strait, tend to have higher wind velocities than do Oakland and Alameda [5].

Fish and Wildlife

Pollution of the bay waters and filling of the major marsh and wetland areas have caused a serious decline in the fishery and wildlife over the years. However, with improving water quality control, there is evidence that the fishery, at least, may be improving.

The bay is utilized by a large number of fish species [13], among which are the anadromous species, primarily striped bass, salmon, sturgeon, steelhead and shad. (The bass utilize the entire bay, while the others tend to use it as a nursery and throughway to the tributary streams for spawning.) The bay also contains other fish such as anchovies, herring, smelt, sole, flounder, sea perch, sharks, rays, and rockfish.

The bay contains oysters and clams at locations in San Pablo Bay and further south in San Francisco Bay, and Dungeness crab and shrimp are also common throughout these two areas. However, all shellfish beds are presently closed to fishing because of pollution.

In total, it has been estimated that about 100 species of fish utilize the bay at different times throughout the year [20]. Most of these provide important support to commercial and sport fisheries in the area.

The bay is also an important resting, feeding, and wintering area for many birds of the Pacific flyway, and it has been estimated that at least 75 species of water birds use the bay. The California Department of Fish and Game presently manages over 18,000 acres for wildlife conservation in the bay area [20].

In addition to the usual fish and wildlife resources, the bay is also utilized by a population of harbor seals and sea lions.

While total use of the fisheries and wildlife resources of the bay is not known, estimates have been made that in 1967 the bay supported about 505,000 man-days of hunting, 370,000 man-days of bird watching, and about 3.6 million man-days of fishing. In 1965 about $2 million worth of fish were commercially harvested from the bay [19, 20].

General Nature of the Land

As previously mentioned, the San Francisco Bay area is a highly scenic combination of hills, valleys, and water. It is a relatively heavily populated, urban area. On the west side, adjacent to the Golden Gate, San Francisco dominates the landscape. On the east side, the ports of Oakland, Alameda, and Richmond dominate. The east side, especially the Richmond area, is heavily industrialized, and six refineries are scattered along the shore from Richmond through Carquinez Strait.

The shoreline of the bay area can be separated into three distinct areas based on current land use [17]. The area from San Francisco through the north shore of San Pablo Bay to Carquinez Strait is a mixture of residential, agricultural, and undeveloped wetlands. The shores of the Carquinez Strait and Suisun Bay have wetlands valuable from a waterfowl standpoint. In addition, portions of Carquinez Strait and the east shore down to Alameda are heavily industrialized.

The uses of the shoreline and their approximate extent are [17]:

Use	Area (miles)
Public recreation	16.2
Private recreation	8.7
Nonrecreational development	143.4
Undeveloped	103.7

Wetlands

In 1850 there were 300 square miles of marsh in the bay area. Since that time, reclamation has eliminated all but about 75 square miles of the marsh. Much of the remaining undeveloped shoreline is in tidal mud flats rich in marine and animal life. Extensive waterfowl resting areas are located in the northern sections of San Pablo Bay, Carquinez Strait, and Suisun Bay.

Geology

The geology of the bay area is important to an evaluation of the environmental impact of specific development because of two phenomena: earthquakes and landslides.

The bay area is within the great earthquake region along the Pacific coast that is one of the most seismically active in the United States. The major faults are [6]:

1. San Andreas -- approximately parallels the coast on the western side of the bay area, running along the San Francisco Peninsula and across the Golden Gate near the bay channel

2. Hayward -- runs along the east bay, parallel to the San Andreas Fault, northward through the area of Richmond and into San Pablo Bay

3. Calaveras -- runs east of the Hayward Fault. It appears to cross the Carquinez Strait, but its exact location in that area is unknown.

There have been over 1,000 recorded earthquakes since 1850 [6]. Although most have been minor, several major earthquakes have occurred, all of which caused severe damage to buildings and other structures. The most famous occurred in 1906 in the San Andreas Fault, causing severe damage to San Francisco.

Landslides are also common throughout the area. They are due mostly to the fact that the very hilly terrain is generally underlaid by unconsolidated material, including a large amount of clay, which becomes very plastic when wet. Prolonged periods of rainfall, earthquakes, and man's alteration of the surface all contribute their share to the occurrence of landslides.

Earthquakes and landslides must be given consideration in the development of oil handling facilities because of the damage they can cause to storage tanks and pipelines. Recently, in fact, a pipeline carrying aircraft fuel from a refinery in the Carquinez Strait area to the Oakland Airport broke as the result of a landslide, causing a major spill.

Population

The current bay area population is about 4.8 million [3]. Current projections are for it to increase to between 6.9 and 8.4 million by 1990. A major portion of this growth is expected to take place in Alameda and Contra Costa Counties, which contain the area designated in the alternatives for deep port development.

Outstanding Conflicts and Attitude

The most outstanding conflict in the bay area appears to be between industrial growth and preservation of the environment. A growing element of the population feels that the bay area should not encourage further industrial development, and heavy industry located on or near the bay (such as oil refineries) has come under particular attack. This can be explained partly by the growing awareness of environmental values on a national and international scale. It is further explained by the fact that the people of the bay area enjoy one of the highest per capita incomes in the United States, and with higher income goes increasing emphasis on nonmonetary social values.

People are very aware of the toll in environmental value that rapid growth and development have levied, and are approving measures to regulate the kinds and amounts of such growth. It is apparent that the bay area's population is choosing to protect and preserve its considerable environmental qualities [7, 12, 15], and is aware of and concerned about oil pollution, especially after the major spill outside the Golden Gate last year.

Regulating and Planning Agencies

The bay area is composed of a large number of municipalities and counties, each with some authority and obligation to plan and regulate the area's activities. Because of the number of agencies, those with a regional focus and regional participation will apparently provide the greatest influence on growth and maintenance of environmental quality. Outstanding among these are:

1. Association of Bay Area Governments (ABAG) -- established to develop a regional plan and a framework for dealing with regional problems in the entire San Francisco Bay metropolitan area [7].

2. San Francisco Bay Conservation and Development Commission (BCDC) -- established to plan for and regulate developments in the bay and landward for 100 feet [12]

3. California Regional Water Quality Control Board -- established to carry out the provisions of the Porter-Cologne Water Quality Act, it is now developing a program of water quality management for San Francisco Bay to upgrade the quality currently existing. This program is in the planning stage [13].

One other program is especially worthy of note: the joint U.S. Geological Survey/Housing and Urban Development program entitled the "San Francisco Bay Region Environment and Resources Planning Study." This study is designed primarily "to improve the capability of the earth sciences in solving environmental problems of urban and regional development." According to planners in the area, the results of the study are already proving useful.

Existing Plans

The San Francisco Bay Plan, prepared by BCDC, was completed and published in January 1969. The plan, which is now being administered and implemented by BCDC, was established to meet two major objectives [12]:

1. To protect the bay as a natural resource for the benefit of present and future generations

2. To develop the bay and its shoreline to their highest potential, with a minimum of bay filling.

The Regional Plan, developed by the Association of Bay Area Governments (ABAG), was completed and published in 1970 [7]. It was developed to ensure orderly growth and the development of the San Francisco Bay region in keeping with the area's natural resources and environment.

A third major study is now underway, and has the objective of formulating a development plan for the San Francisco Bay region that will promote and encourage "the efficient, economic, and logical development of the harbor complex and its hinterland." This study, managed by the Corps of Engineers, has multiagency participation and encompasses engineering, economic, social, and environmental aspects. Work has just begun and is not expected to be completed until 1977 [14].

Analysis and Evaluation of San Francisco Bay Alternatives

Table 28 contains an evaluation of the resources and characteristics of the San Francisco Bay area which may be affected by the alternatives for deep port

Table 28. Evaluation of San Francisco Bay Area

(All alternatives except Moss Landing)

	Aesthetics	Water Quality	Air Quality	Uniqueness *	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
Present value	H	L	M		M	M	M	L	L	H	M	L	H	H	M	M	H	H	M
Projected value	H	M	M		M	M	M	M	M	H	M	L	H	H	M	M	H	H	M

Key:
H = high value, high quality, or high level of use
M = moderate value, moderate quality, or moderate level of use
L = low value, low quality, or low level of use

* Number entered equals number of natural or historic sites in the area of influence.

development. Present values are based on information collected by personal communication, observation, and published information. Projected values are based primarily on current planning activities which have elements related to the natural environment and resource management, and reflect what will be likely to happen without implementation of any of the alternatives proposed for evaluation.

Tables 29 through 32 contain an evaluation of the effects of the four alternatives proposed for San Francisco Bay. Entries are made only in those rows which are applicable to the alternative being evaluated.

Dredging

Each of the four alternatives proposed for the San Francisco Bay area has different dredging requirements. Consequently, the implications vary with the amount of material, the quality of the material, and the location of the area to be dredged, as well as with the location for spoil disposal.

All the alternatives will require deepening of the Bar Channel from its present depth of 50 feet to either 55 or 65 feet, depending upon the alternative. The material on the bar is mostly clean sand and gravel. The bar is constantly in a dynamic state as the material moves with the littoral drift. Consequently, the organisms on the bar are adapted to this kind of change and, given time to recover from the physical relocation, will not be substantially damaged by the dredging.

Although knowledge about the dynamics of the bar is slight, it is believed that material dredged from the Bar Channel should be replaced on the bar to the south of the channel to prevent sand starvation and increased erosion of the beaches south of the Golden Gate. Until more is known, this appears to be a reasonable approach.

Inside the bay the dredging requirements are not so easily dealt with. Alternatives 7-1 and 7-3

Table 29. Evaluation of Deepwater Port Alternative 7-1, San Francisco Bay Area

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		H	L	M		M	M	M	L	L	H	M	L	H	H	M	M	H	H	M
nstruction:																				
Dredging	264	2T	3T			2P						2T	1T	2T					2T	
Spoil Disposal	270	2T	3T			2I	2P	3I	1T	1P		1T	1T	2T					1T	
Pilings & Berths																				
Artificial Island																				
Breakwater																				
Mooring & Anchors																				
Submarine Pipeline																				
Onshore Pipeline	271	1T	1T				2T	2T												1T
Submarine Storage																				
Onshore Storage	271	2T	1T				1T													
:esence:																				
Channel	269		1P											+					+	
Onshore Berths		1P										1P		1P					2P	
Offshore Berths																				
Offshore Island																				
Breakwater																				
Offshore Mooring																				
Overwater Trestle/Pipe																				
Offshore Storage																				
Submarine Pipeline																				
Onshore Pipeline	271											2P			1P			1P		
Onshore Storage	271	2P	1P									2P					1P	1P		
Underwater Storage																				
peration:																				
Channel Maintenance		1P	2P			2P		2I				1P		1P					1P	
Dry Bulk Handling																				
Petroleum Handling	272	2P	2P			1P	2I	2P		2P		2P		2P	1P					
Ship Operations			2P									2P		2P					2P	
Facility Operations																				
Major Oil Spill	272	3T	3T		1T	3P	3I	3T	1T	3T	2T	3T	3T	3T	3T			2T	1T	
econdary Development:	273	2P	2P	3P	2P	1P	2P	3I			1P	1P			1P	1P	+	2P		1P

Table 30. Evaluation of Deepwater Port Alternative 7-3, San Francisco Bay Area

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		H	L	M		M	M	M	L	L	H	M	L	H	H	M	M	H	H	M
Construction:																				
Dredging	264	3T	3T			2P						2T	2T	2T					2T	
Spoil Disposal	270	3T	3T			3I	2P	3I	1T	2P		1T	2T	2T					1T	
Pilings & Berths																				
Artificial Island																				
Breakwater																				
Mooring & Anchors																				
Submarine Pipeline																				
Onshore Pipeline	271	1T	1T				2T	2T												1T
Submarine Storage																				
Onshore Storage	271	2T	1T				1T													
Presence:																				
Channel	269		1P											+					+	
Onshore Berths		2P										1P		1P					2P	
Offshore Berths																				
Offshore Island																				
Breakwater																				
Offshore Mooring																				
Overwater Trestle/Pipe																				
Offshore Storage																				
Submarine Pipeline																				
Onshore Pipeline	271											2P			1P			1P		
Onshore Storage	271	3P	1P									2P			1P		1P	2P		
Underwater Storage																				
Operation:																				
Channel Maintenance		2P	2P			2P		2I				1P		1P					1P	
Dry Bulk Handling																				
Petroleum Handling	272	2P	2P			1P	2I	2P		2P		2P		2P	1P					
Ship Operations			2P									2P		2P					2P	
Facility Operations																				
Major Oil Spill	272	3T	3T		1T	3P	3I	3T	1T	3T	2T	3T	3T	3T	3T			2T	1T	
Secondary Development:	273	2P	2P	3P	2P	1P	2P	3I			1P	1P			1P	1P	+	2P		1P

Table 31. Evaluation of Deepwater Port Alternative 7-2, San Francisco Bay Area

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		H	L	M		M	M	M	L	L	H	M	L	H	H	M	M	H	H	M
nstruction:																				
Dredging	264	2T	3T			2P	1T		1T	1I		2T	2T	2T					2T	
Spoil Disposal	270	2T	2T			2P	2P	3I	1T	2P		2T	2T	2T					2T	
Pilings & Berths																				
Artificial Island																				
Breakwater																				
Mooring & Anchors																				
Submarine Pipeline																				
Onshore Pipeline																				
Submarine Storage																				
Onshore Storage	271	2T	1T				2T													
esence:																				
Channel	269		1P											+					+	
Onshore Berths		2P										1P		1P					2P	
Offshore Berths																				
Offshore Island																				
Breakwater																				
Offshore Mooring																				
Overwater Trestle/Pipe																				
Offshore Storage																				
Submarine Pipeline																				
Onshore Pipeline																				
Onshore Storage	271	2P	1P									2P			1P		1P	2P		
Underwater Storage																				
eration:																				
Channel Maintenance		2P	2P			2P	1P	2I				1P		1P					1P	
Dry Bulk Handling																				
Petroleum Handling	272	2P	2P			1P	2I	2P		2P		2P		2P						
Ship Operations			2P									1P		2P					2P	
Facility Operations																				
Major Oil Spill	272	3T	3T		1T	3P	3I	3T	3T	3T		3T	3T	3T				2T	1T	
Secondary Development:	273	3P	2P	3P	2P	1P	2P	3I			1P	1P			2P	1P	+	2P		1P

Table 32. Evaluation of Deepwater Port Alternative 7-4, San Francisco Bay Area

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		H	L	M		M	M	M	L	L	H	M	L	H	H	M	M	H	H	M
Construction:																				
Dredging	264	2T	3T			2P	1T		1T	2I		2T	3T	2T					2T	
Spoil Disposal	270	3T	3T			3I	2P	3I	1T	2P		2T	2T	2T					2T	
Pilings & Berths																				
Artificial Island																				
Breakwater																				
Mooring & Anchors																				
Submarine Pipeline																				
Onshore Pipeline																				
Submarine Storage																				
Onshore Storage	271	2T	1T				2T													
Presence:																				
Channel	269		2P			1P								+					+	
Onshore Berths		2P										1P		1P					2P	
Offshore Berths																				
Offshore Island																				
Breakwater																				
Offshore Mooring																				
Overwater Trestle/Pipe																				
Offshore Storage																				
Submarine Pipeline																				
Onshore Pipeline																				
Onshore Storage	271	2P	1P									2P			1P		1P	2P		
Underwater Storage																				
Operation:																				
Channel Maintenance		2P	2P			2P	1P	2I				1P		1P					1P	
Dry Bulk Handling																				
Petroleum Handling	272	2P	2P			1P	2I	2P		2P		2P		2P						
Ship Operations			2P									1P		2P					2P	
Facility Operations																				
Major Oil Spill	272	3T	3T		1T	3P	3I	3T	3T	3T		3T	3T	3T				2T	1T	
Secondary Development:	273	3P	2P	3P	2P	1P	2P	3I			1P	1P			2P	1P	+	2P		1P

require dredging of the channels to Richmond to 50 and 60 feet, respectively, and alternatives 7-2 and 7-4 require additional dredging of the channels to Carquinez Strait, again to 50 and 60 feet, respectively.

The sediment material in these channels is generally very fine mud and clay, much of which is carried from the agricultural uplands into the bay and delta by the San Joaquin and Sacramento Rivers. A great deal of this material, especially the upper 2 to 3 feet, contains contaminants such as heavy metals and other industrial and agricultural wastes. Dredging these materials will cause an extensive amount of resuspension of materials in the bay waters, increasing turbidity and decreasing water quality.

The effect of the deeper channels on water circulation and salinity intrusion is not well understood at this time. Coupled with the problems associated with upstream water diversions, the potential salinity changes warrant further investigation, especially for alternatives 7-2 and 7-4, which require major deepening of the Pinole Shoal Channel leading to Carquinez Strait. Salinity changes would not appear to be a major problem for alternatives 7-1 and 7-3.

There is a possibility, especially for the deeper alternatives, that dredging could intrude upon aquifers which underlie part of the bay, permitting intrusion of saline water into the aquifer. This is not considered of major concern for three reasons. First, while the locations of ground-water reservoirs are not well known, it appears that the proposed dredging projects have a low probability of disturbing an aquifer. Second, there has already been extensive saline intrusion into much of the ground water due to overwithdrawal of fresh water. Where this has occurred, the impact of dredging would not be noticeable. Third, a major and increasing proportion of the region's water supply is being derived from surface sources, creating less dependence upon groundwater resources.

Removal of benthic organisms, such as shellfish, does not appear to be a problem in the San Francisco Bay alternatives because the channels are in locations that are already being maintained through dredging.

The major problem in the dredging aspect of the alternatives lies with the disposal of the dredged material. Because of both the polluted nature and the very fine consistency of most of the material, in-bay disposal does not appear to be a desirable approach. The large volumes to be spoiled would create high levels of turbidity over a relatively long period and would have an adverse effect on water quality. This leaves two alternatives: onshore disposal and barging to sea. However, land fills have already covered 80 percent of all the marshes in the bay area [12], and it appears highly unlikely that major land fill projects will be acceptable for the foreseeable future. Ocean disposal, while the only disposal alternative open for polluted material, also entails potential problems. Polluted material currently must be taken out to the 100-fathom line for dumping. Its effects in that area, about 25 miles off shore, are not known. There is a possibility that some of the material remaining in suspension may find its way onto the beach areas. However, deep ocean disposal appears to be the most environmentally acceptable alternative based upon current knowledge.

In summary, the environmental aspects of dredging and spoil disposal are highly significant in all the San Francisco Bay alternatives. The two alternatives for dredging to Richmond naturally have less of an impact than the alternatives which require dredging in the Pinole Shoal Channel, and dredging to 50-foot depths of course has less of an impact than dredging to 60-foot depths.

Major impacts are related to water quality. By causing high levels of turbidity and the potential for resuspension of polluted material, extensive dredging and spoil disposal within the bay would be environmentally detrimental and could conceivably cause a setback in the program to clean up the water in San Francisco Bay.

Onshore Facilities

The major onshore facilities that are required consist of intermediate storage for crude petroleum and, in the case of alternatives 7-1 and 7-3, onshore pipelines from the Richmond facility to the refineries in the Carquinez Strait area.

The actual construction of these facilities will have only temporary environmental effects. There will be some interruption of traffic both in the water areas where berths will be constructed and on shore where pipeline rights-of-way will cross streets and highways. With normal precautions, construction activities should not be environmentally significant. This evaluation assumes, in the case of the pipelines, that land already dedicated to this use will be used and no other land uses will be more than temporarily affected. Pipeline routes exist in the area and should be used whenever possible.

The presence of completed facilities will have an impact that is primarily aesthetic in nature. This is especially true of the intermediate tank farms. Alternative 7-3 will have the greatest visual impact because it will handle the larger vessels and all the crude destined for the Richmond and Carquinez Strait refineries. Alternative 7-2 will probably have the smallest visual impact because it will utilize smaller vessels and provide direct ship supply to all the refineries. Therefore, while increased storage will be needed as refinery capacity expands, no single large intermediate tank farm will be required. In any or all of the alternatives, specific attention should be given to locating the storage tanks so that their visual impact is minimized.

Care must also be taken in the location and construction of pipelines and tanks to minimize the risks of potential damage from landslides and earthquakes. Pipelines from Richmond to Carquinez Strait and Suisun Bay must cross several small fault lines. Safeguards, such as placing automatic valves reasonably close together, should be included in initial designs as a necessary part of environmental protection.

The construction of additional berths to handle the large ships will have a minor impact. The only effect of their presence, outside of a change in the visual aspects of the shoreline, will be the obstruction they present to the movement of commercial and recreational vessels along the shore areas.

Petroleum Handling and Spills

The pollution of the bay and nearby ocean waters by the leaking and spilling of oil is one of the major environmental implications of the port alternatives, and there are numerous potential sources of trouble. Accidental spills associated with loading and unloading, and intentional dumping of bilge waters, ballast, and tank washings, are all sources of oil pollution, but they can be reasonably controlled. Containment facilities must be routinely used during loading and unloading. Coupled with collection equipment, they can control this problem. Facilities for collecting and treating ship wastes, together with stringent regulations, surveillance, and penalties, can overcome ship waste problems.

However, several sources of oil pollution are not so easily controlled. The most outstanding of these is vessel accident -- collision or grounding -- which usually results in major pollution. San Francisco Bay's high level of traffic, relatively swift tidal current, and characteristic fog have frequently combined to create hazardous navigational conditions. This potential for collisions and consequent major spills will remain until much more sophisticated navigational aids and crew training have been instituted.

For those alternatives which utilize the Carquinez Strait for the movement of supertankers, the probability of collision is increased because of the longer distance traversed through the restricted widths of the channels and the strait.

A major uncontained spill along the route of travel for the tankers in the bay will carry a highly significant environmental impact. Because of the prevailing winds, an oil spill will tend to remain in the bay and move north and east, approaching the most important remaining tidelands and wildlife areas.

Another potential source of oil spills and pollution is the rupture of pipeline links caused by landslides or earthquakes. Such incidents have already occurred in the bay area, and pipelines should therefore include safety check valves and other safeguards to prevent major spills in the event of a break or rupture. Also, the possibility of a large storage tank's rupturing is increased by the chance of earthquakes. Particular care should be taken in the selection of sites for tank farms, both from the standpoint of adequately firm foundations and from the standpoint of containing the oil if a tank does burst. Consideration should also be given to locating storage facilities in diverse areas to spread the risk of earthquake damage. For this reason, alternatives 7-2 and 7-4 appear to be more desirable because the storage areas would not be concentrated in one location.

In summary, significant oil spills may result from accidental collisions and geologic phenomena characteristic of the bay area. Regardless of how cautious the designer of the facilities is, a potential will still remain for a major spill in the bay waters.

Secondary Development

Additional refinery capacity and port-related industry are the major developments which would accompany any of the alternatives for San Francisco.

According to the San Francisco Bay Plan proposed by the Bay Conservation and Development Commission [12], three areas are already proposed for industrial development. These areas are located (1) in Richmond; (2) north and eastward through the Carquinez Strait; and (3) along the shore of Suisun Bay. The Regional Plan put out by the Association of Bay Area Governments also dedicates much of this area to industry [7]. Consequently, it appears that, while the development of a deep channel may hasten development, it will not provide the governing impetus to it. It therefore is not considered of great significance.

The Moss Landing Alternative

Introduction

Deepwater port alternative 7-5 calls for the development of a crude petroleum facility for offloading tankers with drafts up to 83 feet and cargo loads up to 400,000 d.w.t. The facility would consist of a series of offshore monobuoy moorings with a submarine pipeline to an onshore tank farm. A pipeline would connect the tank farm to the refineries in the San Francisco Bay area. To supply the projected demand of these refineries for crude, the annual volume of crude moving through the facility would reach 15 million long tons in 1980 and 60 million tons by 2000.

The General Nature of the Area

Moss Landing is a small coastal community located at about the center of Monterey Bay, which is a relatively large and wide water body with little protection from the open sea. A submarine canyon approaches the shore in this area, providing natural deep water close to shore.

Winds and Waves

Prevailing winds are northwesterly and frequently create significant wave and surge conditions dangerous to small boats.

Water Quality

The offshore waters in this area are generally of high quality. This is due to the low level of industrial activity, relatively low level of population, and lack of commercial shipping activity [17, 19].

Navigation

The major navigation in the area arises from recreation and fishing. Monterey Harbor, about 13 miles south of Moss Landing, is heavily used by the commercial fishing fleet, with up to 100 commercial fishing boats operating from here during the fish runs along the coast. In addition, it now has about 350 berths for recreational boats, with plans for 1,300 berths by 1990 [11].

Santa Cruz Harbor, about 27 miles north of Moss Landing, is also used by fishermen and recreational boaters; there are now about 360 recreational craft, with plans for expansion. Moss Landing itself is primarily a fishing and recreation harbor, with very little waterborne commerce.

The Shore

The shoreline of Monterey Bay is dominated by a continuous wide sandy beach, mostly backed by extensive dunes [17]. In many areas the land rises rapidly as one travels inland. The coastline around Monterey is one of the most scenic in California and is highly valued for recreation and residential uses.

Moss Landing is a small community on this coastline and has a shallow-draft harbor sufficient for use by fishing and recreational boats. Its wide sand beaches draw heavy recreational use practically all year. The principal commercial activity in the harbor is a fish cannery, which serves the fishing fleet in the entire area. Accompanying the cannery is an unloading facility where some of the catch can be transferred to the vessels of buyers from other areas for shipment to their facilities.

Public Attitudes and Conflict

The general attitude of the area's citizens toward developments which could cause major modifications of the present environment is negative. A majority of the people who live in this area do so from choice, frequently because of the environmental amenities, and they demonstrate resistance to any environmental changes, as evidenced by the fact that a recent proposal for a development similar to the one proposed here drew a strong negative public response and was abandoned.

Analysis and Evaluation of Moss Landing Alternative

Alternative 7-5, with two monobuoys, a submarine pipeline, onshore tank farms, and a pipeline to San Francisco, would supply crude petroleum to the San Francisco Bay refineries. The site of the facility (Moss Landing) and the associated region that would potentially be affected by the project have been evaluated from an environmental and natural resource point of view. This evaluation, which is strictly the judgment of the analyst, is shown in table 33.

The environmental and ecological impacts of the project upon the area have been estimated and are shown in table 34. Impacts which have been judged significant are discussed briefly in the following sections.

Construction

Because the offshore water at the selected site is naturally about 100 feet deep, no dredging will be required to achieve the specified 95-foot draft. The only dredging required would be to bury the submarine pipeline from buoy to shore and should be negligible in terms of environmental concern. In fact, all construction activity outside the beach area will have little or no environmental impact except for a minor amount of temporary turbidity. It appears that the major impact would be the navigational hazard the facilities present to recreational and fishing boats in the area.

The onshore construction, namely the tank farm and pipeline to the San Francisco Bay area, will cause temporary environmental disruption. As is usually the case when land is excavated, there will be a chance for erosion and transport of the material into the water, causing temporary increases in turbidity. In addition, the presence and noise of construction equipment will temporarily detract from the aesthetic quality of the area.

The pipeline, particularly the southern section, will have an environmental impact. New land areas will

Table 33. Evaluation of Moss Landing Area

	Aesthetics	Water Quality	Air Quality	Uniqueness*	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
Present value	H	H	H		M	M	L	H	M	M	H	H	H	H	L	L	H	L	M
Projected value	H	H	H		M	M	L	H	M	M	H	H	H	H	L	L	H	L	M

Key:
H = high value, high quality, or high level of use
M = moderate value, moderate quality, or moderate level of use
L = low value, low quality, or low level of use

* Number entered equals number of natural or historic sites in the area of influence.

Table 34. Evaluation of Deepwater Port Alternative 7-5, Moss Landing

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		H	H	H		M	M	L	H	M	M	H	H	H	H	L	L	H	L	M
Construction:																				
Dredging	276	1T	1T						1T	1P		1T	1T	1T					1T	
Spoil Disposal																				
Pilings & Berths																				
Artificial Island																				
Breakwater																				
Mooring & Anchors	276								1T	1P		1T		1T					1T	
Submarine Pipeline	276	2T							1T			2T	1T	2T					2T	
Onshore Pipeline	276	3T	2T				2T	1T				2T			2T			1T		1T
Submarine Storage																				
Onshore Storage	276	3T	2T				2T					1T			1T			1T		
Presence:																				
Channel																				
Onshore Berths																				
Offshore Berths																				
Offshore Island																				
Breakwater																				
Offshore Mooring	279								+			2P		2P					2P	
Overwater Trestle/Pipe																				
Offshore Storage																				
Submarine Pipeline	279											1P		1P					1P	
Onshore Pipeline	279	2P										1P			1P	1P		1P		
Onshore Storage	279	2P					1P					2P			1P			1P		
Underwater Storage																				
Operation:																				
Channel Maintenance																				
Dry Bulk Handling																				
Petroleum Handling	279	2P	1P	1P		1P	1P					1P	1P	1P						
Ship Operations																				
Facility Operations																				
Major Oil Spill	279	3T	3T	1T		3T	3I		2T	3T		3T	3T	3T	3T				2T	
Secondary Development:																				

have to be opened up for access by heavy equipment for excavation and material movement. It is assumed that, once inland, the pipeline will follow the rights-of-way of existing lines between Los Angeles and San Francisco, which would minimize environmental disturbance.

Presence of Facilities

The presence of the two offshore monobuoys will have only one impact: they will be added hazards to navigation in the area. All practical precautions should be taken to assure that they are protected by the latest type of navigation signals.

The presence of the onshore storage tanks will be a significant problem, with major impacts on the aesthetic and health and safety aspects of the environment. The selection of a storage location, which has not yet taken place, should include adequate attention to aesthetics. Locating the tank farm back from the shore would alleviate much of the problem.

The only noticeable effect of the submarine pipeline will be the prohibition of anchoring in its vicinity to protect the line from damage. The onshore pipeline will have little impact except that a right-of-way will be maintained for access to the line for inspection and maintenance.

Operation and Oil Spills

The major environmental impact of this alternative will stem from the handling of the product -- crude petroleum.

Monobuoy systems are not noted for their freedom from spills. The hoses from the vessel to the buoy are subject to significant wear because of the movement of the sea surface and will occasionally rupture under pumping pressure.

Because the buoys are located in unprotected waters, a major spill would not be easy to contain. It probably would move onto the shore over a wide area of the Monterey Bay beaches and might move further south to the rocky coast of Monterey Peninsula and Pebble Beach. It could be comparable in significance to the Santa Barbara incident.

Another potential spill danger resides with the onshore pipeline; this is the danger of rupture or break and spills due to earthquake damage. The line will cross the San Andreas Fault as it goes inland, and within the San Francisco Bay area the line will be subject to other fault lines [6].

The probability of a major spill's occurring is unknown. However, if one does occur, the environmental impact, although primarily temporary, would be severe.

<u>Summary</u>

The preceding evaluation is based upon the assumption that no secondary development will accompany the facility. An offshore buoy system will not lend itself to dry bulks or to any cargo other than liquid bulk. However, pressure could arise for the development of refinery and petrochemical capacity adjacent to the tank farm. Adequate planning and zoning is essential if such development is to be controlled.

In summary, the major cause for concern regarding the environmental effects of alternative 7-5 is the potential impact of a major oil spill on the highly valued, highly scenic, and relatively unspoiled shoreline of Monterey Bay.

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XIII. THE PUGET SOUND ALTERNATIVES

Introduction

Deepwater port alternatives 8-1 and 8-2 consist of the development of a crude oil receiving and transfer facility in Puget Sound, Washington. Alternative 8-1 is designed to meet the crude oil requirements of the local Northwest region and also of the San Francisco Bay region. San Francisco would be supplied from the Puget Sound facility by a pipeline.

Alternative 8-2 includes all of the facilities and meets all the objectives of alternative 8-1, in addition to supplying the crude import requirements for Los Angeles, again by a pipeline.

The Character of the Puget Sound Area

The Puget Sound area, located in the northwestern part of the State of Washington, is well recognized and highly valued for its scenic qualities as well as for its natural resources, especially its fisheries and its naturally deep waters. The area is bordered on the east by the Cascade Mountains and on the west by the Olympic Mountains.

The sound is an inland sea that is over 2,500 square miles in area and that has water depths ranging up to 900 feet. Water depths from 100 to 600 feet are located less than a mile from shore in many areas, and some reaches contain no shoal waters at all. Interconnected inlets, bays, and channels are set apart by the many islands scattered throughout the system.

The Strait of Juan de Fuca provides the main connection between the sound and the Pacific Ocean to the west, although the Georgia Strait provides access from the north as well. These connections to the Pacific Ocean and the numerous rivers and streams which enter the sound create a two-layer system in which the fresh water moves seaward over the denser, more saline water moving landward. This is most noticeable well within the sound. Mixing tends to occur in the seaward portion of the straits, thus breaking down the two-layer system [3].

Large areas of tide flats and wetlands are generally located at the mouths of the major rivers. The three major areas are Skagit and Samish Bays to the north and Nisqually Delta on the south. There are also many small wetland areas at the head of many small inlets and bays. Most of the major tidelands have been seriously altered by development.

Major urban development has occurred in the Puget Sound area, particularly around the major harbors. The major urban areas and ports are Seattle, Tacoma, Everett, Olympia, Bellingham, Port Angeles, Port Townsend, and Anacortes. The population of the area is presently about 2 million and is projected to reach about 4 million by the end of this century. About 86 percent of the population resides in the heavily settled Seattle-Tacoma area, while the northern areas have generally remained rural [3].

Navigation

The natural deepwater channels and harbors make commerce and navigation a major use of Puget Sound. This navigation includes the movement of a wide variety of goods as general cargo and bulks in foreign, domestic coastal, and domestic internal trades.

Of the seven major ports in the sound, only Anacortes and Olympia have a controlling depth limit at the harbor entrance; all other port entrances have unlimited navigational depths. These naturally deep waters necessitate a minimum of dredging. The major modifications of shoreline and tidelands have occurred in Everett, where the Snohomish River was deepened for a distance of about 7 miles; and in Seattle, where the Duwamish Waterway development in the Cedar-Green Rivers entailed major dredging and filling for a distance of about 5 miles [3, 7, 8].

Recreational boating is an important use of Puget Sound. In fact, the area has the highest per capita recreational boating participation rate in the entire United States: about 34 percent of the population engages in some form of boat recreation [3]. The principal problem presently associated with this boating is a lack of sufficient public facilities for boat moorings. It has been estimated that there is currently a need for 16,000 rental mooring spaces.

Fish and Wildlife

The land areas surrounding the sound support a wide variety of wildlife. Of particular importance is the resting and wintering area the sound provides for ducks and geese from Canada, Alaska, and eastern Russia. The Nisqually Delta is a significant waterfowl habitat, as are the tideland areas northward from Skagit Bay. Current estimates indicate that over 1/2 million waterfowl winter in the habitats of Puget Sound.

The Puget Sound fishery forms a very important component of the natural resources of the area, both from a recreational and a commercial point of view. An extensive anadromous fishery utilizes the sound. Species include chinook, coho, pink, chum, and sockeye salmon; steelhead trout; sea-run cutthroat trout; and Dolley Varden trout. In addition, rockfish, cod, sole, flounder, shark, rays, perch, anchovy, candlefish, herring and smelt are harvested commercially [3, 8]. Shellfish, including oysters, crabs, hard-shelled clams, shrimp and scallops, are also an important resource.

The average annual commercial harvest of fish and shellfish during 1961 through 1965 was over 98 million pounds and was valued at almost $14 million [3]. In addition, it has been estimated that sport fishermen, seeking the various species including crabs and clams, have spent between $50 and $60 million annually for fishing-related expenses.

Aquaculture, while still in its infancy, is important to the future of Puget Sound. A number of commercially managed oyster operations exist in the sound at this time. In addition, a pilot program to investigate the practicability of raising salmon to "pan size" for market has demonstrated the economic feasibility of such a venture. In fact, the program is now being fully developed as a commercial venture in Manchester, across the sound from Seattle. The Lummi Indians, in the Bellingham area, have also undertaken a commercial aquaculture venture in Lummi Bay. As these activities prove themselves, new and expanded aquacultural enterprises are expected to appear.

Water Quality

Although Puget Sound receives domestic, industrial and agricultural wastes from a large number of sources, the major quality problems are naturally associated with the more heavily populated and industrialized area from Everett to Tacoma. In fact, approximately 70 industrial firms discharge wastes -- most of which are only partially treated -- into the sound in this area. Another major source of pollution is the pulp and paper industry, which has created localized quality problems in a number of areas.

Numerous oil spills have occurred in the sound in both U.S. and Canadian waters, but most have not been extensive and have been cleaned up quite rapidly. Several recent Canadian spills have been of a more spectacular size and much more difficult to handle, but they have not intruded into U.S. waters [1, 3, 7].

Tides, Currents and Weather

The tidal range and tidal currents vary widely over the sound area. Average tides vary from about 7 feet at Port Angeles on the Strait of Juan de Fuca to over 14 feet at Olympia at the southern end of the sound. The maximum tidal ranges in those two ports are 14.5 and 22.5 feet, respectively. The configuration of the sound, with its many islands and deep channels, creates locally high tidal currents which can be hazardous to navigation. Admiralty Inlet, between the Strait of Juan de Fuca and the main Puget Sound area, has normal currents of about 3 m.p.h. on both the flood and ebb, and currents reach 6 m.p.h. on large tides. The Tacoma Narrows commonly experiences currents up to 7 m.p.h.

The mountains to the east and west of the sound protect most of the area from ocean storms. However, there is a high incidence of rainfall and also a significant amount of fog. Both of these phenomena reduce visibility and increase navigational hazards.

In winter, relatively strong northeasterly winds blow over the northern sections of the sound, and the entire sound occasionally experiences strong winter winds. The summer winds are much lighter and are usually from the north and west.

Attitudes and Conflicts

Current major conflicts in resource use appear to be between private ownership and public use of shoreline resources. If this is not an explicitly stated fact, it is reflected in the shortage of shore access for public uses, primarily in the more heavily populated urban areas. In addition, the question of water quality has engendered a small number of specific conflicts between industry and other users. The pulp and paper industry has received heavy pressure aimed at stopping its contribution to water pollution.

Although the people of the Pacific Northwest are very much oriented toward outdoor recreation and environmental quality maintenance, they also recognize the need for industry and commerce to provide basic employment and an economic base. Consequently, they tend to approach the conflict between growth and environment more from an analytical than from an emotional viewpoint. However, they will not stand by while industry of any sort undertakes a major development without public hearings. This was demonstrated when a major oil company attempted to privately develop a refinery complex a short distance north of Everett. Public pressures were so great that the development was abandoned.

Nevertheless, with open planning and honest public participation, it appears that a well-designed complex with all possible environmental safeguards will be accepted, especially if the plans are made to be complementary to community and regional goals for the area.

The general opinion of official planners in the State of Washington and in the communities around Puget Sound is that a major oil facility to accommodate supertankers will find acceptance if it is planned, designed and developed in open forum and with attention to the desires and needs of the people affected, particularly with reference to maintaining the natural environment of the area.

Deepwater Oil Port Site

The most likely location for the development of a major oil terminal and associated industry appears to be in the Ferndale area north of Bellingham, in the northern reaches of Puget Sound. Several oil companies already have major landholdings in this area and some development has already occurred, both in refineries and in aluminum production facilities.

The deep water that exists immediately off shore from this location eliminates the need for channel dredging. Another favorable factor is that the large tankers would not have to travel the heavily used routes to the major port areas of Seattle and Tacoma.

A pipeline presently brings crude oil into the area from Canada, then continues on to the refineries at Anacortes to the south. In addition, product lines go south from these locations to supply the Seattle-Tacoma market and continue southerly as far as Eugene, Oregon.

Ideally, such a deep port could be an integral part of a regional undertaking that would include associated industry and new community development for the area.

Regulating and Planning Agencies

The Puget Sound area contains a large number of jurisdictions. These are primarily associated with the towns, cities and counties of the area, and, of course, with the State of Washington.

Bellingham, in the northern area (previously identified as having the potential for port development), has a combined county and city planning agency which would have a strong influence on port development. Some other regulating and planning agencies which would be involved with port development are:

1. Washington Department of Ecology -- formed to merge the management and control of solid waste, air quality and water quality into one integrated body so that planning and development are conducted in an orderly and effective manner. This state agency has the lead role in the development of a shoreline management program for the state under the Shoreline Management Act of 1971, which will be controlled by the local governments within a given set of guidelines [9].

2. Washington Department of Natural Resources -- has primary responsibility for the management of the state's forest and land resources, including about a million acres of tidelands, shorelands and harbor areas, and navigable lakes and streambeds.

3. Washington Department of Fisheries -- has primary responsibility for maintaining and developing the freshwater and salt-water fisheries in the state.

4. Planning and Community Affairs Agency -- works with local communities in the development of planning programs designed to meet the goals and needs of the cities and towns of the state.

5. Oceanographic Commission of Washington -- established by the Washington State Legislature to promote oceanographic endeavors in the state [2].

Analysis and Evaluation of the Puget Sound Alternatives

Table 35 contains an evaluation of the resources and environmental characteristics of the Puget Sound region. Special emphasis is placed on the area in the vicinity of Bellingham which would be the region most seriously affected by the development of a deep port in that part of the sound.

In general, the Puget Sound region has a high level of environmental quality. The water bodies, forests and surrounding mountains combine to make a highly scenic and aesthetic setting. A low level of development has minimized pollution levels, although some heavily polluted areas -- both air and water -- exist in the urbanized regions. The area is much valued for recreation, and, although water-contact recreation is limited somewhat by the cold waters and generally cool summers, its many miles of protected waters make it the boating capital of the United States. The fisheries are also a major recreational and commercial resource, with a large number of important salt-water species plus a very significant anadromous fishery.

All in all, it is an area with a highly valued outdoor environment. Any major development, including a new oil terminal for supertankers, will not be accepted unless it is thoroughly planned to protect the environment.

Table 36 contains an evaluation of the effects of the alternatives proposed for Puget Sound. This evaluation is based primarily on the local area north

Table 35. Evaluation of Puget Sound Area

	Aesthetics	Water Quality	Air Quality	Uniqueness *	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
Present value	H	H	M		H	H	M	H	H	H	H	M	H	H	M	M	M	H	M
Projected value	H	H	M		H	H	M	H	H	H	H	M	H	H	L	M	M	H	M

Key:
H = high value, high quality, or high level of use
M = moderate value, moderate quality, or moderate level of use
L = low value, low quality, or low level of use

* . ber ent- quals number of natural or historic sites in the area of influence.

Table 36. Evaluation of Deepwater Port Alternatives 8-1 and 8-2, Puget Sound Area

	Page	Aesthetics	Water Quality	Air Quality	Uniqueness	Gen'l Ecology	Wildlife	Wetlands	Finfish	Shellfish	Water Supply	Health & Safety	Water Contact Rec.	Boat Rec.	Shore/Land Rec.	Agriculture	Industry	Residential	Marine Transp.	Land Transp.
		H	H	M		H	H	M	H	H	H	H	M	H	H	M	M	M	H	M
Construction:																				
Dredging																				
Spoil Disposal																				
Pilings & Berths	293	1T	1T			1T	1T					1T		2T					2T	
Artificial Island																				
Breakwater																				
Mooring & Anchors																				
Submarine Pipeline																				
Onshore Pipeline	293	2T	1T	1T			2T					1T			1T					1T
Submarine Storage																				
Onshore Storage	293	2T	1T	1T			1T					1T			1T			1T		
Presence:																				
Channel																				
Onshore Berths																				
Offshore Berths	293	2P								1P		2P		2P					1P	
Offshore Island																				
Breakwater																				
Offshore Mooring																				
Overwater Trestle/Pipe																				
Offshore Storage																				
Submarine Pipeline																				
Onshore Pipeline	293	1P					1P					1P			1P					
Onshore Storage	293	3P	1P	1P		1P	1P					2P			2P			2P		
Underwater Storage																				
Operation:																				
Channel Maintenance																				
Dry Bulk Handling																				
Petroleum Handling	294	2P	2P	1P		2P	1P			2P	1P	2P	1P	1P	2P			2P		
Ship Operations		1P	2P			1P			1P	2P		2P	1P	2P					+	
Facility Operations																				
Major Oil Spill	294	3T	3T		3T	2I	3I	3T	2T	3P		3T	3T	3T	2T			3T	2T	
Secondary Development:		3I	2P	2P	3I	2I	2I				2P	2P			2I	3I	+	3I		2P

of Bellingham, except in those cases where the effects will not be limited to that particular region.

Construction of Facilities

The construction required for the development of an oil terminal is limited to berths, pipelines and storage tanks. No dredging is required.

The effects of construction will be temporary in all cases. Runoff from construction sites can cause local turbidity in nearby waters, but this will subside as soon as the job is completed. The noise of construction equipment can cause local disturbance to wildlife, but again, this will be a temporary problem.

In summary, construction will not significantly affect the environment for more than a short time during the actual construction operations.

Presence of Facilities

The presence of offshore berths, storage tanks and pipelines will have few environmental effects. The principal effect of the berths will be their impact on the movement of boats in the area, and navigation aids will need to be employed to reduce the hazards.

Pipelines will create little impact because it is assumed that they will be placed on existing pipeline rights-of-way, at least as far south as Eugene, Oregon. From that point to San Francisco, no routes have been analyzed. Existing rail lines could provide the necessary right-of-way and access, as they could from San Francisco to Los Angeles (alternative 8-2).

The presence of large oil storage tanks has two principal effects. First, tanks will create a significant visual change to the scene. One partial solution is to locate the tank farm so as to minimize this intrusion; however, it will still cause a detrimental change on the aesthetic quality of the area. Second, the presence of large tanks of petroleum will create a safety hazard from the danger of fire and explosion. Although there are regulations and guidelines for spacing and construction, the hazard to health and safety cannot be completely removed.

Operations and Major Spill

The principal concern stemming from operations is the danger of oil pollution. Routine handling of oil cargoes usually results in some spillage during loading and unloading and ship operations. Care must be taken to virtually eliminate the possibility of such spills. Facilities for storage and treatment of oily wastes from vessels must be an integral part of the design. Also, oil barriers should be in place during all operations.

The major concern, however, which is not so easily handled, is the danger of a major spill caused by the collision or grounding of a large tanker. Such a spill would result in extensive damage to shellfish resources and to recreational pursuits. Although most of the effects would be temporary, with the exception of the effects on wildlife, general ecology and shellfish, the psychological effects of a major spill can be long-lasting. This has been demonstrated in several cases where the demand for recreational facilities dropped significantly even though the oil was for the most part removed and no longer evident.

Tankers would enter through the Strait of Juan de Fuca and then move northward to the Ferndale/Bellingham area, and would not be in the main part of the sound. Therefore, a major spill would not threaten this area. However, the San Juan Island beaches would be vulnerable to a spill, and the cleanup of these beaches would be a tremendous job. Also, with the prevailing northerly winds, a major uncontrolled spill could move down the sound into the heavily populated areas.

Aquaculture could be disastrously affected by a major spill or by the smaller, more frequent spills associated with normal operations. The commercial aquacultural activity of the Lummi Indians is located in the Lummi Bay area just to the south of the proposed development and thus could be heavily impacted.

In summary, the effects of a major spill could be extremely significant to the Puget Sound area.

Secondary Development

Although the alternatives do not include a substantial development of refinery capacity or other industry, the development of a deep port will create a potential for additional development. Such industrial development would create major environmental changes to the area. The rural nature of the area would be altered, and the production of waste products would add to the potential for increased air and water pollution. With a reduction in the scenic and aesthetic quality of the environment, the quality of recreational experiences would also be reduced, especially along the shore and near-shore inland areas. Wildlife, especially waterfowl, would tend to seek out more isolated areas for their nesting and feeding grounds.

Summary

The major environmental impact of an oil port development in the area would stem from the potential of major oil spills and secondary industrial development. These two impacts could have major effects and cause major changes in the natural environment and resources of the region.

All available precautions should be instituted to prevent oil spills. These precautions should include safety design in the vessels, better crew training, advanced aids to navigation, regularly used oil retention equipment during loading and unloading, and an effective plan for combating a major spill.

Secondary development, while not actually a part of the alternatives, should be given careful consideration because of its potential impact on the immediate area. From the standpoint of public attitude, it has been noted that acceptance of such a port would be more likely if it were planned and developed in open public forum as part of a regional development plan that would create a sound economic base of industry and employment coupled with a new-town concept to provide a comprehensive and balanced economic, social and physical environment.

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