**Energy Material Transport,
Now Through 2000, System
Characteristics and Potential
Problems**

**Task 3 Final Report -
Petroleum Transportation**

March 1979

Prepared for the U.S. Department of Energy
under Contract EY-76-C-06-1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

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ENERGY MATERIAL TRANSPORT, NOW THROUGH 2000,
SYSTEM CHARACTERISTICS AND POTENTIAL PROBLEMS

TASK 3 - FINAL REPORT - PETROLEUM
TRANSPORTATION

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FOREWORD

This report is an account of effort in the Petroleum Transportation Task of the Energy Material Transport, Now Through 2000, System Characteristics and Potential Problems Project. This project is sponsored by the Department of Energy, Environmental Control Technology Division. The DOE project monitor is Mr. R. F. Garrison.

The overall objectives of this project are: 1) to provide advanced warning of potential problems that may inhibit the safe and environmentally acceptable development of fossil and nuclear energy material transportation systems between now and the year 2000 and 2) to recommend research, development and other actions to mitigate the potentially adverse impacts of these problems. The results of effort in other tasks of this project are reported as indicated below:

1. An Overview of Transportation in the Nuclear Fuel Cycle, (BNWL-2066).
2. Project Task 2 - Final Report - Coal Transportation, (PNL-2420).
3. Project Task 4 - Final Report - Natural Gas Transportation, (PNL-2422).
4. Assessment of Synfuel Transportation to Year 2000, (PNL-2768).
5. Selected Legal and Regulatory Concerns Affecting Domestic Energy Transportation Systems, (PNL-2989).

This report contains recommendations for new program activity in FY79. These recommendations were included in earlier draft reports submitted to the sponsor when planning for FY79 activities was in progress. At the time of publication it is recognized that these recommendations, if not already implemented, apply at the earliest to program effort planned in FY80.

ACKNOWLEDGMENT

The authors gratefully acknowledge the assistance provided by the many individuals who supplied information during the course of this study. To the extent practicable these contributions are identified as sources of information in Appendices H and I. The authors' interpretation of this information contributed significantly to the assessments contained in this report and is the origin of many statements that are not otherwise referenced.

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ENERGY MATERIAL TRANSPORT, NOW THROUGH YEAR 2000,
SYSTEM CHARACTERISTICS AND POTENTIAL PROBLEMS

TASK 3 - FINAL REPORT - PETROLEUM TRANSPORTATION

1.0 SUMMARY

This report contains a summary characterization of the petroleum transportation system and an assessment of some potential problems that may impact petroleum transportation in the United States during the balance of the century. A primary purpose of this task is to provide information and perspective that contribute to the evaluation of research and development needs and priorities in future programs.

The system characterization in Section 3 includes a review of petroleum product movements, modal operations and comparisons, and transportation regulations and safety. This system overview summarizes domestic production and consumption scenarios to the year 2000. A median scenario based on published projections shows that the U.S. will probably rely on foreign oil to supply between 40 and 50 percent of domestic petroleum needs throughout the balance of the century.

Potential problems in petroleum transportation were identified by the analysis and prioritization of current issues. The relative priorities of problem concerns were judged on the basis of their overall impact on the system and the immediacy of this potential impact. Two classes of concern are distinguished:

1. Potential problems that appear to require new programmatic action, in addition to effort already committed, to minimize the possible future impact of these concerns.

2. Latent concerns that may increase or decrease in priority or entirely change in nature as they develop. While the trend of these concerns should be monitored, new program action does not appear necessary at this time.

Recommendations are made for new programs that address potential problems according to their apparent needs and importance under current conditions. These recommendations are intended to assist the Department of Energy (DOE) and other cognizant agencies in planning future programs and to encourage new research initiatives by the petroleum transportation industry. The specific involvement of the sponsor^(a) of this study in new project activity is recommended where this is considered to be appropriate.

1.1 CONCERNS REQUIRING NEW ACTION

Significant potential problem concerns in domestic petroleum transportation, their consequences and recommended action are identified and discussed in Section 4. The concerns are grouped in the following four categories:

- environmental effects and management of oil spills
- transportation system safety
- transportation logistics
- legal, regulatory and institutional problems.

Recommendations are made for actions that address specific concerns in each of these categories. Many of the recommended projects could be coordinated as tasks in major new programs to effect a considerable economy in manpower and management. The specific concerns and recommendations presented in Section 4 are summarized below.

1.1.1 Environmental Effects and Management of Oil Spills

Oil pollution concerns are paramount in any discussion of petroleum transportation problems. Public doubts concerning the effectiveness of oil spill cleanup methods and uncertainty about the ecological effects of marine

(a) DOE, Environmental Control Technology Division (ECT)

oil pollution may create pressure for regulations that do not effectively mitigate adverse environmental impacts, yet impose unreasonably high costs upon the industry.

Mounting environmental concern is also evidenced in the requirements for approval of major construction projects, such as offshore pipelines. The time required to develop an environmental impact statement (EIS) adds to the planning and construction lead time associated with offshore pipelines. This, in turn, delays the availability of urgently needed links in the petroleum transportation system.

Concerns about leaks from petroleum pipelines and the accuracy of current oil spill modeling techniques are also identified as important environmental problems for petroleum transportation systems. Petroleum pipelines use leak detection devices that work by monitoring pressure and flow fluctuations. Below certain limits the metering is not sensitive to fluctuations caused by small leaks. While small oil spills rarely cause significant environmental effects on land, leaks that reach ground water, waterways or the marine environment may cause environmental damage before such a leak is noticed.

Oil spill modeling techniques are important because accurate predictions of arrival times, locations and sizes of oil slicks are necessary to mobilize cleanup efforts and to provide public information on the potential for environmental damage. Present techniques for predicting oil slick growth yield no better than order of magnitude estimates for slick size and configuration. None of the present models consider oil accumulation in bottom sediments, which is important in determining ecological impacts on marine organisms and the shoreline. Also, no methods have been developed for modeling subsurface spills.

All of the above concerns, and several of those in the following section on transportation safety, relate to the apparently incomplete and fragmented knowledge of specific causes of oil spills during transportation. There is also a lack of data on the cost-effectiveness of spill prevention practices

and devices. The need for a comprehensive program is identified to evaluate oil spill event trees for each mode of transport and to assess the effectiveness of spill prevention devices and practices. The basis of this program would be the following tasks, each aimed at resolving a particular concern.

To dispel public doubts about oil spill cleanup, the United States Coast Guard (USCG) should assess the adequacy of U.S. oil pollution prevention capabilities and review recent developments in oil spill containment and cleanup technology. Results should be used to provide the public with credible information on the status of current abilities to cope with marine oil pollution. A moderately high priority is placed on this assessment. A level of effort of 1 to 2 man-year/year, beginning in FY-1979 or FY-1980, is recommended as an independent project or as a task in a comprehensive program on oil spill management. The ECT should monitor and support this effort to remain cognizant of possible new requirements for technology to protect the marine environment.

An offshore pipeline system safety and environmental effects analysis is needed to provide information specifically oriented to reducing the time required to prepare an EIS. This study should assess the adequacy of current technology for offshore pipelines, including corrosion control, inspection methods and repair procedures, and determine the probable effects of pipeline leaks on surrounding marine life. This assessment should have a moderately high priority and begin in FY-1980 as a 1 to 2 man-year project. The ECT should lead this activity in cooperation with the Department of Transportation (DOT), Office of Pipeline Safety Regulations (OPSR). This effort would also be an appropriate task in a comprehensive program on oil spill management.

The potential environmental impacts and energy loss significance of undetected petroleum pipeline leaks should be evaluated to determine whether new pipeline operating and control techniques are warranted to address this problem. The ECT should place a moderate to low priority on this concern. A level of effort of 1 to 2 man-years starting in FY-1980 is recommended as an independent project or as a task in a comprehensive program.

Future oil spill trajectory modeling should consider incorporating the effects of subsurface transport, the accumulation of toxic oil ingredients in particulates and sediments, and long-term decay processes. The American Petroleum Institute (API) has funded the University of Southern California (USC) to develop a new oil spill model. The USCG should review this model for possible application as a predictive instrument for oil spill drift forecasting. The National Oceanic and Atmospheric Administration (NOAA) should contribute to establishing an adequate data base for improved oil spill drift models. The ongoing effort in this area suggests a lower priority for this action than that for other oil spill-related recommendations. The USCG and NOAA should implement the above studies at a recommended 1 man-year/year level of effort in FY-1980 to complement activities in the USC study.

As indicated above, these tasks could be combined into a comprehensive program on oil spill effects and management, to effectively coordinate the results of these and related studies and to minimize the cost. Such a program should also include tasks outlined in the next section on transportation safety.

1.1.2 Transportation System Safety

It has been determined that human error is a causal factor in 80 to 85 percent of all waterway casualties. Inadequately trained and/or poorly motivated waterway personnel may contribute to higher than acceptable casualty rates. While the USCG is involved in revising personnel qualification regulations, additional work is needed to assess whether human risk factors are adequately considered in casualty prevention devices and practices. The ECT should consider this a high priority and cooperate with the USCG in a 1-1/2 to 2 man-year project in FY-1980. This effort would contribute to a comprehensive program on oil spill management.

The degree to which existing safety regulations are enforced is another concern in petroleum transportation systems. The number of vessel and facility inspections and accident investigations performed by the USCG are increasing. This trend may reduce the USCG manpower available for monitoring other aspects

of waterway transport, which, in turn, may encourage a lower level of safety consciousness on the part of maritime operators. A study of the potential impacts of USCG manpower shortages on marine safety and the environment is recommended. This study should be performed by the USCG, have a moderately high priority and be a continuing effort in USCG planning for future needs. A specific review of the present manpower situation should be a 1/2 man-year effort in FY-1980 and could contribute to oil spill management studies in a comprehensive program.

Recent legislation mandates tanker safety design standards for crude oil and product tankers. These requirements may not provide the most cost-effective means of preventing tanker marine oil pollution and may result in unnecessary increases in oil shipment costs. The DOE should assess the cost-effectiveness of tanker safety options, considering the overall system-level implications and effects of alternatives on the cost and efficiency of transporting petroleum. This study would complement current USCG efforts that focus on specific areas of concern but do not provide enough perspective on tanker operations as an energy material delivery system. This effort should have a moderate priority and be supported at a 1 to 2 man-year level of effort in FY-1980.

All of the above tasks could be coordinated in the comprehensive oil spill effects and management program recommended above.

1.1.3 Transportation Logistics

Petroleum transportation systems may be inadequate to supply future regional demands in an emergency or if disabled by sabotage. No comprehensive emergency plan is presently available that spells out alternative routing and modal substitutions on a national basis. A network analysis of the entire national energy distribution system is recommended to provide a data base for multiscenario contingency planning of energy material transportation under emergency conditions. A vulnerability study should be performed to determine the weaknesses of each transportation mode for specific emergency scenarios. Contingency plans that consider the cross impact between energy

material systems and transportation modes should be formulated for each scenario. DOE should review the relevance of current emergency plans to a comprehensive national transportation contingency plan for energy material transportation. This concern should be considered to have a high priority requiring program-level attention by the DOE and interagency cooperation. The ECT should support the recommended program by providing input on potential safety and environmental impact scenarios associated with energy material transportation during emergencies. The recommended level of effort is 2 to 3 manyears/year as soon as resources are available.

The potential of sabotage to the Trans-Alaska pipeline and other major petroleum pipelines is a threat to the U.S. economy. Further study is warranted to provide a data base for formulating specific response plans to minimize the potential of this threat. These plans would contribute to the overall system emergency planning recommended above. This concern has a high priority and should be addressed at a 2 to 3 man-year level of effort in FY-1980. The DOE should coordinate its effort with the DOT and consult with state and local police agencies, the Federal Bureau of Investigation (FBI) and other agencies with security expertise.

1.1.4 Potential Legal, Regulatory and Institutional Problems

The DOE should develop policy positions to assist the resolution of potential energy transportation problems associated with petroleum industry reorganization, preemption, Federal rights of eminent domain for pipelines, deepwater port licensing and oil spill liability and compensation issues.

Antitrust actions in the courts and legislative proposals in Congress are intended to remedy some of the alleged anticompetitive practices of the petroleum industry. Various measures, including the possibility of divesting major petroleum companies of their pipeline holdings, are being considered. Pending the resolution of these matters, consumers may be faced with a sub-optimal petroleum transportation system and uncertainty within the industry that may deter investments needed to maintain and develop the system. The DOE should develop a policy position on this concern following careful study

and analysis of the impact of previous divestitures, both within the petroleum industry and in other industries, and steps that can be taken to mitigate adverse consequences. An examination of the divestiture issue and other alternatives for improving the performance and efficiency of the nation's oil transportation system should have high priority. Because proposals for improving competition within the oil industry are presently undergoing close scrutiny by the Federal Trade Commission, the Department of Justice and Congress, the DOE should provide information and policy recommendations promptly to ensure that the energy implications of any such program are carefully considered. The suggested level of effort for this program is 2 to 3 man-years starting in FY-1979 or 1980.

Although many Federal laws regulate the movement of energy materials to provide safety and environmental protection, some states assert that Federal regulation is inadequate to protect state interests. These states may adopt laws that regulate energy material transportation more strictly than do Federal laws. Burdensome design requirements or lack of uniformity among state regulations may hamper the required flow of petroleum products. An analysis should be undertaken to identify the various mechanisms available for soliciting state and local concerns regarding energy material transportation and for incorporating such concerns into the development of Federal regulations. An evaluation of the DOT nonpreemption determination process should be initiated to ascertain its effectiveness in resolving state/Federal conflicts and the feasibility of its use in other areas of concern relating to energy material transportation. Because of pending litigation in this area and the prospect for continued conflicts in the future, this concern is of high priority and demands early attention and detailed analysis. While much of the needed action requires the involvement of other agencies, the DOE should actively encourage the development of effective Federal regulations consistent with a goal of ensuring the future adequacy of energy material transportation. A level of effort of 1 to 2 man-year/year starting in FY-1979 or FY-1980 is recommended.

Expansion of the petroleum pipeline network to transport Alaskan crude oil in the lower 48 states may be impeded due to the lack of a Federally granted right of eminent domain. The Federal Land Policy and Management Act of 1976 is a major step toward the development of a uniform code of regulations. However, there is as yet no consistent policy regarding the granting of right of way. An assessment is needed to determine if it would be in the national interest to grant energy material pipelines a Federal right of eminent domain. The BLM should assign a high priority to developing a position on the eminent domain issue. Such a position would assist policy decisions and encourage legislative action. A recommended level of effort is 1 to 1-1/2 man-years starting in FY-1979. Consideration of environmental and safety issues in this effort may require contributions from the ECT.

The administrative aspects of licensing and establishing deepwater ports discourage the construction of these ports by private industry. Because most existing U.S. ports are too shallow to receive very large crude carriers, the efficiency and operational advantages of these large tankers are not being exploited in the transportation of crude oil imports. The resulting necessary reliance on a larger number of smaller tankers increases the cost of transportation and the potential for accidents and congestion in harbors and coastal waterways. The USCG should evaluate current licensing requirements and work with other agencies to achieve a consensus on regulations that apply to deepwater ports. The impacts of various regulatory scenarios on transportation cost, safety, environmental concerns and energy efficiency should be considered by the DOE. The ECT should support the DOE effort in addressing the safety and environmental aspects of this concern. Because of the long lead times needed for planning and construction of deepwater ports, there is a high priority on formulating policy and decisionmaking. The recommended DOE study should require a 1 man-year effort starting in FY-1979.

The current patchwork of Federal and state oil spill liability and compensation laws creates both overlap and gaps in liability and compensation

coverage and may contribute to inefficient routing of crude oil carriers. DOE support of current legislative efforts to establish a national system of oil pollution liability and compensation is encouraged. However, it should be noted that recognition of international liability requirements will impact American import practices. A USCG review of proposed policies, requiring 1/2 to 1 man-year in FY-1980, is recommended as a moderate priority. The ECT should support this effort in issues of safety or environmental concern.

1.2 LATENT CONCERNS

Section 5 addresses current issues that do not appear to warrant new program activity. These latent concerns fall into two categories:

1. perceived concerns that have a low occurrence probability
2. potential problems that are currently being adequately addressed or resolved in ongoing industry and government programs.

The following perceived petroleum transportation concerns are either unsubstantiated or inconsequential:

- effectiveness of vessel traffic services
- loss of aging but crucial pipeline links
- inadequately trained tank truck personnel
- duplicative petroleum product traffic.

The other concerns addressed in Section 5 relate to recognized problems that may impact petroleum transportation. However, current studies and action by industry and government are contributing to the solution of these problems. At this time, new program action does not appear to be necessary in the following areas:

- development of transportation systems for new supply sources
- development of relationships between tanker size and safety
- impacts of the Jones Act on Alaskan crude oil transportation
- effects of inland waterway congestion
- effects of deterioration of railroad trackage and equipment
- impacts of railroad bankruptcy and abandonment

- effects of nonstandard tank truck bottom loading equipment
- fuel economics of tank trucks
- operation of unit tank car trains.

This study is based on perspectives that have developed and changed during the course of the project. Several concerns initially considered to warrant action have been delegated to the latent concern category in this report. Events occurring within the next 5 to 10 years may result in a new spectrum of petroleum transportation issues and problems. The results and recommendations of this study will, therefore, require reinterpretation and revision as the future evolves.

2.0 INTRODUCTION

Petroleum has become the major energy source in the United States. In 1977, petroleum supplied about half of the nation's gross energy needs, or 18.5 million barrels of oil per day. Petroleum consumption rates of 17.8 million bbl/day and 20.0 million bbl/day have been forecast for 1980 and 1990, respectively. Domestic supplies, however, have been forecast at only 11.0 million bbl/day in 1980 and 11.5 bbl/day in 1990. U.S. dependence on foreign oil will probably persist past the end of this century. It is likely that future problems in petroleum transportation will result from the need to develop routes to new sources of supply, environmental and safety concerns perceived by the public and increased regulation of the industry and transportation modes.

The overall objective of this study is to provide advanced warning of potential problems that may inhibit the safe and environmentally acceptable development of the domestic petroleum transportation system between now and the year 2000. The primary purpose of each task in this project is to provide information and perspective that contribute to the evaluation of research and development (R&D) needs and priorities, and to the structure of future program plans relating to energy material transportation.

This report provides a summary characterization of the existing domestic petroleum transportation system and identifies and judges priorities of potential future transportation problems. Problems are viewed as either potential or latent concerns. Potential concerns appear to require new programmatic action, in addition to effort already under way, to minimize the possible future impact of these concerns. Recommendations for specific actions to address these concerns are emphasized in this report. Latent concerns are those issues or potential problems that are currently being adequately addressed or resolved by ongoing industry and government programs. It is recommended that no new program effort be committed to address latent concerns.

Several concerns that initially appeared to be of high priority have been resolved or delegated to lower priority during the course of this study. Other potential problems were judged to increase in importance as this work progressed. This report considers potential problems in petroleum transportation as they appear to exist or can be forecasted in the first quarter of 1979. A principal reference for information used throughout this report is work performed by the Congressional Research Service, which has published detailed reviews and analyses of material energy transportation systems, issues and problems.⁽¹⁾

The balance of this report is organized as follows:

- Section 3 provides a summary characterization of the existing U.S. petroleum transportation system, including forecasts of supply and demand growth to the year 2000.
- Section 4 contains summary assessments of specific potential problems and related programs, in addition to recommendations for new programmatic effort to address these concerns. These recommendations indicate judgments of the level of effort and priority that should be considered in program activities.
- Section 5 identifies latent concerns that are judged to be under control and not to require additional effort at present.

References are listed in Section 6 and supplemental information is contained in Appendices A through I.

3.0 PETROLEUM TRANSPORTATION SYSTEM OVERVIEW

This section presents a summary characterization of the petroleum transportation network currently operating in the United States and provides perspective on the concerns and recommendations contained in Sections 4 and 5.

3.1 PROJECTED PETROLEUM CONSUMPTION AND PRODUCTION SCENARIOS

Over the past 30 years, gross energy consumption in the United States has increased at an annual rate of 2.8%. Of all fuel materials used to supply this energy, petroleum has supplied the highest percentage since 1950. In 1977, petroleum supplied the United States with about half of its gross energy needs.⁽²⁾ Fifty-six percent of this petroleum-supplied energy was utilized in transportation, 18% in industry, 17% for residential and commercial needs, and 9% in the generation of electricity.⁽³⁾ Forecasts available in the literature provide the basis for the following scenarios of change in domestic consumption and production during the balance of the century.

Seven consumption forecasts, some with multiple cases, are compiled in Table 3.1 from studies made by government agencies, industry, and private institutions.^(a) Table 3.2 contains a median petroleum consumption scenario for the U.S. between 1975 and 2000, using averages of the estimates in Table 3.1 for 1980 and 1985.

The only available estimate of consumption in 1990 was obtained from "Energy: A National Issue"⁽⁹⁾ by the Center for Strategic and International Studies (CSIS). The CSIS considered many of the scenarios listed in Table 3.1 and used a median forecast philosophy in developing consumption projections. The CSIS estimate for 1990 is therefore consistent with the averaged projections for 1980 and 1985.

The only petroleum consumption estimate available for the year 2000 is provided by the Bureau of Mines (BOM) study.⁽⁷⁾ Because the 1985 BOM estimate is high compared with the other forecasts, the corresponding year 2000 projection was discounted. This was achieved by applying the annual growth rate from 1985 to 2000 predicted by the BOM to the average of the

(a) References 4 through 10.

**TABLE 3.1. Petroleum^(a) Consumption Estimates for the U.S.
(Million Barrels/Day)**

Sources	1975	1976	1980	1985	1990	2000
1. Ford Foundation Historical Growth ⁽⁴⁾						
A. High Imports			19.8	21.3		
B. High Fossil Fuels			18.4	17.9		
C. High Nuclear			17.9	18.4		
2. Ford Foundation Technical Fix						
A. Base			17.0	13.2		
B. Low Nuclear				16.1		
C. High Nuclear				14.6		
3. MIT ⁽⁵⁾						
A. Econometric Model @ \$11/bbl Oil			14.8			
B. Judgmental Model @ \$11/bbl Oil			13.6			
4. National Petroleum Council-Medium Case ⁽⁶⁾			19.4	21.0		
5. Bureau of Mines ⁽⁷⁾	15.4 ^(b)		19.4	21.5		24.2
6. Federal Energy Administration ⁽⁸⁾						
A. \$7/bbl Oil						
Business-As-Usual Without Conservation			20.6	23.9		
Business-As-Usual With Conservation			19.0	21.2		
Accelerated Supply Without Conservation			20.4	23.8		
Accelerated Supply With Conservation			18.8	20.5		
B. \$11/bbl Oil						
Business-As-Usual Without Conservation			17.4	19.1		
Business-As-Usual With Conservation			16.2	16.9		
Accelerated Supply Without Conservation			17.1	19.2		
Accelerated Supply With Conservation			16.1	17.9		
C. \$13/bbl Oil						
Reference Case			16.3	19.3		
7. Center for Strategic and International Studies ⁽⁹⁾	15.4 ^(b)		18.0		20.0	
8. National Energy Plan ⁽¹⁰⁾						
with Government Control				22.8		
without Government Control				25.0		
9. Energy Information Administration ⁽²⁾		17.7 ^(b)				

(a) Petroleum products refined and processed from crude oil, including still gas, liquefied refinery gas, and natural gas.

(b) Actual value.

TABLE 3.2. Consolidated Petroleum Consumption Estimates for the U.S. (Million Barrels/Day)

<u>1975^(a)</u>	<u>1976^(a)</u>	<u>1980</u>	<u>1985</u>	<u>1990</u>	<u>2000</u>
15.4	17.7	17.8	19.4	20.0	21.7

(a) Actual Value

1985 projections. This provides a trend between 1985 and 2000 which is compatible with the CSIS projection for 1990. Figure 3.1 shows the median consumption forecast in comparison with the historical trend. The projection shows a reduced rate of increase, which may result if conservation efforts are successful.

FIGURE 3.1. Historical and Forecasted Petroleum Consumption in the U.S.

The 11 domestic production forecasts listed in Table 3.3 were used as the basis for generating a median supply scenario. The first nine studies were evaluated in the National Petroleum Council (NPC) report "Domestic Oil and Gas Supply."⁽¹¹⁾ Several of the studies listed were considered to project a potentially inaccurate forecast of the future supply situation. As mentioned in the NPC report, the Ford Foundation and Edison Electric Institute studies^(4,12) failed to give proper recognition to the finite nature of U.S. oil resources. These studies were also considered to include other problems in methodology, making the results questionable. Credibility problems relating to Outer Continental Shelf leasing assumptions may make the supply projections in the Federal Energy Administration's (FEA) report unrealistic.⁽¹³⁾ Because the FEA is currently revising its domestic oil supply projections, the estimates listed in the referenced FEA report were not included in this evaluation. Bankers Trust Company failed to make direct use of a resource inventory and Pace Company projections are being revised. Thus, these studies were also not considered.

TABLE 3.3. Domestic Petroleum Liquids^(a) Production
Estimate (Million Barrels/Day)

Source	1975 ^(b)	1980	1985	1990	2000
1. Bankers Trust Company ⁽¹⁴⁾		12.3	13.2	13.9	
2. Edison Electric Institute ⁽¹²⁾		11.8	15.1		19.7
3. Exxon Company, USA ⁽¹⁵⁾		9.6	10.6	11.2	
4. Federal Energy Administration ⁽¹³⁾		12.8	13.9	13.8	
5. The Ford Foundation ⁽⁴⁾			14.7		17.6
6. Library of Congress ⁽¹⁵⁾		11.0	12.0		
7. The Pace Company ⁽¹⁶⁾		11.5	12.9	13.3	
8. Shell Oil Company ⁽¹⁷⁾		10.8	11.3	12.4	
9. Bureau of Mines ⁽⁷⁾	10.0	11.9	12.5		13.6
10. ERDA ⁽¹⁸⁾		10.9	11.6	11.2	9.2
11. Joint Committee on Atomic Energy ⁽¹⁹⁾		11.5		11.3	

(a) The production estimates for studies 1 through 9 were taken from Reference 11. Some studies contained multiple scenarios in which case the moderate growth rate was used. Data include crude oil and natural gas liquids.

(b) Actual Value

The domestic oil production estimates that were used in this review are summarized in Table 3.4 and shown graphically in Figure 3.2 with historical production data. The mean values of the forecasts were taken to represent a reasonable domestic supply scenario for 1980 through 2000.

**TABLE 3.4. Retained Domestic Oil Supply Estimates
(Million Barrels/Day)**

	1980	1985	1990	2000
Exxon Company, USA ⁽¹⁵⁾	9.6	10.6	11.2	
Shell Oil Company ⁽¹⁷⁾	10.8	11.3	12.4	
ERDA ⁽¹⁸⁾	10.9	11.6	11.2	9.3
Library of Congress ⁽¹⁵⁾	11.0	12.0		
Joint Committee on Atomic Energy ⁽¹⁹⁾	11.5		11.3	
Bureau of Mines ⁽⁷⁾	11.9	12.5		13.6
Range	9.6 to 11.9	10.6 to 12.5	11.2 to 12.4	9.3 to 13.6
Mean	11.0	11.6	11.5	11.5

FIGURE 3.2. Historical and Forecasted Domestic Petroleum Production in the U.S.

The range of the forecasts does not account for the uncertain impact of all future events and issues which may either stimulate or discourage domestic production. Political, institutional, technical and social factors can be expected to have impacts on both the consumption and supply of petroleum products. The above petroleum production and consumption scenarios provide, however, a general indication that domestic production will probably satisfy between 50 and 60% of the domestic demand throughout the balance of the century.

3.2 PETROLEUM TRANSPORT SYSTEMS

Petroleum distribution is achieved by two categories of system - primary and secondary. The system of pipelines, tankers and barges that move crude oil from producing areas to refineries, and similar facilities that move petroleum products in bulk to marketing areas, make up the primary distribution system. Shipments from the bulk terminals by pipeline, truck, barge and rail to consumers characterize the secondary distribution system. Approximately 24,000 bulk terminals handle the interchange of petroleum products between the transport modes. Transport modes and storage facilities shown in Figure 3.3 are the basic elements involved in the movement of petroleum.

The transportation modes for petroleum are pipelines, water carriers, motor carriers and railroads. Modal system descriptions, safety and environmental impacts, and regulations are summarized below.

3.2.1 Pipelines

Pipelines are the workhorses of the domestic transportation system, carrying most of the crude oil delivered to refineries. Oil is obtained from wells and moved to field storage tanks by flow lines. Gathering lines connect these tanks to trunk pipelines which serve as long-distance arteries, usually ending at the refinery or a marine terminal for water transport to the refinery. From the refinery, oil products may also move by pipeline to consuming centers.

System Description. Pipeline diameters vary from as small as 2 in. for collection, distribution and movement between refinery processes, to as large

FIGURE 3.3. Elements of the Petroleum Transport and Distribution System

as 48 in. in major trunk lines. Pumps spaced anywhere from 50 to 150 miles apart keep oil moving through the pipeline at a speed of 2 to 8 miles per hour. The distance between pumping stations depends on the surrounding terrain, the diameter of the pipeline and the type of oil being moved. Energy for pumping stations is frequently purchased from several utility companies and usually from the electric power company located nearest to a pumping station.⁽²⁰⁾ Throughput is dependent on temperature, pumping pressure and pipe strength. The Colonial Pipeline, for example, is a 36 in. diameter steel pipe with over 1,991 miles of mainline. The total carrying capacity of the line is 1,584,000 barrels per day.⁽²¹⁾ A temperature change of 30°F over the entire length of the line, however, will change the occupancy of products shipped by 10,000 barrels. A change in pressure of about 150 psi would have the same effect.⁽¹⁾ Pipelines, especially those transporting crude oil, must be continually cleaned, otherwise substances deposited on the pipe wall will increase friction losses and reduce the effective diameter of the pipe.

Table 3.5 shows the growth of pipeline mileage in the United States between 1950 and 1976. According to an official of the Pipeline Contractors Association, pipeline construction from 1974 to 1977 in the contiguous United States has been minimal. Present pipeline expansion provides for the movement of Alaskan crude oil. Trans-Alaska pipeline data are given in Appendix A.

Figures 3.4 and 3.5 show the capacities of crude oil and petroleum product pipelines. Most product pipelines are operating near capacity, although there are some exceptions. Crude oil lines are not up to capacity because of a decrease in field production and shifts in the sources of crude oil imports.

The oil pipeline industry is dominated by companies who are both shippers and receivers of the commodities moved by pipelines.⁽¹⁾ The impacts of the petroleum industry structure on transportation and the issue of divestiture are discussed in Subsection 4.4.1.

TABLE 3.5. Mileage of Petroleum Pipelines in the United States (miles)

<u>Year</u>	<u>Trunk Lines</u>		<u>Gathering Lines</u>	<u>Total</u>
	<u>Crude</u>	<u>Products</u>		
1950	71,373	20,881	60,560	152,814
1953	75,228	27,236	68,040	170,504
1956	78,594	36,420	73,526	188,540
1959	70,317	44,483	75,182	189,982
1962	79,355	53,200	76,988	200,543
1965	72,383	61,443	77,041	210,867
1968	70,825	64,529	74,124	209,478
1971	75,143	72,396	71,132	218,671
1974	76,250	76,839	69,266	222,355

Source: Reference 3.

Safety and Environmental Impacts. Industry representatives and the panel on Operational Safety in Off-Shore Resources Development of the National Academy of Engineers generally agree that pipelines appear to be the safest transportation system for moving bulk materials.⁽²²⁾ A study made by the American Petroleum Institute revealed that from 1955 through 1964 there were only six deaths and thirteen injuries to members of the public resulting from the release of liquid from from oil pipeline systems.⁽²³⁾ Records of the Department of Transportation, Office of Pipeline Safety Regulation (OPSR), show that for the calendar year 1973 there was one death and one injury to pipeline employees and six deaths and seven injuries to nonemployees.⁽²³⁾

Table 3.6 lists onshore pipeline accidents and casualties for the calendar year 1976 by cause of accident. Unrelated construction activities largely influenced the number of incidents, since 32% of the accidents were caused by construction equipment rupturing pipelines. Approximately 0.006%

FIGURE 3.4. Crude Oil Pipeline Capacities, Thousands of Barrels Daily, 1975
Source: Federal Energy Administration, Office of Oil and Gas

FIGURE 3.5. Product Pipeline Capacities, Thousands of Barrels Daily, 1975
Source: Reference 1

TABLE 3.6. Liquid Pipeline Accidents - 1976

Cause of Accident Operation Accidents	No. of Accidents	% of Total	Deaths		Injuries		Property Damage (\$)			Loss of Commodity (Barrels)
			Carrier Employees	Non Employees	Carrier Employees	Non Employees	Carrier	Other	Total	
Equipment Rupturing Line	67	32.0	0	0	0	0	\$ 83,929 ⁽³⁾	\$110,920 ⁽⁷⁾	\$ 194,849	74,550 ⁽¹³⁾
Corrosion - External	41	19.6	0	0	0	0	11,810	20,200 ⁽⁸⁾	32,010	31,954 ⁽¹⁴⁾
Incorrect Operation by Carrier Personnel	20	9.6	0	0	1	0	11,284	68,300 ⁽⁹⁾	79,584	40,155 ⁽¹⁵⁾
Defective Pipe Seam	14	6.7	0	5 ⁽¹⁾	1	0	4,202	25,405 ⁽¹⁰⁾	29,607	38,494 ⁽¹⁶⁾
Corrosion - Internal	10	4.8	0	0	0	0	151,910 ⁽⁴⁾	2,000	153,910	3,249
Failure of Previously Damaged Pipe	7	3.3	0	0	2 ⁽²⁾	0	47,173 ⁽⁵⁾	120,035 ⁽¹¹⁾	167,208	20,070 ⁽¹⁷⁾
Malfunction of Control or Relief Equipment	1	0.5	0	0	0	0	0	0	0	235
Defective Girth Weld	4	1.9	0	0	1	0	1,665	5,510	7,175	13,025 ⁽¹⁸⁾
Vandalism	3	1.4	0	0	0	0	69	2,250	2,319	7,428 ⁽¹⁹⁾
Malfunction of Valve	4	1.9	0	0	0	0	2,500	1,000	3,500	2,521
Threads Stripped or Broken	2	1.0	0	0	0	0	0	50,000 ⁽¹²⁾	50,000	328
Cold Weather	5	2.4	0	0	0	0	1,505	475	1,980	4,365
Pump or Appurtenance Facilities	5	2.4	0	0	0	0	10	200	210	1,550
Lightning	1	0.5	0	0	0	0	6,550	0	6,550	0
Tank or Appurtenance Facilities	5	2.4	0	0	0	0	4,600	0	4,600	1,560
Motor Vehicle	1	0.5	0	0	0	0	100	0	100	499
Miscellaneous	19	9.1	0	0	0	0	891,795 ⁽⁶⁾	5,400	897,195	15,014 ⁽²⁰⁾
TOTAL	209	100.0	0	5	5	0	\$1,219,102	\$411,695	\$1,630,797	255,037

(1) All deaths caused by one accident.

(2) All injuries caused by one accident.

(3) Includes accident of \$25,000.

(4) Includes accident of \$150,000.

(5) Includes accident of \$40,000.

(6) Includes accidents of \$750,000; \$100,000; and \$35,000.

(7) Includes accidents of \$75,000 and \$13,000.

(8) Includes accident of \$13,000.

(9) Includes accidents of \$50,000 and \$12,000.

(10) Includes accident of \$15,000.

(11) Includes accidents of \$100,000 and \$20,000.

(12) One accident.

(13) Includes accidents with losses of 9,271; 5,236; 4,652; and 4,336 barrels.

(14) Includes accidents with losses of 9,222 and 5,000 barrels.

(15) Includes accidents with losses of 24,305 and 4,859 barrels.

(16) Includes accidents with losses of 5,597; 5,415; 5,387; and 5,250 barrels.

(17) Includes accidents with losses of 6,500; 5,000; and 4,537 barrels.

(18) Includes accidents with losses of 6,125 and 5,000 barrels.

(19) Includes accident with loss of 6,578 barrels.

(20) Includes accident with loss of 6,997 barrels.

Source: Department of Transportation, Materials Transportation Bureau, Washington, D.C.

The numbers in () in this table refer to the footnotes listed on this page and not to the reference list.

of the volume annually moved through onshore pipelines is spilled.⁽²⁴⁾ This volume is kept low by automatic shutoff valves which stop the flow when an accident occurs. Pipeline leaks and their environmental impacts are discussed in Subsections 4.1.2 and 4.1.3.

As seen in Table 3.7, offshore pipelines are statistically safer than onshore pipelines. U.S. Geological Survey statistics indicate that only seven major marine pipeline breaks (1,000 barrels or more) occurred on the Outer Continental Shelf between January 1967 and December 1976. The maximum spill recorded was 160,639 barrels. The other six major spills averaged 7,400 barrels. Despite this safety record, the potential danger of a large-scale accident is considered serious enough that pipeline safety is federally regulated.

TABLE 3.7. Pipeline Breaks and Leaks Connected with Federal Oil and Gas Operations in the Outer Continental Shelf-- January 1967 through December 1976

<u>Accident Cause</u>	<u>Number of Accidents</u>	<u>% of Total</u>	<u>Volume of Oil Spilled (bbls)</u>	<u>% of Total</u>
Anchor Dragging ^(a)	6	33.3	190,652 ^(b)	91.9
Unknown	9	50	9,523	4.6
Internal Corrosion	1	5.6	>5,000	2.4
Hurricane	1	5.6	2,213	1.1
Pigging	<u>1</u>	<u>5.6</u>	<u>>100</u>	<u>0.0</u>
Total	18		207,488	

(a) Includes one accident by a shrimp trawler

(b) Includes accident with loss of 160,639 barrels

Source: Reference 22.

A 1921 amendment to the Explosives and Combustibles Act of 1909 gave the Interstate Commerce Commission safety jurisdiction over oil pipelines. When the Act was amended in 1960 and designated the Explosives and Other

Dangerous Articles Act, the pipelines were inadvertently omitted. Consequently, from 1960-1965, no agency had authority or obligation for safety regulation of the oil pipelines. An amendment to the Act was added in July 1965 to include oil pipelines. However, it was not until April 1, 1970, that a safety code for oil pipelines was put into effect by the DOT.

Regulation. Pipelines that transport oil in interstate commerce are subject to regulation by the Federal Energy Regulatory Commission (FERC). The FERC requires all companies that are engaged in interstate pipeline transportation of oil, except those engaged in transporting oil between their own facilities for their own use, to provide nondiscriminatory services pursuant to FERC-approved rates and charges. However, intrastate oil pipelines are not subject to the extensive federal economic regulations that apply to interstate natural gas pipelines. In contrast to such authority over gas pipelines, neither the DOE nor FERC has authority to require Certificates of Public Convenience and Necessity for the construction or abandonment of oil pipeline facilities. There is also no authority to require expansion of facilities if such an expansion would serve the national interest. Thus, the FERC's principal economic regulatory function is to evaluate pipeline assets and establish rates or charges for the transportation of oil by pipeline in interstate commerce.

The DOT has principal jurisdiction over the safety, design, construction and operation of oil pipelines. The U.S. Geological Survey (USGS) has the authority to grant permits for gathering lines within a production area, and is also responsible for making technical evaluations regarding offshore pipeline specifications, safety measures and environmental impacts.

Additional regulatory requirements may be imposed upon oil pipelines if they cross federal lands. For example, the Mineral Leasing Act of 1920, as amended (30 U.S.C. 185), establishes certain requirements for pipelines to acquire right-of-way through federal lands. Among other things, the Act requires the Secretary of the Interior to impose pipeline safety, environmental protection and financial capability requirements. Pipelines crossing federal lands must be operated as common carriers and are required to transport without discrimination all oil or gas delivered to the pipeline. If pipeline

capacity is insufficient to transport all oil tendered, and part of such tendered oil is produced from federal lands, then the Secretary of Interior is authorized to determine the proportionate amounts to be accepted for shipment. These requirements may be imposed whether or not the pipeline crosses state lines or is otherwise subject to the jurisdiction of the FERC or DOT.

Numerous other federal and state agencies have jurisdiction over various aspects of oil pipeline operations. For example, the Environmental Protection Agency (EPA) or an appropriate state body may limit the emissions of pumping stations into the air. Waste-water discharge permits must also be obtained from the EPA in compliance with the Federal Water Pollution Control Act of 1972. The Corps of Engineers, Department of the Army, must approve the construction of pipelines in estuarine areas.

More than half the states have developed economic regulations for oil pipelines,⁽²³⁾ and almost all of the states have right-of-way laws. With many major pipelines operating inter- and intrastate, conflict can arise, because pipelines must comply with all applicable federal and state regulations. The number of permits required for pipeline construction and delays in construction caused by non-uniform eminent domain codes are discussed in Subsection 4.4.3 of this report.

3.2.2 Water Carriers

Tanker and barge movements are the second most common method for transporting crude oil to the refinery. This movement begins at marine terminals, where many pipelines end. Water carriers may deliver the crude directly to a coastal port or carry it inland by means of the domestic waterway system. A large volume of refined products are also transported to consuming centers by water carriers.

System Description. The location, volume and the percentage of traffic that is petroleum-related are shown in Figure 3.6 for nineteen major U.S. ports. Percentages are based on the tonnage of foreign imports and coastal and internal traffic. In Reference 24, the American Petroleum Institute calculated the petroleum traffic at the same U.S. ports for 1967. The information for 1975, as

FIGURE 3.6. Petroleum Traffic at Major U.S. Ports as Percent of Total Traffic--1975

Source: Waterborne Commerce of the United States.
Army Corps of Engineers, Vicksburg, MS, 1975.

compiled in Appendix B, provides some evidence of net decreases in petroleum traffic at ports on the West and South Coasts, compared with a net increase on the East Coast.

The U.S. flag tanker fleet consisted of 293 vessels on December 31, 1975, with a capacity of 10,601,370 dead weight tons (DWT) and an average speed of 16.4 knots. This represents 3.1% of the world tank ship dead weight tonnage. Table 3.8 provides a profile of the world tanker fleet by registry, and shows that the U.S. fleet is the oldest.

TABLE 3.8. Age of World Tanker Fleet by Major Flag of Registry^(a)
(As of December 31, 1975)

<u>Country</u>	<u>Number</u>	<u>Tons Dead Weight</u>	<u>Average Age</u>
United States	293	10,601,370	14 years 1 month
Liberia	1,122	100,990,202	6 years 4 months
United Kingdom	464	39,268,826	5 years 8 months
Japan	410	40,225,428	5 years 0 months
Norway	365	35,333,030	4 years 10 months
Greece	349	17,795,223	10 years 0 months
France	143	14,138,748	5 years 3 months
Panama	230	10,848,452	10 years 4 months
Italy	191	11,048,270	6 years 5 months
Sweden	86	9,290,768	4 years 3 months
U.S.S.R.	406	6,128,193	10 years 3 months
West Germany	61	5,821,692	5 years 3 months
Spain	93	5,669,738	4 years 11 months
Netherlands	76	5,053,389	8 years 2 months
All Others	<u>803</u>	<u>34,931,079</u>	<u>6 years 11 months</u>
Total	5,092	347,144,408	6 years 6 months

(a) Ocean-going vessels 2,000 gross tons and over.

Source: Reference 3.

The participation of the U.S. tanker fleet in U.S. petroleum movements has been a matter of concern. The Jones Act^(a) requires that all movements between U.S. ports involve U.S. tankers and U.S. crews. Testimony presented in July 1977 before the Subcommittee on Merchant Marine of the House of Representatives, Committee on Merchant Marine and Fisheries, revealed that for the past several years less than 4% of the United States petroleum imports have been transported on U.S. flag vessels.⁽²⁵⁾ In 1975, this corresponded to between 24 and 28% of the crude oil refined in the U.S. being transported by foreign flag vessels. Table 3.9 shows the volume of crude oil imports for 1974 and 1975, and world transportation corridors are shown in Figure 3.7.

TABLE 3.9. Imports of Foreign Crude Oil - 1974 and 1975
(Thousands of Barrels)

Country of Origin	1975	1974
Algeria	96,459	65,764
Angola	26,051	17,536
Bolivia	1,940	2,467
Canada	219,175	288,763
Congo (Brazzaville)	--	670
Ecuador	20,679	15,225
Egypt	1,687	3,227
England	125	--
Gabon	9,811	8,552
Indonesia	138,270	103,482
Iran	101,575	168,956
Iraq	707	--
Kuwait	1,444	1,820
Libya	81,403	1,495
Malaysia	1,951	510
Mexico	25,660	597
Netherlands	1,500	--
Nigeria	272,265	254,358
Norway	4,552	322
Oman	492	236
Qatar	6,657	6,189
Saudi Arabia	256,036	159,827
Trinidad	42,097	23,045
Tunisia	839	4,519
United Arab Emirates	42,585	25,158
Venezuela	144,221	116,437
TOTAL IMPORTS	1,498,181	1,269,155
Foreign Crude Input to Refineries	1,494,412	1,260,130
Domestic Crude Input to Refineries	3,047,014	3,168,596
TOTAL CRUDE INPUT TO REFINERIES	4,541,426	4,428,726

Source: "Petroleum Statement," Mineral Industry
Surveys, U.S. Bureau of Mines, Washington, D.C.,
December 1974 and 1975 and February 1976.

(a) The implications of the Jones Act relating to the transport of Alaskan oil are discussed in Subsection 5.2.2.

ARROWS INDICATE ORIGIN
AND DESTINATION BUT NOT
NECESSARILY SPECIFIC
ROUTES

BUREAU OF MINES
DIVISION OF PETROLEUM
AND NATURAL GAS
JULY 1976

FIGURE 3.7. Preliminary World Crude Oil Movements to Major Consuming Areas--1975
(thousand barrels per day)

Source: "P.A.D. Districts Supply/Demand," Mineral Industry Survey,
U.S. Department of Mines, Washington, D.C. 20241, April 1977.

In 1975, the United States imported nearly 13% of the petroleum products consumed nationally. Because only a small amount was imported by pipeline, foreign tankers could have been responsible for delivering from 9 to 13% of the national demand for petroleum products. Table 3.10 shows that the majority of these imports were received by ports on the Northeastern Coast.

TABLE 3.10. Imports and Local Demand of Petroleum Products - 1975
(Thousands of Barrels Daily)

Product and PAU District	Imports	Local Demand
Motor Gasoline -		
I	164	2,213
II	4	2,285
III	4	991
IV	-	213
I-IV	172	5,702
V	12	973
U.S. TOTAL	184	6,675
Jet Fuel -		
I	77	377
II	2	188
III	5	116
IV	-	30
I-IV	84	711
V	49	290
U.S. TOTAL	133	1,001
Liquefied Gases -		
I	18	179
II	49	362
III	15	370
IV	16	30
I-IV	98	941
V	14	50
U.S. Total	112	991
Kerosine -		
I	3	67
II	-	45
III	-	36
IV	-	3
I-IV	3	151
V	-	8
U.S. Total	3	159
Distillate Fuel Oil -		
I	147	1,271
II	1	873
III	4	333
IV	-	109
I-IV	152	2,586
V	1	263
U.S. Total	153	2,849
Residual Fuel Oil -		
I	1,116	1,460
II	37	260
III	11	281
IV	-	37
I-IV	1,164	2,038
V	30	394
U.S. TOTAL	1,194	2,432
All Products -		
I	1,525	5,567
II	93	4,013
III	39	2,127
IV	16	422
I-IV	1,673	12,129
V	106	1,978
U.S. TOTAL	1,779	14,107

Source: "PAD Districts Supply/Demand," Mineral Industry Surveys, U.S. Bureau of Mines, Washington, D.C., 20241, 1975

Most domestic tanker traffic carries oil from the Gulf Coast producing areas to the Atlantic Seaboard. While various sizes of tankers operate along this route, 26,000 DWT, 35,000 DWT, and 60,000 DWT tank ships handle most of the coastal petroleum tonnage. Characteristic dimensions of oil tankers are shown in Table 3.11.

TABLE 3.11. Typical Dimension of Tankers (feet)

<u>Size (DWT)</u>	<u>Length</u>	<u>Breadth</u>	<u>Draft</u>
16,000	523	68	30
24,000	590	80	32
34,000	661	90	34
50,000	743	100	39
74,000	800	120	41
100,000	895	127	50
210,000	1,070	158	63
310,000	1,130	174	79

Source: Reference 1.

Most tankers are powered by oil-fired steam turbines. Diesel engines were popular in tankers until the 1950s, but proved to be less practical than oil-fired engines. Maintenance is a major part of tanker operation costs and normally requires 15 to 20 days per year for turbine-powered ships and slightly longer for diesel-powered ships.⁽¹⁾

Tankers are loaded or unloaded either through a flexible hose connected to shore pipelines or by means of loading booms made of conventional pipe connected by swivel joints. It requires 24 hours to load or unload a 26,000 DWT tanker and 26 hours to load or unload a 60,000 DWT tanker.⁽²⁶⁾

Water carriers transport crude oil and petroleum products inland by means of the domestic waterway system. Currently, this system consists of 25,543 miles of usable inland channels. The principal waterways that make

up this mileage and their respective lengths are shown in Table 3.12 and Figure 3.8. These waterways serve as a vital link in the national petroleum transport system. For example, the Delaware River handled 102.8 million tons of petroleum in 1974. If this river became impassible, an almost impossible demand would be placed on alternative transportation modes.

As seen in Figure 3.9, most of the East Coast waterway traffic is petroleum-related. However, such is not the case for the Mississippi River system and the West Coast area where pipelines transport most of the petroleum consumed. Appendix B presents a detailed summary of petroleum movements in U.S. waters and documents data presented in Figures 3.6 and 3.9.

Inland waterway service is usually provided by towboats, tugboats and barges. Shallow-draft tankers in the 17,000 to 20,000 DWT range are also used.

Figure 3.10 shows a typical towboat and tugboat. Towboats push rather than pull barges. A characteristic tow consists of 10 to 12 barges, but as many as 40 may be grouped in one tow. Towboats are frequently designed for the characteristics of the waterway on which they will operate. Some towboats are assigned to a particular stretch of the waterway system. Certain areas of the waterway system, such as the mouth of the Ohio River, serve as key points where towboats tradeoff cargoes and crews.⁽³⁾

Tugboats tow barges in open water on the intracoastal canals, in the Gulf of Mexico, off the Atlantic and Pacific Coasts, and in trade to and from Alaska and Hawaii. Unlike towboats, tugs pull barges on a hawser and are usually limited to four barges or less. Many new barges have a large "V" in their sterns so that the nose of a tugboat fits snugly into it. This provides for more efficient energy transfer and better steering control. Virtually all towboats and tugboats are powered by diesel engines.

Tank barges are used for the transport of petroleum and petroleum products. About 3,190 tank barges are in service, having a total cargo capacity of 6,330,298 tons.⁽²⁷⁾ Oil companies own about 12% of the petroleum tank barges and lease an additional 2%; these barges account for 17% of the total oil-carrying barge capacity.⁽¹⁾

**TABLE 3.12. Navigable Lengths and Depths^(a)
of United States Water Routes**

Group	Length in Miles of Waterways					Total
	Under 6 ft	6 to 9 ft	9 to 12 ft	12 to 14 ft	14 ft & Over	
Atlantic Coast Waterways (exclusive of Atlantic Intracoastal Waterway from Norfolk, VA to Key West, FL) but including New York State Barge Canal System	1,426 (1,487)	1,241 (1,445)	584 (589)	938 (965)	1,581 (1,544)	5,768 (6,030)
Atlantic Intracoastal Waterway from Norfolk, VA, to Key West, FL	-- --	65 (106)	65 (65)	1,104 (1,104)	-- --	1,234 (1,329)
Gulf Coast Waterways (exclusive of Gulf Intracoastal Waterway from St. Marks River, FL, to Mexican Border)	2,055 (2,174)	647 (812)	1,133 (2,095)	79 (269)	378 (388)	4,292 (5,738)
Gulf Intracoastal Waterway from St. Marks River, FL, to Mexican Border (including Port Allen-Morgan City Alternate Route)	-- --	-- --	-- --	1,137 (1,180)	-- --	1,137 (1,180)
Mississippi River System	2,020 (4,365)	969 (1,457)	4,957 (5,062)	740 (755)	268 (268)	8,954 (11,907)
Pacific Coast Waterways	730 (733)	498 (515)	237 (237)	26 (27)	2,084 (792)	3,575 (2,304)
Great Lakes	45 (100)	89 (148)	-- (14)	8 (8)	348 (369)	490 (639)
All Other Waterways (exclusive of Alaska)	76 (76)	7 (7)	-- --	1 (1)	7 (7)	91 (91)
TOTAL	6,352 (8,935)	3,516 (4,544)	6,976 (8,062)	4,033 (4,309)	4,666 (3,368)	25,543 (29,218)

(a) The mileages shown in this table represent the lengths of all navigable channels of the United States, including those improved by the Federal Government and other agencies, and those which have not been improved but are usable for commercial navigation.

The mileages shown in parentheses represent the lengths authorized for improvement by the Congress of the United States in legislation known as the Rivers and Harbors Act.

Source: Reference 27.

FIGURE 3.8. Waterways of the United States

FIGURE 3.9. Petroleum Traffic on Major U.S. Waterways as Percent of Total Traffic--1974

Source: See Appendix B data.

TOWBOATS	LENGTH FEET	BREADTH FEET	DRAFT FEET	HORSEPOWER
	117	30	7.6	1000 TO 2000
	142	34	8.0	2000 TO 4000
	160	40	8.6	4000 TO 6000

TUGBOATS	LENGTH FEET	BREADTH FEET	DRAFT FEET	HORSEPOWER
	60-80	21-23	8	350 TO 650
	90	24	10-11	800 TO 1200
	95-105	25-30	12-14	1200 TO 3500
	125-150	30-34	14-15	2000 TO 4500

FIGURE 3.10. Typical Towboats and Tugboats that Operate on the Inland Waterways

Source: Reference 27

Tank barges are sized by channel depth and the sizes of locks on the waterway. Three barge capacities are standard: 1000, 1500, and 3000 ton. Basic types of tank barges used for petroleum transportation include single skin, double skin and cylindrical tank.

Single skin tank barges have bow and stern compartments separated from the midship by transverse collision bulkheads. The entire midship shell is the cargo tank.

Double skin tank barges have an inner and outer shell. The void between the two shells protects against spills and provides space for the hull structural framing. The cargo tank is free of appendages and is therefore easy to clean and line.

Cylindrical tank barges have cargo tanks mounted in the barge hopper. They are used to transport liquids under pressure and high-temperature cargoes.

In recent years, ocean barges have become an important method of petroleum transportation. Ocean barges, ranging in sizes up to 35,000 DWT, supply fuels to population centers, nearby refineries and to transshipment points.

Petroleum-carrying barges operate mainly on the Mississippi River system, Gulf Coast and Atlantic Seaboard. Along the Middle Atlantic Coast, barges receive ocean tanker cargoes and carry them to inland storage centers, refineries, and pipeline and tank truck terminals. Barges carry full loads about 60% of the time.

The capacity of the inland waterway system varies significantly with conditions of the water lane. Two critical factors are the locks and channel width. One lockage usually takes 20 to 30 minutes, unless the tow is larger than the lock.⁽²⁷⁾ In this case, the tow is broken up, passed through the lock and reassembled. This "double-locking" operation doubles the overall locking time; additional time is required to dismantle and reassemble the tow. The Corps of Engineers' locking priority rules specify that any tow requiring more than a double locking must give way to others which may be waiting. This severely reduces the effective economy of scale for the operators of a large tow.⁽¹⁾ According to the American Waterways Operators, Inc.,

the average delay time in Locks and Dam 26 at Alton, Illinois, is from 7 to 11 hours. During heavy traffic some boats are delayed as much as 72 hours.⁽²⁸⁾ It costs approximately \$100 per hour for a barge to wait at a lock.⁽²⁷⁾ The issue of inland waterway congestion is discussed in Subsection 4.3.3.

Transit times alone do not indicate river capacity. However, they do give an appreciation for the length of time required to travel on the inland waterways. Typical transit times for an average tow under ideal conditions are presented in Table 3.13.

TABLE 3.13. Typical Transit Times for an Average Tow under Ideal Conditions

Origin/Destination	Distance (miles)	Transit Time (hours)	
		Upstream	Downstream
Pittsburgh - New Orleans	1,852	338	210
Cincinnati - New Orleans	1,380	259	151
St. Louis - New Orleans	1,053	211	105
Kansas City - New Orleans	1,434	286	144
Minneapolis - New Orleans	1,731	324	190
Chicago - New Orleans	1,418	272	151
Pittsburgh - Houston (via New Orleans)	2,257	405	260
Pittsburgh - Houston (via Atchafalaya River)	2,186	390	254
St. Louis - Houston (via New Orleans)	1,458	268	156
St. Louis - Houston (via Atchafalaya River)	1,387	263	150
Cincinnati - Houston (via New Orleans)	1,785	327	202
Cincinnati - Houston (via Atchafalaya River)	1,714	311	195
Chicago - Houston (via New Orleans)	1,823	339	202
Chicago - Houston (via Atchafalaya River)	1,752	324	195
Minneapolis - Houston (via New Orleans)	2,136	391	241
Minneapolis - Houston (via Atchafalaya River)	2,065	376	234
Pittsburgh - Brownsville (via New Orleans)	2,542	453	296
Pittsburgh - Brownsville (via Atchafalaya River)	2,471	438	290
Chicago - Brownsville (via New Orleans)	2,108	387	237
Chicago - Brownsville (via Atchafalaya River)	2,037	372	230

Source: American Waterways Operators, Reference 27.

Safety and Environmental Impacts. Although an estimated 80% of all hazardous materials shipped by water in the U.S. consists of crude oil and petroleum products, detailed information about the safety of moving these commodities is sparse. However, accident figures for hazardous materials in general can be used to approximate trends for petroleum.

From 1963 to 1968, the fatality rate per billion ton miles for marine transport (including coastal, intercoastal and inland waterways) was markedly lower than that for rail or highway transport, but much higher than that for pipelines.⁽²⁹⁾ In addition, the frequency of accidents per billion ton miles involving hazardous materials was substantially lower for water shipment than for rail or truck over the same period.⁽³⁰⁾ A study comparing hazardous materials transport by barge, truck and rail found that, for all ten materials tested, barge transport was the least likely to experience an accident involving release of cargo.⁽³¹⁾ In the same study, barge transport was shown to result in the least relative hazard to persons and property for most of the materials tested.

A study on towing vessel accidents by the National Transportation Safety Board indicates that personnel errors are the primary cause in about 33% of all reported casualties. Material failure is listed as the cause in 19% of all reported casualties.⁽³²⁾ The Gulf Intercoastal Waterway between Galveston and Corpus Christi has had the highest accident rate; collisions have been the most frequent accident type. Major causes of collisions are: 1) fault of other vessel, 2) human error by unlicensed pilot and 3) adverse weather conditions.⁽³³⁾ As traffic density increases, casualty occurrence rates soar. The adequacy of training for waterway personnel is discussed in Section 4.2.1.

Like towing vessels, tankers are involved in collisions more than any other single accident type. First quarter 1977 casualty figures pertaining to U.S. flag tank ships of 6,000 DWT and over show that contact with channel bottom, docks, moored vessels and buoys accounted for 44% of the accidents. The U.S. flag tanker fleet, which is 7% of the world tank ship fleet by number, experienced only 5.7% of the number of accidents worldwide.⁽³⁴⁾

Not all accidents result in polluting incidents. Statistics based on data from 1969 and 1970 indicate that only one out of six casualties results in oil pollution.⁽³⁵⁾ However, since tankers and barges operate solely on water, the environmental impact of an accident is potentially greater than for overland modes. The release of oil itself does not constitute an immediate hazard to human life; the greatest damage is to ecological systems. In 1975, about 124,600 barrels of petroleum were released into U.S. waters by tank ships and barges.⁽³⁶⁾ The majority of spills were under 100 gallons. Table 3.14 lists the number of incidents and spill volume for tanker and tank barge incidents during 1974 and 1975. Environmental impacts of marine oil pollution and various spill prevention measures are discussed in Section 4.1 of this report.

TABLE 3.14. Polluting Incidents in U.S. Waters--1974 and 1975

Cause	Number of Incidents				Volume in Gallons			
	Tank Ships		Tank Barges		Tank Ships		Tank Barges	
	1974	1975	1974	1975	1974	1975	1974	1975
Hull Rupture or Tank Leak	154	125	332	214	957,790	1,481,288	2,289,120	3,397,368
Transportation Pipeline Rupture	2	2	4	0	451	45	300	--
Other Structural Failure	18	11	16	6	3,123	514	676	2,407
Pipeline Rupture	40	8	14	4	1,534	418	308	2,545
Hose Rupture	27	23	30	38	6,320	9,593	3,501	15,196
Valve Failure	75	40	45	21	25,474	92,082	4,843	2,354
Pump Failure	11	3	7	14	749	717	46	248
Other Rupture	8	4	6	2	2,670	88,046	3,804	5,034
Other Equipment Failure	51	28	83	58	4,552	2,271	25,368	5,917
Tank Overflow	213	62	153	83	50,983	51,977	71,478	25,284
Improper Valve Operation	42	--	16	0	13,964	--	9,205	--
Improper Hose Handling	14	--	19	--	1,394	--	1,221	--
Other Improper Equipment Handling Operation	48	121 ^(a)	33	73 ^(a)	1,883	16,686	2,200	5,190
Other Personal Error	67	54	39	30	2,308	5,300	51,556	3,617
Bilge Pumping	74	30	1	8	39,859	4,866	40	358
Ballast Pumping	15	4	--	2	1,734	212	--	5
Other Intentional Discharge	17	18	5	--	794	11,362	237	--
Natural or Chronic Phenomen	1	3	3	4	0	106	3	79
Unknown	91	108	25	200	316,366	796	4,914	1,601
Total	973	643	833	757	1,434,168	1,766,729	2,468,724	3,467,203

(a) Includes improper valve operation and improper hose handling.

Source: Reference 36.

Uncontrolled non-point sources such as run-off and natural seeps also contribute to the presence of oil in the oceans. Contributions of various sources of oil to the oceans are shown in Table 3.15. Blowouts and well-casing ruptures are other sources of oil spills, as well as refinery accidents and accidents involving offshore rigs.

TABLE 3.15. Sources of Oil in the Oceans

<u>Source</u>	<u>Estimated Contribution (tons/yr)</u>	<u>(percent)</u>
Transportation	2,350,000	34.9
Tankers, Dry Docking		
Terminal Operations,		
Bilges, Accidents		
Coastal Refineries, Municipal and Industrial Waste	875,000	13.0
Offshore Oil Productions	87,500	1.3
River and Urban Runoff	2,100,000	31.2
Atmospheric Fallout	660,000	9.8
Natural Seeps	<u>660,000</u>	<u>9.8</u>
TOTAL	6,732,500	100.0

Source: Reference 37.

Regulation. The U.S. Coast Guard is the principal safety enforcement agency for water carriers. Under the Tanker Act, the Coast Guard regulates the construction, maintenance, inspection, manning and operating of tankers. The Ports and Waterways Act of 1972 extended this authority. Under the Dangerous Cargoes Act, the Coast Guard regulates not only the construction and operation of tank vessels, but in certain instances, the speed at which tank barges may be towed and their relationship to other barges in the makeup of a tow. All tank barges require certification by the Coast Guard. After being placed in service, tank barges are inspected periodically as a prerequisite to renewal of the certificate of inspection.

Persons in charge of navigating towing vessels must be licensed. If tows carry inflammable or combustible liquids in bulk, a licensed officer or certified tankerman must be on board with an endorsed certificate showing qualifications for handling the grade of cargo carried. The ability of Coast Guard personnel to handle the many safety and enforcement responsibilities is discussed in Subsection 4.2.2.

The Federal Energy Regulatory Commission regulates the economic aspects of oil transportation by barge on inland waterways. It settles controversies over rates and charges among shippers, competing modes of transportation and the regulated water carriers. The FERC also grants inland water carriers the right to operate. The Federal Maritime Commission (FMC) regulates the tariffs and practices of common carriers of oil by ocean transport. FMC regulations affect a relatively small proportion of oceanic oil shipments because many such shipments are by private carriers owned or controlled directly by the major petroleum companies.

Other federal agencies that affect oil transportation include the Army's Civil Works Program and the Department of Energy. The Civil Works Program, a responsibility of the Corp of Engineers, is the nation's major federal water resources development activity that includes waterway facilities to reduce the cost of transportation and improve navigation. The Department of Energy has assumed oil allocation and pricing regulatory authority, which can affect oil transport by water. Volume II of Reference 1 (presently being prepared for publication), will contain a detailed matrix showing the involvement of federal agencies in petroleum transportation. Federal statutes, regulations and administrative orders relative to oil pollution control are listed in Appendix C.

3.2.3 Motor Carriers

While cross-country movements of petroleum by truck may not be significant, probably every oil product is carried by tank truck at one time or another between the refinery and the consumer. Motor carriers roll from refineries and terminals to farms, factories, service stations and homes. End use delivery of many petroleum products is almost exclusively by tank truck.

System Description. In 1972, there were 158,000 tank trucks, 60% of which were for-hire carriers. Less than 20% were owned by the major oil companies.^(1,38) Tank trucks vary in size; some were built for long hauls, others for local deliveries. They typically have a capacity of between 5,000 and 16,000 gallons.

Long hauls require use of the rural highway system. Projections indicate that by 1980, this system will consist of over 31,500 miles of interstate, at least 73,000 miles of principal arterials, and a minimum 165,000 miles of minor arterials. Minimum average 1980 speeds for all motor carriers on these highways should range from 52.6 miles per hour on the interstate system to 43.4 miles per hour on minor arterials.⁽³⁹⁾ The 1974 National Truck Characteristic Report indicates that petroleum tank trucks carry full loads 58.5% of the time.

Efficiency is an important factor in a distribution system of this magnitude. Application of current technology can result in a significant decrease in fuel consumption by tank trucks. The industry is beginning to incorporate fuel-saving features into its motor vehicle fleet (see Subsection 5.2.6). These features include low RPM engines, tag axles, radial tires, aerodynamic bolt-ons and declutching fans. Programs to improve driver training and motivation are also being implemented (see Subsection 5.1.3).

Demand for truck transport of petroleum products is seasonal. Although a decline in demand for one product may be somewhat balanced by an increase in demand for another, the equipment needed to transport these products is not easily adaptable from one product to the other. Because some products require delivery at about the same time during the year, some truck tanks are compartmentalized, permitting a customer's multiple fuel needs to be satisfied with a single trip.

Safety and Environmental Impacts. The safety of motor carrier transport of petroleum products is regulated by the United States Department of Transportation, Bureau of Motor Carrier Safety (BMCS). The Bureau promulgates and administers the Motor Carrier Safety Regulations and the Hazardous Materials Regulations governing trucks operating in interstate or foreign commerce.

Safety inspections at carrier and shipper facilities are conducted by BMCS personnel to determine the extent to which a carrier or shipper is complying with applicable regulations. Periodic, unannounced road checks on motor vehicles are also performed. In conducting these road inspections, safety investigators check all parts and accessories necessary for the safe operation of a vehicle.

Due to the lack of sufficiently detailed highway accident data, it is difficult to assess the safety of transporting petroleum by motor carriers. Figure 3.11 indicates trends in accident and fatality rates for motor carriers transporting all types of freight. While the fatality rate has decreased in the last decade the accident rate has shown no clear trend.

FIGURE 3.11. Accident and Fatality Rates of Large Interstate Motor Carriers of Property

Source: Reference 39

Data from the American Petroleum Institute indicate an accident rate of about 5.3 per million vehicle miles during 1975; the ratio of accidents to number of vehicles was 0.2.⁽⁴⁰⁾ In 1973, commercial vehicles had a fatality rate of 7.13 per hundred million miles; Reference 39 predicts this will drop to 5.75 by the year 2000.

Data from large motor carriers show that 48 to 50% of the interstate motor carrier accidents involve collisions with passenger cars. Nearly 7% of all reported accidents involve mechanical defects.⁽³⁹⁾ It is believed that improved mechanical conditions or vehicle systems could have averted many accidents blamed on other causes. The major cause of accidents is credited to human factors. Tables 3.16 and 3.17 indicate accident statistics by accident type and mechanical defect involved.

According to the U.S. Coast Guard, highway vehicles have been responsible for about 2% of the oil spill incidents and 2% of the volume of oil entering U.S. waters; in 1975, nearly 8,500 barrels were spilled.⁽³⁶⁾ The volume of material actually discharged on land is unknown.

Regulation. Regulations governing tank truck transport include those applying to all motor carrier traffic and those specific to the transport of hazardous materials.

Weight and dimensional limitations on trucks and twin trailer restrictions differ by state. Thus, it is often necessary to travel with a vehicle which represents the lowest common denominator of size and weight in order to follow a given route. Other times a carrier will detour around a state to avoid its size and weight restrictions. Twin trailers are not permitted in 15 states, primarily in the East. When a carrier needs to cross a state-line where twin trailers are prohibited, the second trailer must be separated, requiring an extra trip for retrieval.⁽⁴¹⁾

The movement of certain petroleum products, such as gasoline and fuel, are not affected to a large degree by these laws because of the short radius of operation involved. However, other petroleum products which are moved long distances are affected by these legal restrictions.

**TABLE 3.16. Interstate Commercial Vehicle Fatalities
by Accident Type (Percent)**

	<u>Motor Carrier Occupant Facilities</u>	<u>Other Fatalities</u>
<u>Collision with:</u>		
Commercial Truck	5.1	9.5
Fixed Object	4.5	1.3
Automobile	2.9	49.5
Pedestrian	0.2	3.5
Bus	0.1	0.7
Train	0.8	0.3
Bicycle	0	0.9
Animal	0.1	<0.1
Motorcycle	<0.1	2.1
Other	1.2	5.4
All Collision	15.0	73.5
Noncollision	9.2	2.3

Source: Reference 39.

**TABLE 3.17. Accidents, Fatalities, Injuries and Property
Damage by Mechanical Defect Cause**

	<u>Accidents</u>	<u>Fatalities</u>	<u>Injuries</u>	<u>Property Damage (Millions)</u>
Fuel System	81	15	87	\$ 0.5
Wheels/Tires	560	48	493	5.4
Steering	124	4	128	1.1
Suspension	68	5	58	0.7
Transmission	33	5	23	0.2
Driveline	15	0	23	0.1
Engine	42	14	24	0.3
Brakes	541	32	621	2.5
Lights	26	0	19	0.1
Coupling	87	4	47	0.5
Specified (other)	<u>474</u>	<u>24</u>	<u>432</u>	<u>2.7</u>
Total	2,051	151	1,955	\$14.1

Source: Reference 39.

The Department of Transportation is the principal federal regulatory agency responsible for the promulgation and enforcement of motor carrier safety requirements. The Materials Transportation Bureau regulates the packaging of hazardous materials and specifies the type of equipment to be used in shipment (49 CFR 170-179). Driver qualifications are outlined in the Federal Motor Carrier Safety Regulations (49 CFR 390-398). These include medical qualifications and required ability examinations, such as driving and written tests.

The Interstate Commerce Commission regulates the rates and charges of common carrier truck transport. Various units of state and local governments have established prohibitions on the use of certain bridges or tunnels, restricted hours of operation, insurance requirements, limitations on parking or standing, and weight restrictions that apply to hazardous materials transport including petroleum product transport by motor vehicle.

Basic DOT regulations governing tank truck transport of hazardous materials are summarized below:

Parking. Hazardous material carriers must not be parked on or within 5 feet of the traveled portion of public street or highway, except for brief periods when the necessities of operation require the vehicle to be parked and make it impractical to park the vehicle in any other place.

Routes. Unless there is no practical alternative, the vehicle must be operated over routes which do not go through or near heavily populated areas, places where crowds are assembled, tunnels, narrow streets or alleys; it must stop at all railroad grade crossings.

Fires. The vehicle must not be operated near an open fire unless its driver has first taken precautions to ascertain that the vehicle can safely pass the fire without stopping; the vehicle must not be parked within 300 feet of an open fire.

Smoking. No person may smoke or carry a lighted cigarette, cigar, or pipe on or within 25 feet of: 1) a motor vehicle which contains flammable material; or 2) an empty tank motor vehicle which has been used to transport flammable liquids or gases.

Fueling. The vehicle's engine must not be operating and a person must be in control of the fueling process at the point where the fuel tank is filled.

Tires. If equipped with dual tires on any axle, the motor vehicle driver must stop at least once during each 2 hours, or 100 miles of travel, whichever is less, and examine the tires. The driver must also examine the vehicle's tires at the beginning of each trip and each time the vehicle is parked.

3.2.4 Railroad Transportation

In the transportation of petroleum, railroads move a smaller volume than any other mode. Although railroads transport some crude oil to refineries, most rail deliveries of petroleum products are to remote bulk terminals and some major consumers. In 1974, there were 113,642 petroleum tank cars in the United States and 200,916 miles of track.⁽³⁾ The average petroleum tank car traveled 9,000 miles in 1974.⁽⁴²⁾ Tank car carrying capacities range from 4,000 to 60,000 gallons.

System Description. Most large oil companies own their own tank cars and lease others as needed.⁽¹⁾ The railroads own few tank cars, mainly because the tankage needs of their customers are so specialized. For example, unpressurized tank cars without heating coils are generally used for hauling aviation fuels, gasolines and distillate fuel oils. Pressurized cars without heating coils are used for liquefied petroleum gases. Cars with heating coils help keep viscous products, like No. 6 fuel oil, in a liquid state. Insulated cars protect the cargo from heat and cold.

Railroad tank cars are generally loaded through domes in the top of the tanks. A string of tank cars is brought to the filling area by the locomotive and winched through the loading rack. The cars are often loaded simultaneously (up to seven at one time). Operators either on the platform or in a remote control room conduct and monitor the operation. Discharging is normally done through a valve in the bottom of the tank or secondary outlet valves on each side.⁽¹⁾

Not all tank cars are in constant movement. Some are used as movable stocks and remain on a siding for several months before being unloaded. Most of these cars must be considered as combined transportation/storage devices.

One concept that may alter the role of rail transport in the movement of petroleum is the unit train, operating between petroleum supply and demand centers. Such an operation would involve moving 50,000 to 300,000 barrels of oil per day, with rapid loading and unloading facilities. This approach has been suggested as an interim means of moving Alaskan oil inland from the Pacific Coast and is discussed in more detail in Subsection 5.2.7.

Safety and Environmental Impacts. The safety of railroad transport of crude oil and petroleum products is overseen by the government and the railroad industry itself. The Federal Railroad Administration (FRA), requires periodic safety inspections of most tank car components. The DOT, through the Office of Hazardous Materials Operations, defines commodities covered by DOT regulations and regulates commodity packaging. Federal regulations on tank car handling and specifications are contained in 49 CFR 174 and 179, respectively.

In 1974, the rail industry reported 10,694 accidents involving death, injury or property damage in excess of \$750. The accidents resulted in 1,908 fatalities and 20,818 injuries.⁽⁴³⁾ Table 3.18 summarizes rail accident data by type and cause. Eighty percent of the reportable accidents were derailments, 15% were collisions and 6% were other types of accidents. Track defects caused nearly 40% of the accidents.

Available statistics show that nonpressurized, noninsulated tank cars were involved in more accidents with loss of lading (228 accidents/10⁹ miles) than any other category of tank car from 1965 to 1970.⁽¹⁹⁾ This is the type of tank car which carries much of the petroleum and petroleum products transported by rail. However, according to an official of Butler Manufacturing Company, an insulated and jacketed tank car may not be more resistant to rupture than a noninsulated unit. The structural members required to support the insulation and jacketing can, themselves, become the penetrating or rupturing instrument in an accident.

TABLE 3.18. Train Accidents by Accident Type and Cause -- 1974

Derailments	
Human Factors	877
Equipment	1,973
Track Defects	4,193
Other	1,470
Total	<u>8,513</u>
Damages	\$154,548,384
Collisions	
Human Factors	1,314
Equipment Defects	87
Track Defects	55
Other	95
Total	<u>1,551</u>
Damages	\$ 27,761,642
Other	
Human Factors	47
Equipment Defects	115
Track Defects	16
Other	452
Total	<u>630</u>
Damages	\$ 5,390,321
Total Number of Accidents	10,694
Total Damages	\$187,700,347
Total Miles Traveled	833.5
Accidents per Million Miles	12.83
Damages per Million Miles	\$ 225,200

Source: Reference 43.

The extent of damage suffered in accidents depends on the accident cause and train speed. Damage to the tank car and loss or spillage of cargo is more likely in collisions and derailments than in rail grade-crossing accidents. Rail accident statistics show that 58.5% of all accidents occur at a speed less than 30 mph, 32% at 30-50 mph, 9.5% at 50-70 mph, and 0.1% at speeds exceeding 70 mph. However, the severity of those accidents is directly proportional to speed.⁽⁴⁴⁾

Releases of crude oil and petroleum products by rail are a small percent of the total volume of petroleum spilled in a year's time. The U.S. Coast Guard reported that railroads have typically been responsible for 3 to 4% of the total volume of oil released into U.S. waters. In 1975 this amounted to 13,726 barrels.⁽³⁶⁾ Figures estimating the volume of petroleum released on land are not presently available. Data for 1976 will be compiled by the Office of Hazardous Materials from Hazardous Materials Incident Reports which will be submitted in the latter part of 1977.

Regulation. The FRA administers and enforces the federal laws and related regulations designed to promote safety on railroads. The Administration is responsible for the safety-related aspects of track maintenance, signals, hours of service, and transportation of hazardous materials including petroleum products. In addition to its safety jurisdiction, the FRA provides financial assistance to certain railroads as well as research, development and demonstrations for improved and advanced systems.

The American Association of Railroads (AAR) recommends tank car design, fabrication and repair standards. Tank car testing requirements of the AAR include tension and bending tests of metal plate, X-ray or image-intensified fluoroscopy of welds, stress relief heating and hydrostatic tank testing. The tests for tanks, heater systems and safety are conducted on new tanks and at specified intervals on existing tank cars.

As flammable liquids, petroleum products such as fuel oil and gasoline are regulated commodities. Packaging regulations are minimal and pressurized or insulated tank cars are not required.⁽⁴⁵⁾ As indicated by Table 3.19, flammable compressed gas (LPG) is transported in DOT 112A and 114A uninsulated tank cars. Because of the large number of accidents involving these tank cars, the Materials Transportation Bureau issued the following order on September 15, 1977:

Existing and newly built specification 112 and 114 tank cars used to transport flammable gases such as propane, vinyl chloride and butane are required to have both thermal and tank head protection. Newly built cars are to be so equipped starting on January 1, 1978, while existing cars are to be retrofitted over a four-year period ending on December 31, 1981.

All specifications 112 and 114 tank cars, regardless of the hazardous lading being transported, are to be equipped with special couplers designed to resist coupler vertical disengagements. These couplers are to be installed on cars built after December 31, 1977 and retrofitted on all previously built cars by July 1, 1979. This order became effective as of October 19, 1977.⁽⁴⁶⁾

TABLE 3.19. Tank Car Restrictions

<u>Commodity</u>	<u>Classed As</u>	<u>Car Types Permitted</u>
Crude Oil	F.L.	103-W
Gasoline ^(a)	F.L.	111A100-W-1; 103-W; 104-W; 105A; 112A
Jet Fuel	F.L.	111A100-W-1; 111A100-W-1 (IL); 103-W (IL)
Kerosene	C.L.	103-W
Fuel Oil	C.L.	111A100-W-1; 102-W
LPG	F.G.	112A; 114A; 105A

(a) Vapor pressure not to exceed 40 psia @ 100°F.

C.L. - Combustible Liquid

F.G. - Flammable Compressed Gas

F.L. - Flammable Liquid

I.L. - Interior Lined

Source: Reference 45.

Enactment of the order has decreased the number of accidents involving tank cars 112A and 114A. However, LPG is still involved in a major number of incidents for all transportation modes. Statistics from the Materials

Transportation Bureau, DOT, show that tank cars are involved in approximately 80% of all railroad incidents. Since crude oil and its products are permitted in cars other than those regulated by the emergency order, regulations vary for the different petroleum commodities.

The ICC regulates railroad rates and has jurisdiction over the movement and return of rail cars and applications to construct and abandon railroad lines.

Other federal agencies, as discussed in Reference 1, have authority that affect rail transportation.

3.2.5 Comparison of Petroleum Transport Modes

Figure 3.12 and Table 3.20 indicate the involvement of each transport mode in moving crude oil and petroleum products from 1938 to the present. Pipelines continue to be the single largest carrier, offering several advantages over other transport modes.

TABLE 3.20. Percent of Total Crude and Products Carried in Domestic Movements by Each Transport Mode--1974

<u>Transport Mode</u>	<u>Percent Ton-Miles</u>	<u>Percent Tons</u>
Pipeline	59.78	47.20
Water Carrier	35.09	21.74
Motor Carrier	3.27	29.46
Rail	1.86	1.60

Source: Press Release, Shifts in Petroleum Transportation. Association of Oil Pipelines, Washington, DC 20006, May 26, 1976.

Although pipelines require a large initial investment, they are usually the most economical means of transporting large volumes over long distances.

FIGURE 3.12. Percent of Total Crude and Products Carried in Domestic Transportation by Each Mode--1938-1974

Pipelines require less maintenance than any other mode of transportation and can be operated continuously without significant interruptions. Over the past 10 years, some pipelines have been available over 98% of the time. However, over long distances that are nearly equal by land or by sea, large ocean tankers may be more economical than pipelines. When points of origin and destination are near inland water routes, barge transportation often provides the best means of transport, if the volume to be moved is not excessive and the distance is considerable. Tank truck and railroad tank car are the most expensive modes of transportation. Figure 3.13 and Table 3.21 present a summary of petroleum transportation costs.

FIGURE 3.13. Range of Petroleum Transportation Costs
Source: Reference 23.

TABLE 3.21. Comparative Costs of Moving Petroleum

	<u>Mills per bbl</u>	
	<u>Low</u>	<u>High</u>
Tanker	0.13	0.35
Pipeline	0.20	1.00
Barge	0.23	1.50
Rail	1.05	5.00
Truck	4.70	6.50

Source: Unit Train Transport of Alaskan Oil from the West Coast to the Midwest. Federal Energy Administration, Washington, DC 20461.

Although movement by tank truck and rail is expensive, these modes are relatively less susceptible to interference by outside forces. Barge traffic is vulnerable to disruption from natural occurrences such as there being too much or too little water in the waterways. Severe weather, as in the winter of 1976-1977, may prevent the movement of water carriers that are normally vital in supplying population centers with fuel. The need for emergency distribution plans in emergency situations is discussed in Subsection 4.3.1. Pipelines are virtually impervious to the weather, but have fixed routing. Tank trucks, on the other hand, offer unequalled flexibility of movement.

Fuel efficiency of petroleum transport modes varies significantly. As shown in Tables 3.22 and 3.23, large tankers are the most efficient means of transporting petroleum. Data from the American Waterways Operators, Inc.,⁽²⁷⁾ and Hittman Associates, Inc.,⁽⁴⁷⁾ differ as to the efficiency of the modes. Hittman based motor carrier data on a diesel powered tractor-trailer combination with 8,500 gallon payload, whereas the American Waterways Operators, Inc., used nonspecific averaged data. The difference in the pipeline data is probably due to the basis chosen in the computation of efficiency. Because most oil pipelines are powered by electric pumps, some

figures are based on the electric energy supplied to the pumps while other estimates are based on the intrinsic fuel energy required to produce and transmit electric power to the pumps.

TABLE 3.22. Energy Efficiency of Transport Mode
(Fuel Btu/Net Ton-Mile)

<u>Source/Mode</u>	<u>Rail</u>	<u>Barge</u>	<u>Tanker</u>	<u>Motor Carrier</u>	<u>Pipeline</u>
American Waterways Operators, Inc.: ^(a)	750	500	--	2400	1850
Hittman Associates, Inc.: ^(b)	690	650 ^(c)	154 ^(c)	933 ^(d)	450

(a) Reference 27.

(b) Reference 47.

(c) Data given in net ton-miles/gal and converted by assuming 143,000 Btu/gal (residual).

(d) Data given in net ton-miles/gal and converted by assuming 140,000 Btu/gal (diesel).

TABLE 3.23. Ancillary Energy Requirements

<u>Mode</u>	<u>Ancillary Energy, 10⁹ Fuel Btu/10¹² Btu</u>	<u>Distance for Ancillary Energy, Miles</u>	<u>Efficiency, 10⁻⁵ Fuel Btu/Btu-mile</u>
Pipeline	3.69	300	1.23
Tanker	40.7	10,000	0.41
Barge	25.7	1,500	1.71
Tank Truck	14.1	500	2.82
Rail	14.6	500	2.92

Source: Reference 41.

The speed of shipment is quite different for the various modes. Trucks are the fastest, point-to-point.⁽¹⁾ Rail movements are almost as fast while in route. Pipeline throughput speed is much slower, usually varying from 2 to 8 miles per hour. Water carriers normally average 6 miles per hour from point of origin to destination, although some high-speed tows can achieve 15 miles per hour. The speed and other modal characteristics discussed in this subsection are summarized in Table 3.24.

3.3 PETROLEUM STORAGE FACILITIES

At every link in the petroleum industry distribution system, imbalances exist between the quantity of petroleum available and product demand rates. These imbalances require the storage of petroleum at each link in the distribution system to facilitate continuous, efficient operation. Primary distribution system storage facilities include:

- Crude storage tanks at the producing field
- Crude and product storage terminals at refineries
- Crude and product storage terminals associated with pipelines
- Bulk terminals that receive products by tank car, barge, or pipeline.

Secondary storage facilities interact with transport modes at wholesale and retail outlets.

Storage requirements may differ according to the transport mode and material type. For example, pipeline schedulers try to arrange sufficient tankage so that throughput can remain constant throughout the month. A constant throughput minimizes energy consumption. In the transportation of crude oil, tankage must be provided at all receiving terminals as well as at delivery points, primarily at refinery locations. Petroleum products, on the other hand, are distributed through a more widespread system than crude oil. Therefore, industry must maintain considerably more product tankage in order to maintain normal flexibility in the overall operation of the supply system.

TABLE 3.24. Domestic Petroleum Transport Summary

Characteristic/Mode	Pipeline	Water Carrier		Motor Carrier	Rail
Percent of Total Crude Oil Ton-Miles Moved Domestically by Each Mode, 1974	84.4	14.8		0.4	0.4
Percent of Total Crude Oil Tonnage Moved Domestically by Each Mode, 1974	74.81	13.47		11.29	0.43
Average Crude Oil Shipping Distance (miles)	300	950		17	500
Percent of Total Petroleum Product Ton Miles Moved Domestically by Each Mode, 1974	41.9	49.8		5.4	2.9
Percent of Total Petroleum Product Tonnage Moved Domestically by Each Mode, 1974	33.54	25.84		38.45	2.17
Average Product Shipping Distance (miles)	345	753		55	518
		Barge	Tanker		
Comparative Shipping Costs (mils per bbl)	LOW HIGH	0.23 1.50	0.13 0.35	4.70 6.50	1.05 5.00
Average Speed of Each Mode, (mph)	2-8	6	18.9	52.6 (interstate) 43.4 (minor arterials)	Comparable to truck while intransit
Fuel Efficiency of Each Mode 10 ⁻⁵ Btu/Btu mile	1.23	1.71	0.41	2.82	2.92
Safety of Each Mode		1 July 1975 - 30 Sept. 1976	1 July 1975 - 30 Sept. 1976	1975	1974
Year for Which Figures Apply	1976			Hazardous Material Incidents Total	All rail industry accidents
Accidents	209	796 (a)	257 (a)	1146	24,274
Injuries	5	12 (b)	1 (b)	113	26,374
Fatalities	5	5 (c)	0 (c)	129	2,232
Major Causes of Accidents	32% - equipment rupturing line 19.6% - external corrosion 9.6% - incorrect operation by carrier personnel	30% - collision 25% - explosion or fire	30% - collision 25% - explosion and/or fire	Majority of the accidents were caused by driver's error	40% - track defects 20% - equipment defects

(a) Casualties are reported to the Coast Guard whenever the casualty results in any of the following:

- 1) Actual physical damage to property in excess of \$1500;
- 2) Material damage affecting the seaworthiness or efficiency of a vessel;
- 3) Stranding or grounding (with or without damage);
- 4) Loss of life;
- 5) Injury causing any person to remain incapacitated for a period in excess of 72 hr. except injury to harbor workers not resulting in death and not resulting from vessel casualty or vessel equipment casualty.

(b) These figures represent injuries resulting only from vessel casualties. Injuries on board tankships and tank barges not involving a vessel casualty amounted to 171 during that time period.

(c) These figures represent deaths resulting only from vessel casualties. Injuries on board tankships and tank barges not involving a vessel casualty amounted to 40 during that time period.

Figures appearing within this table appear in the body of this report and in References 2, 48 and 49.

In 1975, the petroleum industry was capable of storing 1,814,000,000 barrels in the primary sector and 173,000,000 barrels in the secondary sector.⁽⁵⁰⁾ However, the industry's real supply capability is measured by the volume of inventories available for delivery rather than the total volume of inventories reported. The total reported inventories consist of absolutely unavailable inventories, working stocks above the unavailable level and inventories readily available for distribution. Absolutely unavailable inventories include those in tank bottoms, in pipelines, in refinery pipelines and operating equipment, plus the quantities required for continuous operation of transportation and processing systems, and oil in transit. To operate on a normal basis, an additional substantial increment of working inventory above the unavailable level is necessary. Such working stocks must also be considered unavailable for consumption. The sum of total unavailable inventories and working stocks is termed the minimum operating level.

The combination of tank capacity, minimum operating levels and the unavailable portion of inventories provides a basis for analysis of the oil industry's storage operation within the framework of the existing supply and distribution system. Readily available inventory represents only a small fraction of the total inventory reported as shown in Figure 3.14, which illustrates typical operating conditions of a storage facility.

3.4 CRUDE OIL MOVEMENTS

Crude oil is a blend of thousands of different hydrocarbons, with the mixture varying widely from one oil field to another. The assortment of hydrocarbons in a crude oil and the proportions in which they are mixed determine its particular character and type. Some crudes are pitch black while others are amber, brown or green. Physical properties of crude oil and its products are summarized in Appendix D. Due to the variation among crude oils, transportation systems generally segregate crude by type for movement and delivery. Characteristics such as sulfur content, specific

gravity, asphalt content and other particular refinery requirements usually determine segregation needs. Segregation of crude oils requires increased storage facilities.

SOURCE: PETROLEUM STORAGE CAPACITY, NATIONAL PETROLEUM COUNCIL, WASHINGTON, D.C. 20006, SEPTEMBER 1974

FIGURE 3.14. Operating Conditions of a Storage Facility

Source: Petroleum Storage Capacity, National Petroleum Council, Washington, DC 20006, September 1974

Essentially all crude oil is transported to a refinery, where it is made into various products. A map of the refineries in operation throughout the U.S. is shown in Appendix E. This appendix also includes a description of an average refinery in the U.S.

3.4.1 Transport Highlights

As indicated by Figure 3.15 and Tables 3.25 and 3.26, pipelines have always played a major role in the transport of crude in the United States. Trunk pipelines are generally routed through areas where a number of pipelines converge. This allows for exchanges of oil or transfers to other types of carriers. Examples of such focal points are Midland, Crane, Mexia and Longview, Texas; Cushing, Oklahoma; Casper, Wyoming; and Patoka, Illinois. A large amount of storage capacity is required at these points to enable continuous pipeline operation.

FIGURE 3.15. Percent of Total Crude Carried in Domestic Transportation by each Mode--1938-1974

TABLE 3.25. Characteristics of Transport Modes Carrying Crude in Domestic Movements--1974

Transport Mode	Percent of Total		Million Tons Shipped	Billion Ton-Miles	Average Shipping Distance	Tons Per Container	Haul Frequency
	Ton-Miles	Tons					
Pipeline	84.4	74.81	464.3	301	300	--	Continuous
Water Carrier	14.8	13.47	83.6	53	950	Tanker-Less than 60,000 tons Ocean Barges-Up to 35,000 tons Barge-1,000 to 3,000 tons	Unknown
Motor Carrier ^(a)	0.4	11.29	70.0	1.2	17	According to Weight Limits of State	111,622 Trips per Year
Rail ^(a)	0.4	0.43	2.7	1.6	500	~65 Tons ^(b)	41,550 ^(c) Tank Car Trips

(a) Class I carries only.

(b) Derived by assuming a 20,000 gallon tank car and density of 6.5 lb/gal.

(c) Derived by dividing million tons shipped per year by tons per container.

Sources: Association of Oil Pipelines, Bureau of Mines, American Petroleum Institute and Interstate Commerce Commission.

TABLE 3.26. Percent^(a) of Crude Received by Refineries by Transport Mode--1975

PAD District	Domestic Crude Transported Interstate			Foreign Crude		Domestic Crude Transported Intrastate			Volume Transported
		Tanker and	Tanker and		Tanker and		Tanker Car and	Tanker and	(1000's of Barrels)
	Pipeline	Truck	Barge	Pipeline	Barge	Pipeline	Truck	Barge	
I	3	1	7	6	82	1	0.2	--	512,533
II	58	0.1	1	23	0.01	17	1	--	1,246,317
III	12	0.1	4	0.3	22	55	1	5	1,924,601
IV	35	4	--	11	--	46	5	--	155,261
V	1	1	7	9	35	40	2	5	707,521
U.S. Total	22	1	4	9	24	36	1	3	4,546,233

(a) Horizontally the percentages should add to 100, but may not due to rounding.

Source: "Petroleum Statement," Table 25. Bureau of Mines, Washington, DC 20241, February 1976.

Major interstate pipeline movements of crude flow south from Canada and north from the Gulf Coast, serving mainly the central portion of the United States. Nearly 400 million barrels of crude flow yearly by pipeline from west central Texas to the Gulf Coast near Houston. About one-fourth of this volume continues on to Louisiana. An additional 250 million barrels per year flow to mid-Oklahoma, with a majority of the crude continuing on to Chicago area refineries. Pipelines running from southeastern Louisiana carry 250 million barrels per year northward to Patoka, Illinois, where crude is then transferred to points in Kentucky, Indiana, western Ohio, Michigan and Illinois. Interstate pipeline transport of crude on the East Coast is nonexistent and very sparse in the West. Intrastate pipeline movements are heaviest in Texas, Louisiana, California, Oklahoma, Kansas and Wyoming.

Besides pipeline, water carriers are the only other major interstate transporters of crude. Nearly 30 million barrels per year move from the Gulf Coast to the mid-Atlantic seaboard. However, the majority of crude processed by East Coast refineries comes from imports. Significant water carriage of crude oil also occurs locally along the Gulf Coast. Texas receives more interstate shipments by tanker and barge than any other state. On the West Coast, tankers carry Alaskan oil to Seattle, San Francisco, Los Angeles and Long Beach. California receives 92% of these shipments. The only reported tanker and barge intrastate movements in 1975 occurred in Louisiana, California, Texas and Alabama.

Water carriers will also play a vital role in building up the Nation's strategic petroleum reserve (SPR). Under the latest schedule for filling the SPR, 250 million barrels will be stored by the end of 1978 and 500 million barrels should be in place by the end of 1980; 1 billion barrels could be eventually stored.⁽⁵¹⁾ If one assumes that all SPR oil is transported by water carriers, then the annual volume that must be transported and stored to meet this schedule constitutes 20 to 30% of the annual volume carried by water carriers in domestic movements during the 1970s.

Unlike water carriers, tank trucks and railroads usually carry small volumes of crude oil and typically account for less than 1% of the total

volume of domestic crude oil movements. Most crude carried by truck and rail is transported intrastate. Texas and California handle the majority of intrastate truck shipments. Interstate carriage is heaviest in western Pennsylvania, Kansas, Louisiana, Colorado, Utah, Wyoming and California. Transport of crude by rail is usually done in a 103-W car type; movement by truck is in a nonspec tank. Crude oil movements are governed by DOT Hazardous Material Regulations 49 CFR 170-178.

Reference 1 contains detailed information regarding the flow of crude oil in the United States and includes color maps showing major crude oil transportation corridors for pipeline and water carriage.

3.5 PETROLEUM PRODUCTS

The petroleum products discussed below include:

- Gasoline
- Jet Fuel
- Kerosene
- Distillate Fuel Oil
- Residual Fuel Oil
- LPG

3.5.1 Transport Highlights

Unlike the movement of crude oil, pipeline transportation of petroleum products (Table 3.27) is not the predominant mode. Pipelines transport just over 33% of the petroleum product volume moved within the United States. Figure 3.16 indicates that, in the future, a larger percentage of products may be moved by pipelines.

The major pipeline movement is clearly from Houston-Beaumont, Texas, northeastward to Philadelphia and New York, supplying consuming centers along the route. Almost 700 million barrels a year flow along this northeast corridor. The central states are supplied by a vast network of pipelines. Only a few pipelines extend into the less densely populated western states.

TABLE 3.27. Characteristics of Transport Modes Carrying Petroleum Products in Domestic Movements--1974

Transport Mode	Percent of Total		Million Tons Shipped	Billion Ton-Miles	Average Shipping Distance	Tons Per Container	Haul Frequency
	Ton-Miles	Tons					
Pipeline	41.9	33.54	420.4	205	345	--	Continuous
Water Carrier	49.8	25.84	323.9	244	753	Tanker-Less than 60,000 Tons Ocean Barge-Up to 30,000 Tons Barge-1,000 to 3,000 Tons	Unknown
Motor Carrier ^(a)	5.4	38.45	482	26.5	55	According to Weight Limits of State	3,840,360 Trips per Year
Rail ^(a)	2.9	2.17	27.2	14.1	518	~65 Tons ^(b)	418,460 ^(c) Tank Car Trips

(a) Class I carriers only.

(b) Derived by assuming a 20,000 gallon tank car and a density of 6.5 lb/gal.

(c) Derived by dividing million tons shipped per year by tons per container.

Sources: Association of Oil Pipelines, Bureau of Mines, American Petroleum Institute and Interstate Commerce Commission.

FIGURE 3.16. Percent of Total Products Carried in Domestic Transportation by Each Mode--1938-1974

Water carriers follow the same general pattern as pipelines. The overwhelming movement is from the Gulf Coast (Texas and Louisiana) to the Atlantic states, with the majority of the products going to the mid-Atlantic area. In 1974, about 325 million barrels of petroleum products were shipped around the Florida coast bound for Atlantic ports. The Mississippi River System also handles a large share of the petroleum product traffic. As much as 225 million barrels a year are shipped on the lower Mississippi River.

Tank truck carriage of petroleum products occurs mostly on the local level. Movement of products with flashpoints less than 100°F must be done in an MC 302, MC 303, MC 304, MC 306 or MC 307-spec tank. Products with flash points between 100°F and 200°F may be carried in nonspec tanks, but must be placarded. Because LPG is a compressed flammable gas, it requires special handling and can only be carried in an MC 330 or MC 331-spec tank. Of these, the MC 331 is the only tank currently being built. However, a significant amount of LPG moves in the existing MC 330 tanks.

Rail movements of products amount to nearly ten times the volume of crude carried by rail. However, this volume is still small in comparison to that carried by other modes. Railroads deliver products mainly to remote bulk terminals and major consumers. Special handling of most petroleum products is governed by the Hazardous Material Regulations. For example, maximum filling density in tank cars is specified for LPG carriage.

3.5.2 Gasoline

Gasoline is the petroleum industry's principal product - nearly 104.3 billion gallons were consumed during 1975.⁽³⁾ Over the decade, 1966-1976, 45% of the refinery yields from crude oil have been gasoline. The trend in gasoline production over the past 21 years has been a gradual increase of about one percentage point.⁽⁴²⁾ Gasoline production is variable, with as much as a 33% change in monthly yields during a given year.

Gasoline is the major petroleum product transported from the Gulf to the West Coast. It is typically shipped from the refinery to a distribution terminal by pipeline or barge and from the terminal to retail outlets by large

tank trucks. A spokesman of the National Tank Truck Carriers Association has estimated that 99% of the gasoline carried in the United States moves partially or wholly by tank truck. An estimated 39,900 gasoline trucks are in operation, shipping an average of 8,400 gallons of gasoline per haul.⁽⁵²⁾ Most tank trucks operate within a 50 mile radius. Table 3.28 indicates the major modes of gasoline transport. Figures 3.17 through 3.19 show the general flow of gasoline between Petroleum Administration for Defense (PAD) districts and the volume of intradistrict movements. Appendix F provides additional information on the grouping of states into PAD districts.

TABLE 3.28. Total Domestic Motor Gasoline Movements - 1975

<u>Transport Mode</u>	<u>Million Barrels Carried</u>	<u>Percent of Total Domestic Demand^(a)</u>
Pipeline	1,769.4	71
Water Carrier	711.6	29
Motor Carrier	2,457.8 ^(b)	99
Rail	9.8 ^(c)	0.4
Total Domestic Demand - 2,482,654,476 barrels		

(a) Movements include more than one mode carrying the same shipment.

(b) Converted from short tons to barrels by assuming 0.162 gallons per pound.

(c) Estimated.

3.5.3 Jet Fuel

In 1975, 365.3 million barrels of jet fuel were consumed.⁽³⁾ The transportation sector utilized nearly 99% of this fuel, with the remaining 1% used for electrical power generation. The 10-year average refinery yield of naphtha-type jet fuel is 2.19%; for kerosene-type it is 5.11%. Jet fuel production usually varies by one percentage point through the year with January, June, July and December being months of low productivity. The 8-year period 1968 to 1976 shows a steady decline in the output of naphtha-type jet fuel. The 1975 yield was less than half of that produced in 1968.

FIGURE 3.17. Gasoline Movements Between PAD Districts by Pipeline--1975

FIGURE 3.18. Gasoline Movements Between PAD Districts by Water Carrier--1975

FIGURE 3.19. Total Gasoline Movements Between PAD Districts--1975

On the other hand, kerosene-type jet fuel is a relatively steady fraction of product output, with volumes varying by less than half a percent between 1968 and 1975.⁽⁴²⁾

Little information exists that describes jet fuel movements by transport mode. Table 3.29 identifies volumes carried by pipeline and water carrier only; no data appear to be available for other modes. Figures 3.20 through 3.22 show major corridors of movement between PAD districts. Many military and commercial air fields receive fuel supplies directly by pipeline. Nearly half of all jet fuel transport is intradistrict.

TABLE 3.29. Total Domestic Jet Fuel Movements - 1975

<u>Transport Mode</u>	<u>Million Barrels Carried</u>	<u>Percent of Total Domestic Demand(a)</u>
Pipeline	259.6	71
Water Carrier	72.8 ^(b)	20
Motor Carrier	Unknown	
Rail	Unknown	
Total Domestic Demand - 365,290,000 barrels.		

(a) Movements include more than one mode carrying the same shipment.

(b) Converted from short tons to barrels by assuming the 0.148 gallons per pound.

3.5.4 Kerosene

Total consumption of kerosene in 1975 amounted to 58 million barrels. This volume was 9.9% below the 1974 consumption level, showing a continued decline in kerosene production.⁽⁵³⁾ Refinery yields have dropped annually from a peak of 5.17% in 1964 to 1.22% in 1975. The 10-year average refinery yield is 2.14%. Kerosene production on a monthly basis is usually fairly stable.⁽⁴²⁾

FIGURE 3.20. Jet Fuel Movements Between PAD Districts by Pipeline--1975

FIGURE 3.21. Jet Fuel Movements Between PAD Districts by Water Carrier--1975

FIGURE 3.22. Total Jet Fuel Movements Between PAD Districts--1975

Kerosene is marketed almost exclusively in PAD districts I, II and III. Sales of kerosene in PAD districts IV and V account for less than 7% of the total domestic sales. This explains the general lack of kerosene movements in the western states. Table 3.30 identifies trucks as the major mode for transporting kerosene. Figures 3.23 through 3.25 show kerosene production, movements and demand.

TABLE 3.30. Total Domestic Kerosene Movements - 1975

<u>Transport Mode</u>	<u>Million Barrels Carried</u>	<u>Percent of Total Domestic Demand^(a)</u>
Pipeline	30.86	53
Water Carrier	28.62 ^(b)	49
Motor Carrier ^(c)	52.13 ^(b)	90
Rail ^(c)	Unknown	
Total Domestic Demand - 57,990,000 barrels.		

(a) Movements include more than one mode carrying the same shipment.

(b) Converted from short tons to barrels by assuming 0.148 gallons per pound.

(c) Class I carriers.

3.5.5 Distillate Fuel Oil

Distillates are the lighter fuel oils used as diesel fuel and for heating homes and small apartment buildings. Over 1,016 million barrels of distillate fuel oil were consumed in 1975.⁽⁵³⁾ During the past 10 years, 22% of refinery yields from crude oil have been distillate fuel. Distillate output from refineries shows market seasonality. December and January yields are usually 3 or 4 percentage points above summer months. Yearly production of distillate fuel oil over the past 21 years indicates a slight downward trend; statistics from 1973 to 1975 reflect a sharper decline.⁽⁴²⁾

FIGURE 3.23. Kerosene Movements Between PAD Districts by Pipeline--1975

FIGURE 3.24. Kerosene Movements Between PAD Districts by Water Carrier--1975

FIGURE 3.25. Total Kerosene Movements Between PAD Districts--1975

Approximately 75% of the distillate fuel consumption in the United States occurs in PAD Districts I and II. New York, Pennsylvania and New Jersey alone consume 23% of the national total. To help supply this demand, large volumes of distillate are moved daily from PAD District III to PAD District I by water carrier and pipeline. Major carriers and general corridors are shown in Table 3.31 and Figures 3.26 through 3.28.

TABLE 3.31. Total Domestic Distillate Fuel Oil Movements - 1975

<u>Transport Mode</u>	<u>Million Barrels Carried</u>	<u>Percent of Total Domestic Demand^(a)</u>
Pipeline	667.06	66
Water Carrier	572.38 ^(b)	56
Motor Carrier ^(c)	136.33 ^(b)	13
Rail ^(c)	29.00 ^(d)	3
Not Transported (Used on Site by Oil Companies)	13.6	1
Total Domestic Demand - 1,016,160,000 barrels.		

(a) Movements include more than one mode carrying the same shipment.

(b) Converted from short tons to barrels by assuming 0.13817 gallons per pound.

(c) Class I carriers.

(d) Estimated.

3.5.6 Residual Fuel Oil

Refinery yields of residual oil have averaged 7.55% during the past 10 years. In 1956, refinery yields of residual oil began to drop steadily until 1970. Since that time, refinery output has been consistently increasing. Residual oil production shows some seasonality, as yields usually vary by 2.5 percentage points between the summer low and winter high.⁽⁴²⁾

FIGURE 3.26. Distillate Fuel Oil Movements Between PAD Districts by Pipeline--1975

FIGURE 3.27. Distillate Fuel Oil Movements Between PAD Districts by Water Carrier--1975

FIGURE 3.28. Total Distillate Fuel Oil Movements Between PAD Districts--1975

The major market for residual oil is electric energy generation, which consumed 51% of the total 895 million barrels consumed in the United States during 1975.⁽³⁾ A material balance for a 1000 MWe power plant using residual fuel oil is shown in Appendix G.

More residual fuel oil is imported than any other petroleum product. Domestic refineries were designed to maximize the production of gasoline and other products that traditionally command higher market prices. Utilities and industrial users, particularly along the East Coast, have therefore bought residual oil as a boiler fuel from Caribbean and European refiners.⁽¹⁾

Because residuals are heavy, high-viscosity fuel oils, they usually need to be heated before they can be pumped and handled conveniently. Fuel oil transport by pipeline over long distances is impractical, except for a small amount of residual oil pipeline movement in the East. Figures 3.29 through 3.30 represent the major corridors for residual movements. As shown in Table 3.32, water carriers do most of the long hauls. Tank truck transport of residual fuel oil is seasonal. In 1976, there were approximately 11,850 fuel oil trucks. Each shipment averaged about 9,000 gallons.

TABLE 3.32. Total Domestic Residual Fuel Oil Movements - 1975

<u>Transport Mode</u>	<u>Million Barrels Carried</u>	<u>Percent of Total Domestic Demand^(a)</u>
Pipeline	--(b)	--(b)
Water Carrier	673.6 ^(c)	77
Motor Carrier ^(d)	59.1 ^(c)	7
Rail ^(d)	22.9 ^(e)	3
Not Transported (Used on Site by Oil Companies)	50.5	6
Total Domestic Demand - 873,111,000		

(a) Movements include more than of one mode carrying the same shipment.

(b) No data.

(c) Converted from short tons to barrels by assuming 0.127 gallons per pound.

(d) Class I carriers.

(e) Estimated.

FIGURE 3.29. Residual Fuel Oil Movements Between PAD Districts by Water Carrier--1975

FIGURE 3.30. Total Residual Fuel Oil Movements Between PAD Districts--1975

3.5.7 Liquefied Petroleum Gas

In the United States, about 30% of the LPG consumed is refined from crude oil, while 70% is extracted from natural gas. Total production in 1975 amounted to 430.5 million barrels, while imports totaled nearly 41 million barrels. Production of LPG rose rapidly between 1953 and 1973. Production in 1974 and 1975 showed a downward trend.

As illustrated by Figure 3.31, the distribution of LPG is complex and independent of the petroleum product distribution system. The LPG system presently requires some four billion gallons of primary storage capacity, 70,000 miles of cross-country pipelines, 25,000 transport and delivery trucks, 22,000 railroad tank cars, a water-borne fleet of 150 tankers and barges and 8,000 bulk storage and distribution points.⁽⁵⁴⁾

FIGURE 3.31. Elements of the LPG Transport and Distribution System

LPG characteristically moves from the oil or gas well to the refinery or gas processing plant by pipeline. It may then continue by all of the transport modes to either a distribution plant, underground storage cavern or consumer.

Strict procedures are required for the transportation of LPG over public highways because of the potential hazard of explosion. Interstate transportation by tank truck must comply with the ICC's Motor Carrier Tariff No. 13. Requirements also exist for mounting and operating the equipment and parking and garaging LPG tank trucks.

The central states consume the majority of LPG. Consumption rates decline moving toward the east and west coastlines. However, California and Florida are major consumers and are exceptions to this trend. Demand for LPG is seasonal; winter month demand has recently been from 30 to 50% higher than that in summer months. The volume of LPG carried by transport mode and the interdistrict corridors are shown in Table 3.33 and Figures 3.32 and 3.33

TABLE 3.33. Total Domestic Liquid Petroleum Gas Movements - 1974

<u>Transport Mode</u>	<u>Million Barrels Carried</u>	<u>Percent of Total Domestic Demand(a)</u>
Pipeline	446.90	94.8
Water Carrier	1.06 ^(b)	0.2
Motor Carrier ^(c)	451.28 ^(b)	95.7
Rail ^(c)	19.31 ^(d)	4.1
Not Transported (Used on Site by Oil Companies)	89.66	
Total Domestic Demand - 471,648,429 barrels.		

(a) Movements include more than of one mode carrying the same shipment.

(b) Converted from short tons to barrels by assuming 0.127 gallons per pound.

(c) Class I carriers.

(d) Estimated.

FIGURE 3.32. Liquefied Petroelum Gas Movements Between PAD Districts by Water Carrier

FIGURE 3.33. Total Liquefied Petroleum Gas Movements Between PAD Districts--1975

3.6 SUMMARY COMMENTS

Petroleum is projected to remain the largest single energy source during the balance of the century. However, domestic production peaked in 1970 and will probably continue to decline in the lower 48 states and traditional offshore areas. New sources such as Alaska and the Outer Continental Shelf may supply sufficient petroleum to maintain or slightly increase domestic production between now and 2000. Oil shale and synthetic fuels derived from coal appear unlikely to make more than a token contribution in the next 20 years. The outlook is, therefore, that the U.S. will have a large dependence on foreign petroleum sources throughout the balance of the century.

Potential problems in petroleum transportation may affect the future adequacy of some links in the national distribution system and may also create a deterioration in relations between government and industry and in public acceptance. Section 4 identifies specific potential problems and consequences which may interfere with the development of petroleum transportation systems between now and the year 2000.

SECTION 3: BIBLIOGRAPHY

In addition to the references cited in the text the following bibliography was used to supply data shown in the figures and tables of Section 3 that are not specifically referenced.

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4.0 POTENTIAL PROBLEM IDENTIFICATION, EVALUATION AND RECOMMENDATIONS

The primary objective of this task is to identify and prioritize potential problem concerns which may affect the adequacy of domestic petroleum transportation during the balance of the century. A supporting objective is to recommend necessary and appropriate action to mitigate the potentially adverse effects of problems which may not be receiving adequate attention in other related programs. These assessments and recommendations are intended to provide information and perspective that may be useful to industry and government for evaluating research and development needs and priorities, and for structuring future program plans relating to petroleum transportation.

Specific concerns have been identified which are judged to be important, inadequately addressed by current programs and also appropriate for consideration by the DOE or other agencies for inclusion in future research and development programs. Two categories of these concerns are presented in Section 4: 1) concerns that are potentially serious and may impact petroleum transportation in the next decade; and 2) currently moderate concerns with longer-term potential effects.

Concerns were identified by analysis of problem issues associated with currently projected growth scenarios for petroleum production in the United States, and the characterization of petroleum transportation systems contained in Section 3. Additional information and insight were gained from contact with experts in government and in the petroleum and transportation industries.^(a) The relative priorities of concerns were judged on their potential impact on the whole transportation system and the potential immediacy of that impact.

The diversity of potential problems affecting energy material transportation has suggested the use of a special format for presenting the results of this study. Each specific potential problem is discussed in a subsection that describes the following items:

(a) Sources of information used in Section 4 include the cited references contained in Section 6 and the annotated bibliography and personal contacts indicated in Appendix H.

- Concern
- Basis
- Related Work
- Appraisal
- Recommended Action
- Priority

In this report, a concern is the statement of a potential problem and its consequences that may impact the future development of petroleum transportation systems. The basis is the background evaluation of a potential problem and includes the identification of situations or trends tending to cause the problem. Ongoing or planned programs investigating problem solutions are summarized, when possible, as related work. The appraisal discussion provides the overall perspective on the concern as a guide to recommending action. Recommendations are made for programmatic and task-level effort to address the concern and gaps in the coverage of related programs. A judgment of priority, the appropriate level of manpower, and timing of the recommended effort are included in the discussion of each potential problem.

An almost limitless number of potential problems can be raised as conjectural issues. An attempt has been made to avoid issues that are nebulous, too general, or philosophical. A total of 35 potential problem issues were identified as being worthy of investigation. These issues were analyzed to determine their immediacy and potential impact on petroleum transportation in the balance of the century. This process eliminated some trivial issues and generated the smaller number of concerns addressed in this and the following section. Many concerns are interrelated or are facets of complex problems. For example, several concerns arise from the current lack of knowledge regarding specific causes of oil spills during transportation and the cost-effectiveness of prevention practices and devices.

The concerns discussed in this section are grouped into problem categories as shown in Table 4.1. Within each category, the concerns are organized according to their apparent relative importance. All of these concerns are judged to warrant additional attention in FY 1979 through 1981

programs of the DOE and other government agencies. Other concerns were identified which do not appear to warrant new program activities at present. These concerns are reviewed in Section 5.

TABLE 4.1. Concerns in Petroleum Transportation

<u>Potential Problem Category</u>	<u>Area of Specific Concern</u>
Environmental Effects and Management of Oil Spills	<ul style="list-style-type: none"> • Effects of Marine Oil Pollution • Offshore Pipelines • Environmental Impacts of Pipelines • Oil Spill Trajectory Modeling
Transportation System Safety	<ul style="list-style-type: none"> • Training of Waterway Personnel • Coast Guard Manpower • Cost-Effective Tanker Safety Design
Transportation Logistics	<ul style="list-style-type: none"> • Emergency Distribution Plans • Pipeline Sabotage
Legal, Regulatory and Institutional Problems	<ul style="list-style-type: none"> • Petroleum Industry Reorganization • Preemption • Federal Right of Eminent Domain • Deepwater Port Licensing • Oil Spill Liability and Compensation

4.1 ENVIRONMENTAL EFFECTS AND MANAGEMENT OF OIL SPILLS

Current knowledge regarding the complex path of oil spills through the marine environment is incomplete and sometimes contradictory. This overall concern suggests the need for a program to trace the paths of petroleum in the oceans from the source of spill to where effects on marine organisms are observed. There are two complementary parts to this program. The first part should generate oil spill event trees for each mode of oil transport and estimate the number of oil spills or percentage of spillage related to each source of petroleum release. The second major portion of the recommended program should provide a more complete data base regarding the fate and effects of oil releases in the ocean environment.

An improved understanding of oil spill pathways should offer a sound basis for evaluating the level of environmental protection offered by various spill prevention techniques and devices. This data base could also help to evaluate the cost-effectiveness of implementing new environmental protection methods specific to particular spill sources. It is essential that pending and future decisions on oil production and development be made with a clear understanding of problem causes and potential effects of alternative remedial actions. Knowledge generated by this program should be useful in guiding policy decisions and determining the direction of future development efforts. The need for the above program effort is exemplified by concerns presented in the following subsections.

Current public pressure for increased tanker regulation and restricted development of offshore resources stems from an incomplete understanding of the environmental impacts of oil spills. The study recommended above on the effects of oil releases in the marine environment will help to clarify the nature of potential impacts, both offshore and onshore, and aid in formulating appropriate protective measures.

Accurate modeling of oil spill trajectories, as well as studies of the biological effects of petroleum, require an analysis of the weathering mechanisms of oil in the ocean. The type and degree of weathering is crucial to biologists because the components of oil not only respond differently to weathering agents, but they also have differing toxicities.⁽⁵⁵⁾

The comprehensive oil spill pathway identification program described and justified above covers many aspects of specific concerns in Section 4.1 and 4.2. Actions recommended to address the following concerns are defined below as tasks or projects within the scope of this comprehensive program.

4.1.1 Effects of Marine Oil Pollution

- CONCERN

Public doubts concerning the effectiveness of oil spill cleanup methods and uncertainty regarding ecological effects of marine oil pollution may create pressure for regulatory requirements that do not effectively mitigate adverse environmental impacts, yet impose unreasonably high costs upon the industry.

- BASIS

Approximately 50 percent of the total oil release in the oceans comes from river and urban runoff, atmospheric fallout and natural seeps. The other 50%, approximately 3.5 million tons/year, stems from industry-related sources. Transportation is responsible for more than half of industry-related oil releases.⁽⁵⁶⁾ The actual damage to marine life from an oil spill depends upon the volume, composition and toxicity of the released oil, weather conditions, ecosystems, the physiography of the oil spill area and man's ability to clean up the spill. Field studies present conflicting opinions regarding the threshold limits for damage to marine life from petroleum.

- RELATED WORK

The U.S. Coast Guard (USCG) has proposed an addition to the Ports and Waterways Safety Act of 1972, authorizing the creation of designated safety zones to provide enhanced safety and environmental protection to coastal areas. The amendments, designed to reduce accidental marine pollution, are required to comply with new regulations from the International Convention for the Prevention of Pollution from Ships, 1973. The USCG was also instructed by President Carter to board and inspect foreign flag vessels at U.S. ports yearly to ensure compliance with U.S. safety and environmental protection regulations. The USCG was given authority to deny port access to deficient vessels or to deny departure rights to vessels until deficiencies are corrected. Finally, the USCG has inaugurated a technology review to assess present capabilities for dealing with pollution incidents under adverse weather and sea conditions.

The massive oil spills of the *Argo Merchant* (off Nantucket Island) and the *Sansinena* (in Los Angeles Harbor) prompted Congressional action in an attempt to prevent or minimize future oil spill damages. Legislative proposals to prevent oil spills include bills on tanker structure, oil spill liability, expansion of vessel traffic services and other tanker safety requirements.^(a) Legislation to consolidate all federal oil spill protection research and development under the Environmental Protection Agency has also been introduced.^(b)

(a) S. 682, Tanker and Vessel Safety Act of 1977 and H. R. 3796, Tanker Safety Act of 1977.

(b) House Resolutions 3209, 4666, 4667.

Legislation designating the National Oceanic and Atmospheric Administration as lead agency in developing a comprehensive five-year plan for ocean pollution research, development and monitoring programs (S.1617) was signed into law May 8, 1978, by President Carter. The first five-year plan should be completed by February 15, 1979, and must identify national needs and problems concerning various aspects of ocean pollution; priorities for meeting these needs must also be established.

Many companies manufacture oil spill cleanup equipment and materials, including oil skimmer systems which remove oil from a water surface, containment booms which prevent spreading of the oil, and absorbents which remove oil from water. However, with the exception of USCG and EPA programs, most oil spill cleanup developments are designed for rivers, harbors and ponds, not oceans. These devices are fairly ineffective in even moderate sea, current and wind conditions.

The USCG and EPA are the two federal agencies responsible for oil spill cleanup efforts in the U.S. In 1973, the USCG formed the National Strike Force, composed of specially trained teams who clean up oil spills in the U.S. and worldwide. The USCG also operates the National Response Center, where oil spills can be reported. Companies in industry also pool their talents, resources and equipment to fight oil spills.

A conference on the assessment of the ecological impacts of oil spills was held in Keystone, Colorado on June 14-17, 1978. The conference presented a review of current assessments of the ecological impact of oil spills in the marine and estuarine environments.

- APPRAISAL

Oil spills are the most frequent type of accident during petroleum transportation. Although the actual spill may not constitute an immediate hazard to human life, the effects of oil on ecological systems may be substantial. While all damages may not be permanent, long term ecological disruption may occur. The results of extensive laboratory and field studies on oil pollution effects are varied and often contradictory. An assessment of the

adequacy of current U.S. pollution prevention capabilities and contingency plans and the potential environmental consequences of oil spill incidents is required. The results of this assessment should be communicated to the public.

Seventy-five percent of all marine oil spills involve vessels. The spill rate seems dependent on a number of factors, including shipping lane congestion, weather, tanker equipment reliability and crew training and emergency preparedness. A rash of tanker accidents in 1976 and 1977 has prompted the government to seek stringent safety requirements for all seagoing vessels. However, it is important to consider the economic and diplomatic effects of stricter regulations which are also applicable to foreign vessels. More than 80% of U.S.-owned tanker tonnage is under foreign registry, the majority in Panama and Liberia. More than 95% of U.S. imported petroleum arrives in foreign flag tankers. Thus, the establishment of stricter tanker standards by the U.S. must carefully take into account international implications to prevent inequities and foreign reprisals. Decisions should involve close consultation with U.S. trading partners and appropriate international organizations.

- RECOMMENDED ACTION

The USCG should assess the adequacy of current U.S. pollution prevention capabilities and oil spill contingency plans. The program should include a review of recent developments in oil spill containment and cleanup technology. Results should be used to provide the public with credible information on the status of U.S. abilities to cope with marine oil pollution. The ECT should monitor and support this effort to remain cognizant of possible new requirements for technology to protect the marine environment.

- PRIORITY

A moderately high priority is placed on this assessment. A level of effort of 1 to 2 man-years/year, beginning in FY-1979 or FY-1980, is recommended as an independent project or as a task in a comprehensive program on oil spill management.

4.1.2 Offshore Pipeline Development

- CONCERN

Environmental concerns may lead to undesirable delays in the establishment of pipeline systems serving offshore oil developments.

- BASIS

The construction of offshore or Outer Continental Shelf (OCS) pipelines^(a) involves long lead times, usually about five years. Time-consuming cultural, biological, geophysical and archaeological studies are required in the initial planning stages as part of an environmental impact assessment. Delays are also caused by the interaction of the many agencies which have authority over various aspects of OCS pipelines.

The Department of the Interior, Bureau of Land Management (BLM), has the authority to grant rights-of-way to offshore pipelines. The U.S. Geological Survey (USGS) grants permits and easements for gathering lines within a production area and is also responsible for making technical evaluations regarding pipeline specifications, safety measures and offshore area environmental sensitivities (biological, cultural and geophysical). The USGS and the DOT Office of Pipeline Safety Regulations (OPSR) are the safety regulatory agencies for offshore pipelines and the Federal Energy Regulatory Commission (FERC) regulates the economics of pipeline operation.

Oil releases from pipelines can result in environmental damage. Six of eighteen oil spills from pipeline ruptures or leaks reported to the USGS during 1967-1976 were considered to be major pollution incidents.^(b) Breaks in pipelines are primarily caused by ship anchors and seismic activity.

- RELATED WORK

The Bureau of Land Management (BLM) has submitted a proposal to The Department of the Interior (DOI) for final approval. This document, entitled "Proposal for an Intergovernmental Coordinated Planning Process for

(a) These include pipelines required for deepwater port operations.

(b) Major spills are defined as those of more than 2,380 barrels of oil.

Transportation of OCS Oil and Gas," provides for identification of common corridors for pipelines to minimize the use of the OCS and restrict the location of offshore pipelines.

The OPSR contracted Van Houten Associates to conduct a study of safety practices in the areas of pipeline placement, repair and leak detection techniques and underwater hazards. This "Study of Safety Practices for Offshore Pipeline Facilities" includes effects on marine life from both normal operations and possible leaks and spills.

Since 1969, the Offshore Technology Conference (OTC)^(a) has held annual meetings for the presentation of technical papers related to offshore development. Topics include ocean engineering problems in offshore pipelining and corrosion control.

- APPRAISAL

There is a general lack of technical specification for offshore pipelines. Although the Offshore Technology Conference provides some evidence of ongoing research and development, there is no major research and development program for offshore pipelines. Environmental effects of the lines seem to be dealt with on a case-by-case basis. Environmental impact statements for offshore construction, including drilling operations and deepwater ports, must specifically address the impacts of offshore pipelines included in the facility.

Although pipelines are considered one of the safest methods of transporting petroleum, leaks can occur and may not be detected in time to prevent environmental damage. Not all leaks are required to be reported, as shown in Table 4.2, and the quantity of oil lost is sometimes difficult to measure. Environmental impacts may also be difficult to assess. A pipeline system safety and environmental effects analysis is needed to provide information about marine life pattern changes associated with offshore petroleum pipelines, and to reduce pipeline construction lead times by reducing the time required to develop environmental impact statements.

(a) 6200 North Central Expressway, Dallas, Texas.

TABLE 4.2. Pipeline Accident Report Requirements

<u>Regulating Ordinance</u>	<u>Responsible Agencies</u>	<u>Quantity (bbls)</u>
49 CFR 195.5(a)	DOT, OPSR	50 or more
30 CFR 250.43(b)	DOI, USGS, DOT, USCG	"All spills or leakage of a substantial size or quantity as defined by the supervisor, (USGS) and those of any size or quantity which cannot be immediately controlled also shall be reported."
OCS Order No. 7 (Established in accordance with 30 CFR 250.43)	DOT, USGS,	Less than 15. ^(a) 15-50 ^(b) More than 50. ^(c)

-
- (a) Oral report to District Supervisor (USGS) in 4 hours; confirmed by written report.
 - (b) Oral report to District Supervisor (USGS) in 12 hours; confirmed by written report.
 - (c) Oral report to District Supervisor (USGS) immediately; confirmed by written report.

- RECOMMENDED ACTION

A systems analysis is needed for offshore/Outer Continental Shelf pipeline systems. The study should assess the adequacy of current technology for OCS pipelines, including corrosion control, inspection methods and repair procedures, and determine the probable effects of pipeline leaks on surrounding marine life. The program should be directed toward reducing delays in planning and construction which are attributable to environmental concerns.

- PRIORITY

This is a moderately high priority and should be a 1 to 2 man-year effort beginning in FY-1980. The ECT should lead this activity in cooperation with the OPSR. Part of this effort would also be an appropriate task in a comprehensive program for oil spill management.

4.1.3 Environmental Impact of Pipeline Leaks

- CONCERN

Pipeline leaks that escape immediate detection may result in environmental damage.

- BASIS

Leak detection devices monitoring fluctuations in pressure and flow are regularly used for petroleum pipeline systems. With this type of continued monitoring, leaks are generally detected within twenty-four hours. However, at the lower limits of the detection range, the metering may not be sensitive to pressure and flow fluctuations caused by proportionally small leaks. Leak detection limits vary between 0.1 and 1 percent of the pipeline flow depending on the age of the system and flow conditions. Improved leak detection on the Trans-Alaska Pipeline is provided by metering systems sensitive to 0.1 percent of rated capacity flow. However, with a flow rate of one million barrels per day, the 0.1 percent sensing limit could allow losses of up to 1,000 barrels per day to go undetected.

Thousands of barrels of Prudhoe Bay crude oil were released by a sabotage attempt on the Alaska pipeline on February 15, 1978.⁽⁵⁷⁾ The leak detection system did not detect the leak, which was eventually reported by a private pilot flying over the line. Estimates of the peak rate of oil flow from the leak ranged up to three barrels (126 gallons) per second. The oil was contained in an area 600 feet in diameter around an above-ground section of the pipe about 6 miles east of Fairbanks. Up to 20,000 barrels of oil could have been released if the line had leaked all the oil in the affected section.

- RELATED WORK

Westinghouse, under a contract from Fluor Engineers and Constructors, Inc., developed a leak detection system for the Trans-Alaska oil pipeline. The system is capable of immediate detection of major leaks and early detection of leaks as low as 0.5 percent of capacity flow rate. The detection system depends on measurement repeatability. With constant pressure and temperature, if successive pairs of meter readings do not agree within 0.1

percent for a single batch of crude or within 0.15 percent for different batches of crude, a leak in the pipeline is indicated. Meter readings and related information are gathered and compiled at a center in Valdez, where appropriate action is initiated.

Routine pipeline surveillance and maintenance are important aspects of pipeline safety and accident prevention. During inspection and maintenance, pipelines are shut down while the pressure is monitored. A pressure drop may indicate a leak. However, there is normally at least a two-week interval between inspections. A leak occurring below the detection limit of the flow metering can usually be spotted visually. Pipeline personnel trained in ground and aerial surveillance can spot small pipeline leaks by indications such as a visible oil patch, a yellow vegetation area over the pipeline, a melted patch of snow or an oil sheen on water. Infrared film is also used in aerial surveillance of pipelines for determination of hot and/or cold spots which could indicate a pipeline leak.

- APPRAISAL

Leaks occurring below the detection limit of the flow instrumentation are generally located by routine surveillance. The quantity of oil lost is, however, sometimes difficult to estimate. Small oil spills on land are rarely of significant environmental concern. However, an oil pipeline leak that can reach ground water, waterways or the marine environment may cause environmental damage before it is noticed. This problem warrants further attention.

- RECOMMENDED ACTION

Because some pipeline leaks escape detection for a limited period of time, there is a need to ascertain the maximum amount of oil that could be lost (or intentionally diverted) without triggering the detection system. The potential environmental impacts and energy loss significance of such undetected leaks should be evaluated to determine whether the development of new pipeline operation and control techniques are warranted to address this problem.

- PRIORITY

The ECT should place a moderately low priority on this concern, because most pipelines are overland systems. A level of effort of 1 to 2 man-years, starting in FY-1980, is recommended as a specific project or as a task in a comprehensive program.

4.1.4 Oil Spill Trajectory Modeling

- CONCERN

Current modeling techniques for predicting the movement of oil spills are often inadequate. Inaccurate forecasting of oil slick transport and spreading can hinder clean-up efforts and lead to public reaction.

- BASIS

When an oil spill occurs, measures to minimize environmental impacts require a capability to forecast the short- and long-term behavior of the spilled oil. Accurate predictions of arrival times, locations and sizes of oil slicks are necessary to facilitate measures to protect beaches or areas of special biological significance. Imprecise forecasting can delay the implementation of protective measures. In the *Argo Merchant* incident, for example, the oil was predicted to move shoreward, reaching and perhaps destroying the beaches. The mistaken predictions hindered cleanup measures and the resulting public concern was immediate and intense.

Predictions of oil spill trajectories and the ultimate fate of oil in the marine environment are based on mathematical simulations of the many physical, chemical and biological processes and phenomena which interact in the event of an oil spill. Forecasts are limited by an inadequate understanding of these complex interrelationships. Even the more sophisticated probabilistic models do not consider all of the transport processes of petroleum in the marine environment. These incomplete models may yield misleading predictions regarding the movement of oil slicks. Restraints on predictive abilities also stem from the large amounts of localized data required to realistically operate the mathematical simulations; even if available, the accuracy of input data for some model parameters is questionable.

- RELATED WORK

A new oil spill model is being developed by R. L. Kolpak and a team of researchers at the University of Southern California (USC), funded by the American Petroleum Institute. The USC model, "Mass Balance Fate of Oil," is a complete system model, integrating present knowledge concerning the major physical, chemical and biological processes which are likely to affect oil spilled in the marine environment. The model will include advection and spreading mechanisms and place heavy emphasis upon the weathering processes. It will also include vertical and horizontal mechanisms of transport, thus enabling three-dimensional predictions. Environmental factors such as wind and wave conditions, currents and water and air temperatures are inputs to the model. However, different shoreline terrains upon which the oil may impact are not taken into account. Furthermore, only spills which occur at the surface will be modeled.

- APPRAISAL

Large scale oil spills throughout the world have had major local effects on the ecology of the ocean and coastlines near these spills. There is a growing worldwide concern over the environmental damage that can be caused by accidental releases of petroleum. Oil spill drift forecasting models can be instrumental in identifying areas of maximum environmental threat and directing efficient containment action.

Models have been developed that can predict spreading, transport and potential impacts of some actual spills. However, the development of the models has surpassed the availability of the detailed data required to reliably operate the simulations. Physical and chemical properties of the oil, the motion and composition of the water beneath the slick, and climatological conditions above the slick are all important in analyzing oil slick transformations. Most models, however, do not attempt to consider the full range of potential interactions because of the complexity of the relationships involved. For many of these processes, there is also a significant lack of data suitable for testing the basic hypotheses of modeling efforts.

Present techniques for predicting oil slick growth yield no better than order-of-magnitude estimates for slick size and configuration. None of the present models consider oil accumulation in bottom sediments, which may have ecological impacts on marine organisms and the shoreline. Current modeling techniques are most adequate when applied to relatively protected sites such as harbors and bays, where processes for which little is known (such as dispersion, weathering and wave influence) can usually be neglected for the short travel times involved. In more exposed environments, however, these processes must be considered.

Only surface instantaneous spills have as yet been modeled with any degree of success. Continuous surface oil spills may be partially modeled by approximating the spill as a series of discrete instantaneous releases. No methods presently exist for modeling subsurface spills. More research is necessary to incorporate subsurface transport models, the accumulation of toxic oil ingredients in particulates and sediments, and the long-term effects of decay processes in drift models. The USC model currently being developed may improve the accuracy of oil spill predictions. If not, efforts should be directed toward establishing an adequate data base from which improved and more extensive oil spill drift models may be developed.

- RECOMMENDED ACTION

Although the USC model is being developed as a scientific research tool, the U.S. Coast Guard should review the model, when published, for possible application as a predictive instrument. The need for a model capable of evaluating subsurface spills should also be assessed. The NOAA should contribute to establishing an adequate data base for improved oil spill drift models.

- PRIORITY

The existence of relevant effort in this area suggests a lower priority for this action than that for other oil spill-related recommendations. The U.S. Coast Guard and NOAA should implement the above studies at a recommended 1 man-year/year level of effort in FY-1980 to complement activities in the USC study.

4.2 TRANSPORTATION SYSTEM SAFETY

The concerns in Subsection 4.2 relate to the operational safety of petroleum transportation systems, including oil spill prevention practices. The accident risks associated with current and emerging technologies and the resulting potential for environmental impact should be evaluated in assessing system safety. Although new legislation requires segregated ballast on new oil tankers, there is no agreement as to whether the increased tanker construction costs would be justified by a substantial decrease in oil outflow. It is generally agreed that tanker accidents are responsible for only a few percent of the oil entering the ocean.⁽⁵⁵⁾ The cost-effectiveness of segregated ballast tanks in comparison to other pollution prevention techniques should be analyzed.

Other system safety issues pertain to the conventional waterway transport of petroleum. Human error is the major cause of merchant marine vessel casualties. Inadequately trained waterway personnel or insufficient numbers of enforcement officials may contribute to this problem. These concerns should be investigated from the standpoint of determining the real risk factors involved in the marine transport of petroleum and the effectiveness of various casualty prevention practices. Recommended action addressing concerns in this section can also be considered appropriate for the comprehensive program recommended in Subsection 4.1.

4.2.1 Training of Waterway Personnel

- CONCERN

Inadequately trained and/or poorly motivated waterway personnel may contribute to higher than acceptable vessel casualty rates.

- BASIS

Human error is a causal factor in 80 to 85 percent of all waterway casualties. Industry is concerned about this high incident rate and wants to increase the requirements for qualification of inland waterway personnel to obtain higher competence levels. The increased sophistication of marine petroleum transport vessels and equipment such as fathometers, dual radars, radios, and speaker systems, makes training programs desirable.

- RELATED WORK

The USCG is currently revising regulations which govern the qualifications of personnel involved in the handling, transfer and transportation of hazardous cargoes aboard vessels. The proposed rules⁽⁵⁸⁾ revise regulations governing the qualifications of marine operations personnel in petroleum transport. Also under study is the usefulness of ship simulators as training and examination tools. The House Coast Guard Subcommittee has been conducting hearings since June 1977 on merchant marine safety.

- APPRAISAL

Industry is concerned with the number of vessel casualties attributed to human error and has become involved with schools offering marine training programs, such as Seattle Community College and Lundeburg School of Seamanship. Some companies offer in-house training to their marine operations personnel. Training courses provide new employees with the basic procedures and techniques of marine operations, and review procedures or teach new skills to more experienced employees.

Programs are offered in fire-fighting, hazardous cargo transfer, equipment operations, safety procedures and other areas. Most marine operations personnel belong to unions, which also provide training programs for deckhands, engineers, mechanics and tankermen.

The only licensed officer aboard a tow or tugboat has traditionally been the operator. Regulations for increased qualifications would mean additional licensed personnel aboard petroleum transport vessels and should lead to reductions in marine casualties. Also, stricter standards must be developed and enforced regarding the number of hours one may stand on watch, and the testing and retraining of personnel. Although endorsements and licenses do not necessarily guarantee efficient personnel, they may result in an improved awareness of safety precautions and procedures. However, no comprehensive data base currently exists to show the cost-effectiveness of individual casualty prevention practices.

- RECOMMENDED ACTION

The USCG is presently involved in revising personnel qualification regulations. However, an assessment is needed to determine whether human risk factors are adequately accounted for in the marine transport of petroleum. The ECT and the USCG should cooperate in this assessment as an independent project or as a task in a comprehensive program.

- PRIORITY

This is considered to be a high priority and should be started in FY-1980 at a 1 1/2 to 2 man-year level of effort.

4.2.2 Insufficient Coast Guard Manpower

- CONCERN

The number of vessel and facility inspections and accident investigations are increasing as a result of the increasing number of regulations requiring enforcement by the USCG. This trend may reduce the Coast Guard manpower available for monitoring other aspects of waterway transport; this in turn may encourage a lower level of safety consciousness on the part of maritime operators.

- BASIS

The USCG is the principal enforcement agency for regulations governing the operation of vessels in coastal and inland waterways. The many regulations pertaining to petroleum cargo vessels require the USCG to use its limited manpower by establishing priorities for inspection and investigation of incidents. As both regulations and traffic increase, the USCG enforcement function may become too thinly spread to remain fully effective in encouraging all aspects of safe operation on U.S. waterways. Some operators, as a result, may risk reducing their compliance with safety regulations and thereby increase the probability of accidents.

Vessel construction standards and testing procedures are established by the American Bureau of Shipping (ABS) and published annually. The USCG inspects vessel construction plans for adherence to ABS standards and must

approve plans on the basis of lifesaving, engineering and electrical equipment specifications. The USCG checks the vessels periodically while under construction to ensure agreement with final specifications. The USCG is also responsible for vessel manning requirements. Inspections of "in-use" vessels require from one to three days, depending on the age of the ship and its previous history of deficiencies.

The USCG investigates about 5,000 accidents per year; each investigation usually requires one to two days. Approximately 3,000 of these accidents include vessel casualties,^(a) material damage, groundings and strandings. Every accident reported to the USCG must be investigated, including collisions, rammings, oil spills and fatalities. The District Safety Officer sends all accident reports to USCG headquarters. The Headquarters Commandant must address the recommendations contained in these accident reports.

- RELATED WORK

The Marine Investigation Division (MID) in the Office of Merchant Marine Safety was created in June 1976 to consolidate the investigative functions of the USCG Marine Safety Program. In forming the MID, the USCG recognized the need for a single division dedicated to investigative activities and to review, evaluate and follow up on required action.

- APPRAISAL

The USCG enforces a large number of regulations pertaining to marine vessels and facilities, crew size and qualifications, and navigation. Inspections and investigations proceed according to priorities which are established by the basic responsibilities of the USCG for safety of life at sea and protection of the marine environment. These priorities must often be changed to accommodate new requirements. In areas that have a small number of USCG personnel, this often means that investigations will require more time and inspections will be less frequent. The USCG is also responsible for overseeing oil spill-control operations if local authorities are unable to effectively

(a) Involving \$1,500 or more property damage to the vessel or facility.

handle or coordinate response activities. The USCG may have as few as half the personnel needed to effectively deal with marine accidents and oil spills.

- RECOMMENDED ACTION

A study of the impacts of potential USCG manpower shortages on marine safety and the environment is recommended. The U.S. Outer Continental Shelf and coastal areas may receive improved environmental protection if there are sufficient personnel to inspect vessels and facilities and investigate accidents on a timely, rather than a priority basis.

- PRIORITY

This study should be performed by the USCG, have a moderately high priority and be a continuing effort in USCG planning for future needs. A specific review of the effects of the present manpower situation should be supported in FY-1980 at the 1/2 man-year level of effort as a contribution to the oil spill management studies recommended in Section 4.1.

4.2.3 Cost-Effective Tanker Safety Design Standards

- CONCERN

Recent legislation mandates tanker safety design standards for crude oil and product tankers. These requirements may not provide the most cost-effective means of preventing tankers being a source of marine oil pollution and may result in unnecessary increases in oil shipment costs.

- BASIS

Senate Bill 682, which has been written into law as Public Law 95-494, sets up a list of design requirements for new and existing petroleum tankers. New crude oil carriers of 20,000 DWT or greater must be fitted with segregated ballast tanks (SBT), crude oil washing^(a) (COW) and inert gas (IGS) systems. Separate water- and oil-ballast tanks prevent the mixing of oil and water in the same tank and eliminate the need to fill cargo tanks with sea-water ballast. At present, the release of oily ballast water before reloading accounts for

(a) Crude oil washing uses the force of crude oil circulating in the cargo tanks to remove heavy residues and to sweep away oil left sticking to surfaces.

about 1.5 out of the 1.8 million tons of oil discharged annually into the sea from ships. Tank washing systems that use sprayed oil instead of water also reduce mixing of oil and water and resultant ocean pollution. Inert gas systems pump an inert or nonflammable gas into partly empty tankers to avoid fuel-vapor explosions.

Other requirements of the new law include the following: 1) existing crude oil carriers of 40,000 DWT or greater^(a) must have clean ballast tanks (CBT), SBT or COW systems; IGS must also be installed, according to a timing schedule set by ship size; and 2) petroleum product tankers greater than 40,000 DWT^(a) (and new product tankers over 30,000 DWT) must be equipped with CBT or SBT and have IGS installed. Standards for inspection and certification, backup radar and improved emergency steering are also included for existing tankers.

- RELATED WORK

Current Coast Guard studies on tanker safety design include the following:

- A feasibility study on retrofitting tankers between 20,000 and 70,000 DWT with segregated ballast.
- An evaluation of the costs and benefits of crude washing in cleaning oil tanks;
- An evaluation of design, construction and equipment standards for oil-carrying barges;
- A study of long-range vessel surveillance and control systems;
- An evaluation of devices to improve the maneuverability and stopping ability of large tankers. This research will include the use of a ship simulator.

- APPRAISAL

The use of segregated ballast tanks will diminish oil pollution resulting from routine ballasting and tank-cleaning operations and the spills

(a) The design standards also apply to existing tankers between 20,000 and 40,000 DWT which will be more than 15 years old in April 1978.

occurring as a result of human error or poor operating procedures during these processes. However, cargo tanks would still require cleaning in case of ship repairs or to carry some cargos, such as refined products, or even special crudes, which might be contaminated by the residues of other crude oil.

The use of separate tanks to prevent the mixing of ballast water and the lighter petroleum cargo floating on top of it is an expensive pollution prevention alternative. Converting existing tankers to segregated ballast tanks would reduce oil-carrying capacity by about 15 percent, and may cost between \$300,000 and \$3 million per vessel. There may also be a possibility of ships being unable to reach design speeds because of a reduced draft when sailing under ballast. Introducing segregated ballast tanks to the existing world tanker fleet will inevitably increase the cost of oil delivered by sea, perhaps by as much as 2 percent. There may also be difficulties in establishing monitoring equipment for oil/water mixtures and providing shore-based reception and disposal facilities for oily mixtures and residues which could no longer be discharged at sea.

A simpler, and less costly approach might be to allow the mixture of oil and water to settle for a few days in calm weather and then discharge relatively clean water. Another approach is to discharge dirty ballast into dockside "slop" tanks, as many U.S. tankers do.

Although segregated ballast is effective in limiting oil pollution from routine cleaning operations, it does not prevent releases in an accident situation. Furthermore, the new safety regulations will not be fully implemented for another five years. Interim prevention measures and the development of future oil pollution prevention standards and techniques as recommended in Section 4.1 should consider all available alternatives on the basis of acceptable public risk and cost/benefit assessments.

- RECOMMENDED ACTION

The DOE should assess the cost-effectiveness of tanker safety options considering the overall system-level implications and effects of alternatives on the cost and efficiency of transporting petroleum. This study would complement

current USCG efforts that appear to focus on specific areas of concern yet do not provide enough perspective on tanker operations as an energy material delivery system.

- PRIORITY

This effort should have a moderate priority and be supported at a 1 to 2 man-year level of effort in FY-1980.

4.3 TRANSPORTATION LOGISTICS

Potential problems are anticipated that may affect the adequacy of future petroleum transportation under emergency conditions and in response to increasing demand. These concerns suggest the need for a complete network vulnerability analysis of the national petroleum energy distribution system. Contingency plans for a variety of circumstances, including sabotage, emergency deliveries and route congestion need to be formulated to ensure uninterrupted and efficient delivery of petroleum products. This program should consider all fuels and transport modes. Specific tasks of this overall program are defined as recommended projects in the concern summaries presented in this subsection.

The severe winter of 1976-1977 is a recent example of natural phenomena creating emergency distribution problems. The cold weather blocked rail, water and truck traffic. Some barges on inland waterways were immobilized for as long as 45 days.⁽⁶⁰⁾ Although pipelines are not as susceptible to weather conditions as are other modes, they are vulnerable to sabotage. This problem is exemplified by recent sabotage on the Trans-Alaska Pipeline. Physical deterioration or inadequate capacity of facilities may also restrict the flow of petroleum materials. The need to address these problems is discussed below.

4.3.1 Emergency Distribution

- CONCERN

Petroleum transportation systems may be inadequate to supply future regional demands under emergency conditions.

- BASIS

The petroleum transportation system is designed to handle volumes somewhat in excess of normal demand. However, the peak demand for seasonal products, such as heating oil and liquefied petroleum gas (LPG), sometimes strains the capacity of links in the petroleum delivery system. Both natural and manmade conditions may result in supply system inadequacies. At the national level, future emergencies may result from loss of a foreign oil supply or military action. Local or regional emergencies may occur as a result of sabotage, congestion and natural disasters.

Under Section 101 of the Defense Production Act, a program has been developed by the Federal Preparedness Agency (FPA), DOE and the Department of Commerce (DOC) for the use of priorities and allocations for materials and equipment necessary to maximize domestic energy supplies. In the event of a national emergency, such as during wartime, the Defense Production Act Title I authorities can be used to control goods and services in the civil market. Federal agencies such as the Department of Transportation would allocate civilian transportation, DOE would allocate energy production and end use and DOC would control industrial production. The Treasury Department is authorized to grant waivers of the Jones Act, and the Maritime Administration may perform emergency planning regarding the movement of petroleum from overseas.

The Federal Disaster Assistance Administration (FDAA), in the Department of Housing and Urban Development, deals with natural disaster emergencies. Under the Disaster Relief Act,⁽⁶¹⁾ the President can declare certain areas to be in a state of disaster or emergency; FDAA may then mobilize men and equipment to aid in this situation. However, the Office of Emergency Transportation is currently proposing that the FDAA amend the Disaster Relief Act so that the Secretary of Transportation may obtain priority and allocation authority in nondefense situations.

The Federal Energy Administration, now part of the DOE, is responsible for handling all types of energy deficiencies; however, there is no approved national contingency plan for dealing with fuel shortages. The USCG is the

major agency for keeping navigational channels clear of obstructions. The Interstate Commerce Commission (ICC) handles emergency alternative routing, including rerouting orders for both rail and motor carriers and priority orders on freight to be carried. Emergency operating grants may be issued to motor carriers to provide special service. Certain restrictions on motor carriers may also be temporarily waived, such as permitting uncertified tank trucks to haul fuel. However, the ICC has no master plan for emergency situations, and, to date, crises have been dealt with on a case-by-case basis.

The above agencies take emergency action only as required. In the winter of 1976-77, for example, the Bureau of Motor Carrier Safety temporarily waived the maximum driving time regulations of 60 hours per week for tank truck drivers. Weight limits for fuel-carrying vehicles were also temporarily increased in 16 states. Besides fostering inefficient and possibly unsafe practices, the lack of cohesive emergency planning and delayed remedial action may also escalate the already high costs of interruptions in energy supply systems. The cold weather crisis of 1976-1977 demonstrated that industries in the affected regions were extremely vulnerable to fuel shortages. The problems encountered were caused by a decline in natural gas production and the disruption or unavailability of alternative fuel supplies. Companies were also affected by transport delays. The cold weather stalled rail, water, and truck traffic, slowing deliveries of raw materials and products. Ice gorges immobilized an estimated 6,500 barges, some for as long as 45 days. Railroad yards in Buffalo and other cities were inoperable. There were severe cutbacks in employment and output. General Motors Corporation alone suffered a production loss of around 150,000 cars and trucks and a loss of 4 million man-hours. Total unemployment caused by the weather reached two million.

- RELATED WORK

The study, "LP Gas Supply and Demand," by the LP Gas Federal Advisory Committee considers the supply, demand and transportation characteristics of LPG. A discussion of overseas transportation and necessary terminal

facilities is included and additions to current transportation facilities are suggested. The report was submitted to FEA on June 28, 1977.

A task force was formed by the FEA in July 1977 to produce a Winter Energy Emergency Planning Guide. This study will attempt to define emergency plans in the event of another severely cold winter with fuel shortages. Allocation and other federal measures to alleviate shortages (other than rerouting) will be investigated. A handbook for state government officials, entitled "State Planning for Winter Energy Emergencies," has been compiled.

The FEA Strategic Petroleum Storage Planning Program started in 1977 has the objective of providing for military petroleum requirements and priority demands in the civilian economy. This program should buffer the immediate effects of a possible embargo on oil imports. The development of storage facilities for crude petroleum and product reserves and the stocking of these facilities are the primary goals of the program.

In 1976, the regulations of the Mandatory Petroleum Allocation Program were evaluated by the FEA. This data was assimilated into a contingency program for future use. The ongoing study, "Embargo Contingency Plans," seeks to identify potential contingency alternatives and to amend various contingency plans adopted as circumstances change.

President Carter's energy policy proposes the creation of an emergency management information system to acquire the necessary data on local energy supplies and demand to respond to an oil embargo, natural gas shortage, or other energy emergency. The objective of the system is to assemble and provide rapid access to information that is used in the management of energy emergencies, including the capability to monitor and forecast supply and demand conditions and to assess the probable impact of alternative emergency response measures.

- APPRAISAL

There is no presently available comprehensive emergency plan which spells out alternative routing for various transportation modes at a national level. Before the organization of the DOE, there has been no central agency for dealing with energy material transportation under emergency situations.

Agencies responding to disaster situations have been forced to make decisions on remedial action quickly, under great stress, with fragmented authority for all emergencies less than a state of total war. These circumstances may lead to less than optimal choices and possibly unsafe transportation practices.

Classified plans for energy supply during military emergencies and contingency plans for dealing with future embargoes or any stoppage of petroleum supplies do exist. These include the establishment of strategic petroleum reserves and emergency rationing plans. The FEA's Winter Energy Emergency Plan addresses aspects of planning for natural disasters. However, this program deals with allocation measures, not transportation problems.

The impacts of changing fuel consumption patterns on emergency planning situations should also be investigated. Problems of final delivery to the consumer must be resolved. The coordination of emergency systems and the formulation of contingency plans are areas in which further work must be done.

- RECOMMENDED ACTION

A whole-system network analysis of the national energy distribution system is recommended to provide a data base for multiscenario contingency planning of energy material transportation under emergency conditions. A vulnerability study should be performed to determine the weaknesses of each transportation mode for specific emergency scenarios. Contingency plans should be formulated for each scenario that consider the cross impact between energy material systems and transportation modes. DOE should review current emergency plans to determine if they are adequate and complementary to a comprehensive national transportation contingency plan for energy material transportation.

The analysis should include possible impacts of changing fuel consumption patterns on the distribution system requirements and should periodically update scenario forecasting to accommodate changing conditions in the future.

- PRIORITY

This concern should be considered a high priority requiring program-level attention by the DOE with interagency cooperation. The ECT should support the recommended program by providing input on potential safety and

environmental impact scenarios associated with energy material transportation during emergencies. The recommended level of effort is 2 to 3 man-years/year as soon as resources are available.

4.3.2 Pipeline Sabotage

- CONCERN

The potential of sabotage to the Trans-Alaska pipeline and other major petroleum pipelines is a threat to the U.S. economy. Responses to such activity appear inadequate.

- BASIS

The Alaska oil pipeline is expected to eventually supply 15 percent of U.S. oil production and 7 percent of total U.S. oil consumption. The 800-mile pipeline, 420 miles of which are above ground, traverses through rugged, remote terrain subject to severe winter weather. The line crosses numerous bridges and has 151 valves and 12 pump stations.⁽⁶²⁾ The pipeline has been the subject of several sabotage attempts, one of which resulted in a release of oil. It has been estimated that a series of concurrent multiple explosions in the middle of winter could result in line rupture and crude oil freezing severe enough to shut down the pipeline for as long as one year.

- RELATED WORK

The Senate Judiciary Subcommittee investigating the pipeline sabotage problem concluded their report⁽⁶³⁾ by recommending the establishment of a Federal Office of Energy Security within the then new Department of Energy to coordinate security studies and make recommendations to the Congress on the need for additional security measures.

- APPRAISAL

The Alaska oil pipeline may be the most important link in the national petroleum transportation network that is vulnerable to sabotage. It is above ground and located in an extremely remote area. Essentially all security planning for the line to date has been by the pipeline owner (the Alyeska Pipeline Service Company) and the Alaska Department of Public Safety. There has been little federal involvement, other than a study by the U.S.

Coast Guard on the maritime security of the pipeline's southern terminus at Valdez. Coordinated federal study of the problem and establishment of preventive measures and response capability are needed and have been recommended by a Senate Subcommittee.

Vulnerability to sabotage is not limited to the Alaska pipeline. One expert testifying before the Senate subcommittee stated that concerted effort by a group of less than 50 people could cut off the supply of domestic oil and gas to the northeastern states.⁽⁶³⁾

- RECOMMENDED ACTION

The need for a pipeline security study is indicated. Among the items meriting consideration are the following questions:

1. How vulnerable is the Alaska pipeline?
2. If the pipeline is shut down, how would the U.S. economy be affected?
3. What security and intelligence measures can be used to protect pipelines?
4. What security measures, such as increased strategic petroleum reserves, standby rationing, additional surveillance of key portions of the line and the development of quick repair capabilities are most cost-effective?

The answers to these questions are needed as a data base for formulating the emergency contingency plans recommended in the previous concern summary.

- PRIORITY

The potential severity of this concern dictates a high priority and should be addressed at a 2 to 3 man-year level of effort in FY-1980. The DOE should coordinate its effort with the DOT and consult with the state and local police agencies, the Federal Bureau of Investigation (FBI) and other agencies with security expertise.

4.4 POTENTIAL LEGAL, REGULATORY AND INSTITUTIONAL PROBLEMS

The efficiency of the petroleum transportation system may be substantially affected by federal and state laws, including facility licensing procedures, eminent domain laws and oil spill liability requirements. Unnecessarily restrictive legislation, as well as conflicts between state and federal policies, may potentially limit the economic operation and necessary expansion of petroleum transportation and affect the future overall adequacy of the petroleum supply system.

The issue of oil company divestiture is of major concern. A reorganization of the petroleum industry may affect oil prices and transportation efficiency. The nonuniformity of and conflict between state and federal laws may hamper the movement of energy materials. Increased costs and the inefficient use of tankers, barges or rolling stock may result from failure to preempt certain state or local activities. Oil spill liability and compensation laws and pipeline right of way codes are also inconsistent from state to state and may limit crude oil carrier routing and pipeline expansion. Current licensing requirements for deepwater ports discourage the construction of these facilities by private industry. Since supertankers cannot use shallow conventional ports, the flow of crude oil imports to the U.S. may continue to be provided by smaller, less economical tankers.

Although these issues, for the most part, will be decided in Congress and in courts, the DOE and other governmental agencies should be a source of information and policy recommendations in these areas to support future decision-making and legislative action.

4.4.1 Petroleum Industry Reorganization

- CONCERN

The major petroleum companies are involved in each of the four basic stages of the industry: production, transportation, refining and marketing. These companies are also linked by a system of cooperative arrangements between firms. Most of the major petroleum companies have further diversified into coal and uranium, which are alternative fuels for oil and natural gas.

Antitrust actions in the courts and legislative proposals in Congress are intended to remedy some of these alleged anticompetitive practices through a variety of means, including the possibility of divesting major petroleum companies of their pipeline holdings. Pending the resolution of these matters, consumers may be faced with a suboptimal petroleum transportation system and uncertainty within the industry which may deter investments needed to maintain and develop the system.

- BASIS

On July 18, 1973, the Federal Trade Commission issued a complaint against the eight largest domestic oil companies, alleging a noncompetitive market structure in their refining activities on the East and Gulf coasts because of control of crude oil production and transportation. John H. Shenefield, Assistant Attorney General, Antitrust Division, has indicated support for petroleum company divestiture by judicial or legislative means. A number of states have commenced antitrust actions against major petroleum companies, seeking triple damages and other appropriate compensation.

During a recent session of Congress, the U.S. Senate Judiciary Committee reported the "Petroleum Industry Competition Act of 1976,"⁽⁶⁴⁾ which would have precluded major petroleum companies from engaging in more than two of the four basic stages of the industry. This bill, however, was not acted upon by the full Senate. During this session of Congress, initial scrimmages have been held on proposals to prohibit major oil companies from further purchases of coal or uranium assets.

Several alternatives for petroleum industry restructuring are being considered by the Federal Trade Commission, the Department of Justice and the Congress. Although divestiture of the petroleum industry has been debated for over thirty years, the issue may receive serious future consideration for three reasons: 1) the current Administration is sympathetic to improving competition; 2) petroleum and energy prices have a major impact on the economy; and 3) the Organization of Petroleum Exporting Countries (OPEC), a cartel of producing nations, is engaging in pricing and production policies that encourage monopolization.

The petroleum industry has expressed concern about the effects of divestiture on its continued ability to operate. The industry argues that divestiture would raise prices, reduce efficiency and diminish both domestic and international petroleum production, and therefore would adversely affect the economy and employment.

- APPRAISAL

The 20 major petroleum companies control 75 percent of domestic crude oil production and 90 percent of known reserves. They either own or control production, pipeline transportation, refining and marketing operations. In 1973, over 92 percent of the crude oil pipeline shipments reported to the Interstate Commerce Commission originated in pipelines that were owned and controlled by the top 20 petroleum companies.

Because it is crucial that oil flow to the refineries be continuous, there must be a high degree of cooperation and coordination between the production, refining and transportation interfaces in the delivery system. However, the U.S. Senate Judiciary Committee concluded that the petroleum industry structure is not competitive and that this results in, among other things, inefficiency in transportation and virtual exclusion of nonoil companies from providing pipeline transportation services.

The current structure of the oil industry may be contrary to the public interest in several ways. First, the major companies have nearly complete control over petroleum movements through the United States. A pipeline owned by major companies seldom seeks to provide transportation services to new customers, because such users are likely to be competitors. In contrast, independent pipeline companies would be in business to transport oil for any customer and would have every incentive to serve as many customers as possible.

Second, control of crude and product pipelines has the anticompetitive effect of controlling the conditions under which independent refiners obtain oil or sell their output. Interdependence among major companies is promoted by jointly planning and operating transportation lines. Planning requires the sharing of information, which inevitably informs each owner about his partner's capabilities and intentions. In other industries, information of

this kind is usually considered confidential and is carefully guarded. Control over transportation may assist the major petroleum companies in allocating markets and limiting competition among themselves and with independents.

Third, vertical integration, including ownership of transportation facilities, places major petroleum companies in a position to dominate and control petroleum consumption by permitting transfer pricing at any phase of the business. A new petroleum company may have to engage in all four phases of the petroleum business to become an effective competitor.

Major oil companies contend that ownership of pipelines is necessary because of the unwillingness of independent investors to construct pipelines. This, however, is directly related to their ability to secure throughput agreements for the transportation of the oil. With major petroleum companies reluctant to participate in the negotiation and compromise connected with developing a throughput agreement, independents may not be encouraged to construct or operate pipelines. Without divestiture, oil companies which are currently integrated have no incentive to bargain for oil transportation with an independent pipeline operator. Thus, it appears that if a climate for good faith bargaining can be established between oil companies and pipeline operators, there may not be any significant adverse impact on the movement of petroleum through pipelines as a result of divestiture. Indeed, some will argue that divestiture could provide the nation with an improved and more efficient transportation system.

If oil company divestiture is forced by the government, there may be a transition period of uncertainty and confusion as petroleum companies are reorganized and new operators gain control of and learn the business. During this period, the efficiency of petroleum product transportation could deteriorate and possibly create disruptions in supply and shortages which would be felt by consumers.

While the ultimate determination of whether or not divestiture should occur will be made by the courts or Congress, DOE assistance is needed during the public debate of this subject to develop recommendations that would improve competition within the petroleum industry while minimizing any disruption upon the energy transportation system.

- RECOMMENDED ACTION

DOE should develop a policy position on this issue, following careful study and analysis of the impact of previous divestitures, both within the petroleum industry and in other industries, and steps that can be taken to mitigate adverse⁷ consequences.

If a decision to implement divestiture is made, DOE should develop and analyze methods available for accomplishing corporate reorganizations with the least amount of disruption to energy transportation and delivery systems. This may include recommendations for appropriate legislation or the formulation of amendments to judicial divestiture decrees.

If divestiture does not occur, DOE should provide leadership in examining alternative methods to encourage more efficient, lower cost petroleum transportation. Such alternatives may include the recommendation of regulatory revisions, an extension of DOE authority to order increases in pipeline capacity, the construction of any needed additional terminal facilities, and the regulation of pipeline rates to assure availability to all shippers, whether owners or not, on a nondiscriminatory basis. Since Section 306 of the Department of Energy Organization Act transfers to DOE all functions of the ICC relating to the transportation of oil by pipeline, the DOE would be in a position to implement many of these regulatory changes.

- PRIORITY

An examination of the divestiture issue and other alternatives for improving the performance and efficiency of the nation's oil transportation system should have high priority. Since proposals for improving competition within the oil industry are undergoing close scrutiny by the Federal Trade Commission, the Department of Justice and the Congress, the DOE should promptly provide information and policy recommendations to ensure that the energy implications of any such program are carefully considered. In addition, pending the consideration of divestiture matters, urgent attention should be accorded to improving DOE's regulatory framework over oil transportation by pipeline. The suggested level of effort for this program is 2 to 3 man-years starting in FY-1979 or FY-1980.

4.4.2 Preemption

- CONCERN

Although many federal laws regulate the movement of energy materials for safety and environmental reasons, some states assert that federal regulation is inadequate to protect state interests. These states may adopt laws which regulate energy materials transportation more strictly than federal laws do. Burdensome design requirements or lack of uniformity among state regulations may hamper the required flow of petroleum products.

- BASIS

State action in at least two areas of transportation regulation has caused considerable concern among energy material shippers. A number of coastal states have passed legislation regulating oil tanker traffic within their coastal jurisdiction^(a) while others have passed legislation regulating highway and rail transportation of hazardous materials (including LNG and nuclear fuels) within their state borders.^(b) In both areas, there are concurrent federal laws which were ostensibly designed to accomplish objectives identical with those of the state legislation. The states acting in these areas, however, feel that federal regulation is inadequate to protect local interests. Thus, stricter regulations have been implemented, which in some cases may hinder the movement of petroleum products.

- RELATED WORK

The foremost illustration of the issues involved in this concern is the Atlantic Richfield Company's challenge to the Washington State tanker law. The Washington law regulates oil tankers operating in Puget Sound. Section 2 of the statute requires any tanker in excess of 50,000 DWT to employ a locally licensed pilot; Section 3(1) bars those tankers greater than

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- (a) See, for example, Conn. Gen. Stat. Ann. § 25-54 cc (equipment on board vessels to contain oil spills); Me. Rev. Stat. Ann. Tit. 38, § 560 (3) (authority to prohibit anchorage of oil tankers); N. H. Rev. Stat. Ann. § 145-A: 11 (operation and equipment of oil tankers).
 - (b) See, e.g., Conn. Public Act No. 76-321 (June 1, 1976); Org. Reg. Stat. 469.530; 1976 Laws of New York State, Chapter 641, § 14f.

125,000 DWT from entering Puget Sound waters; and Section 3(2) prescribes minimum design specifications for tankers between 40,000 and 125,000 DWT, which may be waived for tankers accompanied by a sufficient number of tugboats.⁽⁶⁵⁾ In September 1976, a three-judge federal district court held that the state law was preempted by the Ports and Waterways Safety Act of 1972⁽⁶⁶⁾ and therefore could not legally be enforced. The decision was based, in part, on the reasoning that a uniform set of regulations governing types of ships permitted within U.S. coastal waters is desirable and that the Coast Guard is vested with the authority to establish regulations for vessels entering Puget Sound.⁽⁶⁷⁾ The Coast guard has subsequently established restrictions on the size of tankers in Puget Sound on a temporary basis. The district court decision was appealed to the U.S. Supreme Court.

The Supreme Court, on March 6, 1978, struck down most of the provisions of the Washington State Tanker law⁽⁶⁸⁾ on the basis that states are preempted by federal law from limiting the size of oil tankers using their territorial waters. The Justices, did, however, allow the state to require tug escorts for tankers in Puget Sound, at least until federal authorities issue guidance on tug-escort requirements. The state may also require local pilots for vessels engaged in trade with foreign countries, although the state cannot impose such a requirement on vessels involved in domestic trade. This outcome may affect the validity of other state laws regulating oil tankers, as well as have implications concerning the power of states to regulate other energy material transportation modes.

Commentators have noted that the Court's recent trend toward reconciliation of federal and state regulation and the changes in personnel since the last Court decision upholding preemption of a state law indicate that substantial review of the preemption doctrine (in the environmental area) may occur, perhaps allowing states greater regulatory authority than they have possessed in the recent past.^(a) Congress may also have a role in the

(a) See generally, Comment, Fallout from the California Nuclear Initiative, 6 ELR 10174 (August 1976); Note, The Preemption Doctrine: Shifting Perspectives on Federalism and the Burger Court, 75 Colum. L. Rev. 623 (1975).

ultimate disposition of such cases. Senator Warren Magnuson (D.-Wash.) announced previous to the Supreme Court ruling that if the district court decision were upheld, he would introduce legislation to give coastal states regulatory authority over supertankers to protect local interests.⁽⁶⁹⁾

- APPRAISAL

Legislation to protect local interests is viewed as necessary by the states because the Coast Guard has not yet developed national design standards which address various state concerns.⁽⁷⁰⁾ The states' argument is that where there is no clear preemption of state regulatory authority, states are free to regulate matters of local concern, even though the regulation affects interstate commerce.⁽⁷¹⁾ The shippers, on the other hand, feel that a variety of state regulations will prevent the efficient use of tankers and may lead to higher prices for oil, as well as interfere with any standards set by international agreements, causing retaliatory foreign controls against United States shipping.⁽⁷²⁾

The conflict is as old as American federalism and will continue as long as states feel that their concerns are not being addressed on the federal level. The question is not one of how to prevent state action, but of how to best address state concerns during the development phase of federal regulations affecting energy materials transportation.

Although the conflict concerning federal/state regulatory authority over oil tankers will rely on the courts for its resolution, other mechanisms are available to balance state and federal interests.

One approach would be to address state and local concerns while federal administrative regulations are being developed. This would involve soliciting state input and incorporating concerns expressed prior to the proposal and adoption of federal regulations. The states would thus have some assurance that their concerns would be addressed at the administrative agency level, which may help avoid subsequent adverse reactions to federal regulatory authority. The difficulty with this approach is that federal agencies promulgate many proposed regulations and it is unrealistic to expect states to be involved routinely or to intervene in such proceedings.

Another approach is to allow for inconsistent state regulation, even though state authority may otherwise be preempted by federal regulations. This approach of allowing for a "nonpreemption determination" has recently been adopted by the Department of Transportation (DOT) in hazardous materials regulations.⁽⁷³⁾ The Hazardous Materials Transportation Act (HMTA)⁽⁷⁴⁾ expressly preempts "any requirement, of a State or political subdivision thereof, which is inconsistent with any requirement" of HMTA or regulations issued under HMTA. The Act also provides that preemption of such inconsistent state or local requirements is terminated if the state can convince DOT that its requirement provides a greater level of public safety than the federal requirements and does not unduly burden commerce. The administrative process has two steps. A determination as to inconsistency is first made. Then, if the ruling is adverse to the state, the state may elect to file for a non-preemption determination.

The City of New York is currently involved in this process. The City, in January 1976, amended its health code to restrict the movement of radioactive materials through the City.⁽⁷⁵⁾ A challenge to this regulation as being inconsistent with DOT regulations was filed in March 1977 by Associated Universities, Inc., which operates Brookhaven National Laboratory for scientific research and is both a consignee and shipper of radioactive materials. Brookhaven is located in Upton, Long Island, and the only land route from Brookhaven to the mainland is through the City. On April 4, DOT issued an initial administrative ruling that determined that the New York regulation was not inconsistent with the requirements of HMTA or the regulations issued thereunder. DOT determined that the New York City requirement was in the nature of a routing restriction, that there were no HMTA routing requirements, and that the New York requirement was thus not inconsistent with Federal requirements. However, DOT also announced its intent to commence Federal Rulemaking to consider the need for routing requirements under HMTA for highway carriage of radioactive materials.^(a) This decision is subject to appeal.

(a) DOT Materials Transportation Bureau, Inconsistency Ruling (IR-1) April 4, 1978.

Whether a decision made with the expertise of DOT will result in a resolution of the conflict in a manner more acceptable to the parties involved than a decision made in the courts remains to be seen. However, an administrative determination may be made more quickly than one which must move through the court system. At this point, however, greater acceptability and a quicker resolution can only be assumed, for the nonpreemption determination process has not yet been completed by any state or local government.

The consideration of state-level answers could lead to a restructuring of federal regulations and the adoption of regulations which are more effective in accomplishing their intended purpose. An approach which would incorporate this objective may be to establish federal standards and permit the states to set their own possibly more stringent requirements. These requirements would be enforced after receiving federal approval for their implementation. This approval process could include a round of negotiations to reconcile differences in state and federal requirements.

- RECOMMENDED ACTION

An analysis should be undertaken to identify the various mechanisms available for soliciting state and local concerns regarding energy materials transportation and for incorporating such concerns into the development of federal regulations. These mechanisms may include federal funding for federal/state conferences and legislation which allows, encourages, and facilitates state input even after adoption of federal regulations.

An evaluation of the DOT nonpreemption determination process should be initiated to ascertain its effectiveness in resolving state/federal conflicts and the feasibility of its use in other areas of concern relating to energy material transportation.

- PRIORITY

Because of pending litigation in this area and the prospect for continued conflicts in the future, this concern is of high priority and demands early attention and detailed analysis. While much of the needed action requires the involvement of other agencies, the DOE should play an active role in encouraging the development of effective federal regulations consistent with

a goal of ensuring the adequacy of energy materials transportation in the future. A level of effort of 1 to 2 man-years/year starting in FY-1979 or FY-1980 is recommended.

4.4.3 Federal Right of Eminent Domain

- CONCERN

Expansion of the petroleum pipeline network to transport Alaskan crude oil in the lower 48 states may be impeded due to the lack of a federally granted right of eminent domain.

- BASIS

Although the majority of the states in the U.S. (42 of the 50) have granted the right of eminent domain to common carrier petroleum pipelines, there is no uniformity in the codes. Pipeline construction can be delayed by negotiations for rights of way. Further delays result from the number of federal, state and local agencies that must grant permits or otherwise be involved. An environmental impact statement is also required, the approval of which may result in delays of two years or more.

- RELATED WORK

The Federal Land Policy and Management Act of 1976 authorizes the establishment of uniform regulations for the use of public lands through coordinated efforts of the Bureau of Land Management (BLM) (Department of the Interior), and the Forest Service (Department of Agriculture). These agencies are working toward establishing a uniform set of regulations for common carrier petroleum and natural gas pipelines.

Oil and gas pipelines are regulated under the Mineral Leasing Act of 1920, amended in 1973.⁽⁷⁶⁾ A new, uniform set of regulations for oil and gas pipelines has been sent to the Department of Interior for corrections, additions and approval. The proposed regulations authorize the DOT Secretary to grant rights of way for pipelines that cross two or more parcels of land administered by different federal agencies. They also provide for stipulation of construction and operation conditions by the Secretary. Authority for granting and managing such pipeline rights of way has been delegated to the BLM.

Natural gas pipelines regulated by the Federal Energy Regulatory Commission have a federally-granted right of eminent domain. Coal slurry pipelines are seeking legislation on both the federal and state levels to provide them with the right of eminent domain.

- APPRAISAL

Environmental concerns and an apparent fear of competition by the railroad lobby are major causes of delay in pipeline construction. Obstacles to construction are also encountered in securing rights of way, the length of delay being dependent upon the route and the length of pipeline and the number of separate rights of way to be negotiated. Various federal, state and local agencies must grant permits or easements for pipeline construction. The ownership of the land determines which agency is appropriate (see Table 4.3). Lengthy court proceedings stemming from conflicting regulations are another source of delay. Conflicts arising when two or more requests are made for a specific right of way area are also referred to the courts.

The Federal Land Policy and Management Act of 1976 is a major step toward the development of a uniform code of regulations. However, there is as yet no consistent policy regarding the granting of rights of way. A national policy on this issue is required to facilitate pipeline construction and to reduce lead times.

- RECOMMENDED ACTION

An assessment is needed to determine if it would be in the national interest to grant energy material pipelines a federal right of eminent domain. The BLM, already working on establishing a uniform set of pipeline regulations, should specifically address the eminent domain issue. Consideration of environmental and safety issues in this effort may require contributions from the ECT.

- PRIORITY

A high priority is indicated because of the lead times involved. A position on the eminent domain issue would assist policy decisions and encourage legislative action. A recommended level of effort for this program is 1 to 1 1/2 man-years starting in FY-1979.

TABLE 4.3. Federal Agency Regulations for Pipeline Construction

Federal Action Agency	Activity Requiring Approval	Form of Approval	Authority
Bureau of Land Management (Department of Interior)	Construction and easement across BLM lands.	Permits for right-of-way and temporary use outside of right-of-way.	Sec. 28 Mineral Leasing Act as Amended. 43 CFR 2800 43 CFR 288 43 CFR 2800 Federal Policy & Mgt. Act of 1976.
Bureau of Indian Affairs (Department of Interior)	Survey, construction, and easement across Indian Tribal Lands.	Permits for right-of-way and temporary use outside of right-of-way.	33 Stat. 65 39 Stat. 973; 25 USC 321 62 Stat. 17; 25 USC 323-328; 25 CFR 161
National Park Service (Department of Interior)	Construction and easement across National Parks.	Permit for temporary use outside of right-of-way.	36 CFR 5.7.
Fish and Wildlife Service (Department of Interior)	Construction involving temporary use of National Wildlife Refuge or areas with wetland protection easements.	Permit for temporary use outside of right-of-way.	43 CFR 2800
Bureau of Reclamation (Department of Interior)	Crossing of land and facilities within an existing irrigation project developed by the Bureau of Reclamation.	Crossing agreement contract.	32 Stat. 388 43 CFR 230
Bonneville Power Administration (Department of Interior)	Crossing of Bonneville Power Administration easement.	Joint use permit.	Permit negotiated, no regulations.
Forest Service (Department of Agriculture)	Construction and easement in National Forest lands.	Special use permit.	36 CFR 251.50 et seq. 36 CFR 212.10
Corps of Engineers (Department of Army)	Dredging, filling, breakwater construction, construction of a pipeline in an estuary area.	Department of Army permits.	River and Harbor Act of 1899; Water Pollution Control Act as Amended 1972; 33 CFR 209.120
Environmental Protection Agency NPDES (Discharge Permits)	Wastewater discharges.	Permit.	Water Pollution Control Act as amended 1972 33 CFR 209.120 40 CFR 124-125
PSD (Prevention of Significant Deterioration)	Air emissions from certain facilities.	Approval to construct or modify.	40 CFR 52
Federal Aviation Administration (Department of Transportation)	Construction of obstruction more than 200 feet high, construction of obstructions near airports, construction of any kind near or on airport.	Applicant to serve notice subject to disapproval.	Federal Aviation Regulation Part 77.
Coast Guard (Department of Transportation)	Construction of bridges over navigable waters.	Permit.	General Bridge Act of 1946 as amended 60 Stat. 847; 33 USC 525 et seq.
Federal Communications Commission Safety & Special Radio Services Bureau	Operation of microwave transmission towers.	Notification of operation.	Communications and Satellite Act, 1962; 76 Stat. 419; USC 701, 744.
Interstate Commerce Commission	Operation of pipeline as a common carrier.	Approval for tariff, rate of depreciation, and fair value rate base.	49 CFR, Subtitle B, 1000-1399
	Radio communications equipment operation.	License	47 CFR Chapter 1

4.4.4 Licensing of Deepwater Ports

- CONCERN

The administrative aspects of licensing and establishing deepwater ports discourage the construction of these ports by private industry. Since most existing U.S. ports are too shallow to receive VLCCs^(a), the efficiency and operational advantages of these large tankers are not being exploited in the transportation of crude oil imports. The resulting necessary reliance on a larger number of smaller tankers increases the cost of transportation and the potential for accidents and congestion in harbors and coastal waterways.

- BASIS

Petroleum will most likely remain the prime energy source over the next 30 years, with imports becoming increasingly important. A median crude oil import forecast for 1985 is approximately 10 million bbl/day (comparing Figures 3.1 and 3.2), or 47 percent of the projected national oil consumption rate. Petroleum import supply sources are shifting from Canada and Venezuela to the more remote locations of the Middle East and Nigeria. Longer distances and projected growth in petroleum imports create a demand for increased tanker tonnage. The 250,000 DWT ship, having a 60-foot draft, may be the most economic size alternative. Although there are about 150 deepwater loading/unloading facilities in operation worldwide, there are currently only two U.S. ports^(b) (Valdez, Alaska, and Puget Sound, Washington) capable of handling these larger vessels. There are no deepwater ports in the Mid-Atlantic area, where nearly all crude oil is imported by tanker. Current deepwater port proposals center in the Gulf of Mexico.

There are alternatives to the use of deepwater port facilities. Lightering and/or transshipment partially employ the VLCC economy, but the double

(a) Very Large Crude Carrier. These ships range in size from 100,000 to 500,000 DWT, may exceed 1,000 feet in length and have drafts of up to 90 feet or more.

(b) Until recently, the use of Puget Sound was restricted by a Washington State law forbidding entry to ships larger than 125,000 DWT. This state law was struck down by a Supreme Court ruling on March 6, 1978 (Subsection 4.4.2). Washington State may attempt in the future to effectively limit tanker size in Puget Sound by controlling port size and siting.

cargo transfer is more expensive than direct shipment. There are also congestion problems and a greater accident potential associated with the use of a large fleet of small vessels. The option of locating deepwater terminals in another country could lead to a supply security risk for the U.S. Another transport option would be to dredge, maintain and modernize existing ports to handle larger tankers. This alternative however, involves severe economic and environmental problems. Other options include increasing domestic supplies of oil and other energy materials while reducing dependence on foreign oil by conservation measures. Most forecasts of oil supply and demand show this scenario to be impractical during the balance of this century.

In issuing licenses for deepwater ports, the DOT must be assured that 1) the construction of the port is in the national interest; 2) there are no foreseeable antitrust problems with the operation of the port; and that 3) the port presents no safety or environmental hazards. Industry objections to current licensing conditions include the following:

- Deepwater port owners/operators may be liable for the negligence of government agencies.
- Deepwater port owners are required to unconditionally guarantee major obligations of the project, without regard to the port's financial viability as a separate corporation.
- Government restrictions on owner's rights and prerogatives to manage and operate the port.
- Oil spill liability and insurance requirements.
- Marine tankers which use port facilities must fulfill certain design and liability requirements.
- Open membership requirements.
- RELATED WORK

Louisiana Offshore Oil Port (LOOP), Inc., has accepted the terms of a deepwater port license from the Secretary of Transportation. The license contains safeguards against anti-competitive abuses of ownership, control

or operation of the deepwater port. The port will be located in the Gulf of Mexico, south of Grand Isle, Louisiana, and will initially be capable of handling about 1.3 million barrels of oil per day. It is planned to later increase the port capacity to 3.4 million bbl/day. Construction for the \$350 million terminal is expected to begin in 1979. The port is expected to be ready to unload its first tanker late in 1980.

The Texas Deepwater Port Authority (TDPA) was established in 1977 by the state to salvage the privately financed SEADOCK proposal. SEADOCK collapsed after three of its largest members pulled out, mainly because of strict antitrust provisions in the DOT license. The TDPA will issue bonds to finance the construction of the oil terminal, to be located 26 miles offshore from Freeport, Texas, in about 100 feet of water. TDPA would lease the port to users who would operate the terminal. Revenue from operation of the port would provide funds for payments to bondholders. TDPA has filed an application for transfer of a license issued earlier to SEADOCK, Inc., with the DOT.

Inshore deepwater ports are being considered on the Texas Coast, by the Port of Corpus Christi and the Port of Galveston. Both involve deepening of existing channels to accommodate 250,000 to 400,000 DWT tankers. These ports would require approval by the Corps of Engineers, but do not fall under the jurisdiction of the Deepwater Port Act.

- APPRAISAL

Regulatory power over deepwater ports is fragmented and may result in agencies working at cross-purposes, or instituting conflicting regulations. Deepwater ports situated in local waters are required to have permits from the U.S. Army Corps of Engineers. They are not, however, subject to the Federal Deepwater Port Act. Ports constructed inside the three-mile limit are regulated and licensed in a totally different manner from ports outside this limit. There is no guarantee that ports located in local waters would meet the stringent minimum safety and environmental standards set at the federal level. These local ports also lack coverage under the insurance and liability sections of the Deepwater Port Act.

Licenses issued by the Secretary of Transportation for the construction and operation of deepwater ports include provisions aimed at preventing monopolies. The LOOP license mandates open membership and seeks to inhibit preferential use of the dock by the owners. If the facilities become overcrowded, the owners are required to expand them. The license also tries to ensure that port owners who also own pipelines will not discriminate against non-owner shippers. LOOP, Inc., has accepted the license terms, despite objections by and the subsequent withdrawal of one of its shareholders, Union Oil of California (12 percent interest).

Deepwater ports appear to be the most attractive alternatives among options to facilitate the anticipated increase in oil imports. However, certain aspects of the licensing process and the wide variation in construction and licensing requirements between inland and offshore deepwater ports may hamper the development of these ports. Regulatory power over the ports should be consolidated to assure operation in the safe and environmentally acceptable manner intended by the Deepwater Port Act. Lead times for planning and preparation are 3 to 5 years and another 2 to 5 years is needed for construction. These lead times require immediate decisions on deepwater port regulatory policies that will encourage construction of these facilities in time to handle future increases in oil imports efficiently and safely.

- RECOMMENDED ACTION

The USCG should evaluate current licensing requirements and work with other agencies to achieve a consensus on the regulations applying to deepwater ports. The impacts of various regulatory scenarios on transportation cost, safety, environmental concerns and energy efficiency should be considered by the DOE. The ECT should support the DOE effort in addressing the safety and environmental aspects of this concern.

- PRIORITY

Lead times for the planning and construction of deepwater ports place a high priority on formulating policy and decision-making. The recommended DOE study should require a 1 man-year effort starting in FY-1979.

4.4.5 Oil Spill Liability and Compensation Laws

- CONCERN

The current patchwork of federal and state oil spill liability and compensation laws creates both overlap and gaps in liability and compensation coverage and may contribute to inefficient routing of crude oil carriers.

- BASIS

All of the 23 coastal states have statutes on oil pollution, varying widely in their coverage and application. At the federal level, the Federal Water Pollution Control Act (FWPCA), the Trans-Alaska Pipeline Authorization Act (TAP), the Deepwater Port Act (DPA) and proposed amendments to the Outer Continental Shelf Lands Act all address oil spill liability. International coverage is provided by the Intergovernmental Maritime Consultative Organization (IMCO). Independent oil spill funds have been established by the oil and shipping industries.

Liability requirements in Florida have virtually stopped barge and tanker traffic, although amendments to the Florida Pollution Spill Prevention and Control Act have eased the situation somewhat by establishing a liability fund. Payments of 2 cents per barrel excise tax on shipping oil have, so far, created a fund of approximately \$16 million, covering claims which have averaged several thousand dollars.

- RELATED WORK

The Coast Guard and Treasury Department are conducting a study on the development of a fee collection mechanism. A fee of not more than 3 cents per barrel on imported oil or oil to be exported from refineries or terminals would be collected if pending legislation is passed.

The Comprehensive Oil Pollution and Compensation Act of 1977^(a) passed the Committee on Merchant Marine and Fisheries on September 12, 1977. It is presently awaiting action before the Senate Commerce and Environmental Committees.

(a) House Resolution 6803.

- APPRAISAL

Oil shipment routing has so far been affected only moderately by state liability laws. However, underwriters have found it impossible to provide insurance coverage to meet all of the varying standards and limits of liability provided in the different state laws. Coverage for claims resulting from oil pollution is currently excluded from the standard general liability coverage offered by insurers. Most large oil companies self-insure their cargoes and vessel hulls.

Oil and shipping industry lobbying efforts support comprehensive oil spill liability and compensation legislation which includes federal pre-emption of state laws. However, some states are asking to be allowed to impose more stringent requirements than those of the federal government (Subsection 4.4.2). The costs of these variable state laws will be passed on to the consumer. Petroleum transportation would benefit from the passage of comprehensive federal liability laws.

- RECOMMENDED ACTION

DOE support of current legislative efforts to establish a national system of oil pollution liability and compensation is encouraged. However, it should be noted that recognition of international liability requirements will impact American import practices. A study by the USCG to review proposed policies would be useful.

- PRIORITY

A USCG review of proposed policies, requiring a half to one man-year in FY-1980, is recommended as a moderate priority. The ECT should support this effort in issues of safety or environmental concern.

5.0 LATENT CONCERNS

This section contains a brief account of latent concerns which, at present, do not appear to warrant additional attention in new programs. Latent concerns fall into two categories:

1. Perceived concerns which have a low probability of occurrence or were unsubstantiated by the available information.
2. Potential problems which are currently being adequately addressed or resolved by ongoing industry or government programs.

The DOE and other affected agencies should maintain an awareness of possible future changes in the importance of these concerns.^(a)

5.1 PERCEIVED CONCERNS

The following concerns are the focus of current research and debate. For the reasons stated below, these concerns are judged, in their present perspective, to be either unsubstantiated or inconsequential.

5.1.1 Effectiveness of Vessel Traffic Services

- CONCERN

Newspaper reports have suggested that the Vessel Traffic Services (VTS) operated by the U.S. Coast Guard (USCG) may tend to increase rather than decrease the accident potential in harbors where VTS are used. If this is true, the press treatment of this concern may have a negative impact on the acceptance and cooperation needed on the part of vessel operators to make the VTS useful to navigation.

- BASIS

Several negative comments on the operation of the VTS attributed to a captain and a pilot of oil tankers operating in Puget Sound have been reported

(a) Sources of information used in Section 5 include the cited references in Section 6 and the annotated bibliography and personnel contacts indicated in Appendix I.

by the press.^(a) The principal thrust of criticism was that inexperienced USCG officers in charge of the VTS may provide navigational guidance contrary to sound professional judgment and that VTS should be manned by civilians. Press coverage of an official reaction to these comments has not been apparent.

- RELATED WORK

The USCG has installed VTS in three coastal areas (San Francisco, Puget Sound and Houston-Galveston) and is in the process of developing VTS in New Orleans, Valdez and New York. The goal of an ongoing, five-year VTS study is to reduce the number of groundings, collisions and polluting incidents by use of improved traffic management. The Transportation Systems Center will participate in this study, investigating stress and stress-related conditions in an attempt to reduce the human error factor in accidents. The USCG provides special training to personnel assigned to VTS and is using the findings of its R&D work to improve VTS effectiveness. The potential of applying VTS in coastal waters out to the 200-mile limit was investigated in a 6-month study by the USCG authorized by President Carter.

- APPRAISAL

Use of VTS is advisory only and does not usurp the ship captain's prerogative and responsibilities for the safe control of his vessel. The VTS personnel are required to undergo both classroom instruction and practical training aboard various types of vessels, and only the most experienced officers fill VTS watch officer positions.

The VTS operations differ by port areas. Requalification of VTS personnel and mandatory communication (vessels entering must report to VTS) are requirements in Puget Sound. However, in San Francisco requalification is not required and communication is voluntary. In any case, cooperation with VTS-supplied guidance information is required on the part of vessel operators to make the system an effective aid to safe navigation.

(a) Cf. Newspapers in the Pacific Northwest on or about February 14, 1977. The comments of Captain Keisch and Pilot Endrody were implied to be typical opinions.

The concern as treated by the news media cannot be substantiated. Experience with VTS to date has been encouraging and can be correlated with reduced accident frequency. As shown in Table 5.1, vessel accidents (groundings, ramming and collisions) and injuries have generally been reduced by using VTS in San Francisco Bay, Puget Sound and Houston-Galveston.⁽⁷⁷⁾ The apparent anomaly in collision, ramming and grounding trends in Puget Sound may be attributed to the fact that while VTS operations went into effect in September, 1972, they did not affect the Strait of Juan de Fuca until March, 1975. Available statistics indicate that all collisions and groundings in the Puget Sound area in 1973 occurred in the Strait of Juan de Fuca. Effort in on-going and planned programs can be anticipated to improve VTS in the future. No additional effort is warranted at present.

TABLE 5.1. Annual Average Collision, Damage and Injury Statistics Before and After VTS Operation^(a)

	<u>FY 63-69</u> <u>(Before VTS)</u>	<u>FY 73-75</u> <u>(VTS Operational)</u>
<u>San Francisco</u>		
Number of Collisions	12.4	2.3
Number of Collisions, Ramming and Groundings	25.4	14.7
Dollars Damage	\$2,274,000	\$1,660,000
Deaths and Injuries	1.1	0
<u>Puget Sound</u>		
Number of Collisions	3.5	1.0
Number of Collisions, Ramming and Groundings	10.5	17 ^(b)
Dollars Damage	\$807,000	\$411,000
Deaths and Injuries	0.9	0

(a) Taken from paper G-WLE 2/73, January 11, 1977, and substantiated by Rear Admiral Anthony F. Fugaro's statement. ⁽¹⁾

(b) This number includes accident statistics from the Strait of Juan de Fuca where VTS did not become operational until March 1975.

5.1.2 Loss of Aging But Crucial Pipeline Links

- CONCERN

Critical links in the petroleum pipeline distribution system may be lost partially or totally because of their age, resulting in serious disruption of the petroleum distribution system.

- BASIS

In Project Independence Blueprint,⁽⁷⁸⁾ it was suggested that once pipelines are constructed, they continue to operate indefinitely, sometimes under suboptimal conditions of reduced pressure and throughput. Pipelines in excess of thirty years old are still in regular use. Failure of some older lines in crucial links of the system may result in disruption of a major portion of the petroleum distribution system.

- APPRAISAL

Continuous monitoring, maintenance and surveillance of petroleum pipelines by industry has so far provided petroleum distribution that is both safe and economical. Pipelines are cleaned on a regular basis and inspected for corrosion. Older pipelines are subject to relatively closer scrutiny than are newer pipelines, to avoid the repair and cleanup costs that a line break would incur. Maintenance routines and contingency plans are prepared in advance to provide for safe and efficient repair in the event of a breakdown.

The related concern that aged pipelines decrease the efficiency of petroleum transport significantly has not been supported by available information. Industry has taken measures to maintain the safety of pipelines and to provide alternative routing if needed.

In summary, ongoing industrial effort appears adequate for the prevention of a serious disruption in the petroleum distribution network. There may be a future need for the DOT and DOE to assess the potential impact of a massive petroleum pipeline system failure or the development of improved in-situ monitoring systems. However, no new programmatic action is recommended at this time.

5.1.3 Inadequately Trained Tank Truck Personnel

- CONCERN

Some inadequately trained drivers and poorly maintained equipment may be used in the truck transport of petroleum products, which could result in increased accident rates.

- BASIS

All interstate motor carriers must be authorized to operate by the ICC, unless they are privately owned or are hauling exempt commodities (which do not include petroleum products.) According to sources in the industry, private companies are believed to be financing motor carriers which operate tank trucks as for-hire common carriers. By classifying these tank trucks as privately-owned, ICC rate regulation may be avoided. These vehicles can therefore offer lower rates than regulated motor carriers.

It is felt that nonregulated interstate motor carriers would be less financially able to maintain adequate personnel and equipment standards. Insufficiently trained drivers handling hazardous materials may increase the risk of highway accidents. It was also suggested that, in the event of severe and costly accidents, owners of nonregulated carriers could declare bankruptcy to avoid liability. By reorganizing under a different name, these carriers could resume operation and thereby perpetuate the overall problem.

- RELATED WORK

The Bureau of Motor Carrier Safety (BMCS) is currently developing a driver training program. A curriculum for driver-training schools has been established; efforts to make these training programs mandatory within three years are in progress. An apprenticeship program will then be set up whereby prospective drivers under 21 years of age may begin training.

Exxon Corporation conducts in-house training programs for drivers involved in the handling of flammable materials. The Union Oil Company has a mandatory program to familiarize drivers with federal motor carrier safety regulations, particularly those applicable to the handling of hazardous materials. They use the BMCS booklet and are tested annually in their knowledge of federal safety regulations.

Consolidated Freightways Tanklines requires student trips with an experienced person for all new drivers until the student is considered able to handle the job himself. If a driver has never hauled hazardous materials before, he will be required to take as many student trips as the company feels he needs to qualify. Written tests on road safety and ICC regulations are also given to all hired drivers.

The BMCS publishes and distributes driver handbooks which outline the training necessary for handling hazardous materials. Regulations are presented in laymen's terms for easy reading and understanding.

- APPRAISAL

This concern cannot be substantiated as a significant potential problem. Stringent regulations are in effect at the federal level regarding driver qualifications and equipment safety for all motor carriers. Safety inspections by the BMCS and driver education and training by industry continually reinforce safety consciousness. Accident rates do not reveal a larger involvement of non-ICC regulated carriers. There is a decreasing trend in the number of accidents per year, for both private and authorized carriers. When common carriers are used by private industry, most major companies employ ICC-regulated carriers. There have been no official reports of a petroleum tanker company declaring bankruptcy in response to a lawsuit. Minimum insurance levels are required for all motor carriers by the states, if not by the ICC.

However, changes in the level of effectiveness of current enforcement practices and doubts regarding future manpower availability require that the DOT, ICC and DOE remain aware of any trends which may support this concern in the future. No new programmatic action appears to be warranted at this time.

5.1.4 Duplicative Petroleum Product Traffic

- CONCERN

The complexity of the petroleum product distribution network may result in fuels being moved over longer distances than necessary, increasing the potential for higher costs and accidents and reducing the efficiency of operation.

- BASIS

The focus of this concern is the following example. A study by the Oceanographic Institute of Washington⁽⁷⁹⁾ has identified duplications of petroleum product traffic between the states of Washington and California; these are believed to result from the lack of a single coherent distribution system. There are six suppliers of products within Washington State and more than a dozen from outside the state. Each has a unique system of suppliers, distributors and outlets, using different combinations of transport modes to bring products to market. Standard Oil of California moves petroleum products into the Pacific Northwest by barge and tanker from California and by pipeline from Utah, while Atlantic Richfield Company exports products by barge and tanks from its refinery in Cherry Point, Washington, to other ports in PADD V.^(a) In 1973, Washington exported 5,805,000 barrels of distillate fuel oil to California, yet in that same year imported 4,948,000 barrels of distillate fuel from California. Similar situations may exist elsewhere in the nation.

- APPRAISAL

The Pacific Northwest has no commercially productive oil fields at present. Petroleum products used in western Washington come mainly from Puget Sound refineries. The Olympic Pipeline, originating at the four major refineries in Anacortes and Ferndale, operates as the only products pipeline in western Washington and Oregon. Eastern Washington is supplied with refined petroleum primarily by imports through the Yellowstone Pipeline from Billings, Montana, and the Chevron Pipeline from Salt Lake City, Utah. Eastern Washington is separated from the West Coast by the Cascade Mountains. The situation in PADD V thus seems to be explained by the geography of the area and present pipeline availability.

In 1973, about 60 percent of the total output of the four major refineries in Washington was shipped by Olympic Pipeline. The remaining products left the refineries by vessel and barge; about half of these products went to

(a) Petroleum Administration for Defense District V (Washington, California, Oregon, Arizona, Hawaii, Nevada and Alaska).

California and destinations outside the Northwest. The products which are transferred between states thus do not constitute a major percentage of refined petroleum production in Washington.

Product flow statistics by state are difficult to obtain. Neither the Bureau of Mines nor Waterborne Commerce statistics identify commodity flow by both origin and final destination. Existing duplicate traffic is a natural result of free market competition. Contractual agreements and new governmental regulation to reduce this traffic would be an unacceptable solution. Furthermore, it appears that the profit motive of a company would operate to reduce inefficient and costly traffic duplications wherever possible. No new programmatic action is recommended.

5.2 POTENTIAL PROBLEMS UNDER CONTROL

The following concerns relate to recognized problems. However, current studies and action by industry and government are contributing to the solution of these problems. At this time, no new program action appears necessary in the following areas:

- Locational shifts in supply sources
- Tanker size/safety relationships
- Impact of the Jones Act on Alaskan crude oil transportation
- Inland waterway congestion
- Deterioration of rail trackage and equipment
- Railroad bankruptcy and abandonment
- Nonstandard tank truck bottom loading equipment
- Tank truck fuel economy
- Interconnected unit oil trains

5.2.1 Locational Shifts in Supply Sources

- CONCERN

The petroleum transport system may not be able to respond adequately to new transportation requirements resulting from expected major changes in petroleum source locations.

- BASIS

As production of petroleum within the 48 contiguous states declines from the 1973 peak level, new fields on the Alaskan North Slope and the Outer Continental Shelf will assume increasing importance. The shifting of oil imports from Canada and Venezuela to those from Saudi Arabia and Nigeria further disturbs historical patterns of oil flow. Refinery locations and capacities which were rational for the flow pattern from old sources may not be suitable for new sources. The new and more distant petroleum source locations will require new transportation and distribution systems. Domestic petroleum and gas sources will be opening up in Alaska, Northern Canada and the Outer Continental Shelf. Transportation from these new and more distant sources, by ship or by pipelines, may involve new routes and new problems.

- RELATED WORK

In an ongoing study, "Transportation of Energy Materials," the DOT identifies the major shifts that are expected in fuel sources and the corresponding needs for transportation. It is anticipated that the DOT will participate in planning the expansion of the transportation system and in policy decisions. In FY 1976, DOT research in this area was largely devoted to compiling data on the characteristics and capacities of the existing transportation system and developing methodology for analysis and comparison of system and modal choices for energy material transportation. Later research is expected to complete the data base and extend the application of the developed methodology to specific problem areas.

- APPRAISAL

There appear to be, at present, adequate planning and enough flexibility in the various transportation modes to accommodate the petroleum flow which will result from expected shifts to new sources. Crude oil pipeline traffic is projected to increase the most because of oil movement from the Alaskan North Slope to ice-free water and transfer of surplus oil from the West Coast to the Great Lakes area. Pipeline expansion may include submarine connections from deep water ports and offshore sites to onshore pipelines and refineries.

The inland waterway system will probably experience few major physical improvements between now and 1990, although U.S. internal waterway traffic is expected to grow almost 40 percent in the same period. The U.S. Army Corps of Engineers estimates that major capacity constraints either exist now or will develop by 1990 at several locks and dams, including Lock and Dam 26 on the Mississippi River. The railroads presently carry less than two percent of the total petroleum traffic and are capable of significant increases in capacity to absorb traffic that might be displaced from congested waterways (see Subsection 5.2.4).

Current refinery sites are not optimally located for new petroleum sources and may require additional transportation to receive supplies. However, it is generally less expensive to move products from existing refineries to consumers than to build new refineries. Therefore, the location of existing refineries can be expected to maintain the present flow pattern of petroleum products well into the 1980s.

Ongoing studies by the DOT address shifts in energy supply sources and potential problems concerning the adequacy of energy transport system capacity and alternatives. No additional programmatic action is recommended.

5.2.2 Tanker Size/Safety Relationships

- CONCERN

The fear that bigger tankers will increase safety risks may limit efficient petroleum transport and contribute to port congestion.

- BASIS

The U.S. is relying increasingly on petroleum imported from the Middle East and Nigeria. Over long distances, the use of supertankers, or VLCCs^(a), instead of smaller tankers, can reduce petroleum transportation costs by as much as 2-1/2 to 3 cents per gallon. Although approximately 20 U.S. flag tankers over 150,000 DWT have recently been constructed, an increased number

(a) Very Large Crude Carrier: ships ranging in size from 100,000 to 500,000 DWT.

of smaller vessels have been employed to meet new import demands. Casualty rates have also shown an increase. There appears to be a relationship between the number of vessels in a given area (regardless of vessel size) and the number of casualties.

Because of the greater cargo capacity, many members of the public fear that a tank rupture in a VLCC could release far more oil than that in a smaller tanker. The VLCCs are also less maneuverable and harder to stop than smaller vessels.

- RELATED WORK

Maritime Administration records indicate that U.S. vessels of 164,000, 190,000, 225,000, 265,000 and 390,000 DWT have been or are being constructed. These vessels could be used for importing petroleum from foreign countries and possibly for the transport of Alaskan crude to the continental U.S.

A 1973 Environmental Impact Study (EIS) by the Maritime Administration⁽⁵⁹⁾ included an analysis of the relationship between tanker polluting incidents and tanker size. The probability of oil spillage and the amount of oil outflow were not found to be a direct function of vessel size.

Washington State tried to prohibit tankers larger than 125,000 DWT from entering Puget Sound. The Atlantic Richfield Company filed a successful suit against the State of Washington to have the law declared invalid, claiming it conflicted with federal regulations, particularly the Ports and Waterways Safety Act of 1972.^(a) The Secretary of Transportation, however, has promulgated temporary regulations that similarly restrict movements of large tankers in Puget Sound, until a safety study, now in progress, can be completed by the Coast Guard.

- APPRAISAL

Structural failure of tankers been the single largest cause of oil pollution in marine transportation. However, modern construction technology, such as automatic cutting and welding, and advanced testing procedures,

(a) The Supreme Court struck down most provisions of the Washington State Tanker Law on March 6, 1978 (see Subsection 4.4.2).

including X-ray inspections, have improved the structural integrity of today's ships. There are also national and international regulations covering vessel design, construction and operation. The American Bureau of Shipping must approve vessel designs and inspect and certify completed ships. The U.S. Coast Guard enforces safety and pollution prevention regulations for U.S. flag vessels and foreign flag vessels operating in U.S. waters. The International Maritime Consultative Organization (IMCO) promotes maritime safety and pollution prevention on a worldwide basis. Improved international safety policies for petroleum transportation were formulated at the February 1978 IMCO conference on Tanker Safety and Pollution Prevention. Tanker safety measures recommended at the conference, and since written into law, include requirements for segregated ballast or crude oil washing systems. Inert gas systems are also required on new and existing carriers. The new law, P.L. 95-474, applies to all existing tankers^(a) over 40,000 DWT, all new crude oil tankers over 20,000 DWT and new product tankers over 30,000 DWT.

Safety features are built into the VLCC to prevent large-scale oil pollution. The cargo area is divided into many sturdy tanks, protecting against total loss of petroleum cargoes in the event of a collision or grounding. Most large tankers are also equipped with inert gas systems which inject noncombustible gases into the cargo tanks, lowering the oxygen level and thereby hindering explosions.

VLCC crews undergo special training to acquaint them with handling procedures particular to the VLCC. For example, training schools in Holland have electronically-simulated ship-handling courses, and in France, ship handling is learned by operating scale models on a lake. A Computer Aided Operations Research Facility (CAORF) at Kingspoint, U.S., is also used for training ship pilots.

A study⁽⁸⁰⁾ of worldwide large-scale oil releases from tankers from 1969 through 1973 shows that nearly four-fifths of the accidents can be expected

(a) The tanker construction requirements also apply to existing tankers between 20,000 and 40,000 DWT which were more than 15 years old in April 1978.

to occur in coastal or harbor waters. However, most U.S. ports are not deep enough to permit the entrance of VLCCs (see Subsection 4.4.4). New tanker design requirements will serve to enhance the safety of these larger vessels. While this concern should be monitored as the use of VLCCs increases after the completion of planned deepwater ports, no new program action is recommended at present.

5.2.3 Impact of the Jones Act on Alaskan Crude Oil Transportation

- CONCERN

The requirements of the Jones Act which preclude the use of foreign flag tankers in U.S. domestic traffic may contribute to a shortage of U.S. tankers for transporting Alaskan crude oil to U.S. ports.

- BASIS

The Jones Act (Merchant Marine Act of 1920) requires that vessels used in U.S. domestic trade be built in the U.S., operated under U.S. laws, owned by U.S. citizens, and manned by U.S. crews. As of June 1975, 205 U.S. flag vessels of over 1,000 DWT each were being used in domestic coastal traffic. Seventy-five percent of this trade is in petroleum and involves 156 tankers, totalling 4,855,000 DWT. U.S. tankers are also required for the transport of a portion of the foreign oil to be used in the strategic petroleum reserve (SPR). The anticipated increase in Alaskan crude oil traffic to U.S. ports must be handled by U.S. tankers according to the Jones Act, adding new competition for the use of tankers in the U.S. flag fleet.

Further demand for U.S. flag tankers was projected to stem from cargo preference legislation. The cargo preference proposal would require that 4 1/2% of imported oil be moved in American flag ships and that the percentage be raised to 9 1/2% over the next five years. As late as August 1977, there was little doubt that this proposal would become law.⁽⁸¹⁾ Whether there will be enough U.S. tankers to meet the combined future demand of these traffic requirements was a question worthy of review in the latter half of 1977.

- APPRAISAL

This concern does not appear to be supported by the available data and the course of recent events. In October 1977, the cargo preference proposal was defeated in the House by a vote of 257-165. The Senate Commerce Committee subsequently cancelled a planned meeting on its version of the bill. Thus, this requirement for U.S. flag tankers is no longer an issue.

The DOT⁽⁸²⁾ predicted the need for 35 modern tankers with a total capacity of 3,650,000 DWT for transporting Alaskan crude oil. The FEA projected a required fleet of 34 tankers. The latter source indicated that 29 of the required U.S. flag tankers would have been available in September 1977. Maritime records indicate that new tanker construction includes sixteen vessels: six of 164,000 DWT; two of 225,000 DWT; five of 265,000 DWT; and three of 390,000 DWT. Two 150,000 DWT and two 190,000 DWT tankers are presently under construction.

Major oil companies are making charter arrangements for tankers to ensure their transportation capabilities for Alaskan oil. Sohio has chartered approximately 30 tankers and plans to add five to ten more. Exxon has chartered nine ships and will also use six of its own tankers.

Edwin M. Hood, president of the Shipbuilder's Council of America, was reported⁽⁸¹⁾ to expect orders for about 6 million DWT of new U.S. tankers between 1978 and 1982. If the demand for U.S. ships remains as strong as most of the industry expects, shipyards anticipate expanding employment in the next few years.

Efforts of the petroleum and shipbuilding industries appear to be sufficient to dispel the concern about the adequacy of the U.S. tanker fleet. No new government action is warranted in this area.

5.2.4 Inland Waterway Congestion

- CONCERN

Congestion on inland waterways may impact petroleum distribution by slowing barge traffic, escalating costs and increasing the potential of casualties and oil spills.

- BASIS

Crude petroleum, gasoline, kerosene, and jet, distillate and residual fuels account for approximately 34% of all commodities transported on the inland waterways. More than 60% of all petroleum products are transported by barge on inland waterways, in coastal waters and within ports of the U.S. Increasing consumer demand has resulted in a steady growth (from 1970 to 1975) in waterway traffic ton-miles and numbers of towing vessels and tank barges.⁽⁸³⁾ Inland waterway transportation is the lowest-cost mode of travel for commodities to which barge service is adaptable.

There are between 200 and 300 locks and dams on the inland waterways of the U.S. Most of the locks are on the Ohio and Monongahela Rivers and the New York State Barge Canal; there are also locks and dams on the Mississippi River. When disabled or closed for repairs, lock and dam systems block waterway transportation. The Army Corps of Engineers is responsible for constructing, developing, maintaining and operating the locks and dams on inland waterways, and established standard lock dimensions in 1959. However, many locks still in operation were built before 1959 and do not conform to the current standards.

A specific example of waterway traffic congestion is Locks and Dam No. 26 located at Alton, Illinois. Because of the age and deteriorated condition of the installation, tows are frequently delayed between 7 and 72 hours, depending on weather conditions and the amount of waterway traffic.

- RELATED WORK

In the 1960s, the Corps of Engineers studied the situation at Locks and Dam No. 26. A controversial proposal to replace the present lock, add another lock and increase the navigable depth of the adjacent river channel was submitted by the Corps. After a 1974 injunction and court case, a modified recommendation for replacement and increased capacity of No. 26 was presented to Congress on August 25, 1976.

The Locks and Dam No. 26 replacement issue was amended to include a waterway user charge. The Waterway Construction Act of 1977 was amended by the Senate, requiring the DOE to study the impact of waterway user charges and report to Congress by January 1979.

The waterway user charge issue has been studied by various agencies. A 1975 General Accounting Office report⁽⁸⁴⁾ concluded that a fuel tax of about seven cents a gallon in 1973 would have fully absorbed waterway operation and maintenance expenses. However, charges were expected to divert barge traffic to other modes. A 1976 study by CACI, Inc.⁽⁸⁵⁾ for the Corps of Engineers concluded that a fuel tax set high enough to recover 50 percent of waterway operation and maintenance expenditures would reduce waterway traffic by 5.5 percent. A 1977 DOT study⁽⁸⁶⁾ examined the impact of a fuel tax set high enough to recover total expenditures for operation and maintenance and concluded that 12 to 15 percent of waterborne traffic would probably shift to other modes.

- APPRAISAL

Other than slowing traffic, congestion has the potential of increasing transportation cost and causing casualties (groundings, ramblings, or collision) and pollution. Waterway transportation is a major mode for the distribution of many commodities in the eastern states. Pipeline, rail and truck compete with inland waterway carriers for petroleum transport. User charge legislation has been passed, and should act to reduce waterway congestion as some traffic shifts to other modes and revenues become available to fund facility improvements. The economic forces involved should decrease inland waterway congestion as modal shifts occur. Further review of the concern may be required to determine if local impacts may develop that are not covered by alternative supply routes. However, no new programmatic action is recommended at this time.

5.2.5 Deterioration of Rail Trackage and Equipment

- CONCERN

The deterioration of railroad trackage and equipment has resulted in an increasing number of railroad accidents involving hazardous materials. This trend may increase the risk of transporting petroleum products by rail.

- BASIS

A major factor in this concern is the poor financial condition of many of the nation's railroads. The current low rate of rail income combined with

effects of inflation have resulted in widespread deferred maintenance and capital expenditure. The resultant deterioration in rail trackage and equipment has led to a steady increase in the rate of rail accidents, as shown in Table 5.2. Causes of rail accidents are listed in Table 5.3.

TABLE 5.2. Train Accidents⁽⁸⁷⁾

	<u>Total</u>	<u>Accidents per Million Train Miles</u>	<u>Derailment</u>	<u>% of All Accidents</u>	<u>Derailments per Million Train Miles</u>
1972	7,532	9.64	5,509	73	7.05
1973	9,698	11.67	7,389	76	8.89
1974	10,694	12.83	8,513	80	10.22

TABLE 5.3. Cause of Train Accidents⁽⁸⁷⁾

	<u>% Accidents Due to Defects in Track or Structures</u>	<u>% Accidents Due to Equipment Failure</u>	<u>% of Accidents Due to Human Factors</u>
1965	19	29	29
1967	25	26	27
1970	30.5	23.3	27
1972	33.4	21	24.6
1974	40	20.1	21

A preliminary estimate by the Association of American Railroads⁽⁸²⁾ indicated that, as of September 1975, the industry's level of deferred maintenance for track and roadbed alone was \$2.5 billion and delayed capital improvements amounted to \$2.1 billion. Deferred maintenance and delayed capital expenditures for equipment were estimated at \$369 million and \$2.1 billion respectively.

- RELATED WORK

In 1976, the 4-R Act (Railroad Revitalization and Regulatory Reform Act) was signed into law for the purpose of restructuring the nation's rail network. The Act provides the following features:

- Loan guarantees and other forms of financing to support rehabilitation and improvement projects.
- A Railroad Rehabilitation and Improvement Fund established to provide capital for facility maintenance, rehabilitation, improvements and acquisitions and other financial needs approved by the Secretary of Transportation.
- Rail lines of the U.S. were categorized according to reasonable measures of priority so that government investments in track could be directed where they would do the most good.

The Secretary of Transportation is directed to conduct a number of studies of the U.S. railroad system. Reports on these studies included the following topics:

- The potential for cost savings and improved service by restructuring rail systems
- Potential economies and improvements resulting from improved local and terminal operations
- Cost savings if rehabilitation is limited to portions essential to interstate commerce and national defense
- An assessment of the extent to which common or public ownership of fixed facilities could improve the system
- The effect of alternative rail corporate structures
- The assignment of priorities to properties for improvement
- An analysis of the financial and physical condition of facilities, rolling stock and equipment of the nation's railroads.

New specifications⁽⁸⁸⁾ for railroad pressure tank cars requiring new safety appliances on 112 and 114 type tank cars have been issued by the DOT Materials Transportation Bureau. Improved thermal and tank car heat protection and shelf couplers were required on tank cars of the above types built after January 1, 1978. A retrofit schedule to apply these improvements to cars built previously is also specified.

- APPRAISAL

This concern and other problems associated with the deterioration of railroad plant and equipment are being addressed effectively by the efforts reviewed above. The provisions of the 4-R Act have already resulted in a significant improvement of track and equipment on some Eastern and Midwestern railroads. The safety of tank cars carrying LPG and other flammable and hazardous materials will be improved as a result of the new safety appliance requirements. No new effort appears to be warranted in this area.

5.2.6 Railroad Bankruptcy and Abandonment

- CONCERN

Poor financial status and a lack of liability coverage may cause the bankruptcy of some railroads in the event of a disastrous accident. Potential bankruptcy and pressure to increase the abandonment of unprofitable railroad lines increases the risk that critical links of the national rail system may be affected and may result in the interruption of petroleum transportation.

- BASIS

While railroad revenues have increased 13 percent and ton-miles have increased 23 percent since 1955, pretax earnings have dropped 50 percent. Although the ICC requires motor carriers to carry liability insurance or indicate self-insurance capability, no federal insurance requirement for rail carriers is evident. Furthermore, no states are known to have specifications for minimum liability coverage. The trend has been to lower maximum liability limits as insurance rates rise.⁽⁸⁹⁾ Potential accidents involving many deaths or injuries and extensive property damage may thus cause some railroads to declare bankruptcy, resulting in a possibly critical gap in the national transportation system.

Abandonment of railroads is increasing rapidly and is not confined to Eastern railroads. A rail washout or other major disruption on a little-used or unprofitable section may be a significant event which triggers applications for abandonment. Some cases of abandonment are denied, usually because ICC disagrees with the railroad's financial figures or because the

affected communities are expected to need continued railroad services. Approximately 1,000 miles of rail have been abandoned to date, with 3,751 miles pending. A further 7,713 miles of railroad are under study for potential abandonment and an additional 13,126 miles of rail are expected to be relinquished in the next three years. The resulting savings on maintenance are expected to be near \$20 million.

- RELATED WORK

The Regional Rail Reorganization (RRR) Act of 1973 recommended that a new organization, ConRail, be formed to operate the lines of seven bankrupt railroads in the northeast region of the U.S. Of the original 24,000 route-miles of line, it was recommended that 5,757 miles of track be either abandoned or continued under subsidy.

The Railroad Revitalization and Regulatory Reform (RRRR) Act of 1976 made available \$2.1 billion in government funds for working capital, re-financing, acquisition of equipment, and for modernization, rehabilitation and maintenance of properties acquired from bankrupt railroads. Section 901 of the act also mandates studies on rehabilitation costs, public ownership, corporate structure, high-speed trains and an analysis of the financial and physical condition of U.S. railroads.

- APPRAISAL

This concern relates to a problem with a decreasing potential for occurrence. The abandonment of unprofitable railroad lines is desirable as a contribution to the protection of the financial health of the railroads. The ICC can grant permission to abandon specific lines after an exhaustive investigation and hearings. Before it grants this permission, the ICC investigates the social, economic and environmental ramifications of the proposed abandonment. This process should identify the existence of any possible "critical link" nature of a proposed abandonment.

Recent legislation deals directly with railroad bankruptcy and abandonment issues. In both the RRR Act of 1973 and the RRRR Act of 1976, Congress acknowledged that private railroads should no longer be forced to provide unprofitable services on light-density lines. The establishment of ConRail

assured continued rail service on bankrupt lines and provides a precedent of massive federal assistance to protect vital railroad service. Currently only 1.6 percent of the total petroleum traffic is transported by rail. For all these reasons, it is unlikely that railroad financial conditions and abandonment policy will significantly affect the future transportation of petroleum and its products. There is no incentive for new program action in this area.

5.2.7 Nonstandard Tank Truck Bottom Loading Equipment

- CONCERN

Nonstandard bottom loading equipment creates an operational problem for common carrier tank truck operators hauling petroleum fuel products for many different companies.

- BASIS

Tank trucks must use expensive adapters to accommodate the existing variety of loading systems. Although the API recommends standard equipment, not all companies are so equipped. A similar problem exists with color coding for delivery hoses. EPA standards require separate hoses for each petroleum product. Color coding is used to identify the product for which a particular hose is suited. For example, red may represent unleaded gasoline, blue may stand for regular and yellow may denote premium. These codes differ for individual gas stations and companies. Because the common carrier serves many companies, a number of adapters must be hauled to permit loading or unloading at different stations.

- RELATED WORK

In 1960, the API Transportation Department studied bottom loading and prepared a report which pointed out the need for uniform standards for tank vehicle bottom loading equipment.⁽⁹⁰⁾ Studies related to this topic have been going on for 10 years.

The objective of the API recommended practice is to provide an industry standard for bottom loading and vapor recovery on DOT MC-306 tank vehicles, including:

- Standards and Recommendations for a 101.6 mm (4 in.) adapter for bottom loading.
- Standards and Recommendations applicable to tank vehicles equipped for bottom loading.
- Standards and Recommendations applicable to tank vehicles equipped for vapor recovery.
- Standards and Recommendations for loading installations equipped for bottom loading and/or vapor recovery.

A representative of Emco Wheaton, a major manufacturer of bottom loading systems, stated that all of its API adapters meet the API RP 1004 specifications. Union 76 Oil and Atlantic Richfield Companies are in the process of converting all of their terminals to API standard bottom loading systems. Continental Oil Company and Exxon Corporation use tank trucks which employ the standard bottom loading systems recommended by API.

- APPRAISAL

A standard for bottom loading systems and associated equipment has been in existence since 1964. Most of the industry is using a common adapter, in accordance with API recommended standards. Those who do not use the standard API equipment employ primarily privately-owned trucks.

Many major manufacturers today sell only API standard equipment. The lack of complete standardization seems largely a result of the normal industry purchasing cycle. Due to the expense involved, many companies have not yet completed the phasing-in of new equipment.

The lifetime of a loading rack may range from 10 to 30 years, depending on maintenance factors. The problem can be expected to generally disappear when the next equipment purchase cycle is completed in a few years. The requirements of the EPA and the Occupational Safety and Health Administration (OSHA) regarding gasoline vapor containment may shorten this time period. No new programmatic action is recommended.

5.2.8 Tank Truck Fuel Economy

- CONCERN

Current design characteristics of tank trucks and their components contribute to poor fuel efficiency in the transportation of petroleum products on the highway. Regulations which restrict the sizes and weights of tank trucks also hamper the achievement of improved fuel economy.

- BASIS

A Department of Transportation study⁽⁹¹⁾ indicated poor aerodynamic efficiencies for tank trucks. Eighty percent of commercial vehicle fuel is consumed by Class VI (local operation) and Class VIII (over-the-road) trucks (Class VI = 19,501 - 26,000 lb, Class VIII = over 33,000 lb). Thus, an improvement in aerodynamic design, along with other energy-saving features such as reducing the rolling resistance of tires, or size/weight increases could result in substantial fuel savings.

- RELATED WORK

The American Trucking Association (ATA) is conducting a study to determine how truckers can best conserve fuel. The ATA survey, conducted by Dr. W. Edwards Deming, will study the fuel savings brought about by such improvements as radial tires, improved truck design, air shields and modified maintenance and loading practices. It will also investigate the effects of stronger enforcement of the national 55 mph speed limit and intensified driver training.

AeroBoost Products, Pasadena, California, has developed a new perforated wind deflector for trucks. The device offers fuel savings, faster travel times and protection from buffeting winds. Designed for long-haul tractor trailers, fuel savings are expected to be as much as \$1,000 per year per tractor. Fuel savings of up to 15 percent in normal highway operations have been realized by using the AeroBoost III.

Other studies sponsored by the Department of Transportation are currently in progress. These include:

- Commercial Vehicle Fuel Economy Information Testing and Advisory Services
- Energy Efficient Commercial Vehicle Driving
- The Role of Heavy Vehicles in the Highway System (Federal Highway Administration)
- Safety Comparison of Doubles vs. Tractor-Semitrailer (update of a 1974 report by the Bureau of Motor Carrier Safety)

Other recent studies on fuel economy improvements for trucks are included in Appendix I, Subsection 5.2.8.

- APPRAISAL

A review of ongoing research by industry and government agencies indicates that tank truck design is undergoing continual change and improvement. High fuel costs ensure a constant search by the trucking industry for new ways to save fuel. The problem of twin trailers is encountered primarily in the eastern states. It is especially severe along the Appalachians, where a string of states (Alabama, Tennessee, North Carolina, South Carolina, Virginia, West Virginia and Pennsylvania) effectively blocks twin trailer traffic from reaching eastern seaboard cities. Political pressure, probably from competing modes and the public, impedes the use of larger vehicles which are more economical to operate.

Improvements in truck design to improve fuel economy are being made and phased-in with the normal industry purchasing cycle. No new programmatic action appears to be warranted.

5.2.9 Interconnected Unit Oil Trains

- CONCERN

The future use of unit oil trains with interconnected tank cars may increase the risk of oil spills and environmental consequences on specific routes.

- BASIS

Interconnected unit oil trains have been proposed for shipping Alaskan oil from the West Coast. Other applications may be considered in the future. There may be insufficient knowledge regarding the safety of these trains and operational risk associated with new technology components.

TANK TRAIN, a proprietary product of General American Transportation Corporation (GATX), is a system of interconnected tank cars. A string of cars may be loaded from one connection at flow rates of up to 3,000 gallons per minute. A 90-car unit train of 23,150-gallon tank cars in five 18-car strings could load or unload 49,607 barrels of oil in less than six hours. Flexible hose connections are installed between each pair of tank cars at the top of the car. Each car is isolated by a tank isolation valve once it is loaded and is constructed with standard four-inch insulation to protect against rupture.

This closed system has some possible environmental advantages over conventional rail cars. When loading, displaced vapors may be vented to the atmosphere, processed through scrubbing equipment, flared, or collected and reprocessed. Either compressed air or inert gas is used in unloading, depending on the characteristics of the transported liquid.

- RELATED WORK

GATX has developed the interconnected tank cars and tested them thoroughly under extreme conditions over the last three years. The tests included impact and hydrostatic tests on interconnecting flexible hoses. Field tests were conducted for three years in Alaska with a three-car prototype. The only accidents reported to date involving oil loss were one with faulty equipment and one or two with improperly closed fittings.

Since September, 1977, two 60-car 1,389,000-gallon-capacity TANK-TRAINS have been used to transport fuel oil from Sarnia, Ontario to Essexville, MI. The operation, a 30-mile roundtrip, is the largest application to date of the interconnected tank car principle developed by General American Transportation. The Sarnia-Essexville shuttle fills fuel oil needs of two 600,000-kW generating units.

Other representative TANK TRAIN operations are that of CIBRO Petroleum, which ships fuel oil from its Albany, New York facility to the Schlitz brewery in Syracuse; and an Allied Chemical train that carries sulfuric acid (in cars of a different design). Burlington Northern has been investigating a long-haul TANK TRAIN operation to carry Alaskan oil from Port Westwood, Oregon to Cut Bank, Montana.⁽⁹²⁾

- APPRAISAL

Railroad transport may once again constitute a significant portion of crude oil movements if the unit train concept proves successful on a large scale. The interconnected tank cars are currently being used by several companies. GATX claims the following advantages for the TANK TRAIN system: less handling of the oil, greater flow rates, increased system safety, environmental acceptability, minimum capital investment, minimum operating labor and greater market penetration.

Current operations of the interconnected tank car system reflect few problems which are unique to the unit trains. Although there may be a future need to assess route-specific system risks, no new programmatic action is recommended at this time.

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APPENDIX A

FACTS ABOUT PRUDHOE BAY RESERVES AND
THE TRANS-ALASKA PIPELINE

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FACTS ABOUT PRUDHOE BAY RESERVES AND THE TRANS-ALASKA PIPELINE

Estimated proved crude oil reserves at the end of 1975:

Prudhoe Bay Area	.	.	.	.	.	.	9.6 Billion Barrels
All Alaska	.	.	.	.	.	.	10.0 Billion Barrels
Total United States	.	.	.	.	.	.	32.7 Billion Barrels

Estimated proved natural gas reserves at the end of 1974:

Prudhoe Bay Area	.	.	.	.	.	.	25.0 Trillion Cu. Ft.
All Alaska	.	.	.	.	.	.	32.0 Trillion Cu. Ft.
Total United States	.	.	.	.	.	.	228.2 Trillion Cu. Ft.

Characteristics of the Trans-Alaska Pipeline System (TAPS):

- Cost of \$7.7 billion and approximately 132 million man-hours; an expected lifetime of 40 years.
- 800 miles long, running south from Prudhoe Bay to Valdez.
- 4 feet in diameter
- In geological fault areas, the pipe is designed with some flexibility; it can move 5 feet vertically and 20 feet horizontally without rupture, and can bend 6 feet in a 100-foot span without wrinkling.
- Approximate time for pipeline construction was 3 years, although it took over eight years from the planning stages in 1969 until the first oil entered the pipeline on June 20, 1977. Oil flow started at 180,000 bbl/day, increasing to 300,000 bbl/day, and was scheduled to move at a 1+ mph schedule.
- The Phase II output of 1.2 million bbl/day has been delayed at least until early 1978, due to the loss of pump station #8 by an explosion.

- Each of 8 pump stations will have 3 pumps at the Phase II operating level, 4 pumps in 12 stations at the ultimate 2 million barrel per day Phase III level.
- Three pump stations have their own 10,000 bbl/day refineries to make turbine fuel from the crude to power eight of the line's 12 pump stations.
- There are about 151 mainline valves - 62 remotely operated 48-inch gate valves, 80 check valves to keep oil from flowing backwards and 9 gate and check combinations.
- Some 56,000 of the 78,000 vertical support members for the aboveground 420 miles of pipe contain 112,000 heat tubes that transfer heat from the ground to the air and keep the permafrost frozen.
- There are 3 major computer systems, many smaller ones and 3 different communications systems - earth satellite, microwave and radio - with a central control room at Valdez and satellite centers at each pump station.
- The only oil inventory tanks on the line, other than the pipeline itself, will be two 210,000-barrel tanks at Pump Station #1 and 14 (later 18) 21-million gallon tanks at Valdez, each of which holds enough oil to load a 62,000 ton tanker.
- At Valdez, the crude oil flows by gravity down to the loading docks at rates of up to 4.6 million gallons per hour per dock.

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APPENDIX B

WATERBORNE PETROLEUM STATISTICS

APPENDIX B

WATERBORNE PETROLEUM STATISTICS

This appendix describes the movement of petroleum in U.S. waters. Figure B-1 illustrates the commodities carried by water in 1975. Table B-1 describes the petroleum traffic at major U.S. ports in 1975. Tables B-2 through B-9 describe the amounts of crude petroleum, gasoline, jet fuel, kerosene, fuel oil, residual and distillate, and liquefied petroleum gas that were transported in 1974. Waterway systems are also described.

FOREIGN COMMERCE

DOMESTIC COMMERCE

Source: Waterborne Commerce of the United States, Part 5
National Summaries, Army Corps of Engineers,
Vicksburg, Mississippi, 1975.

FIGURE B-1. Principal Commodities Carried by Water
 Calendar Year 1975, Total Commerce

TABLE B-1. Petroleum Traffic at Major U.S. Ports - 1975 (Short Tons)^(a)

Port	Foreign Imports (FI)	Domestic Coastal & Domestic Receipts (CR & IR)	Total FI, CR & IR Traffic(b)	% of Total FI, CR & IR Traffic(b)
Portland, ME	23,129,332	3,578,842	26,791,324	99.7
Total(b)	23,158,652	3,632,672		
Boston	5,030,362	13,303,529	20,147,051	91.0
Total(b)	5,987,864	14,159,287		
Providence	852,270	5,622,277	7,209,289	89.8
Total(b)	1,135,147	6,074,142		
New York	38,742,388	26,041,374	85,782,182	75.5
Total(b)	48,965,523	36,816,659		
Philadelphia	14,883,968	9,494,644	39,854,918	61.2
Total(b)	28,386,479	11,468,439		
Baltimore	3,297,775	5,562,857	30,428,506	29.1
Total(b)	20,656,890	9,771,616		
Savannah	1,492,516	1,047,489	5,039,428	50.4
Total(b)	3,120,987	1,918,441		
Brunswick	386,411	74,079	946,281	48.7
Total(b)	861,135	85,146		
Savannah & Brunswick Combined Total	1,878,927	1,121,568	5,985,709	50.1
Mobile	218,472	1,845,731	15,818,601	13.0
Total(b)	7,895,820	7,922,781		
Baton Rouge	4,700,803	3,706,001	25,741,683	32.7
Total(b)	11,994,698	13,746,985		
New Orleans	6,015,867	12,247,650	64,962,835	28.1
Total(b)	12,204,698	52,758,137		
New Orleans & Baton Rouge Combined Total	10,716,670	15,953,651	90,704,518	29.4
Houston	14,146,162	5,468,222	32,583,571	60.2
Total(b)	18,273,391	14,310,180		
Galveston	189,685	125,940	1,252,571	25.2
Total(b)	854,359	397,768		
Houston & Galveston Combined Total	14,335,847	5,594,162	33,835,698	58.9
San Diego	90,158	895,288	1,563,370	63.0
Total(b)	241,020	1,322,350		
Los Angeles	11,083,799	5,275,044	19,946,260	82.0
Total(b)	13,131,402	6,814,358		
San Francisco	24,774	318,572	1,368,214	25.1
Total(b)	721,186	647,028		
Portland, OR	472,423	2,517,912	8,600,451	34.8
Total(b)	2,030,438	6,570,013		
Seattle	364,151	782,607	3,203,878	35.8
Total(b)	1,848,762	1,355,116		
Major Imports Petroleum Traffic(a)	125,121,316	97,908,058		18.4
Major Ports Total(b)	201,468,451	189,771,618		32.3
National Total Traffic(b)	476,572,516	735,864,695	1,212,437,211	

(a) Includes crude oil, gasoline, jet fuel, kerosene, distillate fuel oil, residual fuel oil and liquefied gases only.

(b) Includes total traffic of all commodities.

Source: Waterborne Commerce of the United States, Army Corps of Engineers, Vicksburg, Mississippi, 1975.

TABLE B-2. Petroleum Traffic on the U.S. Waterways - 1974^(a)

Waterway	Oceangoing			Inland Waterway			Total Net Tons	% of Total Traffic
	Net Tons	% of Total Oceangoing Traffic	% of Total Traffic	Net Tons	% of Total Inland Traffic	% of Total Traffic		
Upper Mississippi River				9,830,175	15.92	15.85	9,830,175	15.85
Mississippi River	34,836,356	30.90	11.51	56,673,155	29.85	18.73	91,509,511	30.24
Ohio River				19,520,827	14.02	14.01	19,520,827	14.01
Illinois Waterway				7,528,719	16.62	16.62	7,528,719	16.62
Missouri River				72,114	0.94	0.94	72,114	0.94
McClellan-Kerr Arkansas River Navigation System				630,971	10.52	10.52	630,971	10.52
Allegheny River				346,208	6.11	6.11	346,208	6.11
Monongahela River				2,476,799	6.47	6.47	2,476,799	6.47
Kanawha River				878,234	6.87	6.87	878,234	6.87
Cumberland River				782,846	7.09	7.09	727,229	7.09
Tennessee River				1,511,881	5.57	5.57	1,511,881	5.57
Gulf Intracoastal Waterway	122,822	24.88	0.10	54,722,014	46.19	46.00	54,844,836	46.10
Houston Ship Channel	33,100,014	55.53	37.15	12,028,645	40.78	13.50	45,128,659	50.65
Black Warrior, Warrior and Tombigbee River System				956,566	6.15	6.15	956,566	6.15
Apalachicola, Chattahoo- chee, and Flint River				263,847	27.77	27.74	263,847	27.74
James River				2,705,287	38.50	35.07	2,705,287	35.07
Atlantic Intracoastal Waterway #1				1,237,262	35.24	34.98	1,237,262	34.98
Atlantic Intracoastal Waterway #2	35,517	56.02	2.36	1,355,373	93.98	90.03	1,390,890	92.39
Delaware River	77,529,637	69.07	53.96	25,236,240	80.29	17.56	102,765,877	71.53
Potomac River	3,184,129	93.55	48.00	2,530,085	78.34	38.14	5,714,214	86.14
Chesapeake Bay				14,143,587	47.14	47.14	14,143,587	47.14
Columbia River	3,171,118	14.02	8.10	1,223,661	7.40	3.13	4,394,779	11.23
Hudson River	3,960,011	30.60	10.29	14,389,951	56.34	37.40	18,349,962	47.69
New York State Barge Canal				1,789,479	80.50	80.50	1,789,479	80.50
Willamette River				33,855	0.61	0.57	33,855	0.57
Sacramento River				115,691	43.37	7.79	115,691	7.79
San Joaquin River	618,624	21.41	16.62	416,693	50.04	11.19	1,035,317	27.81

Source: Inland Waterborne Commerce Statistics, the American Waterways Operators, Inc., Arlington, Virginia 22209, 1974.

(a) Includes crude oil, gasoline, jet fuel, kerosine, distillate fuel oil, residual fuel oil and liquefied gases only.

TABLE B-3. Crude Petroleum Traffic on the U.S. Waterways - 1974

Waterway	Oceangoing			Inland Waterway				
	Net Tons	% of Total Oceangoing Traffic	% of Total Traffic	Net Tons	% of Total Inland Traffic	% of Total Traffic	Total Net Tons	% of Total Traffic
Upper Mississippi River				503,060	0.81	0.81	503,060	0.81
Mississippi River	22,630,238	20.07	7.48	18,700,478	9.85	6.18	41,330,716	13.66
Ohio River				643,902	0.46	0.46	643,902	0.46
Illinois Waterway				64,556	0.14	0.14	64,556	0.14
Missouri River								
McClellan-Kerr Arkansas River Navigation System								
Allegheny River								
Monongahela River								
Kanawha River								
Cumberland River								
Tennessee River								
Gulf Intracoastal Waterway				26,207,086	22.12	22.03	26,207,806	22.03
Houston Ship Channel	14,874,768	24.95	16.69	3,934,147	13.34	4.42	18,808,915	21.11
Black Warrior, Warrior and Tombigbee River System				699,120	4.50	4.50	699,120	4.50
Apalachicola, Chattahoo- chee, and Flint River								
James River								
Atlantic Intracoastal Waterway #1								
Atlantic Intracoastal Waterway #2								
Delaware River	48,397,190	43.12	33.69	9,068,542	28.85	6.31	57,465,732	40.00
Potomac River								
Chesapeake Bay				463,970	1.55	1.55	463,970	1.55
Columbia River	468,004	2.07	1.20				468,004	1.20
Hudson River								
New York State Barge Canal								
Willamette River								
Sacramento River								
San Joaquin River								

Source: Inland Waterborne Commerce Statistics, the American Waterways Operators, Inc., Arlington, Virginia 22209, 1974.

TABLE B-4. Gasoline Traffic on the U.S. Waterways - 1974

Waterway	Oceangoing			Inland Waterway			Total Net Tons	% of Total Traffic
	Net Tons	% of Total Oceangoing Traffic	% of Total Traffic	Net Tons	% of Total Inland Traffic	% of Total Traffic		
Upper Mississippi River				3,982,998	6.45	6.42	3,982,998	6.42
Mississippi River	4,132,009	3.66	1.37	14,374,465	7.57	4.75	18,506,474	6.12
Ohio River				10,125,058	7.27	7.27	10,125,058	7.27
Illinois Waterway				1,861,005	4.11	4.11	1,861,005	4.11
Missouri River				72,114	0.94	0.94	72,114	0.94
McClellan-Kerr Arkansas River Navigation System								
Allegheny River				155,087	2.74	2.74	155,087	2.74
Monongahela River				986,867	2.58	2.58	986,867	2.58
Kanawha River				609,120	4.77	4.77	609,120	4.77
Cumberland River				473,904	4.29	4.29	473,904	4.29
Tennessee River				839,081	3.09	3.09	839,081	3.09
Gulf Intracoastal Waterway	91,458	18.52	0.08	8,126,741	6.86	6.83	8,218,199	6.91
Houston Ship Channel	7,802,763	13.09	8.76	894,247	3.03	1.00	8,697,010	9.76
Black Warrior, Warrior and Tombigbee River System								
Apalachicola, Chattahoo- chee, and Flint River				92,315	9.71	9.71	92,315	9.71
James River				26,137	0.37	0.34	26,137	0.34
Atlantic Intracoastal Waterway #1				138,793	3.95	3.92	138,793	3.92
Atlantic Intracoastal Waterway #2								
Delaware River	9,329,946	8.31	6.49	3,029,697	9.64	2.11	12,359,643	8.60
Potomac River	3,967	0.12	0.06	53,313	1.65	0.80	57,280	0.86
Chesapeake Bay				4,161,233	13.87	13.87	4,161,233	13.87
Columbia River	722,821	3.20	1.85	431,034	2.61	1.10	1,153,855	2.95
Hudson River	662,237	5.12	1.72	3,622,053	14.18	9.41	4,284,290	11.13
New York State Barge Canal				466,483	20.99	20.99	466,483	20.99
Willamette River								
Sacramento River				80,080	30.02	5.39	80,080	5.39
San Joaquin River				153,167	18.39	4.11	153,167	4.11

Source: Inland Waterborne Commerce Statistics, the American Waterways Operators, Inc., Arlington, Virginia 22209, 1974.

TABLE B-5. Jet Fuel Traffic on the U.S. Waterways - 1974

Waterway	Oceangoing			Inland Waterway			Total Net Tons	% of Total Traffic
	Net Tons	% of Total Oceangoing Traffic	% of Total Traffic	Net Tons	% of Total Inland Traffic	% of Total Traffic		
Upper Mississippi River				323,751	0.52	0.52	323,751	0.52
Mississippi River	618,662	0.55	0.20	1,300,571	0.69	0.43	1,919,233	0.63
Ohio River				886,782	0.64	0.64	886,782	0.64
Illinois Waterway								
Missouri River								
McClellan-Kerr Arkansas River Navigation System								
Allegheny River								
Monongahela River								
Kanawha River				22,704	0.18	0.18	22,704	0.18
Cumberland River				55,446	0.50	0.50	55,446	0.50
Tennessee River								
Gulf Intracoastal Waterway				889,994	0.75	0.75	889,994	0.75
Houston Ship Channel	683,191	1.15	0.77	192,876	0.65	0.22	876,067	0.98
Black Warrior, Warrior and Tombigbee River System								
Apalachicola, Chattahoo- chee, and Flint River								
James River								
Atlantic Intracoastal Waterway #1				102,457	2.92	2.90	102,457	2.90
Atlantic Intracoastal Waterway #2								
Delaware River	348,683	0.31	0.24	859,452	2.73	0.60	1,208,135	0.84
Potomac River	51,126	1.50	0.77	156,284	4.84	2.36	207,410	3.13
Chesapeake Bay				545,887	1.82	1.82	545,887	1.82
Columbia River	24,218	0.11	0.06	22,144	0.13	0.06	46,362	0.12
Hudson River	6,435	0.05	0.02	236,810	0.93	0.62	243,245	0.63
New York State Barge Canal				153,978	6.93	6.93	153,978	6.93
Willamette River								
Sacramento River				5,646	2.12	0.38	5,646	0.38
San Joaquin River	44,957	1.56	1.21	1,061	0.13	0.03	46,018	1.24

Source: Inland Waterborne Commerce Statistics, the American Waterways Operators, Inc., Arlington, Virginia 22209, 1974.

TABLE B-6. Kerosene Traffic on the U.S. Waterways - 1974

Waterway	Oceangoing			Inland Waterway			Total Net Tons	% of Total Traffic
	Net Tons	% of Total Oceangoing Traffic	% of Total Traffic	Net Tons	% of Total Inland Traffic	% of Total Traffic		
Upper Mississippi River				24,350	0.04	0.04	24,350	0.04
Mississippi River	387,250	0.34	0.13	279,675	0.15	0.09	666,925	0.22
Ohio River				352,812	0.25	0.25	352,812	0.25
Illinois Waterway								
Missouri River								
McClellan-Kerr Arkansas River Navigation System								
Allegheny River				10,897	0.19	0.19	10,897	0.19
Monongahela River				70,925	0.19	0.19	70,925	0.19
Kanawha River				27,252	0.21	0.21	27,252	0.21
Cumberland River				6,983	0.06	0.06	6,983	0.06
Tennessee River								
Gulf Intracoastal Waterway	4,342	0.88	0.00	330,636	0.28	0.28	334,978	0.28
Houston Ship Channel	755,793	1.27	0.85	46,855	0.16	0.05	802,648	0.90
Black Warrior, Warrior and Tombigbee River System								
Apalachicola, Chattahoo- chee, and Flint River								
James River								
Atlantic Intracoastal Waterway #1				21,714	0.62	0.61	21,714	0.61
Atlantic Intracoastal Waterway #2								
Delaware River	696,388	0.62	0.48	200,458	0.64	0.14	896,846	0.62
Potomac River	41,300	1.21	0.62	13,305	0.41	0.20	54,605	0.82
Chesapeake Bay				228,905	0.76	0.76	228,905	0.76
Columbia River	50,206	0.22	0.13				50,206	0.13
Hudson River	49,292	0.38	0.13	235,575	0.92	0.61	284,867	0.74
New York State Barge Canal				85,588	3.85	3.85	85,588	3.85
Willamette River								
Sacramento River								
San Joaquin River								

Source: Inland Waterborne Commerce Statistics, the American Waterways Operators, Inc., Arlington, Virginia 22209, 1974.

TABLE B-7. Distillate Fuel Oil Traffic on the U.S. Waterways - 1974

Waterway	Oceangoing			Inland Waterway			Total Net Tons	% of Total Traffic
	Net Tons	% of Total Oceangoing Traffic	% of Total Traffic	Net Tons	% of Total Inland Traffic	% of Total Traffic		
Upper Mississippi River				1,856,641	3.01	2.99	1,856,641	2.99
Mississippi River	3,600,406	3.19	1.19	7,564,049	3.98	2.50	11,164,455	3.69
Ohio River				3,977,888	2.86	2.86	3,977,888	2.86
Illinois Waterway				1,835,645	4.05	4.05	1,835,645	4.05
Missouri River								
McClellan-Kerr Arkansas River Navigation System				145,394	2.42	2.42	145,394	2.42
Allegheny River				136,865	2.42	2.42	136,865	2.42
Monongahela River				494,784	1.29	1.29	494,784	1.29
Kanawha River				219,158	1.71	1.71	219,158	1.71
Cumberland River				190,896	1.73	1.73	190,896	1.73
Tennessee River				307,748	1.13	1.13	307,748	1.13
Gulf Intracoastal Waterway	25,557	5.18	0.02	6,692,710	5.65	5.63	6,718,267	5.65
Houston Ship Channel	6,032,268	10.12	6.77	2,115,298	7.17	2.37	8,147,566	9.14
Black Warrior, Warrior and Tombigbee River System				48,229	0.31	0.31	48,229	0.31
Apalachicola, Chattahoochee, and Flint Rivers				23,371	2.46	2.46	23,371	2.46
James River				75,136	1.07	0.97	75,136	0.97
Atlantic Intracoastal Waterway #1				270,181	7.69	7.64	270,181	7.64
Atlantic Intracoastal Waterway #2				520	0.04	0.03	520	0.03
Delaware River	7,185,575	6.40	5.00	4,814,728	15.32	3.35	12,000,303	8.35
Potomac River	184,498	5.42	2.78	311,363	9.64	4.69	495,861	7.48
Chesapeake Bay				4,013,547	13.38	13.38	4,013,547	13.38
Columbia River	1,062,901	4.70	2.72	435,420	2.63	1.11	1,498,321	3.83
Hudson River	773,016	5.97	2.01	4,622,633	18.10	12.01	5,395,649	14.02
New York State Barge Canal				630,764	28.38	28.38	630,764	28.38
Willamette River								
Sacramento River				29,965	11.23	2.02	29,965	2.02
San Joaquin River	174,758	6.05	4.69	94,552	11.35	2.54	269,310	7.23

Source: Inland Waterborne Commerce Statistics, the American Waterways Operators, Inc., Arlington, Virginia 22209, 1974.

TABLE B-8. Residual Fuel Oil Traffic on the U.S. Waterways - 1974

Waterway	Oceangoing			Inland Waterway			Total Net Tons	% of Total Traffic
	Net Tons	% of Total Oceangoing Traffic	% of Total Traffic	Net Tons	% of Total Inland Traffic	% of Total Traffic		
Upper Mississippi River				3,139,375	5.08	5.06	3,139,375	5.06
Mississippi River	3,319,257	2.94	1.10	13,700,428	7.22	4.53	17,019,685	5.62
Ohio River				3,361,494	2.41	2.41	3,361,494	2.41
Illinois Waterway				3,767,463	8.32	8.32	3,767,463	8.32
Missouri River								
McClellan-Kerr Arkansas River Navigation System				485,577	8.09	8.09	485,577	8.09
Allegheny River				43,359	0.77	0.77	43,359	0.77
Monongahela River				924,223	2.42	2.42	924,223	2.42
Kanawha River								
Cumberland River				55,617	0.50	0.50	55,617	0.50
Tennessee River				303,839	1.12	1.12	303,839	1.12
Gulf Intracoastal Waterway				11,985,220	10.12	10.07	11,985,220	10.07
Houston Ship Channel	2,010,927	3.37	2.26	4,738,085	16.06	5.32	6,749,012	7.57
Black Warrior, Warrior and Tombigbee River System				209,217	1.35	1.35	209,217	1.35
Apalachicola, Chattahoo- chee, and Flint Rivers				148,161	15.59	15.59	148,161	15.59
James River				2,604,014	37.06	33.75	2,604,014	33.75
Atlantic Intracoastal Waterway #1				704,117	20.05	19.91	704,117	19.91
Atlantic Intracoastal Waterway #2	35,517	56.02	2.36	1,354,853	93.95	89.99	1,390,370	92.35
Delaware River	11,571,855	10.31	8.05	7,263,363	23.11	5.06	18,835,218	13.11
Potomac River	2,903,238	85.30	43.77	1,995,820	61.79	30.09	4,899,058	73.85
Chesapeake Bay				4,730,000	15.77	15.77	4,730,000	15.77
Columbia River	842,968	3.73	2.15	335,063	2.03	0.86	1,178,031	3.01
Hudson River	2,469,031	19.08	6.42	5,672,880	22.21	14.74	8,141,911	21.16
New York State Barge Canal				452,666	20.36	20.36	452,666	20.36
Willamette River				33,855	0.61	0.57	33,855	0.57
Sacramento River								
San Joaquin River	398,909	13.80	10.72	167,913	20.16	4.51	566,822	15.23

Source: Inland Waterborne Commerce Statistics, the American Waterways Operators, Inc., Arlington, Virginia 22209, 1974.

TABLE B-9. Liquefied Gas Traffic on the U.S. Waterways - 1974^(a)

Waterway	Oceangoing			Inland Waterway			Total Net Tons	% of Total Traffic
	Net Tons	% of Total Oceangoing Traffic	% of Total Traffic	Net Tons	% of Total Inland Traffic	% of Total Traffic		
Upper Mississippi River								
Mississippi River	148,534	0.13	0.05	753,489	0.40	0.25	902,023	0.30
Ohio River				172,891	0.12	0.12	172,891	0.12
Illinois Waterway								
Missouri River								
McClellan-Kerr Arkansas River Navigation System								
Allegheny River								
Monongahela River								
Kanawha River								
Cumberland River								
Tennessee River				61,213	0.23	0.23	61,213	0.23
Gulf Intracoastal Waterway	1,465	0.30	0.00	489,627	0.41	0.41	491,092	0.41
Houston Ship Channel	940,304	1.58	1.06	107,137	0.36	0.12	1,047,441	1.18
Black Warrior, Warrior and Tombigbee River System								
Apalachicola, Chattahoochee, and Flint River								
James River								
Atlantic Intracoastal Waterway #1								
Atlantic Intracoastal Waterway #2								
Delaware River								
Potomac River								
Chesapeake Bay				45	0.00	0.00	45	0.00
Columbia River								
Hudson River								
New York State Barge Canal								
Willamette River								
Sacramento River								
San Joaquin River								

Source: Inland Waterborne Commerce Statistics, the American Waterways Operators, Inc., Arlington, Virginia 22209, 1974.

(a) Includes LPG and coal gases.

WATERWAY SYSTEM DESCRIPTIONS

Upper Mississippi River	From Minneapolis, MN, to the mouth of the Missouri River - 663 miles. Controlling depth: 9 feet.
Mississippi River	From Minneapolis, MN, to the mouth of Passes - 1,837 miles. Controlling depths: 9 to 40 feet.
Ohio River	From Pittsburgh, PA, at junction of Allegheny and Monongahela Rivers to the confluence of the Ohio and the Mississippi Rivers at Cairo, IL - 981 miles. Controlling depth: 9 feet.
Illinois Waterway	From Illinois River at Grafton, IL, to Turning Basin No. 5 on Calumet River (includes Calumet-Sag Channel) - 353.6 miles. Controlling depths: 9 to 12 feet.
Missouri River	From Fort Benton, MT, to the mouth of the Missouri River - 2073.2 miles. Controlling depths: 7.5 to 9 feet.
McClellan-Kerr Arkansas River Navigation System	From confluence of White and Mississippi Rivers to Catoosa, OK, via White River, Arkansas Post Canal, Arkansas, and Verdigris Rivers - 448 miles. Channel depth minimum: 9 feet.
Allegheny River	From Pittsburgh, PA, at the confluence of the Allegheny and Ohio Rivers above East Brady, PA - 72 miles. Controlling depth: 9 feet.
Monongahela River	From Pittsburgh, PA, at the confluence of the Monongahela, Ohio and Allegheny Rivers to Fairmont, WV - 129 miles. Controlling depths: 7 to 9 feet.
Kanawha River	Deepwater, WV, to the confluence of the Kanawha and Ohio Rivers at Point Pleasant, WV - 91 miles. Controlling depth: 9 feet.

Cumberland River	From the junction with the Ohio River near Smithland, KY, to Celina, TN - 380.8 miles. Controlling depths: 8 to 9 feet.
Tennessee River	From the junction of French and Holston Rivers at Knoxville, TN, to the confluence of the Tennessee and the Ohio Rivers at Paducah, KY - 652 miles. Controlling depth: 9 feet.
Gulf Intracoastal Waterway	From Apalachee Bay, FL, to Brownsville TX - 1108.9 miles. Alternate Route: Morgan City, LA, to Port Allen, LA - 64 miles. Controlling depths: 10 to 12 feet.
Houston Ship Channel	From Galveston Harbor, TX, through San Jacinto River and Buffalo Bayou to turning basin at Houston, TX - 52 miles. Controlling depths: 6 to 37 feet.
Black Warrior, Warrior and Tombigbe River System	From mouth of Chickasaw Creek to mile 427.6 on Sipsey Fork, and mile 407 on Locust Fork of the Black Warrior River. Controlling depth: 9 feet.
Apalachicola, Chattahoochee, and Flint Rivers	From Apalachicola Bay to the confluence of the Chattahoochee and Flint Rivers, the Chattahoochee River to Columbus, GA (268 miles), and the Flint River to Bainbridge, GA (29 miles). Total - 297 miles. Controlling depth: 9 feet.
James River	From Richmond, VA, to Hampton Roads at Newport News, VA - 89 miles. Controlling depths: 17.8 to 25 feet.
Atlantic Intracoastal Waterway #1	From Norfolk, VA, to St. Johns River at Jacksonville, FL - 739 miles. Controlling depth: 12 feet.
Atlantic Intracoastal Waterway #2	From St. Johns River at Jacksonville to Miami, FL - 349 miles. Controlling depths: 10 to 12 feet.
Delaware River	From Trenton, NJ, to Deepwater Point at mouth of Delaware Bay - 129 miles. Controlling depths: 10 to 40 feet.

Potomac River	From mouth to Giesboro Point at Washington, DC - 108 miles. Controlling depth: 20.5 feet.
Chesapeake Bay	From Baltimore, MD to the Capes of Virginia - 200 miles.
Columbia River	From the International boundary, south to the mouth of the Snake River, and westerly between OR and WA to the mouth of the Columbia River at the Pacific Ocean. Navigation mileage - 340. Controlling depths: 4 to 35 feet.
Hudson River	From deepwater in Upper Bay, NY to Waterford, NY - 155 miles. Controlling depths: 12 to 27 feet.
New York State Barge Canal	From Tonawanda, NY, to Whitehall, NY, including the Erie, Oswego, Cayuga, Seneca, and Champlain Canals - 522 miles. Controlling depths: 12 to 14 feet.
Willamette River	From Corvallis, OR, to the confluence of the Willamette and Columbia Rivers at Portland, OR - 132 miles. Controlling depths: 2.5 to 8 feet.
Sacramento River	From mouth of river to Red Bluff via river route - 245 miles. Controlling depths: 6 to 15 feet.
San Joaquin River	From Stockton, CA, to the mouth of San Joaquin River at Suisun Bay - 45 miles. From Stockton Channel to Hills Ferry - 86 miles. Controlling depths: 3 to 30 feet.

APPENDIX C

FEDERAL STATUTES, REGULATIONS AND ADMINISTRATIVE ORDERS
RELATIVE TO OIL POLLUTION CONTROL

APPENDIX C

FEDERAL STATUTES, REGULATIONS AND ADMINISTRATIVE ORDERS RELATIVE TO OIL POLLUTION CONTROL

Federal statutes, regulations and administrative orders relative to oil pollution control are administered by several departments and agencies. The following is a tabular summary of these legal authorities. The data was taken from: Risk Analysis of the Oil Transportation System, a report to the 43rd Legislature of the State of Washington, prepared by the Oceanographic Commission of Washington, Seattle, WA 98109, September 1972.

Federal Oil Pollution Control Statutes

Statutes	Operating Agencies Involved	Prohibited Act or Authorization	Territorial Application	Sanctions	Excepted Discharges
Refuse Act, 1899 (33 U.S.C. 407 et seq)	1. Corps 2. U.S.C.G. 3. Customs 4. Justice	To discharge from ship... (foreign & domestic) or from shore or waterfront facility, any refuse matter of any kind or description (even commercially valuable petroleum).	1. U.S. navigable waters (USNW) 2. Tributaries, if floats or washes into USNW. 3. On banks, if likely to be washed into USNW.	1. \$500.00-\$2500.00; 30 days to 1 yr. or both 2. Vessel liable "in rem" for penalties.	"Sewage" flowing from streets and sewers.
Water Quality Improvement Act of 1970 PL 91-224	1. EPA 2. DOT 3. Corps 4. Customs 5. Justice	The discharge of oil into the water in harmful quantities.	U.S. navigable waters, adjoining shorelines, the contiguous zone.	1. Failing to report prohibited discharges (a) fine up to \$10K (b) imprisonment up to one year or both. 2. Knowingly discharging penalty up to 10K. 3. Violating regulations penalty up to \$5K. 4. Cleanup costs (a) vessels up to \$14K or \$100 per GRT (b) offshore/shore-side facilities up to \$8K.	1. As permitted by regulation. 2. In the contiguous zone as permitted by '54 Convention.
Oil Pollution Act 1961 as amended (33 U.S.C. 1001-1015) implements International Convention on Prevention of Pollution of Sea by Oil	1. U.S.C.G. 2. Customs 3. Corps 4. Justice 5. State	1. Any discharge or escape of persistent oil from vessels subject to Act, i.e., all U.S. seagoing vessels including tankers (whose tanks carry only oil). Except: (a) tankers under 150 gross tons; (c) vessels on whaling operations; (d) vessels while using Great Lakes & tributaries; and, (e) naval vessels and auxiliaries.	1. Prohibited zone: (a) measured from baseline from which territorial sea is established; (b) generally extends 50 miles to sea; (c) extends out 100 miles to sea off Northeast Coast of U.S.; (d) extends out 100 miles to sea off West Coast of Canada, (e) modifications published in Notices to Mariners.	1. Penalty: (a) \$500.00 to \$2500.00 or 1 yr. or both - any person or company; (b) ship other than one owned & operated by U.S. liable "in rem" for above penalty, and (c) suspension or revocation of license.	1. Discharges: (a) to secure safety of ship, cargo or life at sea; (b) due to damage to vessel or unavoidable leakage, if all reasonable precautions taken after damage occurred or leakage discovered; (c) of residue from fuel or lube oil purification or clarification as far from land as possible.

Statutes	Operating Agencies Involved	Prohibited Act or Authorization	Territorial Application	Sanctions	Excepted Discharges
		2. Any discharge of oil vessel subject to Act, of 20,000 or plus gross tons, whose bldg. contract executed on or after May 18, 1967. 3. Vessels, subject to Act, which are tankers or use oil fuel must keep <u>Oil Record Book</u> with entries of certain discharges or escapes of oils. 4. Forward to State Dept. evidence of discharge or escape from foreign vessel.	2. Unlimited - except if in Master's opinion special circumstances make it neither reasonable nor practicable to retain oil on board, discharge, outside prohibited zone is permitted. 3. Penalties re. <u>Oil Record Book</u> : (a) person failing to comply - fine of from \$500 to \$1000. (b) person making false entry (i) fine \$500 to \$1000 or (ii) imprisonment for 8 mos. or both. 4. Prohibited zone (No. 1 above).		(d) oil mixtures from bilges containing only lube oil drained or leaked from machinery spaces. (e) vessels, other than tanker, proceeding to a port with inadequate reception facilities.
Federal Water Pollution Control Act, as amended (33 U.S.C. 1151 et. seq.)	1. Administrator EPA	1. To participate in oil & other hazardous substances pollution spills & recommend solutions when requested by state or interstate agencies. 2. To provide technical assistance to public & private agencies. 3. To recommend limits on pollutants, including oil & hazardous substances. 4. To "approve" state adopted water quality standards and to establish federal standards where state standards are not submitted or are inadequate. Standards ordinarily include criteria limiting discharges of oil or hazardous substances.	1. U.S. navigable waters & tributaries. Interstate waters as defined in this Act, including coastal waters.	1. Enforcement-conference pursuant to Sec. 10 may result in Federal legal action to enforce recommendations. 2. Abatement action pursuant to Sec. 10(c) (5) where discharge reduces quality below established standard.	

Statutes	Operating Agencies Involved	Prohibited Act or Authorization	Territorial Application	Sanctions	Excepted Discharges
Section 12, Fed. Water Pollution Control Act, as amended by P.L. 91-224 (April 3, 1970) (33 U.S.C. 1151, et. seq.)	1. EPA 2. DOT 3. Corps 4. Customs 5. Justice	President shall promulgate regulations designating hazardous substances and recommending methods for removal.	U.S. navigable waters, adjoining shorelines, the contiguous zone	President shall make recommendation to Congress not later than Nov. 1, 1970. Clean up fund of Section 11 available here.	

RELATED FEDERAL STATUTES

Statutes	Administrative Authority	Authorized Action	Territorial Considerations
U.S. Navy Ship Salvage Authority (10 U.S.C. 7361)	Secretary of Navy (U.S. Navy Ship System Command, Supervisor of Salvage)	1. To salvage, by contract or otherwise: (a) U.S. Naval vessels; (b) Private vessel (foreign or domestic) subject to availability of salvage forces; and, (i) if not abandoned nor under governmental control nor other salvage facilities reasonably available & competent private authority requests help, i.e., ship's master, owner, or underwriter, (ii) if abandoned or under control of U.S.C.S., FWPCA, Corps of Engineers, Office of Emergency Preparedness, or federal court - competent requesting agency becomes customer.	1. (a) for U.S. Naval vessels - Navy has direct responsibility anywhere; (b) for private vessels (i) U.S. navigable waters and high seas. (ii) U.S. navigable waters, U.S. territorial waters and those within the authority of requesting government agency by law or treaty.
Outer Continental Shelf Land Act of 1953 (43 U.S.C. 1331-1343)	Secretary of the Interior (a) Bur. of Land Mgmt. (b) U.S.G.S. Secretary of Transportation (a) U.S.C.G.	1. To regulate leases for exploitation of Shelf lands, terms & conditions calculated to prevent pollution in off-shore oil or mining operations. Regulations provide that lessee shall not pollute; shall take certain preventive actions and if pollution occurs, lessee shall make appropriate notifications and shall be liable for clean up.	1. U.S. Continental Shelf Lands
Disaster Relief Act of 1970 (84 Stat. 1744)	The President Director, Office of Emergency Preparedness per E.O. 11575, Dec. 31, 1970	1. To declare a major disaster at the request of a governor of a state. 2. If declared, to direct federal agencies to assist by: (a) Using or lending, with or without compensation, to state & local governments, equipment, supplies, facilities, personnel, etc. other than extension of credit under any act. (b) Performing, on public or private land, work to preserve life and property. (c) Provide temporary housing or emergency shelter. (d) Clear debris & wreckage. (e) Make emergency repairs & temporary replacements to public facilities of state and local governments.	1. Major disaster areas as declared by President. 2. U.S., its territories & possessions.

<u>Statutes</u>	<u>Administrative Authority</u>	<u>Authorized Action</u>	<u>Territorial Considerations</u>
14 U.S.C. 81 <u>et seq.</u>	U.S.C.G.	<ol style="list-style-type: none"> OEP can give direct financial assistance to State & local governments for items in 2 above. To aid distressed persons & protect property. Sec. 88 (b) in USNW and on the high seas. To establish, maintain & operate aids to maritime navigation in USNW, waters above the U.S. continental shelf and other specified areas. To mark for protection of navigation any wreck in USNW (Sec. 86) not properly marked by owner (33 U.S.C. 409) 	
14 U.S.C. 141(a)	U.S.C.G.	<ol style="list-style-type: none"> On request may use personnel & facilities to assist any government agency, to perform any activity for which such personnel are especially qualified. 	<ol style="list-style-type: none"> Limited only by international law re. Territorial waters
Magnuson Act (50 U.S.C. 191)	designated U.S.C.G. Officers (33 CFR 6) when directed by Executive order (presently implemented by E.O. 10173 as amended)	<ol style="list-style-type: none"> Prevent anything from being placed on board any vessel or waterfront facility as defined in 33 CFR 6.01-4, when necessary to prevent damage to U.S. waters. Establish security zones into which no person or vessel may enter or take anything. Control vessel movement & take full or partial possession or control of any vessel when necessary to prevent danger to U.S. waters. Prevent mooring to or compel shifting of any vessel from waterfront facility if it endangers such vessel, other vessels, harbor, any facility therein because conditions exist in or about water front - not limited to fire hazards & unsatisfactory operations. 	<ol style="list-style-type: none"> U.S. Territorial waters
Dangerous Cargo Act (46 U.S.C. 170)	U.S.C.G.	<ol style="list-style-type: none"> Authority to establish regulations for handling, stowage, storage and use of dangerous articles or substances on board vessels Authority to establish regulations for disposing of dangerous articles or substances found to be in an unsafe condition 	U.S. Territorial waters
Tank Vessel Act (46 U.S.C. 391a)	U.S.C.G.	<ol style="list-style-type: none"> Authority to establish additional rules for provision against hazards of life and property created by vessels having on board flammable or combustible liquid cargo in bulk. 	U.S. Territorial waters

TREATIES AND INTERNATIONAL CONVENTIONS

<u>Title</u>	<u>Parties</u>	<u>Substance of Agreement</u>	<u>Territorial Considerations</u>
Treaty re. Reciprocal Rights in Conveyance of Prisoners and Wrecking & Salvage (35 Stat. 2035, TS 502)	U.S. - Great Britain signed for Canada (1908)	<ol style="list-style-type: none"> Vessels & wrecking equipment of U.S. or Canada permitted to salvage wrecks, render aid to vessels in distress or disabled across the international boundary line. 	<ol style="list-style-type: none"> In portion of St. Lawrence River through which boundary line passes. Lakes Ontario, Erie, St. Clair, Huron, Superior. Niagara, Detroit, St. Clair & St. Marie River. Canals at Sault St. Marie.

Title	Parties	Substance of Agreement	Territorial Considerations
Boundary Waters Treaty (35 Stat. 2448, TS 548)	U.S. - Great Britain signed for Canada (1909)	1. Established international Joint Commission with jurisdiction over all cases re. use, obstruction or diversion of waters including water pollution. No mechanism for enforcement directly by Commission, findings & recommendations reported to respective governments for enforcement action within its territorial limits.	5. Shores & territorial waters on Pacific & Atlantic within 30 miles of boundary line. 1. U.S. - Canadian boundary waters
Treaty to Facilitate Assistance to & Salvage of Vessels in Territorial Waters (49 Stat. 3359, TS 905)	U.S. - Mexico (1936)	1. Vessels & rescue apparatus, public & private, may aid vessels and crew of its own nationality, when disabled or in distress. 2. Captain, master or owner of rescue vessel of either country must notify that country when entering or intending to enter territorial waters of the other country as early as possible and may freely proceed with rescue unless advised by the other country that adequate assistance is available or for any other reason rescue is not necessary.	1. On shores or with territorial waters of the other nation - (a) within 720 mile radius of intersection of international boundary line & Pacific Coast or (b) within 200 miles radius of intersection of international boundary line & coast of Gulf of Mexico.
Convention of High Seas (1958) TIAS 5200 (13 U.S.T. 2312)	U.S. (1962) - Denmark, Finland, Italy, Japan, Mexico, Netherlands, U.K., USSR, inter alia	1. Article XXIV - Member nations responsible for drafting regulations to prevent pollution of seas by oil. 2. Article XXV - same for radioactive wastes & other harmful agents by vessels under its control.	High Sea
Geneva Convention on Territorial Sea & Contiguous Zone (1958) (15 U.S.T. 1606) (TIAS 5639)	U.S. (1964) - Denmark, Finland, Italy, Japan, Netherlands, U.K., USSR, inter alia	1. To exercise necessary controls to prevent infringement of nations sanitary regulations within its territory or territorial sea.	1. Not to exceed 12 miles outward from the baseline from which the territorial sea is measured.
Convention on Continental Shelf (1958) (TIAS 5578) (15 U.S.T. 471)	U.S. (1964) - Denmark, Finland, France, Mexico, Netherlands, U.K., USSR, inter alia	Coastal government has: exclusive & sovereign right to explore and exploit natural resources of the Shelf as long as it does not unjustifiably interfere with navigation, fishing or conservation of living sea resources nor with fundamental oceanographic or other scientific research destined for open publication.	U.S. Continental Shelf - 200 meter isobath curve contiguous to land or to a depth that admits of the exploitation of said area.
Convention for Prevention of Pollution by Sea by Oil (1954) (12 U.S.T. 2959 (1969) amended 17 U.S.T. 1523)	U.S. (1961) - Belgium, Denmark, Finland, France, West Germany, Greece, Italy, Japan, Liberia, Mexico, Netherlands, Nigeria, Norway, Panama, Spain, Sweden, U.K., inter alia.	1. To prevent discharge or escape of oily substances by sea-going vessels - see Oil Pollution Act of 1961 as amended in 1966 for U.S. implementation. (33 U.S.C. 1001-1015) (Note: Oily substance is defined as resistant oil) 2. Maintenance of Oil Record Book.	1. Prohibited zone: All seas within 50 miles from nearest land (baseline established) and other areas as defined in the convention.

APPENDIX D

MATERIAL CHARACTERISTICS OF CRUDE OIL AND ITS PRODUCTS

APPENDIX D

MATERIAL CHARACTERISTICS OF CRUDE OIL AND ITS PRODUCTS

The information reproduced on the following pages is taken from: CHRIS: Hazardous Chemical Data, CG-446-Z, Department of Transportation, U.S. Coast Guard, Washington, DC 20590. The characteristics, hazards and safety precautions for several forms of petroleum are described.

OIL

OILS: CRUDE

Common Synonyms Petroleum		Oil; liquid	Dark	Acrid odor
Floats on water. Flammable vapor may be produced.				
Stop discharge if possible. Keep people away. Call fire department. Avoid contact with liquid. Isolate and remove discharged material. Notify local health and pollution control agencies.				
Fire	Combustible. Extinguish with dry chemical, foam, or carbon dioxide. Water may be ineffective on fire. Cool exposed containers with water.			
Exposure	CALL FOR MEDICAL AID. VAPOR Not irritating to eyes, nose, or throat. LIQUID Irritating to skin and eyes. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water.			
Water Pollution	HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS. Polluting to shoreline. May be dangerous if it enters water intakes. Notify local health and wildlife officials. Notify operators of nearby water intakes.			
1. RESPONSE TO DISCHARGE (See Response Methods Handbook, CG 446-4) Mechanical containment Should be removed Chemical and physical treatment		2. LABELS No hazard label required by Code of Federal Regulations		
3. CHEMICAL DESIGNATIONS 3.1 Synonyms: Petroleum 3.2 Coast Guard Compatibility Classification: Petroleum oil 3.3 Chemical Formula: Not applicable 3.4 IMCO/United Nations Numerical Designation: 3.1/1267		4. OBSERVABLE CHARACTERISTICS 4.1 Physical State (as shipped): Liquid 4.2 Color: Dark 4.3 Odor: Offensive; tarry		
5. HEALTH HAZARDS 5.1 Personal Protective Equipment: Goggles or face shield; rubber gloves and boots. 5.2 Symptoms Following Exposure: May irritate eyes and skin. 5.3 Treatment for Exposure: EYES: flush with water for at least 15 min. SKIN: wipe off and wash with soap and water. 5.4 Toxicity by Inhalation (Threshold Limit Value): Data not available 5.5 Short-Term Inhalation Limits: Data not available 5.6 Toxicity by Ingestion: Data not available 5.7 Late Toxicity: Data not available 5.8 Vapor (Gas) Irritant Characteristics: Vapors are nonirritating to the eyes and throat. 5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. 5.10 Odor Threshold: Data not available				

6. FIRE HAZARDS

- 6.1 Flash Point: Data not available
6.2 Flammable Limits in Air: Data not available
6.3 Fire Extinguishing Agents: Dry chemical, foam, or carbon dioxide
6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective
6.5 Special Hazards of Combustion Products: Not pertinent
6.6 Behavior in Fire: Not pertinent
6.7 Ignition Temperature: Data not available
6.8 Electrical Hazard: Not pertinent
6.9 Burning Rate: 4 mm/min.

8. WATER POLLUTION

- 8.1 Aquatic Toxicity: 3 ppm/°/fresh water fish/toxic/fresh water 200 ppm/24 hr/corals: porites/20-90% normal response/salt water *Time period not specified.
8.2 Watertow Toxicity: Data not available
8.3 Biological Oxygen Demand (BOD): Data not available
8.4 Food Chain Concentration Potential: None

9. SELECTED MANUFACTURERS

1. Exxon Co.
Houston, Tex. 77001
2. Shell Oil Co.
1 Shell Plaza
Houston, Tex. 77001
3. Sun Oil Co.
St. Davids, Pa. 19087

7. CHEMICAL REACTIVITY

- 7.1 Reactivity with Water: No reaction
7.2 Reactivity with Common Materials: No reaction
7.3 Stability During Transport: Stable
7.4 Neutralizing Agents for Acids and Caustics: Not pertinent
7.5 Polymerization: Not pertinent
7.6 Inhibitor of Polymerization: Not pertinent

10. SHIPPING INFORMATION

- 10.1 Grades or Purity: Wide variety, depending on oil field where produced.
10.2 Storage Temperature: Ambient
10.3 Inert Atmosphere: No requirement
10.4 Venting: Open (flame arrester)

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CG 446-3)
A-T-U

12. HAZARD CLASSIFICATIONS

- 12.1 Code of Federal Regulations:
Combustible liquid
12.2 NAB Hazard Rating for Bulk Water Transportation:
Category	Rating
Fire	1-3
Health	
Vapor Irritant	0
Liquid or Solid Irritant	1
Poisons	1
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	2
Aesthetic Effect	4
Reactivity	
Other Chemicals	0
Water	0
Self-Reaction	0
- 12.3 NFPA Hazard Classifications:
Category	Classification
Health Hazard (Blue)	1
Flammability (Red)	3
Reactivity (Yellow)	0

13. PHYSICAL AND CHEMICAL PROPERTIES

- 13.1 Physical State at 15°C and 1 atm: Liquid
13.2 Molecular Weight: Not pertinent
13.3 Boiling Point at 1 atm: 90-->750°F = 32-->400°C = 305-->673°K
13.4 Freezing Point: Not pertinent
13.5 Critical Temperature: Not pertinent
13.6 Critical Pressure: Not pertinent
13.7 Specific Gravity: 0.70 - 0.98 at 15°C (liquid)
13.8 Liquid Surface Tension: 24 - 38 dynes/cm = 0.024 - 0.038 N/m at 20°C
13.9 Liquid-Water Interfacial Tension: (est.) 50 dynes/cm = 0.05 N/m at 20°C
13.10 Vapor (Gas) Specific Gravity: Not pertinent
13.11 Ratio of Specific Heats of Vapor (Gas): Not pertinent
13.12 Latent Heat of Vaporization: 140--150 Btu/lb = 76--86 cal/g = 3.2--3.6 X 10⁵ J/kg
13.13 Heat of Combustion: -18,252 Btu/lb = -10,140 cal/g = -424.54 X 10³ J/kg
13.14 Heat of Decomposition: Not pertinent
13.15 Heat of Solution: Not pertinent
13.16 Heat of Polymerization: Not pertinent

(Continued on pages 5 and 6)

NOTES

GAT

GASOLINES: AUTOMOTIVE

(< 4.23g load/gal)

Common Synonyms	Watery liquid Colorless to pale brown or pink Gasoline odor
	Floats on water. Flammable, irritating vapor is produced.
	Stop discharge if possible. Keep people away. Shut off ignition sources and call fire department. Stay upwind and use water spray to "knock down" vapor. Isolate and remove discharged material. Notify local health and pollution control agencies.
Fire	FLAMMABLE. Flashback along vapor trail may occur. Vapor may explode if ignited in an enclosed area. Extinguish with dry chemical, foam, or carbon dioxide. Water may be ineffective on fire. Cool exposed containers with water.
Exposure	CALL FOR MEDICAL AID. VAPOR Irritating to eyes, nose and throat. If inhaled, will cause dizziness, headache, difficult breathing or loss of consciousness. Move to fresh air. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen. LIQUID Irritating to skin and eyes. If swallowed, will cause nausea or vomiting. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk. DO NOT INDUCE VOMITING.
Water Pollution	HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS. Fouling to shoreline. May be dangerous if it enters water intakes. Notify local health and wildlife officials. Notify operators of nearby water intakes.
1. RESPONSE TO DISCHARGE (See Response Methods Handbook, CG 446-A) Issue warning - high flammability Evacuate area Disperse and flush	2. LABELS PRESENT NEW
3. CHEMICAL DESIGNATIONS 3.1 Synonyms: Motor spirit Petrol 3.2 Coast Guard Compatibility Classification: Petroleum oils 3.3 Chemical Formula: (Mixture of hydrocarbons) 3.4 IMCO/United Nations Numerical Designation: 3.1/1203	4. OBSERVABLE CHARACTERISTICS 4.1 Physical State (as shipped): Liquid 4.2 Color: Colorless to brown 4.3 Odor: Gasoline
5. HEALTH HAZARDS 5.1 Personal Protective Equipment: Protective goggles, gloves. 5.2 Symptoms Following Exposure: Irritation of mucous membranes and stimulation followed by depression of central nervous system. Breathing of vapor may also cause dizziness, headache, and incoordination or, in more severe cases, anesthesia, coma, and respiratory arrest. If liquid enters lungs, it will cause severe irritation, coughing, gagging, pulmonary edema, and, later, signs of bronchopneumonia and pneumonitis. Swallowing may cause irregular heartbeat. 5.3 Treatment for Exposure: INHALATION: maintain respiration and administer oxygen, enforce bed rest if liquid is in lungs. INGESTION: do NOT induce vomiting; stomach should be lavaged (by doctor) if appreciable quantity is swallowed. EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water. 5.4 Toxicity by Inhalation (Threshold Limit Value): No single TLV applies. 5.5 Short-Term Inhalation Limits: 500 ppm for 30 min. 5.6 Toxicity by Ingestion: Grade 2; LD ₅₀ 0.5 to 5 g/kg. 5.7 Late Toxicity: None 5.8 Vapor (Gas) Irritant Characteristics: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary. 5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. 5.10 Odor Threshold: 0.25 ppm	

6. FIRE HAZARDS 6.1 Flash Point: -36°F C.C. 6.2 Flammable Limits in Air: 1.4% - 7.4% 6.3 Fire Extinguishing Agents: Foam, carbon dioxide, dry chemical 6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective 6.5 Special Hazards of Combustion Products: None 6.6 Behavior in Fire: Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back. 6.7 Ignition Temperature: 853°F 6.8 Electrical Hazard: Class I, Group D 6.9 Burning Rate: 4 mm/min.	8. WATER POLLUTION 8.1 Aquatic Toxicity: 90 ppm/24 hr/juvenile American shad/ TLm/fresh water 91 mg/l/24 hr/juvenile American shad/ TLm/salt water 8.2 Waterfowl Toxicity: Data not available 8.3 Biological Oxygen Demand (BOD): 8%, 5 days 8.4 Food Chain Concentration Potential: None																																				
7. CHEMICAL REACTIVITY 7.1 Reactivity with Water: No reaction 7.2 Reactivity with Common Materials: No reaction 7.3 Stability During Transport: Stable 7.4 Neutralizing Agents for Acids and Caustics: Not pertinent 7.5 Polymerization: Not pertinent 7.6 Inhibitor of Polymerization: Not pertinent	9. SELECTED MANUFACTURERS 1. Exxon Co. 30 Rockefeller Plaza New York, N. Y. 10020 2. Shell Oil Co. 1 Shell Plaza Houston, Texas 77001 3. Sun Oil Co. St. Davids, Pa. 19087																																				
11. HAZARD ASSESSMENT CODE (See Hazard Assessment Handbook, CG 446-3) A-T-U-V-W	10. SHIPPING INFORMATION 10.1 Grades or Purity: Various octane ratings; military specifications 10.2 Storage Temperature: Ambient 10.3 Inert Atmosphere: No requirement 10.4 Venting: Open (flame arrester) or pressure-vacuum																																				
12. HAZARD CLASSIFICATIONS 12.1 Code of Federal Regulations: Flammable liquid 12.2 NAS Hazard Rating for Bulk Water Transportation: <table><thead><tr><th>Category</th><th>Rating</th></tr></thead><tbody><tr><td>Fire</td><td>3</td></tr><tr><td>Health</td><td></td></tr><tr><td>Vapor Irritant</td><td>1</td></tr><tr><td>Liquid or Solid Irritant</td><td>1</td></tr><tr><td>Poisons</td><td>2</td></tr><tr><td>Water Pollution</td><td></td></tr><tr><td>Human Toxicity</td><td>1</td></tr><tr><td>Aquatic Toxicity</td><td>2</td></tr><tr><td>Aesthetic Effect</td><td>2</td></tr><tr><td>Reactivity</td><td></td></tr><tr><td>Other Chemicals</td><td>0</td></tr><tr><td>Water</td><td>0</td></tr><tr><td>Self-Reaction</td><td>0</td></tr></tbody></table> 12.3 NFPA Hazard Classifications: <table><thead><tr><th>Category</th><th>Classification</th></tr></thead><tbody><tr><td>Health Hazard (Blue)</td><td>1</td></tr><tr><td>Flammability (Red)</td><td>3</td></tr><tr><td>Reactivity (Yellow)</td><td>0</td></tr></tbody></table>	Category	Rating	Fire	3	Health		Vapor Irritant	1	Liquid or Solid Irritant	1	Poisons	2	Water Pollution		Human Toxicity	1	Aquatic Toxicity	2	Aesthetic Effect	2	Reactivity		Other Chemicals	0	Water	0	Self-Reaction	0	Category	Classification	Health Hazard (Blue)	1	Flammability (Red)	3	Reactivity (Yellow)	0	13. PHYSICAL AND CHEMICAL PROPERTIES 13.1 Physical State at 15°C and 1 atm: Liquid 13.2 Molecular Weight: Not pertinent 13.3 Boiling Point at 1 atm: 140 - 390°F = 60 - 199°C = 333 - 472°K 13.4 Freezing Point: Not pertinent 13.5 Critical Temperature: Not pertinent 13.6 Critical Pressure: Not pertinent 13.7 Specific Gravity: 0.71 - 0.747 at 20°C (liquid) 13.8 Liquid Surface Tension: 19 - 23 dynes/cm = 0.019 - 0.023 N/m at 20°C 13.9 Liquid-Water Interfacial Tension: 49 - 51 dynes/cm = 0.049 - 0.051 N/m at 20°C 13.10 Vapor (Gas) Specific Gravity: 3.4 13.11 Ratio of Specific Heats of Vapor (Gas): (est.) 1.054 13.12 Latent Heat of Vaporization: 130 - 150 Btu/lb = 71 - 81 cal/g = 3.0 - 3.4 × 10 ⁵ J/kg 13.13 Heat of Combustion: -18,720 Btu/lb = -10,400 cal/g = -435.1 × 10 ³ J/kg 13.14 Heat of Decomposition: Not pertinent 13.15 Heat of Solution: Not pertinent 13.16 Heat of Polymerization: Not pertinent
Category	Rating																																				
Fire	3																																				
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NOTES (Continued on pages 5 and 6)																																					

Common Synonyms		Watery liquid	Colorless	Fuel oil odor
Floats on water. Irritating, combustible vapor may be produced.				
Stop discharge if possible. Call fire department. Stay upwind and use water spray to "knock down" vapor. Avoid contact with liquid and vapor. Isolate and remove discharged material. Notify local health and pollution control agencies.				
Fire		Combustible. Extinguish with dry chemical, foam, or carbon dioxide. Water may be ineffective on fire. Cool exposed containers with water.		
Exposure		CALL FOR MEDICAL AID. VAPOR Irritating to eyes, nose and throat. If inhaled, will cause coughing, dizziness, headache, or difficult breathing. Move to fresh air. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen. LIQUID Irritating to skin and eyes. Harmful if swallowed. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk. DO NOT INDUCE VOMITING.		
Water Pollution		Dangerous to aquatic life in high concentrations. Fouling to shoreline. May be dangerous if it enters water intakes. Notify local health and wildlife officials. Notify operators of nearby water intakes.		
1. RESPONSE TO DISCHARGE (See Response Methods Handbook CG 446-4) Mechanical containment Should be removed Chemical and physical treatment			2. LABELS No hazard label required by Code of Federal Regulations	
3. CHEMICAL DESIGNATIONS 3.1 Synonyms: No common synonyms 3.2 Coast Guard Compatibility Classification: Petrolium oil 3.3 Chemical Formula: C ₁₂ H ₂₆ 3.4 IMCO/United Nations Numerical Designation: 33/1223			4. OBSERVABLE CHARACTERISTICS 4.1 Physical State (as shipped): Liquid 4.2 Color: Colorless to light brown 4.3 Odor: Like fuel oil	
5. HEALTH HAZARDS 5.1 Personal Protective Equipment: Protective gloves, goggles or face shield. 5.2 Symptoms Following Exposure: Vapor causes slight irritation of eyes and nose. Liquid irritates stomach; if taken into lungs, causes coughing, distress, and rapidly developing pulmonary edema. 5.3 Treatment for Exposure: ASPIRATION: enforce bed rest, administer oxygen, call a doctor. INGESTION: do NOT induce vomiting, call a doctor. EYES: wash with plenty of water. SKIN: wipe off and wash with soap and water. 5.4 Toxicity by Inhalation (Threshold Limit Value): 200 ppm 5.5 Short-Term Inhalation Limits: Data not available 5.6 Toxicity by Ingestion: Grade 2, LD ₅₀ 0.5 to 5 g/kg 5.7 Late Toxicity: Data not available 5.8 Vapor (Gas) Irritant Characteristics: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary. 5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. 5.10 Odor Threshold: 1 ppm				

<p style="text-align: center;">6. FIRE HAZARDS</p> <p>6.1 Flash Point: 110-150°F</p> <p>6.2 Flammable Limits in Air: Data not available</p> <p>6.3 Fire Extinguishing Agents: Foam, dry chemical, or carbon dioxide</p> <p>6.4 Fire Extinguishing Agents Not to be Used: Not pertinent</p> <p>6.5 Special Hazards of Combustion Products: Not pertinent</p> <p>6.6 Behavior in Fire: Not pertinent</p> <p>6.7 Ignition Temperature: Data not available</p> <p>6.8 Electrical Hazard: Not pertinent</p> <p>6.9 Burning Rate: 4 mm/min</p>	<p style="text-align: center;">8. WATER POLLUTION</p> <p>8.1 Aquatic Toxicity: 2990 ppm/24 hr/bluegill/TL_m/fresh water</p> <p>8.2 Waterbody Toxicity: Data not available</p> <p>8.3 Biological Oxygen Demand (BOD): 5%; 5 days</p> <p>8.4 Food Chain Concentration Potential: None</p>																																				
<p style="text-align: center;">7. CHEMICAL REACTIVITY</p> <p>7.1 Reactivity with Water: No reaction</p> <p>7.2 Reactivity with Common Materials: No reaction</p> <p>7.3 Stability During Transport: Stable</p> <p>7.4 Neutralizing Agents for Acids and Caustics: Not pertinent</p> <p>7.5 Polymerization: Not pertinent</p> <p>7.6 Inhibitor of Polymerization: Not pertinent</p>	<p style="text-align: center;">9. SELECTED MANUFACTURERS</p> <p>1. Exxon Co. 30 Rockefeller Plaza New York, N. Y. 10020</p> <p>2. Shell Oil Co. 1 Shell Plaza Houston, Tex. 77001</p> <p>3. Sun Oil Co. 240 Radnor Rd. St. Davids, Pa. 19087</p>																																				
<p style="text-align: center;">11. HAZARD ASSESSMENT CODE</p> <p style="font-size: small;">(See Hazard Assessment Handbook, CG 446-3)</p> <p style="text-align: center;">A-T-L</p>	<p style="text-align: center;">10. SHIPPING INFORMATION</p> <p>10.1 Grades or Purity: 100%</p> <p>10.2 Storage Temperature: Ambient</p> <p>10.3 Inert Atmosphere: No requirement</p> <p>10.4 Venting: Open (flame arrester)</p>																																				
<p style="text-align: center;">12. HAZARD CLASSIFICATIONS</p> <p>12.1 Code of Federal Regulations: Not listed</p> <p>12.2 NAB Hazard Rating for Bulk Water Transportation:</p> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Category</th> <th style="text-align: left;">Rating</th> </tr> </thead> <tbody> <tr> <td>Fire</td> <td>3</td> </tr> <tr> <td>Health</td> <td></td> </tr> <tr> <td> Vapor Irritant</td> <td>1</td> </tr> <tr> <td> Liquid or Solid Irritant</td> <td>1</td> </tr> <tr> <td> Poisons</td> <td>1</td> </tr> <tr> <td>Water Pollution</td> <td></td> </tr> <tr> <td> Human Toxicity</td> <td>1</td> </tr> <tr> <td> Aquatic Toxicity</td> <td>1</td> </tr> <tr> <td> Aesthetic Effect</td> <td>2</td> </tr> <tr> <td>Reactivity</td> <td></td> </tr> <tr> <td> Other Chemicals</td> <td>0</td> </tr> <tr> <td> Water</td> <td>0</td> </tr> <tr> <td> Self-Reaction</td> <td>0</td> </tr> </tbody> </table> <p>12.3 NFPA Hazard Classifications:</p> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">Category</th> <th style="text-align: left;">Classification</th> </tr> </thead> <tbody> <tr> <td>Health Hazard (Blue)</td> <td>0</td> </tr> <tr> <td>Flammability (Red)</td> <td>2</td> </tr> <tr> <td>Reactivity (Yellow)</td> <td>0</td> </tr> </tbody> </table>	Category	Rating	Fire	3	Health		Vapor Irritant	1	Liquid or Solid Irritant	1	Poisons	1	Water Pollution		Human Toxicity	1	Aquatic Toxicity	1	Aesthetic Effect	2	Reactivity		Other Chemicals	0	Water	0	Self-Reaction	0	Category	Classification	Health Hazard (Blue)	0	Flammability (Red)	2	Reactivity (Yellow)	0	<p style="text-align: center;">13. PHYSICAL AND CHEMICAL PROPERTIES</p> <p>13.1 Physical State at 15°C and 1 atm: Liquid</p> <p>13.2 Molecular Weight: Not pertinent</p> <p>13.3 Boiling Point at 1 atm: 86, -500°F = 30, -260°C = 303, -533°K</p> <p>13.4 Freezing Point: Not pertinent</p> <p>13.5 Critical Temperature: Not pertinent</p> <p>13.6 Critical Pressure: Not pertinent</p> <p>13.7 Specific Gravity: 0.80 at 20°C (liquid)</p> <p>13.8 Liquid Surface Tension: (est.) 25 dynes/cm = 0.025 N/m at 20°C</p> <p>13.9 Liquid-Water Interfacial Tension: (est.) 50 dynes/cm = 0.05 N/m at 20°C</p> <p>13.10 Vapor (Gas) Specific Gravity: Not pertinent</p> <p>13.11 Ratio of Specific Heats of Vapor (Gas): (est.) 1.030</p> <p>13.12 Latent Heat of Vaporization: 140 Btu/lb = 78 cal/g = 3.3 X 10³ J/kg</p> <p>13.13 Heat of Combustion: -18,340 Btu/lb = -10,360 cal/g = -431.24 X 10³ J/kg</p> <p>13.14 Heat of Decomposition: Not pertinent</p> <p>13.15 Heat of Solution: Not pertinent</p> <p>13.16 Heat of Polymerization: Not pertinent</p>
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(Continued on pages 5 and 6.)

NOTES

JPF	JET FUELS: JP-4
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Common Synonyms	Watery liquid Colorless Fuel oil odor Floats on water.
<p>Stop discharge if possible. Keep people away. Shut off ignition sources and call fire department. Avoid contact with liquid. Isolate and remove discharged material. Notify local health and pollution control agencies.</p>	
Fire	<p>FLAMMABLE. Extinguish with dry chemical, foam, or carbon dioxide. Water may be ineffective on fire. Cool exposed containers with water.</p>
Exposure	<p>CALL FOR MEDICAL AID. LIQUID. Irritating to skin and eyes. Harmful if swallowed. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk. DO NOT INDUCE VOMITING.</p>
Water Pollution	<p>Dangerous to aquatic life in high concentrations. Polluting to shoreline. May be dangerous if it enters water intakes. Notify local health and wildlife officials. Notify operators of nearby water intakes.</p>
<p>1. RESPONSE TO DISCHARGE (See Response Methods Handbook, CG 446-4) Issue warning: high flammability Mechanical containment Should be removed Chemical and physical treatment</p>	<p>2. LABELS</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> PRESENT </div> <div style="text-align: center;"> NEW </div> </div>
<p>3. CHEMICAL DESIGNATIONS</p> <p>3.1 Synonyms: No common synonyms</p> <p>3.2 Coast Guard Compatibility Classification: Petroleum oil</p> <p>3.3 Chemical Formula: $C_{12}H_{26}$</p> <p>3.4 IMCO/United Nations Numerical Designation: 3.2/1863</p>	<p>4. OBSERVABLE CHARACTERISTICS</p> <p>4.1 Physical State (as shipped): Liquid</p> <p>4.2 Color: Colorless to light brown</p> <p>4.3 Odor: Like fuel oil</p>
<p>5. HEALTH HAZARDS</p> <p>5.1 Personal Protective Equipment: Protective gloves, goggles or face shield.</p> <p>5.2 Symptoms Following Exposure: Vapor causes slight irritation of eyes and nose. Liquid irritates stomach; if taken into lungs, causes coughing, distress, and rapidly developing pulmonary edema.</p> <p>5.3 Treatment for Exposure: ASPIRATION: enforce bed rest; administer oxygen; call a doctor. INGESTION: do NOT induce vomiting; call a doctor. EYES: wash with plenty of water. SKIN: wipe off and wash with soap and water.</p> <p>5.4 Toxicity by Inhalation (Threshold Limit Value): 200 ppm</p> <p>5.5 Short-Term Inhalation Limits: Data not available</p> <p>5.6 Toxicity by Ingestion: Grade 2; LD₅₀ 0.5 to 5 g/kg</p> <p>5.7 Late Toxicity: Data not available</p> <p>5.8 Vapor (Gas) Irritant Characteristics: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary.</p> <p>5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.</p> <p>5.10 Odor Threshold: 1 ppm</p>	

<p>6. FIRE HAZARDS</p> <p>6.1 Flash Point: -10°F to +30°F C.C.</p> <p>6.2 Flammable Limits in Air: 1.3%—8.0%</p> <p>6.3 Fire Extinguishing Agents: Foam, dry chemical, or carbon dioxide</p> <p>6.4 Fire Extinguishing Agents Not to be Used: Not pertinent</p> <p>6.5 Special Hazards of Combustion Products: Not pertinent</p> <p>6.6 Behavior in Fire: Not pertinent</p> <p>6.7 Ignition Temperature: 464°F</p> <p>6.8 Electrical Hazard: Not pertinent</p> <p>6.9 Burning Rate: 4 mm/min</p>	<p>8. WATER POLLUTION</p> <p>8.1 Aquatic Toxicity: 500 ppm*/salmon fingerling/lethal/fresh water *Time period not specified</p> <p>8.2 Waterfowl Toxicity: Data not available</p> <p>8.3 Biological Oxygen Demand (BOD): 53%, 5 days</p> <p>8.4 Food Chain Concentration Potential: None</p>																																				
<p>7. CHEMICAL REACTIVITY</p> <p>7.1 Reactivity with Water: No reaction</p> <p>7.2 Reactivity with Common Materials: No reaction</p> <p>7.3 Stability During Transport: Stable</p> <p>7.4 Neutralizing Agents for Acids and Caustics: Not pertinent</p> <p>7.5 Polymerization: Not pertinent</p> <p>7.6 Inhibitor of Polymerization: Not pertinent</p>	<p>9. SELECTED MANUFACTURERS</p> <p>1. Exxon Co. 30 Rockefeller Plaza New York, N. Y. 10020</p> <p>2. Shell Oil Co. 1 Shell Plaza Houston, Tex. 77001</p> <p>3. Sun Oil Co. 240 Radnor Rd. St. Davids, Pa. 19087</p>																																				
<p>11. HAZARD ASSESSMENT CODE (See Hazard Assessment Handbook, CG 446-3) A-T-U</p>	<p>10. SHIPPING INFORMATION</p> <p>10.1 Grades or Purity: 100%</p> <p>10.2 Storage Temperature: Ambient</p> <p>10.3 Inert Atmosphere: No requirement</p> <p>10.4 Venting: Open (flame arrester) or pressure-vacuum</p>																																				
<p>12. HAZARD CLASSIFICATIONS</p> <p>12.1 Code of Federal Regulations: Flammable liquid</p> <p>12.2 NAS Hazard Rating for Bulk Water Transportation:</p> <table> <thead> <tr> <th>Category</th><th>Rating</th></tr> </thead> <tbody> <tr> <td>Fire</td><td>3</td></tr> <tr> <td>Health</td><td></td></tr> <tr> <td> Vapor Irritant</td><td>1</td></tr> <tr> <td> Liquid or Solid Irritant</td><td>1</td></tr> <tr> <td> Poisons</td><td>1</td></tr> <tr> <td>Water Pollution</td><td></td></tr> <tr> <td> Human Toxicity</td><td>1</td></tr> <tr> <td> Aquatic Toxicity</td><td>1</td></tr> <tr> <td> Aesthetic Effect</td><td>3</td></tr> <tr> <td>Reactivity</td><td></td></tr> <tr> <td> Other Chemicals</td><td>0</td></tr> <tr> <td> Water</td><td>0</td></tr> <tr> <td> Self-Reaction</td><td>0</td></tr> </tbody> </table> <p>12.3 MFPA Hazard Classifications:</p> <table> <thead> <tr> <th>Category</th><th>Classification</th></tr> </thead> <tbody> <tr> <td>Health Hazard (Blue)</td><td>0</td></tr> <tr> <td>Flammability (Red)</td><td>2</td></tr> <tr> <td>Reactivity (Yellow)</td><td>0</td></tr> </tbody> </table>	Category	Rating	Fire	3	Health		Vapor Irritant	1	Liquid or Solid Irritant	1	Poisons	1	Water Pollution		Human Toxicity	1	Aquatic Toxicity	1	Aesthetic Effect	3	Reactivity		Other Chemicals	0	Water	0	Self-Reaction	0	Category	Classification	Health Hazard (Blue)	0	Flammability (Red)	2	Reactivity (Yellow)	0	<p>13. PHYSICAL AND CHEMICAL PROPERTIES</p> <p>13.1 Physical State at 15°C and 1 atm: Liquid</p> <p>13.2 Molecular Weight: Not pertinent</p> <p>13.3 Boiling Point at 1 atm: 349–549°F = 176–287°C = 449–560°K</p> <p>13.4 Freezing Point: -54°F = -48°C = -22°K</p> <p>13.5 Critical Temperature: Not pertinent</p> <p>13.6 Critical Pressure: Not pertinent</p> <p>13.7 Specific Gravity: 0.81 at 20°C (liquid)</p> <p>13.8 Liquid Surface Tension: (est.) 25 dynes/cm = 0.025 N/m at 20°C</p> <p>13.9 Liquid-Water Interfacial Tension: (est.) 50 dynes/cm = 0.05 N/m at 20°C</p> <p>13.10 Vapor (Gas) Specific Gravity: Not pertinent</p> <p>13.11 Ratio of Specific Heats of Vapor (Gas): (est.) 1.030</p> <p>13.12 Latent Heat of Vaporization: 140 Btu/lb = 78 cal/g = 3.3×10^4 J/kg</p> <p>13.13 Heat of Combustion: -18,540 Btu/lb = -10,300 cal/g = -431.24×10^3 J/kg</p> <p>13.14 Heat of Decomposition: Not pertinent</p> <p>13.15 Heat of Solution: Not pertinent</p> <p>13.16 Heat of Polymerization: Not pertinent</p>
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(Continued on pages 5 and 6)

NOTES

KRS

KEROSENE

<div>Common Synonyms</div> <div>Illuminating oil Kerosine Range oil Fuel oil No. 1 Jet Fuel: JP-1</div>	<div>Watery liquid</div> <div>Floats on water.</div>	<div>Colorless</div>	<div>Fuel oil odor</div>
<div>Stop discharge if possible. Call fire department. Avoid contact with liquid. Isolate and remove discharged material. Notify local health and pollution control agencies.</div>			
<div>Fire</div>	<div>Combustible. Extinguish with dry chemical, foam, or carbon dioxide. Water may be ineffective on fire. Cool exposed containers with water.</div>		
<div>Exposure</div>	<div>CALL FOR MEDICAL AID.</div> <div>LIQUID Irritating to skin and eyes. Harmful if swallowed. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk. DO NOT INDUCE VOMITING.</div>		
<div>Water Pollution</div>	<div>Dangerous to aquatic life in high concentrations. Fouling to shoreline. May be dangerous if it enters water intakes. Notify local health and wildlife officials. Notify operators of nearby water intakes.</div>		
<div>1. RESPONSE TO DISCHARGE</div> <div>(See Response Methods Handbook, CG 446-4)</div> <div>Mechanical containment Should be removed Chemical and physical treatment</div>		<div>2. LABELS</div> <div>No hazard label required by Code of Federal Regulations</div>	
<div>3. CHEMICAL DESIGNATIONS</div> <div>3.1 Synonyms: No. 1 Fuel oil Kerosine Illuminating oil Range oil JP-1</div> <div>3.2 Coast Guard Compatibility Classification: Petroleum oil</div> <div>3.3 Chemical Formula: $C_{12}H_{26}$</div> <div>3.4 IMCO/United Nations Numerical Designation: 3.3/1223</div>		<div>4. OBSERVABLE CHARACTERISTICS</div> <div>4.1 Physical State (as shipped): Liquid</div> <div>4.2 Color: Colorless to light brown</div> <div>4.3 Odor: Characteristic; like fuel oil</div>	
<div>5. HEALTH HAZARDS</div> <div>5.1 Personal Protective Equipment: Protective gloves; goggles or face shield.</div> <div>5.2 Symptoms Following Exposure: Vapor causes slight irritation of eyes and nose. Liquid irritates stomach; if taken into lungs, causes coughing, distress, and rapidly developing pulmonary edema.</div> <div>5.3 Treatment for Exposure: ASPIRATION: enforce bed rest; administer oxygen; call a doctor. INGESTION: do NOT induce vomiting; call a doctor. EYES: wash with plenty of water. SKIN: wipe off and wash with soap and water.</div> <div>5.4 Toxicity by Inhalation (Threshold Limit Value): 200 ppm</div> <div>5.5 Short-Term Inhalation Limits: Data not available</div> <div>5.6 Toxicity by Ingestion: Grade I, LD₅₀ 5 to 15 g/kg</div> <div>5.7 Late Toxicity: Data not available</div> <div>5.8 Vapor (Gas) Irritant Characteristics: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary.</div> <div>5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.</div> <div>5.10 Odor Threshold: 1 ppm</div>			

6. FIRE HAZARDS 6.1 Flesh Point: 100°F (min.) C.C. 6.2 Flammable Limits in Air: 0.7% - 5% 6.3 Fire Extinguishing Agents: Foam, dry chemical, or carbon dioxide 6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective 6.5 Special Hazards of Combustion Products: Not pertinent 6.6 Behavior in Fire: Not pertinent 6.7 Ignition Temperature: 444°F 6.8 Electrical Hazard: Not pertinent 6.9 Burning Rate: 4 mm/min	8. WATER POLLUTION 8.1 Aquatic Toxicity: 2990 ppm/24 hr/bluegill/TL _m /fresh water 8.2 Waterfowl Toxicity: Data not available 8.3 Biological Oxygen Demand (BOD): 53%, 5 days 8.4 Food Chain Concentration Potential: None																																				
7. CHEMICAL REACTIVITY 7.1 Reactivity with Water: No reaction 7.2 Reactivity with Common Materials: No reaction 7.3 Stability During Transport: Stable 7.4 Neutralizing Agents for Acids and Caustics: Not pertinent 7.5 Polymerization: Not pertinent 7.6 Inhibitor of Polymerization: Not pertinent	9. SELECTED MANUFACTURERS 1. Atlantic Richfield Co. 717 Fifth Ave. New York, N. Y. 10022 2. Shell Oil Co. 1 Shell Plaza Houston, Tex. 77001 3. Sun Oil Co. 240 Radnor Rd. St. Davids, Pa. 19087																																				
11. HAZARD ASSESSMENT CODE <small>(See Hazard Assessment Handbook, CG 446-3)</small> A-T-U	10. SHIPPING INFORMATION 10.1 Grades or Purity: Light hydrocarbon distillate: 100% 10.2 Storage Temperature: Ambient 10.3 Inert Atmosphere: No requirement 10.4 Venting: Open (flame arrester)																																				
12. HAZARD CLASSIFICATIONS 12.1 Code of Federal Regulations: Not listed 12.2 NAS Hazard Rating for Bulk Water Transportation: <table> <thead> <tr> <th>Category</th><th>Rating</th></tr> </thead> <tbody> <tr> <td>Fire</td><td>2</td></tr> <tr> <td>Health</td><td></td></tr> <tr> <td> Vapor Irritant</td><td>1</td></tr> <tr> <td> Liquid or Solid Irritant</td><td>1</td></tr> <tr> <td> Poisons</td><td>1</td></tr> <tr> <td>Water Pollution</td><td></td></tr> <tr> <td> Human Toxicity</td><td>1</td></tr> <tr> <td> Aquatic Toxicity</td><td>1</td></tr> <tr> <td> Aesthetic Effect</td><td>3</td></tr> <tr> <td>Reactivity</td><td></td></tr> <tr> <td> Other Chemicals</td><td>0</td></tr> <tr> <td> Water</td><td>0</td></tr> <tr> <td> Self-Reaction</td><td>0</td></tr> </tbody> </table> 12.3 NIHA Hazard Classifications: <table> <thead> <tr> <th>Category</th><th>Classification</th></tr> </thead> <tbody> <tr> <td>Health Hazard (Blue)</td><td>0</td></tr> <tr> <td>Flammability (Red)</td><td>2</td></tr> <tr> <td>Reactivity (Yellow)</td><td>0</td></tr> </tbody> </table>	Category	Rating	Fire	2	Health		Vapor Irritant	1	Liquid or Solid Irritant	1	Poisons	1	Water Pollution		Human Toxicity	1	Aquatic Toxicity	1	Aesthetic Effect	3	Reactivity		Other Chemicals	0	Water	0	Self-Reaction	0	Category	Classification	Health Hazard (Blue)	0	Flammability (Red)	2	Reactivity (Yellow)	0	13. PHYSICAL AND CHEMICAL PROPERTIES 13.1 Physical State at 15°C and 1 atm: Liquid 13.2 Molecular Weight: Not pertinent 13.3 Boiling Point at 1 atm: 392-500°F = 200-260°C = 473-533°K 13.4 Freezing Point: -50°F = -45.6°C = 227.6°K 13.5 Critical Temperature: Not pertinent 13.6 Critical Pressure: Not pertinent 13.7 Specific Gravity: 0.80 at 15°C (liquid) 13.8 Liquid Surface Tension: 23-32 dynes/cm = 0.023-0.032 N/m at 20°C 13.9 Liquid-Water Interfacial Tension: 47-49 dynes/cm = 0.047-0.049 N/m at 20°C 13.10 Vapor (Gas) Specific Gravity: Not pertinent 13.11 Ratio of Specific Heats of Vapor (Gas): Not pertinent 13.12 Latent Heat of Vaporization: 110 Btu/lb = 60 cal/g = 2.5×10^5 J/kg 13.13 Heat of Combustion: -18,540 Btu/lb = -10,300 cal/g = -431.24×10^3 J/kg 13.14 Heat of Decomposition: Not pertinent 13.15 Heat of Solution: Not pertinent 13.16 Heat of Polymerization: Not pertinent
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NOTES																																					

(Continued on pages 5 and 6)

DSR

DISTILLATES: STRAIGHT RUN

Common Synonyms Straight run gasoline	Watery liquid	Colorless	Gasoline-like odor
Floats on water. Flammable, irritating vapor is produced.			
Stop discharge if possible. Keep people away. Call fire department. Avoid contact with liquid and vapor. Stay upwind and use water spray to "knock down" vapor. Isolate and remove discharged material. Notify local health and pollution control agencies.			
Fire	FLAMMABLE. Flashback along vapor trail may occur. Vapor may explode if ignited in an enclosed area. Extinguish with foam or dry chemicals. Water may be ineffective on fire. Cool exposed containers with water.		
Exposure	CALL FOR MEDICAL AID. VAPOR Irritating to eyes, nose and throat. Move to fresh air. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen. LIQUIDS Irritating to eyes. Harmful if swallowed. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk. DO NOT INDUCE VOMITING.		
Water Pollution	HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS. Fouling to shoreline. May be dangerous if it enters water intakes. Notify local health and wildlife officials. Notify operators of nearby water intakes.		
1. RESPONSE TO DISCHARGE (See Response Methods Handbook, CG 445-4) Issue warning -- high flammability Evacuate area Disperse and flush		2. LABELS
3. CHEMICAL DESIGNATIONS 3.1 Synonyms: Petroleum distillate 3.2 Coast Guard Compatibility Classification: Petroleum oil 3.3 Chemical Formula: Not pertinent 3.4 IMCO/United Nations Numerical Designation: 3.1, 3.2, 3.3/1268		4. OBSERVABLE CHARACTERISTICS 4.1 Physical State (as shipped): Liquid 4.2 Color: Colorless 4.3 Odor: Gasoline	
5. HEALTH HAZARDS 5.1 Personal Protective Equipment: Data not available 5.2 Symptoms Following Exposure: INHALATION: irritation of upper respiratory tract; dizziness, headache, coma; respiratory arrest; cardiac arrhythmias may occur. ASPIRATION: severe lung irritation, coughing, pulmonary edema, signs of bronchopneumonia; acute central nervous system excitation, followed by depression. INGESTION: irritation of mouth and stomach; other symptoms as above. 5.3 Treatment for Exposure: Seek medical attention. INHALATION: maintain respiration and administer oxygen. ASPIRATION: enforce bed rest and administer oxygen. INGESTION: do NOT induce vomiting; lavage carefully if appreciable quantity was swallowed; guard against aspiration into lungs. EYES: wash with plenty of water. SKIN: remove by wiping and wash with soap and water. 5.4 Toxicity by Inhalation (Threshold Limit Value): No single TLV applicable 5.5 Short-Term Inhalation Limits: 500 ppm for 30 min. 5.6 Toxicity by Ingestion: Grade 2, LD ₅₀ 0.5 g/kg 5.7 Late Toxicity: None 5.8 Vapor (Gas) Irritant Characteristics: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary. 5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. 5.10 Odor Threshold: 0.25 ppm			

6. FIRE HAZARDS 6.1 Flash Point: (a) <0°F C.C. (b) 0°- 73°F C.C. (c) 73°-141°F C.C. 6.2 Flammable Limits in Air: 1.1-8.7% 6.3 Fire Extinguishing Agents: Foam, carbon dioxide, dry chemical 6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective 6.5 Special Hazards of Combustion Products: Not pertinent 6.6 Behavior in Fire: Not pertinent 6.7 Ignition Temperature: Data not available 6.8 Electrical Hazard: Class I, group D 6.9 Burning Rate: Approx. 4 mm/min.	8. WATER POLLUTION 8.1 Aquatic Toxicity: 90 ppm/24 hr/juvenile American shad/ TL _m /fresh water 91 ppm/24 hr/juvenile American shad/ TL _m /salt water 8.2 Waterfowl Toxicity: Data not available 8.3 Biological Oxygen Demand (BOD): 8%, 5 days 8.4 Food Chain Concentration Potential: None																												
7. CHEMICAL REACTIVITY 7.1 Reactivity with Water: No reaction 7.2 Reactivity with Common Materials: No reaction 7.3 Stability During Transport: Stable 7.4 Neutralizing Agents for Acids and Caustics: Not pertinent 7.5 Polymerization: Not pertinent 7.6 Inhibitor of Polymerization: Not pertinent	9. SELECTED MANUFACTURERS 1. Atlantic Richfield Co. 717 Fifth Ave. New York, N. Y. 10022 2. Mobil Oil Corp. 150 E. 42nd St. New York, N. Y. 10017 3. Shell Oil Co. One Shell Plaza Houston, Tex. 77001																												
11. HAZARD ASSESSMENT CODE (See Hazard Assessment Handbook, CG 446-3) A-T-U-V-W	10. SHIPPING INFORMATION 10.1 Grades or Purity: Composition varies with range of distillation temperatures used. 10.2 Storage Temperature: Ambient 10.3 Inert Atmosphere: No requirement 10.4 Venting: Data not available																												
12. HAZARD CLASSIFICATIONS 12.1 Code of Federal Regulations: Flammable liquid 12.2 NAB Hazard Rating for Bulk Water Transportation: <table> <thead> <tr> <th>Category</th><th>Rating</th></tr> </thead> <tbody> <tr> <td>Fire</td><td>3</td></tr> <tr> <td>Health</td><td></td></tr> <tr> <td>Vapor Irritant</td><td>1</td></tr> <tr> <td>Liquid or Solid Irritant</td><td>1</td></tr> <tr> <td>Poisons</td><td>2</td></tr> <tr> <td>Water Pollution</td><td></td></tr> <tr> <td>Human Toxicity</td><td>1</td></tr> <tr> <td>Aquatic Toxicity</td><td>2</td></tr> <tr> <td>Aesthetic Effect</td><td>2</td></tr> <tr> <td>Reactivity</td><td></td></tr> <tr> <td>Other Chemicals</td><td>0</td></tr> <tr> <td>Water</td><td>0</td></tr> <tr> <td>Self-Reaction</td><td>0</td></tr> </tbody> </table> 12.3 NFPA Hazard Classifications: Not listed	Category	Rating	Fire	3	Health		Vapor Irritant	1	Liquid or Solid Irritant	1	Poisons	2	Water Pollution		Human Toxicity	1	Aquatic Toxicity	2	Aesthetic Effect	2	Reactivity		Other Chemicals	0	Water	0	Self-Reaction	0	13. PHYSICAL AND CHEMICAL PROPERTIES 13.1 Physical State at 15°C and 1 atm: Liquid 13.2 Molecular Weight: Not pertinent 13.3 Boiling Point at 1 atm: 58-275°F = 14-135°C = 287-408°K 13.4 Freezing Point: Not pertinent 13.5 Critical Temperature: Not pertinent 13.6 Critical Pressure: Not pertinent 13.7 Specific Gravity: 0.71-0.75 at 15°C (liquid) 13.8 Liquid Surface Tension: 19-23 dynes/cm = 0.019-0.023 N/m at 20°C 13.9 Liquid-Water Interfacial Tension: 49-51 dynes/cm = 0.049-0.051 N/m at 20°C 13.10 Vapor (Gas) Specific Gravity: 3.4 13.11 Ratio of Specific Heats of Vapor (Gas): (est.) 1.054 13.12 Latent Heat of Vaporization: 130-150 Btu/lb = 71-81 cal/g = 3.0-3.4 × 10 ⁵ J/kg 13.13 Heat of Combustion: -18,720 Btu/lb = -10,400 cal/g = -435.4 × 10 ³ J/kg 13.14 Heat of Decomposition: Not pertinent 13.15 Heat of Solution: Not pertinent 13.16 Heat of Polymerization: Not pertinent
Category	Rating																												
Fire	3																												
Health																													
Vapor Irritant	1																												
Liquid or Solid Irritant	1																												
Poisons	2																												
Water Pollution																													
Human Toxicity	1																												
Aquatic Toxicity	2																												
Aesthetic Effect	2																												
Reactivity																													
Other Chemicals	0																												
Water	0																												
Self-Reaction	0																												
(Continued on pages 5 and 6)																													
NOTES																													

Common Synonyms Fuel oil 1-D Fuel oil 2-D		Oily liquid	Yellow-brown	Lube or fuel oil odor
		Floats on water.		
Stop discharge if possible. Call fire department. Avoid contact with liquid. Isolate and remove discharged material. Notify local health and pollution control agencies.				
Fire	Combustible. Extinguish with dry chemical, foam, or carbon dioxide. Water may be ineffective on fire. Cool exposed containers with water.			
Exposure	CALL FOR MEDICAL AID. LIQUID Irritating to skin and eyes. Harmful if swallowed. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES: hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk. DO NOT INDUCE VOMITING.			
Water Pollution	Dangerous to aquatic life in high concentrations. Fouling to shoreline. May be dangerous if it enters water intakes. Notify local health and wildlife officials. Notify operators of nearby water intakes			
1. RESPONSE TO DISCHARGE (See Response Methods Handbook, CG 448-4) Mechanical containment Should be removed Chemical and physical treatment		2. LABELS No hazard label required by Code of Federal Regulations		
3. CHEMICAL DESIGNATIONS 3.1 Synonyms: Fuel Oil 1-D Fuel Oil 2-D 3.2 Coast Guard Compatibility Classification: Petroleum oil 3.3 Chemical Formula: Not applicable 3.4 IMCO/United Nations Numerical Designation: 3.1/1270		4. OBSERVABLE CHARACTERISTICS 4.1 Physical State (as shipped): Liquid 4.2 Color: Light brown 4.3 Odor: Like fuel oil		
5. HEALTH HAZARDS 5.1 Personal Protective Equipment: Goggles or face shield 5.2 Symptoms Following Exposure: If liquid is ingested, an increased frequency of bowel movements will occur. 5.3 Treatment for Exposure: INGESTION: do NOT induce vomiting. SKIN: wipe off, wash with soap and water. EYES: wash with copious amounts of water for at least 15 min. 5.4 Toxicity by Inhalation (Threshold Limit Value): No single TLV applicable. 5.5 Short-Term Inhalation Limits: Data not available 5.6 Toxicity by Ingestion: Grade 1; LD ₅₀ 5 to 15 g/kg 5.7 Late Toxicity: Data not available 5.8 Vapor (Gas) Irritant Characteristics: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary. 5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. 5.10 Odor Threshold: Data not available				

6. FIRE HAZARDS 6.1 Flash Point: (1-D) 100°F C.C.; (2-D) 125°F C.C. 6.2 Flammable Limits in Air: 1.3 - 6.0 vol. % 6.3 Fire Extinguishing Agents: Dry chemical, foam, or carbon dioxide 6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective 6.5 Special Hazards of Combustion Products: Not pertinent 6.6 Behavior in Fire: Not pertinent 6.7 Ignition Temperature: (1-D) 350-625°F (2-D) 490-545°F 6.8 Electrical Hazard: Not pertinent 6.9 Burning Rate: 4 mm/min		8. WATER POLLUTION 8.1 Aquatic Toxicity: 204 mg/l /24 hr/juvenile American shad/ TL _m /salt water 8.2 Waterfowl Toxicity: Data not available 8.3 Biological Oxygen Demand (BOD): Data not available 8.4 Food Chain Concentration Potential: None									
7. CHEMICAL REACTIVITY 7.1 Reactivity with Water: No reaction 7.2 Reactivity with Common Materials: No reaction 7.3 Stability During Transport: Stable 7.4 Neutralizing Agents for Acids and Caustics: Not pertinent 7.5 Polymerization: Not pertinent 7.6 Inhibitor of Polymerization: Not pertinent		9. SELECTED MANUFACTURERS 1. Exxon Co. Houston, Tex. 77001 2. Shell Oil Co. 1 Shell Plaza Houston, Tex. 77001 3. Sun Oil Co. St. Davids, Pa. 19087									
11. HAZARD ASSESSMENT CODE (See Hazard Assessment Handbook, CG 448-3) A-T-U		10. SHIPPING INFORMATION 10.1 Grades or Purity: Diesel Fuel 1-D (ASTM); Diesel Fuel 2-D (ASTM) 10.2 Storage Temperature: Ambient 10.3 Inert Atmosphere: No requirement 10.4 Venting: Open (flame arrester)									
12. HAZARD CLASSIFICATIONS 12.1 Code of Federal Regulations: Combustible liquid 12.2 NAS Hazard Rating for Bulk Water Transportation: Not listed 12.3 NFPA Hazard Classifications: <table><tr><th>Category</th><th>Classification</th></tr><tr><td>Health Hazard (Blue)</td><td>0</td></tr><tr><td>Flammability (Red)</td><td>2</td></tr><tr><td>Reactivity (Yellow)</td><td>0</td></tr></table>		Category	Classification	Health Hazard (Blue)	0	Flammability (Red)	2	Reactivity (Yellow)	0	13. PHYSICAL AND CHEMICAL PROPERTIES 13.1 Physical State at 15°C and 1 atm: Liquid 13.2 Molecular Weight: Not pertinent 13.3 Boiling Point at 1 atm: 550 - 640°F = 288 - 338°C = 561 - 612°K 13.4 Freezing Point: 0 to -30°F = -18 to -34°C = 255 to 239°K 13.5 Critical Temperature: Not pertinent 13.6 Critical Pressure: Not pertinent 13.7 Specific Gravity: 0.876 at 20°C (liquid) 13.8 Liquid Surface Tension: (est.) 25 dynes/cm = 0.025 N/m at 20°C 13.9 Liquid-Water Interfacial Tension: (est.) 50 dynes/cm = 0.05 N/m at 20°C 13.10 Vapor (Gas) Specific Gravity: Not pertinent 13.11 Ratio of Specific Heats of Vapor (Gas): Not pertinent 13.12 Latent Heat of Vaporization: Not pertinent 13.13 Heat of Combustion: (est.) = 18,000 Btu/lb = -10,000 cal/g = -420 × 10 ³ J/kg 13.14 Heat of Decomposition: Not pertinent 13.15 Heat of Solution: Not pertinent 13.16 Heat of Polymerization: Not pertinent	
Category	Classification										
Health Hazard (Blue)	0										
Flammability (Red)	2										
Reactivity (Yellow)	0										
<i>(Continued on pages 5 and 6)</i>											
NOTES											

(Continued on pages 5 and 6)

<div>Common Synonyms Home-heating oil</div>	<div>Oily liquid</div> <div>Yellow-brown</div> <div>Lube or fuel oil odor</div> <div>Floats on water.</div>
<div>Stop discharge if possible. Call fire department. Avoid contact with liquid. Isolate and remove discharged material. Notify local health and pollution control agencies.</div>	
<div>Fire</div>	<div>Combustible.</div> <div>Extinguish with dry chemical, foam or carbon dioxide.</div> <div>Water may be ineffective on fire.</div> <div>Cool exposed containers with water.</div>
<div>Exposure</div>	<div>CALL FOR MEDICAL AID.</div> <div>LIQUID</div> <div>Irritating to skin and eyes.</div> <div>If swallowed, will cause nausea, vomiting.</div> <div>Remove contaminated clothing and shoes.</div> <div>Flush affected areas with plenty of water.</div> <div>IF IN EYES, hold eyelids open and flush with plenty of water.</div> <div>IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.</div> <div>DO NOT INDUCE VOMITING.</div>
<div>Water Pollution</div>	<div>Dangerous to aquatic life in high concentrations.</div> <div>Fouling to shoreline.</div> <div>May be dangerous if it enters water intakes.</div> <div>Notify local health and wildlife officials.</div> <div>Notify operators of nearby water intakes.</div>
<div>1. RESPONSE TO DISCHARGE</div> <div>(See Response Methods Handbook, CG 446-4)</div> <div>Mechanical containment</div> <div>Should be removed</div> <div>Chemical and physical treatment</div>	<div>2. LABELS</div> <div>No hazard label required by</div> <div>Code of Federal Regulations</div>
<div>3. CHEMICAL DESIGNATIONS</div> <div>3.1 Synonyms: Home heating oil</div> <div>3.2 Coast Guard Compatibility Classification: Petroleum oil</div> <div>3.3 Chemical Formula: Not applicable</div> <div>3.4 IMCO/United Nations Numerical Designation: 3.3/1223</div>	<div>4. OBSERVABLE CHARACTERISTICS</div> <div>4.1 Physical State (as shipped): Liquid</div> <div>4.2 Color: Light brown</div> <div>4.3 Odor: Like kerosene; characteristic</div>
<div>5. HEALTH HAZARDS</div> <div>5.1 Personal Protective Equipment: Protective gloves; goggles or face shield.</div> <div>5.2 Symptoms Following Exposure: INHALATION causes headache and slight dizziness. INGESTION causes nausea, vomiting, and cramping; depression of central nervous system ranging from mild headache to anesthesia, coma, and death; pulmonary irritation secondary to exhalation of solvent; signs of kidney and liver damage may be delayed. ASPIRATION causes severe lung irritation with coughing, gagging, dyspnea, substernal distress, and rapidly developing pulmonary edema; later, signs of bronchopneumonia and pneumonitis; acute onset of central nervous system excitement followed by depression.</div> <div>5.3 Treatment for Exposure: INGESTION: do NOT induce vomiting. ASPIRATION: enforce bed rest; administer oxygen; seek medical attention. EYES: wash with copious quantity of water. SKIN: remove solvent by wiping and wash with soap and water.</div> <div>5.4 Toxicity by Inhalation (Threshold Limit Value): No single value applicable.</div> <div>5.5 Short-Term Inhalation Limits: Data not available</div> <div>5.6 Toxicity by Ingestion: Grade I: LD₅₀ 5-15 g/kg</div> <div>5.7 Late Toxicity: Data not available</div> <div>5.8 Vapor (Gas) Irritant Characteristics: Slight smarting of eyes or respiratory system if present in high concentrations. The effect is temporary.</div> <div>5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin.</div> <div>5.10 Odor Threshold: Data not available</div>	

6. FIRE HAZARDS 6.1 Flash Point: 136°F C.C. 6.2 Flammable Limits in Air: Data not available 6.3 Fire Extinguishing Agents: Dry chemical, foam, or carbon dioxide 6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective 6.5 Special Hazards of Combustion Products: Not pertinent 6.6 Behavior in Fire: Not pertinent 6.7 Ignition Temperature: 494°F 6.8 Electrical Hazard: Not pertinent 6.9 Burning Rate: 4 mm/min.		8. WATER POLLUTION 8.1 Aquatic Toxicity: 200 ppm/24 hr/juvenile American shad/TL _m /fresh water 20 ppm/96 hr/rainbow trout eggs/TL _m /salt water 8.2 Waterfowl Toxicity: Data not available 8.3 Biological Oxygen Demand (BOD): Data not available 8.4 Food Chain Concentration Potential: None									
7. CHEMICAL REACTIVITY 7.1 Reactivity with Water: No reaction 7.2 Reactivity with Common Materials: No reaction 7.3 Stability During Transport: Stable 7.4 Neutralizing Agents for Acids and Caustics: Not pertinent 7.5 Polymerization: Not pertinent 7.6 Inhibitor of Polymerization: Not pertinent		9. SELECTED MANUFACTURERS 1. Atlantic Richfield Co. 717 Fifth Ave. New York, N. Y. 10022 2. Shell Oil Co. 1 Shell Plaza Houston, Tex. 77001 3. Sun Oil Co. St. Davids, Pa. 19087									
11. HAZARD ASSESSMENT CODE (See Hazard Assessment Handbook, CG 446-3) A-T-U		10. SHIPPING INFORMATION 10.1 Grade or Purity: Commercial 10.2 Storage Temperature: Ambient 10.3 Inert Atmosphere: No requirement 10.4 Venting: Open (flame arrester)									
12. HAZARD CLASSIFICATIONS 12.1 Code of Federal Regulations: Not listed 12.2 NAS Hazard Rating for Bulk Water Transportation: Not listed 12.3 MFPA Hazard Classifications: <table><tr><th>Category</th><th>Classification</th></tr><tr><td>Health Hazard (Blue)</td><td>0</td></tr><tr><td>Flammability (Red)</td><td>2</td></tr><tr><td>Reactivity (Yellow)</td><td>0</td></tr></table>		Category	Classification	Health Hazard (Blue)	0	Flammability (Red)	2	Reactivity (Yellow)	0	13. PHYSICAL AND CHEMICAL PROPERTIES 13.1 Physical State at 15°C and 1 atm: Liquid 13.2 Molecular Weight: Not pertinent 13.3 Boiling Point at 1 atm: 540-640°F = 282-338°C = 555-611°K 13.4 Freezing Point: -20°F = -29°C = 244°K 13.5 Critical Temperature: Not pertinent 13.6 Critical Pressure: Not pertinent 13.7 Specific Gravity: 0.87-0.90 at 20°C (liquid) 13.8 Liquid Surface Tension: (est.) 25 dynes/cm = 0.025 N/m at 20°C 13.9 Liquid-Water Interfacial Tension: (est.) 50 dynes/cm = 0.05 N/m at 20°C 13.10 Vapor (Gas) Specific Gravity: Not pertinent 13.11 Ratio of Specific Heats of Vapor (Gas): Not pertinent 13.12 Latent Heat of Vaporization: Not pertinent 13.13 Heat of Combustion: -19,440 Btu/lb = -10,800 cal/g = -452.17 × 10 ³ J/kg 13.14 Heat of Decomposition: Not pertinent 13.15 Heat of Solution: Not pertinent 13.16 Heat of Polymerization: Not pertinent	
Category	Classification										
Health Hazard (Blue)	0										
Flammability (Red)	2										
Reactivity (Yellow)	0										
<i>(Continued on pages 5 and 6)</i>											
NOTES											

Common Synonyms Residual fuel oil No. 4	Oily liquid Dark Lube or fuel oil odor Floats on water.
Stop discharge if possible. Call fire department. Avoid contact with liquid. Isolate and remove discharged material. Notify local health and pollution control agencies.	
Fire	Combustible. Extinguish with dry chemical, foam or carbon dioxide. Water may be ineffective on fire. Cool exposed containers with water.
Exposure	CALL FOR MEDICAL AID. LIQUID Irritating to skin and eyes. Harmful if swallowed. Remove contaminated clothing and shoes. Flush affected area with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk. DO NOT INDUCE VOMITING.
Water Pollution	Effect of low concentrations on aquatic life is unknown. Fouling to shoreline. May be dangerous if it enters water intakes. Notify local health and wildlife officials. Notify operators of nearby water intakes.
<div> <div>1. RESPONSE TO DISCHARGE</div> <div>(See Response Methods Handbook, CG 446-4)</div> <div>Mechanical containment</div> <div>Should be removed</div> <div>Chemical and physical treatment</div> </div> <div> <div>2. LABELS</div> <div>No hazard label required by</div> <div>Code of Federal Regulations</div> </div>	
<div>3. CHEMICAL DESIGNATIONS</div> <div>3.1 Synonyms: Residual fuel oil, No. 4</div> <div>3.2 Coast Guard Competibility Classification: Petroleum oil</div> <div>3.3 Chemical Formula: Not applicable</div> <div>3.4 IMCO/United Nations Numerical Designation: 3.3/1223</div>	<div>4. OBSERVABLE CHARACTERISTICS</div> <div>4.1 Physical State (as shipped): Liquid</div> <div>4.2 Color: Brown</div> <div>4.3 Odor: Characteristic, like kerosene</div>
<div>5. HEALTH HAZARDS</div> <div>5.1 Personal Protective Equipment: Protective gloves, goggles or face shield.</div> <div>5.2 Symptoms Following Exposure: INGESTION: gastrointestinal irritation. ASPIRATION: pulmonary irritation is normally minimal but may become more severe several hours after exposure.</div> <div>5.3 Treatment for Exposure: INGESTION: do NOT lavage or induce vomiting. ASPIRATION: treatment probably not required; delayed development of pulmonary irritation can be detected by serial chest x-rays; consider prophylactic antibiotic regime if condition warrants. EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water.</div> <div>5.4 Toxicity by Inhalation (Threshold Limit Value): Not pertinent</div> <div>5.5 Short-Term Inhalation Limits: Not pertinent</div> <div>5.6 Toxicity by Ingestion: Grade I: LD₅₀ 5 to 15 g/kg</div> <div>5.7 Late Toxicity: Data not available</div> <div>5.8 Vapor (Gas) Irritant Characteristics: None</div> <div>5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.</div> <div>5.10 Odor Threshold: Data not available</div>	

<div>6. FIRE HAZARDS</div> <div>6.1 Flash Point: >130°F C.C.</div> <div>6.2 Flammable Limits in Air: 1.0% - 5%</div> <div>6.3 Fire Extinguishing Agents: Dry chemical, foam, or carbon dioxide</div> <div>6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective.</div> <div>6.5 Special Hazards of Combustion Products: Not pertinent</div> <div>6.6 Behavior in Fire: Not pertinent</div> <div>6.7 Ignition Temperature: 505°F</div> <div>6.8 Electrical Hazard: Not pertinent</div> <div>6.9 Burning Rate: 4 mm/min.</div>	<div>8. WATER POLLUTION</div> <div>8.1 Aquatic Toxicity: Data not available</div> <div>8.2 Waterfowl Toxicity: Data not available</div> <div>8.3 Biological Oxygen Demand (BOD): Data not available</div> <div>8.4 Food Chain Concentration Potential: None</div>								
<div>7. CHEMICAL REACTIVITY</div> <div>7.1 Reactivity with Water: No reaction</div> <div>7.2 Reactivity with Common Materials: No reaction</div> <div>7.3 Stability During Transport: Stable</div> <div>7.4 Neutralizing Agents for Acids and Caustics: Not pertinent</div> <div>7.5 Polymerization: Not pertinent</div> <div>7.6 Inhibitor of Polymerization: Not pertinent</div>	<div>9. SELECTED MANUFACTURERS</div> <div>1. Atlantic Richfield Co. 717 Fifth Ave. New York, N. Y. 10022</div> <div>2. Shell Oil Co. 1 Shell Plaza Houston, Tex. 77001</div> <div>3. Sun Oil Co. St. Davids, Pa. 19087</div>								
<div>11. HAZARD ASSESSMENT CODE</div> <div>(See Hazard Assessment Handbook, CG 446-3)</div> <div>A-T-U</div>	<div>10. SHIPPING INFORMATION</div> <div>10.1 Grades or Purity: Commercial</div> <div>10.2 Storage Temperature: Ambient</div> <div>10.3 Inert Atmosphere: No requirement</div> <div>10.4 Venting: Open (flame arrester)</div>								
<div>12. HAZARD CLASSIFICATIONS</div> <div>12.1 Code of Federal Regulations: Not listed</div> <div>12.2 NAB Hazard Rating for Bulk Water Transportation: Not listed</div> <div>12.3 NFPA Hazard Classifications:</div> <table> <tr> <th>Category</th><th>Classification</th></tr> <tr> <td>Health Hazard (Blue)</td><td>0</td></tr> <tr> <td>Flammability (Red)</td><td>2</td></tr> <tr> <td>Reactivity (Yellow)</td><td>0</td></tr> </table>	Category	Classification	Health Hazard (Blue)	0	Flammability (Red)	2	Reactivity (Yellow)	0	<div>13. PHYSICAL AND CHEMICAL PROPERTIES</div> <div>13.1 Physical State at 15°C and 1 atm: Liquid</div> <div>13.2 Molecular Weight: Not pertinent</div> <div>13.3 Boiling Point at 1 atm: 214 to >1092°F = 101 to >588°C = 374 to 861°K</div> <div>13.4 Freezing Point: -20 to +15°F = -29 to -9°C = 244 to 264°K</div> <div>13.5 Critical Temperature: Not pertinent</div> <div>13.6 Critical Pressure: Not pertinent</div> <div>13.7 Specific Gravity: 0.90 (approx.) at 20°C (liquid)</div> <div>13.8 Liquid Surface Tension: (est.) 25 dynes/cm = 0.025 N/m at 20°C</div> <div>13.9 Liquid-Water Interfacial Tension: (est.) 50 dynes/cm = 0.05 N/m at 20°C</div> <div>13.10 Vapor (Gas) Specific Gravity: Not pertinent</div> <div>13.11 Ratio of Specific Heats of Vapor (Gas): Not pertinent</div> <div>13.12 Latent Heat of Vaporization: Not pertinent</div> <div>13.13 Heat of Combustion: -17,460 Btu/lb = -9,700 cal/g = -406.1 × 10³ J/kg</div> <div>13.14 Heat of Decomposition: Not pertinent</div> <div>13.15 Heat of Solution: Not pertinent</div> <div>13.16 Heat of Polymerization: Not pertinent</div>
Category	Classification								
Health Hazard (Blue)	0								
Flammability (Red)	2								
Reactivity (Yellow)	0								
<div>NOTES</div> <div>(Continued on pages 5 and 6)</div>									

Common Synonyms Residual fuel oil No. 5		Oily liquid	Dark	Strong lube oil odor
Usually floats on water.				
Stop discharge if possible. Call fire department. Avoid contact with liquid. Isolate and remove discharged material. Notify local health and pollution control agencies.				
Fire	Combustible. Extinguish with dry chemical, foam or carbon dioxide. Water may be ineffective on fire. Cool exposed containers with water.			
Exposure	CALL FOR MEDICAL AID. LIQUID Irritating to skin and eyes. Harmful if swallowed. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk. DO NOT INDUCE VOMITING.			
Water Pollution	Effect of low concentrations on aquatic life is unknown. Fouling to shoreline. May be dangerous if it enters water intakes. Notify local health and wildlife officials. Notify operators of nearby water intakes.			
1. RESPONSE TO DISCHARGE (See Response Methods Handbook, CG 446-4) Mechanical containment Should be removed Chemical and physical treatment		2. LABELS No hazard label required by Code of Federal Regulations		
3. CHEMICAL DESIGNATIONS 3.1 Synonyms: Residual fuel oil, No. 5 3.2 Coast Guard Compatibility Classification: Petroleum oil 3.3 Chemical Formula: Not applicable 3.4 IMCO/United Nations Numerical Designation: 3.3/1223		4. OBSERVABLE CHARACTERISTICS 4.1 Physical State (as shipped): Liquid 4.2 Color: Brown 4.3 Odor: Characteristic; like kerosene		
5. HEALTH HAZARDS 5.1 Personal Protective Equipment: Protective gloves; goggles or face shield. 5.2 Symptoms Following Exposure: INGESTION: gastrointestinal irritation. ASPIRATION: pulmonary irritation is normally minimal but may become more severe several hours after exposure. 5.3 Treatment for Exposure: INGESTION: do NOT lavage or induce vomiting. ASPIRATION: treatment probably not required; delayed development of pulmonary irritation can be detected by serial chest x-rays; consider prophylactic antibiotic regime if condition warrants. EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water. 5.4 Toxicity by Inhalation (Threshold Limit Value): Not pertinent 5.5 Short-Term Inhalation Limits: Not pertinent 5.6 Toxicity by Ingestion: Grade I; LD ₅₀ 5 to 15 g/kg 5.7 Late Toxicity: Data not available 5.8 Vapor (Gas) Irritant Characteristics: None 5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. 5.10 Odor Threshold: Data not available				

6. FIRE HAZARDS 6.1 Flash Point: > 130°F C.C. 6.2 Flammable Limits in Air: 1%—5% 6.3 Fire Extinguishing Agents: Dry chemical, foam, or carbon dioxide 6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective. 6.5 Special Hazards of Combustion Products: Not pertinent 6.6 Behavior in Fire: Not pertinent 6.7 Ignition Temperature: Data not available 6.8 Electrical Hazard: Not pertinent 6.9 Burning Rate: 4 mm/min.		8. WATER POLLUTION 8.1 Aquatic Toxicity: Data not available 8.2 Waterlow Toxicity: Data not available 8.3 Biological Oxygen Demand (BOD): Data not available 8.4 Food Chain Concentration Potential: None									
7. CHEMICAL REACTIVITY 7.1 Reactivity with Water: No reaction 7.2 Reactivity with Common Materials: No reaction 7.3 Stability During Transport: Stable 7.4 Neutralizing Agents for Acids and Caustics: Not pertinent 7.5 Polymerization: Not pertinent 7.6 Inhibitor of Polymerization: Not pertinent		9. SELECTED MANUFACTURERS 1. Atlantic Richfield Co. 717 Fifth Ave. New York, N. Y. 10022 2. Shell Oil Co. 1 Shell Plaza Houston, Tex. 77001 3. Sun Oil Co. St. Davids, Pa. 19087									
11. HAZARD ASSESSMENT CODE (See Hazard Assessment Handbook, CG 446-3) A-T-U		10. SHIPPING INFORMATION 10.1 Grades or Purity: Fuel oil No. 5 (heavy); Fuel oil No. 5 (light) 10.2 Storage Temperature: Ambient 10.3 Inert Atmosphere: No requirement 10.4 Venting: Open (flame arrester)									
12. HAZARD CLASSIFICATIONS 12.1 Code of Federal Regulations: Not listed 12.2 NAS Hazard Rating for Bulk Water Transportation: Not listed 12.3 NFPA Hazard Classifications: <table><tr><th>Category</th><th>Classification</th></tr><tr><td>Health Hazard (Blue)</td><td>0</td></tr><tr><td>Flammability (Red)</td><td>2</td></tr><tr><td>Reactivity (Yellow)</td><td>0</td></tr></table>		Category	Classification	Health Hazard (Blue)	0	Flammability (Red)	2	Reactivity (Yellow)	0	13. PHYSICAL AND CHEMICAL PROPERTIES 13.1 Physical State at 15°C and 1 atm: Liquid 13.2 Molecular Weight: Not pertinent 13.3 Boiling Point at 1 atm: 426—> 1062°F = 218—>570°C = 491—>843°K 13.4 Freezing Point: 0°F = -18°C = 255°K 13.5 Critical Temperature: Not pertinent 13.6 Critical Pressure: Not pertinent 13.7 Specific Gravity: 0.90 (approx.) at 20°C (liquid) 13.8 Liquid Surface Tension: (est.) 25 dynes/cm = 0.025 N/m at 20°C 13.9 Liquid-Water Interfacial Tension: (est.) 50 dynes/cm = 0.05 N/m at 20°C 13.10 Vapor (Gas) Specific Gravity: Not pertinent 13.11 Ratio of Specific Heats of Vapor (Gas): Not pertinent 13.12 Latent Heat of Vaporization: Not pertinent 13.13 Heat of Combustion: -18,000 Btu/lb = -10,000 cal/g = -418.68 × 10 ³ J/kg 13.14 Heat of Decomposition: Not pertinent 13.15 Heat of Solution: Not pertinent 13.16 Heat of Polymerization: Not pertinent	
Category	Classification										
Health Hazard (Blue)	0										
Flammability (Red)	2										
Reactivity (Yellow)	0										
<div>(Continued on pages 5 and 6)</div> <div>NOTES</div>											

Common Synonyms Bunker C oil Residual fuel oil No. 6		Thick liquid Black Tar odor Usually floats on water.
Stop discharge if possible. Call fire department. Avoid contact with liquid. Isolate and remove discharged material. Notify local health and pollution control agencies.		
Fire	Combustible. Extinguish with dry chemical, foam or carbon dioxide. Water may be ineffective on fire. Cool exposed containers with water.	
Exposure	CALL FOR MEDICAL AID. LIQUID Irritating to skin and eyes. Harmful if swallowed. Remove contaminated clothing and shoes. Flush affected areas with plenty of water. IF IN EYES, hold eyelids open and flush with plenty of water. IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk. DO NOT INDUCE VOMITING.	
Water Pollution	Dangerous to aquatic life in high concentrations. Fouling to shoreline. May be dangerous if it enters water intakes. Notify local health and wildlife officials. Notify operators of nearby water intakes.	
1. RESPONSE TO DISCHARGE <small>(See Response Methods Handbook, CG 446-4)</small> Mechanical containment Should be removed Chemical and physical treatment		2. LABELS No hazard label required by Code of Federal Regulations
3. CHEMICAL DESIGNATIONS 3.1 Synonyms: Bunker C oil Residual fuel oil No. 6 3.2 Coast Guard Compatibility Classification: Petroleum oil 3.3 Chemical Formula: Not applicable 3.4 IMCO/United Nations Numerical Designation: 3.3/1223		4. OBSERVABLE CHARACTERISTICS 4.1 Physical State (as shipped): Liquid 4.2 Color: Dark 4.3 Odor: Tarry; like kerosene
5. HEALTH HAZARDS 5.1 Personal Protective Equipment: Protective gloves; goggles or face shield. 5.2 Symptoms Following Exposure: INGESTION: gastrointestinal irritation. ASPIRATION: pulmonary irritation is normally minimal but may become more severe several hours after exposure. 5.3 Treatment for Exposure: INGESTION: do NOT lavage or induce vomiting. ASPIRATION: treatment probably not required; delayed development of pulmonary irritation can be detected by serial chest x-rays; consider prophylactic antibiotic regime if condition warrants. EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water. 5.4 Toxicity by Inhalation (Threshold Limit Value): Not pertinent 5.5 Short-Term Inhalation Limits: Not pertinent 5.6 Toxicity by Ingestion: Grade I; LD ₅₀ 5 to 15 g/kg 5.7 Late Toxicity: Data not available 5.8 Vapor (Gas) Irritant Characteristics: None 5.9 Liquid or Solid Irritant Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. 5.10 Odor Threshold: Data not available		

<div>6. FIRE HAZARDS</div> <div>6.1 Flash Point: > 150°F C.C.</div> <div>6.2 Flammable Limits in Air: 1%– 5%</div> <div>6.3 Fire Extinguishing Agents: Dry chemical, foam, or carbon dioxide</div> <div>6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective</div> <div>6.5 Special Hazards of Combustion Products: Not pertinent</div> <div>6.6 Behavior in Fire: Not pertinent</div> <div>6.7 Ignition Temperature: 765°F</div> <div>6.8 Electrical Hazard: Not pertinent</div> <div>6.9 Burning Rate: 4 mm/min.</div>		<div>8. WATER POLLUTION</div> <div>8.1 Aquatic Toxicity: 2400 ppm/48 hr/juvenile American shad/ TL_m/fresh water 2417 mg/l/48 hr/juvenile American shad/ TL_m/salt water</div> <div>8.2 Waterfowl Toxicity: Data not available</div> <div>8.3 Biological Oxygen Demand (BOD): Data not available</div> <div>8.4 Food Chain Concentration Potential: Data not available</div>									
<div>7. CHEMICAL REACTIVITY</div> <div>7.1 Reactivity with Water: No reaction</div> <div>7.2 Reactivity with Common Materials: No reaction</div> <div>7.3 Stability During Transport: Stable</div> <div>7.4 Neutralizing Agents for Acids and Caustics: Not pertinent</div> <div>7.5 Polymerization: Not pertinent</div> <div>7.6 Inhibitor of Polymerization: Not pertinent</div>		<div>9. SELECTED MANUFACTURERS</div> <div>1. Atlantic Richfield Co. 717 Fifth Ave. New York, N. Y. 10022</div> <div>2. Shell Oil Co. 1 Shell Plaza Houston, Tex. 77001</div> <div>3. Sun Oil Co. St. Davids, Pa. 19087</div>									
		<div>10. SHIPPING INFORMATION</div> <div>10.1 Grades or Purity: Commercial</div> <div>10.2 Storage Temperature: Elevated</div> <div>10.3 Inert Atmosphere: No requirement</div> <div>10.4 Venting: Open (flame arrester)</div>									
<div>11. HAZARD ASSESSMENT CODE</div> <div>(See Hazard Assessment Handbook, CG 446-3)</div> <div>A-T-U</div>		<div>13. PHYSICAL AND CHEMICAL PROPERTIES</div> <div>13.1 Physical State at 15°C and 1 atm: Liquid</div> <div>13.2 Molecular Weight: Not pertinent</div> <div>13.3 Boiling Point at 1 atm: 415-->> 1093°F = 212-->> 588°C = 485-->> 861°K</div> <div>13.4 Freezing Point: 25 to 55°F = -4 to +13°C = 269 to 286°K</div> <div>13.5 Critical Temperature: Not pertinent</div> <div>13.6 Critical Pressure: Not pertinent</div> <div>13.7 Specific Gravity: 0.95 (approx.) at 20°C (liquid)</div> <div>13.8 Liquid Surface Tension: (est.) 25 dynes/cm = 0.025 N/m at 20°C</div> <div>13.9 Liquid-Water Interfacial Tension: (est.) 50 dynes/cm = 0.05 N/m at 20°C</div> <div>13.10 Vapor (Gas) Specific Gravity: Not pertinent</div> <div>13.11 Ratio of Specific Heats of Vapor (Gas): Not pertinent</div> <div>13.12 Latent Heat of Vaporization: Not pertinent</div> <div>13.13 Heat of Combustion: -18,000 Btu/lb = -10,000 cal/g = -418.68 × 10³ J/kg</div> <div>13.14 Heat of Decomposition: Not pertinent</div> <div>13.15 Heat of Solution: Not pertinent</div> <div>13.16 Heat of Polymerization: Not pertinent</div>									
<div>12. HAZARD CLASSIFICATIONS</div> <div>12.1 Code of Federal Regulations: Not listed</div> <div>12.2 NAS Hazard Rating for Bulk Water Transportation: Not listed</div> <div>12.3 NFPA Hazard Classifications:</div> <table><thead><tr><th>Category</th><th>Classification</th></tr></thead><tbody><tr><td>Health Hazard (Blue)</td><td>0</td></tr><tr><td>Flammability (Red)</td><td>2</td></tr><tr><td>Reactivity (Yellow)</td><td>0</td></tr></tbody></table>		Category	Classification	Health Hazard (Blue)	0	Flammability (Red)	2	Reactivity (Yellow)	0		
Category	Classification										
Health Hazard (Blue)	0										
Flammability (Red)	2										
Reactivity (Yellow)	0										
<div>NOTES</div>											

(Continued on pages 5 and 6)

(Continued on pages 5 and 6)

LPG	<h1>LIQUEFIED PETROLEUM GAS</h1>
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<p>Common Synonyms: Propane/butane(propylene) Pyrofax LPG</p>	<p>Liquefied compressed gas Colorless Weak odor; may have skunk odor added</p> <p>Floats and boils on water. Flammable vapor cloud is produced.</p>
Fire	<p>Stop discharge if possible. Keep people away. Shut off ignition sources and call fire department. Stay upwind and use water spray to "knock down" vapor. Evacuate area in case of large discharge. Avoid contact with liquid. Notify local health and pollution control agencies.</p> <p>FLAMMABLE. Flashback along vapor trail may occur. Containers may explode in fire. May explode if ignited in an enclosed area.</p> <p>Stop discharge if possible. Cool exposed containers and protect men effecting shutoff with water. Let fire burn.</p>
Exposure	<p>VAPOR Not irritating to eyes, nose and throat. If inhaled, will cause dizziness, difficult breathing, or loss of consciousness.</p> <p>CALL FOR MEDICAL AID.</p> <p>LIQUID Will cause frostbite.</p> <p>Move to fresh air. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen.</p> <p>Flush affected areas with plenty of water. DO NOT RUB AFFECTED AREAS.</p>
Water Pollution	Not harmful to aquatic life.
<p>1. RESPONSE TO DISCHARGE (See Response Methods Handbook, CG 446-4)</p> <p>Issue warning—high flammability Restrict access Evacuate area</p>	<p>2. LABELS</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> PRESENT </div> <div style="text-align: center;"> NEW </div> </div>
<p>3. CHEMICAL DESIGNATIONS</p> <p>3.1 Synonyms: Bottled gas; Propane-butane-(propylene) Pyrofax; LPG</p> <p>3.2 Coast Guard Compatibility Classification: Saturated hydrocarbon or olefin</p> <p>3.3 Chemical Formula: C₃H₈; C₃H₆-C₄H₁₀ (mixture)</p> <p>3.4 IMCO/United Nations Numerical Designation: 2.0/1075</p>	<p>4. OBSERVABLE CHARACTERISTICS</p> <p>4.1 Physical State (as shipped): Liquefied compressed gas</p> <p>4.2 Color: Colorless</p> <p>4.3 Odor: Mild, but commercial LPG has a skunk-like odorant added as a warning.</p>
<p>5. HEALTH HAZARDS</p> <p>5.1 Personal Protective Equipment: Self-contained breathing apparatus for high concentrations of gas.</p> <p>5.2 Symptoms Following Exposure: Concentrations in air greater than 10% cause dizziness in a few minutes. 1% concentrations give the same symptom in 10 min. High concentrations cause asphyxiation.</p> <p>5.3 Treatment for Exposure: Remove victim to open air. If he is overcome by gas, apply artificial resuscitation. Guard against self-injury if confused.</p> <p>5.4 Toxicity by Inhalation (Threshold Limit Value): 1000 ppm</p> <p>5.5 Short-Term Inhalation Limits: Data not available</p> <p>5.6 Toxicity by Ingestion: Not pertinent</p> <p>5.7 Late Toxicity: None</p> <p>5.8 Vapor (Gas) Irritant Characteristics: Vapors are nonirritating to the eyes and throat.</p> <p>5.9 Liquid or Solid Irritant Characteristics: No appreciable hazard. Practically harmless to the skin because it is very volatile and evaporates quickly. May cause frostbite.</p> <p>5.10 Odor Threshold: 5000-20,000 ppm</p>	

<p>6. FIRE HAZARDS</p> <p>6.1 Flash Point: Propane: -156°F C.C.; butane: -76°F C.C.</p> <p>6.2 Flammable Limits in Air: Propane: 2.2%—9.5%; butane: 1.8%—8.4%</p> <p>6.3 Fire Extinguishing Agents: Allow to burn while cooling adjacent equipment with water spray. Extinguish small fires with dry chemicals. Shut off leak if possible.</p> <p>6.4 Fire Extinguishing Agents Not to be Used: Water (let fire burn)</p> <p>6.5 Special Hazards of Combustion Products: Not pertinent</p> <p>6.6 Behavior in Fire: Containers may explode in fire. Vapor heavier than air and may travel a long distance to a source of ignition and flash back.</p> <p style="text-align: right; font-size: small;">(Continued on page 4)</p>	<p>8. WATER POLLUTION</p> <p>8.1 Aquatic Toxicity: None</p> <p>8.2 Waterfowl Toxicity: None</p> <p>8.3 Biological Oxygen Demand (BOD): None</p> <p>8.4 Food Chain Concentration Potential: None</p>																																				
<p>7. CHEMICAL REACTIVITY</p> <p>7.1 Reactivity with Water: No reaction</p> <p>7.2 Reactivity with Common Materials: No reaction</p> <p>7.3 Stability During Transport: Stable</p> <p>7.4 Neutralizing Agents for Acids and Caustics: Not pertinent</p> <p>7.5 Polymerization: Not pertinent</p> <p>7.6 Inhibitor of Polymerization: Not pertinent</p>	<p>9. SELECTED MANUFACTURERS</p> <ol style="list-style-type: none"> Exxon Co. Houston, Tex. 77001 Phillips Petroleum Co. Bartlesville, Okla. 74004 Sun Oil Co. St. Davids, Pa. 19087 																																				
<p>10. SHIPPING INFORMATION</p> <p>10.1 Grades or Purity: Various grades, mostly propane. In some areas propylene may be included. The proportion may be varied with the season.</p> <p>10.2 Storage Temperature: Ambient</p> <p>10.3 Inert Atmosphere: No requirement</p> <p>10.4 Venting: Safety relief</p>																																					
<p>11. HAZARD ASSESSMENT CODE (See Hazard Assessment Handbook, CG 446-3)</p> <p>A-B-C-D-E-F-G</p>	<p>13. PHYSICAL AND CHEMICAL PROPERTIES*</p> <p>13.1 Physical State at 15°C and 1 atm: Gas</p> <p>13.2 Molecular Weight: >44</p> <p>13.3 Boiling Point at 1 atm: > -40°F = > -40°C = > 233°K</p> <p>13.4 Freezing Point: Not pertinent</p> <p>13.5 Critical Temperature: -142.01°F = -96.67°C = 176.53°K</p> <p>13.6 Critical Pressure: 616.5 psia = 41.94 atm = 4,249 MN/m²</p> <p>13.7 Specific Gravity: 0.51 0.58 at -50°C (liquid)</p> <p>13.8 Liquid Surface Tension: 16 dynes/cm = 0.016 N/m at -47°C</p> <p>13.9 Liquid-Water Intertacial Tension: (ext.) 50 dynes/cm = 0.05 N/m at -38°C</p> <p>13.10 Vapor (Gas) Specific Gravity: 1.5</p> <p>13.11 Ratio of Specific Heats of Vapor (Gas): 1.130</p> <p>13.12 Latent Heat of Vaporization: 183.2 Btu/lb = 101.8 cal/g = 4.262 X 10³ J/kg</p> <p>13.13 Heat of Combustion: -19,782 Btu/lb = -10,990 cal/g = -460.13 X 10³ J/kg</p> <p>13.14 Heat of Decomposition: Not pertinent</p> <p>13.15 Heat of Solution: Not pertinent</p> <p>13.16 Heat of Polymerization: Not pertinent</p> <p style="font-size: x-small;">*Physical properties apply to propane; no "standard" LPG exists.</p> <p style="text-align: right; font-size: x-small;">(Continued on pages 5 and 6)</p>																																				
<p>12. HAZARD CLASSIFICATIONS</p> <p>12.1 Code of Federal Regulations: Flammable compressed gas</p> <p>12.2 HAZARD Rating for Bulk Water Transportation:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Category</th><th>Rating</th></tr> </thead> <tbody> <tr> <td>Fire</td><td>4</td></tr> <tr> <td>Health</td><td></td></tr> <tr> <td> Vapor Irritant</td><td>0</td></tr> <tr> <td> Liquid or Solid Irritant</td><td>0</td></tr> <tr> <td> Poisons</td><td>0</td></tr> <tr> <td>Water Pollution</td><td></td></tr> <tr> <td> Human Toxicity</td><td>0</td></tr> <tr> <td> Aquatic Toxicity</td><td>0</td></tr> <tr> <td> Aesthetic Effect</td><td>0</td></tr> <tr> <td>Reactivity</td><td></td></tr> <tr> <td> Other Chemicals</td><td>0</td></tr> <tr> <td> Water</td><td>0</td></tr> <tr> <td> Self-Reaction</td><td>0</td></tr> </tbody> </table> <p>12.3 NFPA Hazard Classifications:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Category</th><th>Classification</th></tr> </thead> <tbody> <tr> <td>Health Hazard (Blue)</td><td>1</td></tr> <tr> <td>Flammability (Red)</td><td>4</td></tr> <tr> <td>Reactivity (Yellow)</td><td>0</td></tr> </tbody> </table>		Category	Rating	Fire	4	Health		Vapor Irritant	0	Liquid or Solid Irritant	0	Poisons	0	Water Pollution		Human Toxicity	0	Aquatic Toxicity	0	Aesthetic Effect	0	Reactivity		Other Chemicals	0	Water	0	Self-Reaction	0	Category	Classification	Health Hazard (Blue)	1	Flammability (Red)	4	Reactivity (Yellow)	0
Category	Rating																																				
Fire	4																																				
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Flammability (Red)	4																																				
Reactivity (Yellow)	0																																				
<p>6. FIRE HAZARDS (Cont'd.)</p> <p>6.7 Ignition Temperature: Propane: 871°F; butane: 761°F</p> <p>6.8 Electrical Hazard: Class I, Group D</p> <p>6.9 Burning Rate: 8.2 mm/min.</p>																																					

APPENDIX E

PETROLEUM REFINERIES IN THE UNITED STATES

APPENDIX E

PETROLEUM REFINERIES IN THE UNITED STATES

This appendix illustrates the location, typical operation, residuals produced and costs for petroleum refineries in the U.S. Figures E-1 and E-2 indicate locations and typical process flows. Tables E-1 and E-2 present amounts of residuals produced and costs of refining.

Source: "P.A.D. Districts Supply/Demand," Mineral Industry Surveys, U.S. Department of the Interior, Bureau of Mines, Washington, D.C. 20241, February 1976.

FIGURE E-1. Petroleum Refineries in the United States and Puerto Rico

Note: Numbers in parentheses represent process capabilities in barrels per stream day (B/SD) in a hypothetical 100,000 B/SD refinery.

Source: Environmental Impacts, Efficiency, and Cost of Energy Supply and End Use, Vol. 1, Hittman Associates, Inc., Columbia, Maryland 21044, November 1974.

FIGURE E-2. National Average Refinery Flowchart

SYSTEM	Water Pollutants (Tons/10 ¹² Btu's)										Air Pollutants (Tons/10 ¹² Btu's)						Solids (Tons/10 ¹² Btu's)	F/ I ^a Land Acre-year 10 ¹² Btu's	Occupational Health 10 ¹² Btu's		
	Acids	Bases	PO ₄	NO ₃	Total Dissolved Solids	Suspended Solids	Organics	BOD	COD	Thermal (Btu's/10 ¹²)	Particulates	NO _x	SO _x	Hydrocarbons	CO	Aldehydes			Deaths	Injuries	Man-Day ^c Lost
NATIONAL AVERAGE REFINERY																					
Uncontrolled National Oil	U	U	NA	NA	35.8	22.2	6.	6.92	20.2	7.06 x10 ¹⁰	9.1	22.8	240.	232.	611.	3.73	7.57	10.3/0 10.3	.0004	.0362	2.05
Controlled National Oil	U	U	NA	NA	34.	.694	.35	.694	4.24	0	2.73	19.7	21.	23.6	.166	3.71	43.7	10.3/0 10.3	.0004	.0362	2.05
Uncontrolled Domestic Onshore	U	U	NA	NA	35.8	22.2	6.	6.92	20.2	7.06 x10 ¹⁰	9.1	22.8	246.	232.	611.	3.73	7.57	10.3/0 10.3	.0004	.0362	2.05
Controlled Domestic Onshore	U	U	NA	NA	34.	.694	.35	.694	4.24	0	2.73	19.7	21.3	23.6	.166	3.71	43.7	10.3/0 10.3	.0004	.0362	2.05
Uncontrolled Domestic Offshore	U	U	NA	NA	35.8	22.2	6.	6.92	20.2	7.06 x10 ¹⁰	9.1	22.8	181.	232.	611.	3.73	7.57	10.3/0 10.3	.0004	.0362	2.05
Controlled Domestic Offshore	U	U	NA	NA	34.	.694	.35	.694	4.24	0	2.73	19.7	17.9	23.6	.166	3.71	43.7	10.3/0 10.3	.0004	.0362	2.05
CONVENTIONAL REFINERY																					
Domestic Crude	.2	NC	NC	NC	50.	2.2	NC	NC	NC	0	1.1	12.8	SO ₂ 66.7	13.9	1.7	NC	3.9	1.	.0014	.107	25.5
OIL REFINERY	NC	NC	NC	1.5	1.6	7.3	1.8	6.3	NC	NC	3.3	23.7	35.5	19.1	1.4	.8	NC	NC	U	U	U

NA = not applicable, NC = not considered, U = unknown.

^aFixed Land Requirement ($\frac{\text{Acre} \cdot \text{year}}{10^{12} \text{ Btu's}}$) / Incremental Land Requirement ($\frac{\text{Acres}}{10^{12} \text{ Btu's}}$).

Source: Energy Alternatives: A Comparative Analysis, University of Oklahoma, May 1975.

TABLE E-1. Crude Oil Refining Residuals

TABLE E-2. Crude Oil Refining Costs (1972)

	Fixed Cost (dollars per 10^{12} Btu's input)	Operating Cost (dollars per 10^{12} Btu's input)	Total Cost (dollars per 10^{12} Btu's input)
National average refinery			
Uncontrolled national oil	76,800	242,000	319,000
Controlled national oil	85,600	248,000	334,000

Source: Environmental Impacts, Efficiency, and Cost of Energy Supply and End Use, Vol. 1, Hittman Associates, Inc., Columbia, Maryland 21044, November 1974.

APPENDIX F

PETROLEUM ADMINISTRATION FOR DEFENSE (PAD) DISTRICTS

APPENDIX F

PETROLEUM ADMINISTRATION FOR DEFENSE (PAD) DISTRICTS

The PAD districts are illustrated below; states belonging to each district are listed below the map.

PAD I

Maine
New Hampshire
Vermont
New York
Massachusetts
Rhode Island
Connecticut
Pennsylvania
New Jersey

PAD II

North Dakota
South Dakota
Minnesota
Wisconsin
Michigan
Ohio
Indiana
Oklahoma

Maryland
Delaware
West Virginia
Virginia
North Carolina
South Carolina
Georgia
Florida

Tennessee
Missouri
Iowa
Nebraska
Kansas
Illinois
Kentucky

PAD III

New Mexico
Alabama
Louisiana

PAD IV

Montana
Idaho
Wyoming

PAD V

Washington
Oregon
Arizona
Hawaii

Texas
Arkansas
Mississippi

Utah
Colorado

California
Nevada
Alaska

APPENDIX G

MATERIAL BALANCE FOR 1000 MWe POWER PLANT

APPENDIX G

MATERIAL BALANCE FOR 1000 MWe POWER PLANT

The Material Balance for 1000 Mwe power plant can be illustrated as follows:

PLANT SPECIFICATIONS

Efficiency 0.39
Load Factor 0.75

Source: Comparative Risk/Cost Benefit Study of Alternate Sources of Electrical Energy, WASH-1224, Atomic Energy Commission, December 1974.

APPENDIX H

SOURCE INFORMATION FOR SECTION 4

APPENDIX H

SOURCE INFORMATION FOR SECTION 4

Appendix H contains a bibliography and acknowledges individuals who contributed information on concerns addressed in Section 4 of this report. Information sources are listed below according to the section number and topic heading used in the body of the report.

4.1 ENVIRONMENTAL EFFECTS AND MANAGEMENT OF OIL SPILLS

4.1.1 Effects of Marine Oil Pollution

Literature

Editorial Research Reports, "Tanker Safety," Mary Costello, Vol. 1, No. 9, March 4, 1977. The U.S. concern over recent oil tanker accidents and proposals for tanker safety improvement are discussed. Foreign flag tankers, as well as suggestions for the prevention of future tanker oil pollution incidents and the international implications, were discussed in the article.

A Summary of Accidents Related to Non-Nuclear Energy, "Crude Oil," Energy/Environment R&D Decision Series, EPA, May 1977. This document contains a short discussion on crude oil with accident data pertaining to the oil industry and refinery processes. Shipping and pipeline transport plus offshore production of petroleum were all mentioned briefly.

Oil and Gas Journal, "Field Studies Show Oil Production and Environment Remain Compatible," Edward W. Mertens, March 7, 1977. Conclusions from field studies conducted at Santa Barbara, California; Lake Maracaibo, Venezuela; Bermuda; and Timbalier Bay, Gulf of Mexico are summarized. Most published literature concerning effects of oil on marine life is the result of laboratory work. Results from extensive field studies contained in this article indicate that oil production and the environment are compatible.

"What We Know About the Fate and Effects of Oil in the Marine Environment," Jack W. Anderson, BNW Marine Research Laboratory, April 22, 1977. This is a publication of results of acute toxicity tests conducted at BNW's Marine

Research Laboratory. The findings of these laboratory tests indicate that chronic exposure to low concentrations of petroleum hydrocarbons represents a danger to marine life.

Fuel Oil and Related Products, 1977 National Plant Engineering and Maintenance Conference, May 9-12, 1977. The EPA rules and regulations for oil spill prevention are discussed. Although the requirements are not specifically stated, their application and purpose is discussed.

Pollution Engineering, "Spill Prevention and Control: A Special Report," W. H. Weiss, November 1976. This article reviews spill control and cleanup materials (i.e., sorbents, booms, separator pumps), discusses spill handling procedures and includes a spill-prevention plan checklist which is a condensation of a plan prepared by the EPA. Three major companies, an oil, a chemical and a rubber company, have spill prevention and control plans that are included in this paper.

Journal of Water Pollution Control Federation, "Spill Cleanup - What are the Capabilities?," May 1977. The development and organization of the National Contingency Plan are explained. Involvement of the federal government and industrial and private sectors in oil spill cleanup and efforts to handle pollution emergencies are also discussed.

<u>Telephone Contacts</u>		
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Mr. Wallace Sansone	Director of Policy and Plans	Department of Commerce, Maritime Administration
Dr. George Steinman	Chief of Environmental Activities	Department of Commerce Maritime Administration

4.1.2 Offshore Pipeline Development

Literature

Deepwater Port Act of 1974, PL 93-627, 88 Stat. 2126, approved January 3, 1975. Section 21, parts a, b, and c of the Act deal specifically with safety and operation of pipelines which serve deepwater ports, although the text is brief.

Outer Continental Shelf Lands Act, Chapter 345, PL 212, approved August 7, 1953. "An Act to provide for the jurisdiction of the United States over the submerged lands of the Outer Continental Shelf, and to authorize the Secretary of the Interior to lease such lands for certain purposes."

Code of Federal Regulations, "Transportation of Liquids by Pipeline," Title 49, Subtitle B, Part 195. Two separate laws, Part I Interstate Commerce Act (Title 49, Chapter 1, U.S. Code) and Explosives and Other Dangerous Articles Act (Title 18, Chapter 39, Sections 831-835, U.S. Code) provide the economic and safety basis for the pipeline regulations. The four subparts include the regulations for pipeline construction, design and accidents. However, for oil discharged into water, accidents are reported to the Department of Transportation, U.S. Coast Guard.

Code of Federal Regulations, "Discharge of Oil," Title 40, Part 110. Regulations concerning offshore pipelines, included in Title 40 - Protection of the Environment, are presented. Pipeline leaks which produce a sheen or film upon water, discoloration of a water surface or the adjoining shoreline, regardless of the quantity, are reported to the U.S. Coast Guard (USCG), Department of Transportation.

Code of Federal Regulations, "Oil and Gas and Sulphur Operations in the Outer Continental Shelf," Title 30, Part 250. The majority of the regulations pertain to the OCS production fields and wells, the jurisdiction and functions of the supervisor and requirements for leases. Sections 250.18, 250.19 and 250.43 contain regulations that pertain to pipelines and accidents.

Code of Federal Regulations, "For Pipelines on the OCS," Title 43, Part 2880, Subpart 2883. Regulations pertaining to application for rights-of-way, approval of rights-of-way and pipeline construction are contained in this section of the CFR, which are administered by the Department of the Interior, Bureau of Land Management.

Amendment No. 195-11; Docket No. OPSO-35, Title 49 Transportation, Chapter 1 - Materials Transportation Bureau, Department of Transportation, Subchapter D - Pipeline Safety, Part 195 - "Transportation of Liquids by Pipeline," Offshore Pipeline Facilities, August 9, 1976. "This amendment

modifies many of the design, construction, testing, operation and maintenance regulations in Part 195 as they relate to the offshore transportation by pipeline in interstate or foreign commerce of hazardous materials, petroleum or petroleum products. The purpose of the amendment is to more clearly delineate the applicability of Part 195 to offshore liquid pipelines and to better assure the safe operation of those pipelines."

OCS Order No. 7, "Pollution and Waste Disposal," U.S. Department of the Interior, Geological Survey Conservation Division, effective October 1, 1976. The OCS Orders are numbered directives which are issued to implement provisions of 30 CFR 250. This OCS Order was established in accordance with 30 CFR 250.43 and specifies more clearly the meaning of "substantial size or quantity," in 250.43(a).

OCS Order No. 9, "Oil and Gas Pipelines," U.S. Department of the Interior, Geological Survey Conservation Division, effective October 30, 1970. OCS Order No. 9 has two subdivisions, 1) General Design and 2) Application. 1.E states, "All pipelines shall be maintained in good operating condition at all times and inspected monthly for indication of leakage using aircraft, floating equipment, or other methods."

Policies, Practices and Responsibilities for Safety and Environmental Protection in Oil and Gas Operations on the OCS, U.S. Geological Survey, June 1977. The document sets forth the policies, practices and responsibilities of the USGS to assure safety of operations, prevention of pollution, protection of life and property and minimal environmental damage risks. These provide the basis for development, revision and implementation of detailed programs, plans and other actions required for effective OCS regulation.

Federal Register, "Memorandum of Understanding Between the Department of Transportation (DOT) and the Department of the Interior (DOI) Regarding Offshore Pipelines," Vol. 41, No. 114, signed May 6, 1976. "In recognition of each of the parties' respective regulatory responsibilities, the DOT and the DOI agree that a memorandum of understanding is needed to avoid duplication of regulatory efforts regarding offshore pipelines and to maximize the exchange of relevant information."

Coastal Effects of Offshore Energy Systems, Office of Technology Assessment, Vol. I and II, November 1976. The objective of this study was to investigate the impact of three energy systems (oil and gas developments, deepwater ports and floating nuclear powerplants) on the ocean and coastal environment of the New Jersey and Delaware mid-Atlantic OCS. Although no section dealt directly with offshore pipelines, there was specific mention made of the lack of baseline studies.

Leak Detection in Underwater Oil Pipelines, Patricia A. Jackson, National Maritime Research Center (defunct), Galveston, Texas, September 1973. "A brief state-of-the-art review of leak detection devices suitable for underwater oil pipelines is discussed. The review was performed to provide appropriate pollution control information prior to the construction of underwater oil pipelines from deepwater tanker terminals to shore facilities."

Telephone Contacts

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Mr. Sam Whitehill	Environmental Affairs Coordinator	Exxon Pipeline Company
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Mr. Stanley Radack	Staff Petroleum Engineer, Offshore, Los Angeles Field Office	Department of Interior, U.S. Geological Survey
Mr. Charles Perrott	Petroleum Engineer	Department of Interior, U.S. Geological Survey
Dr. Lehman	Deputy Director	National Oceanic and Atmospheric Administration, Office of Ecology
Mr. Pete Johnson	Staff Member - Oceans Program	U.S. Congress, Office of Technology Assessment

4.1.3 Environmental Impacts of Pipelines

Literature

Code of Federal Regulations, "Transportation of Liquids by Pipeline," Title 49, Subtitle B, Part 195. Two separate laws, Part I, Interstate Commerce Act (Title 49, Chapter I, U.S. Code) and Explosives and Other Dangerous Articles Act (Title 18, Chapter 39, Sections 831-835, U.S. Code) provided the economic and safety basis for the pipeline regulations. The four subparts include regulations for pipeline construction, design and accidents.

Code of Federal Regulations, "Discharge of Oil," Title 40, Part 110. Regulations that concern pipelines which cross river beds or have contact with water bodies are included in Title 40 - Protection of the Environment. Pipeline leaks which produce a sheen or film upon water, discoloration of a water surface or the adjoining, shoreline, regardless of the quantity, are reported to the U.S. Coast Guard (USCG), Department of Transportation. For 1975, USCG reported that 564 or 5.6% of the total number of oil spill accidents on water were attributed to pipeline spills.

PIRS, "Pipeline Spills for 1976," USCG. The Pollution Incident Reporting System (PIRS) was promulgated in December 1971, for the purpose of data collection on oil discharges and other polluting incidents reported to or detected by the USCG in accordance with 40 CFR 110. The PIRS provides management information for the Marine Environmental Protection Program and serves as a national data base for incident pollution information.

"Summary of Liquid Pipeline Accidents Reported on DOT Form 7000-1 from January 1, 1976 through December 31, 1976," Department of Transportation, Office of Pipeline Safety Regulation, May 1, 1977. The summary includes the number and percentage of accidents listed by cause of accident, commodity involved and damage incurred. The three major causes of accidents were equipment rupturing line, external corrosion and defective pipe seam. Information contained in the summary is useful to the DOT and helpful to the pipeline industry to locate safety problem areas.

Pipeline and Gas Journal, "Ultrasonic Flowmeter Nucleus of Unique Leak Detection System," E.S. Chaney and B. L. Johnston, Westinghouse Oceanic Division, October 1976. The article is a discussion of the ultrasonic principle, leak detection application, petroleum application development, error sources and calibration.

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Mr. Ron Jones	Transportation Department Associate - Pipelines	American Petroleum Institute

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Mr. Sam Whitehill	Environmental Affairs Coordinator	Exxon Pipeline Company
Mr. Mark Ives	Environmental Protection Division/Statistics Manager	U.S. Coast Guard, Department of Transportation

4.1.4 Oil Spill Trajectory Modeling

Literature

Modeling Methods for Predicting Oil Spill Movement, Robert J. Rath, Oceanographic Institute of Washington, prepared for the Oceanographic Commission of Washington, March 1977. The purpose of this study was to provide an overview, as reflected in the literature, of the state-of-the-art of two-dimensional oil spreading and drift modeling capabilities. Seventeen key papers and techniques were evaluated.

A Review and Evaluation of Basic Techniques for Predicting the Behavior of Surface Oil Slicks, Keith D. Stolzenbach, et al., MIT Department of Civil Engineering, Report No. 222, sponsored by Marine Assessment Division of NOAA, February 1977. The study reviews the basic analytical techniques presently available for making predictive estimates regarding spilled oil. Fifteen composite oil slick models are reviewed and evaluated. This review also provides an evaluation of the current needs for additional basic research and data collection.

Southern California Outer Continental Shelf Oil Development: Analysis of Key Issues, Environmental Science and Engineering, University of California, Los Angeles, 1976. This report addresses selected topics relating to the impact of offshore oil production from the perspective of Southern California urban regions. Chapter four evaluates eight modeling techniques which simulate the fate of petroleum products in the marine environment.

A Mathematical Model for Predicting the Transport of Oil Slicks in Marine Waters, S. W. Ahlstrom, Battelle Pacific Northwest Laboratories, December 1975. This report discusses a current version of a mathematical oil slick trajectory model. When used in a deterministic mode, the primary objective of the model calculations is to predict the location, areal extent and chemical composition of a specific spill as a function of time.

"A Probabilistic Approach for Dispersion of Oil at Sea," M. H. Fallah and R. M. Stark, Ocean Engineering, Vol. 3, pp. 145-156, Pergamon Press, 1976. This paper considers the volume of "lost" oil due to dispersion in a rough sea. Probabilistic descriptions are derived for the volume of oil dispersed in subsurface water as a function of time, physical properties of the oil slick and the random environmental characteristics. A simple example illustrates the results.

"Literature Review: Movement of Spilled Oil at Sea," M. H. Fallah and R. M. Stark, Marine Technology Society Journal, Vol. 10, No. 1, pp. 3-18, January 1976. An overview of some of the important works on understanding the movement of spilled oil is presented. Works on four distinct modes of oil-water interaction are recognized: spreading, drift, diffusion and dissipation. About 230 references are included, citing information on movement of oil slicks, oil pollution, detection of oil slicks, containment and cleanup of oil spills, and the degradation of oil spills.

"Wind and Current Effects on Large-Scale Oil Slicks," S. P. Murray, pp. 523-533 of Proceedings of the Seventh Annual Offshore Technology Conference, Vol. 3, 1975. An easily utilized regression model for slick area and orientation as a function of wind velocity and local conditions is presented.

"Determination of the Sea Surface Stress and Drift Current by Similarity Theory," G. C. Hess in Radiological and Environmental Research Division Annual Report, January-December 1974, ANL-75-3 (Part 4), pp. 112-119. This model is concerned with air flow over the ocean with application to predicting drift of oil slicks when the Coriolis parameter and the magnitude of the geostrophic wind are known.

Predicted Oil Slick Movement from Various Locations Off the New Jersey-Delaware Coastline, Ivan M. Lissauer and Jerry C. Bacon, Final Report, prepared for the U.S. Coast Guard Office of Research and Development, Report No. CG-D-137-75, June 1975. Average monthly wind speeds and directions and average monthly current patterns were used for predicting oil slick movement from three potential deepwater port and drilling sites. Probable areas of impact along the shoreline are indicated.

A Computer Simulation Technique for Oil Spills off the New Jersey-Delaware Coastline, Martin Miller, Jerry Bacon and Ivan Lissauer, U.S. Coast Guard, Report No. CG-D-171-75, September 1975. A hydrodynamical-numerical model for the New York Bight area was coupled with a wind generating model to produce temporal patterns of concentration of oil. Shoreline impact determinations were made for four spill sites for the average winter storm conditions and average summer high pressure systems generated by the models.

"Monte Carlo Simulation of Oil Slick Movements," Mehmet Tayfun and Hsiang Wang, Journal of the Waterways, Harbors and Coastal Engineering Division, pp. 309-324, August 1973. A random walk analogy and a time series model are described to simulate, by the Monte Carlo approach, the movement of an oil slick under the actions of deterministic water currents and random wind effects. An illustrative application based on some of the previous empirical results and on actual data is given.

Preliminary Projections of Oil Spill Movement for Three Potential Deep-water Port Sites in the Gulf of Mexico, I. M. Lissauer and J. P. Welsh, Final Report, U.S. Coast Guard Office of Research and Development, Report No. CG-D-19-76, December 1975. Average monthly wind speeds and directions and average monthly current patterns were used for predicting oil slick movement from three potential deepwater port sites. Seasonal patterns of oil slick drift and probable areas of impact along the shoreline were indicated.

A Numerical Model for Simulation of Oil Spreading and Transport and Its Application for Predicting Oil Slick Movement in Bays, Shen Wang and Li-San Hwang, Tetra Tech Report TT-P-345-74-1, sponsored by U.S. Coast Guard Research and Development Center, February 1974. This study is aimed at developing a

computer model which is capable of predicting oil slick transport in harbors and bays. By means of numerical approximation, the model is able to simulate the spreading and movement of oil slicks on the ocean surface and to predict their destinations.

Oil Spill Drift Forecasting Model, C. R. Cole, H. P. Foote and J. R. Eliason, Battelle Pacific Northwest Laboratories, June 1973. The movement and spreading of oil slicks on the ocean surface are simulated by a forecasting model as a combination of the various phenomena which affect the spreading and transport of oil. Transport as a result of permanent ocean currents, tidal currents and winddrift is considered.

Operational Oil Spill Drift Forecasting, L. E. Webb, R. Taranto and E. Hashimoto, Fleet Weather Central, Norfolk, Virginia, 1971. The surface current parameters influencing oil spill drift used in this proposed forecast method are permanent currents, wind drift, geostrophic and tidal currents. A basic operational forecast using the vector sum of pertinent parameters is presented.

Forecasting Oil Slick Behavior - A Preliminary Guide, Frederick Arthlieb, Applied Technology Division, U.S. Coast Guard Office of Research and Development, July 1971. A method for predicting the behavior of oil slicks at sea is developed using the results of current research. It permits the estimation of the growth of an oil slick due either to a sudden release of a known volume of oil, or to a continuous oil flow. Empirical observations are used as the basis for estimating slick drift due to wind and currents.

4.2 TRANSPORTATION SYSTEM SAFETY

4.2.1 Training of Waterway Personnel

Literature

"Coast Guard/MARAD Policy Statement Concerning Qualifications of Crews of U.S. Merchant Vessels," September 6, 1974. The purpose of this statement is to establish policy and program guidelines for cooperative interagency effort to more efficiently ensure that U.S. merchant marine vessels are manned by

qualified, trained and efficient civilian personnel. Engineering advances of the past have not been accompanied by innovative and progressive advances in critical areas of crew training and qualifications. The interagency effort is addressed to new training and qualification courses and examination procedures.

Log, "Drozak Blasts USCG Failures on Safety," Vol. 39, No. 7, p. 5, Official publication of the Seafarers International Union, July 1977. This article listed a number of unsafe conditions which exist on marine vessels and discussed the lack of prevention as a reason for marine casualties.

Inlandboatman of the Pacific, "Coast Guard's Safety Record Draws SIU Fire," Vol. 3, No. 4, p. 4, Official Publication of the Inlandboatmen's Union of the Pacific, August 30, 1977. This article also discusses the unsafe conditions aboard vessels as a probable cause for marine casualties.

Code of Federal Regulations, Title 46, Chapter I, Part 10 and 12. The requirements and regulations pertaining to examinations, endorsements, licenses, pilots, masters, mates, radio officers, and engineers for inspected and uninspected vessels are contained in Part 10. Certification requirements for able seamen, lifeboatmen, qualified members of the engine department, tankermen and other ratings are included in Part 12.

Code of Federal Regulations, Title 46, Chapter I, Part 157, "Manning Requirements." This set of regulations provides uniform minimum requirements for manning of U.S. vessels. Section 157.20-1 lists the vessels to which the regulations apply; Section 157.10 defines the manning personnel, i.e., able seaman, chief engineer, master of inspected and uninspected vessels; Section 157.30 contains special provisions, i.e., manning of seagoing barges, officers for uninspected vessels.

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Mr. Don Snyder	Management - Petrochemical Barges	Union Meckling Corporation, Dravo Subsidiary
Mr. Harold Muth	Industry and Government Relations	American Waterway Operators, Inc.
Mr. Neil Schuster	Research Director	American Waterway Operators, Inc.
Captain Nelson Emery	Vessel Manning and Per- sonnel Qualifications	U.S. Coast Guard Headquarters, Department of Transportation
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Captain Leonard Earle	Environmental Coordinator, Barge Operations, Marine Department	Exxon Company USA Exxon Corporation
Mr. Bob Kalmus	Director of Vocational Education	Lundeberg School of Seamanship
Mr. Pat Patterson	Manpower Development Officer	Maritime Administration, Department of Commerce

4.2.2 Insufficient Coast Guard Manpower

Literature

Code of Federal Regulations, Title 46, "Shipping," Chapters I and III. Parts 1-29 include licensing, registration and certification of vessel crewmembers. Parts 90-109 include regulations which concern the construction, inspection and certification of the vessels while Parts 150-164 deal with vessel manning requirements and lifesaving, electrical and engineering equipment specifications.

Code of Federal Regulations, Title 33, "Navigation, Navigable Waters," Chapter I. These regulations pertain to navigation requirements for inland waters, ports and waterways safety, bridges and anchorages.

United States Code, Title 46, Part 239, "Investigation of Marine Casualties - Casualty Involving Loss of Life; Reports," (46 USC 239). This

portion of the codes specifies the Commandant's responsibilities in establishing rules and regulations for investigation of marine casualties/accidents which may or may not result in loss of life. It also authorizes the Commandant to make necessary regulations to secure proper administration of 46 USC 239.

Ports and Waterways Safety Act of 1972, Public Law 92-340. The purpose of this legislation is to promote safety and protection of the environmental quality of ports and navigable waters of the United States. The Act provides a comprehensive and systematic approach to the pollution problem of the marine environment and a means for obtaining better vessels and improved vessel traffic management.

Federal Register, Vol. 42, No. 79, "Proposed Rules." The Department of Transportation, USCG, has attempted to revise regulations which govern the qualifications of personnel involved in the handling, transfer and transportation of dangerous cargoes aboard vessels. The "Proposed Rules" revise regulations which govern qualifications of the person in charge of oil transfer operations. The revised regulations are to sections contained in 33 CFR 155 and 46 CFR Chapter I.

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Captain Cope	Deputy Chief, Office of Public and International Division	Department of Transportation, USCG Headquarters
Captain Al Hampton	Chief, Marine Investigation Division	Department of Transportation, USCG Headquarters
Captain Gilbert Dunn	Office of Maritime Advisor to Secretary of Department of Transportation	Department of Transportation, USCG Headquarters
Mr. L. Coluciello	Marine Safety Board	Department of Transportation, NTSB

4.2.3 Cost-Effective Tanker Safety Design Standards

Literature

"Cracking the Tanker Safety Problem", Juan Cameron, Fortune, April 1977, pp. 150-152. This article discusses the factors which contribute to tanker accidents and oil spills and the effectiveness of current oil pollution prevention practices.

"Tankers: Safety in Segregation", Tony Loftas, New Scientist, February 9, 1978, pp. 348-350. This article presents the pros and cons of segregated ballast tanks and other proposed oil pollution prevention mechanisms.

"International Safety Measures for Tankers Adopted by IMCO", Sea Technology, April 1978, p. 41. This article presents the results of the International Conference on Tanker Safety and Pollution Prevention held in London during February 1978.

Oil Transportation by Tankers: An Analysis of Marine Pollution and Safety Measures, Office of Technology Assessment, July 1975. Prepared to describe the status and trends of tanker operations and pollution problems, the report describes the advantages and disadvantages of the technical and administrative improvements which can be made.

Editorial Research Reports, "Tanker Safety," M. Costello, March 4, 1977. This report describes the world's current tanker situation, exploring the different available options for improving tanker safety.

Segregated Ballast Tanker Arrangements for Pollution Abatement Due to Accidents, W. O. Grey, et al., IMCO Symposium on Prevention of Pollution from Ships, October 1975. This study was performed to determine the best segregated ballast tank arrangements to reduce oil outflow during accidents. Twelve arrangements were evaluated from existing accident records and rated according to performance.

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Mr. Bill Cleary	Chief of Ship Character- istics Branch	U.S. Coast Guard
Lt. Adamchak	Chemical Engineering	U.S. Coast Guard
Ms. Barbara Burke	Director of Legislation	American Institute of Merchant Shipping
Mr. Terry McKay	Naval Architect	U.S. Coast Guard
Mr. Terry Halpin	Chief Engineer	FMC Corporation
Mr. George Uberti	Chief Development Engineer	National Steel and Ship- building Co.
Captain H. G. Lyons	Deputy Chief - Merchant Marine Safety	U.S. Coast Guard
Captain Shubert	Deputy Chief - Systems and Environmental Protection	U.S. Coast Guard

4.3 TRANSPORTATION LOGISTICS

4.3.1 Emergency Distribution

Literature

Disaster Relief Act of 1970, Public Law 91-606. This act provides an orderly and continuing means of assistance by the federal government to state and local governments in carrying out their responsibilities to alleviate the suffering and damage which result from disasters.

Emergency Petroleum Allocation Act of 1973, Public Law 93-159. This act grants the President of the United States temporary authority to deal with shortages of crude oil, residual fuel oil and refined petroleum products or dislocations in their national distribution system.

Petroleum Storage for National Security, Committee on Emergency Preparedness, National Petroleum Council, Washington, D.C., August 1975. The major factors involved in the implementation of a security storage system are discussed in the study: the optimum size of the system in terms of volume and deliverability, the technology and economics of storage facilities; the sources, types and financing of storage fill; and federal actions that could assist or deter the development of the system. An international overview of security storage is also presented.

Vulnerability of Total Petroleum Systems, Maynard M. Stephens, Office of Oil and Gas, Defense Civil Preparedness Agency, May 1973. This report explains the operation of the petroleum industry and discloses segments of vulnerability which, if damaged by any means, could have serious repercussions on the nation.

Sealift Procurement and National Security Study, Multiagency Study, 1972. This study yields projections of shipping requirements and capabilities for a major war. Projections of both detailed military transportation requirements and nonmilitary needs are incorporated.

Civil Defense and Emergency Planning for the Petroleum and Gas Industries, National Petroleum Council, Washington, D.C., Volume I and II (under one cover), 1964. This publication discusses the objectives of emergency planning, possible types of confrontations, natural hazards and sabotage that could disrupt the normal operations of the oil business. Recommendations are given for company emergency programs which can be coordinated with the emergency Petroleum and Gas Administration national program.

Emergency Resources Management Plan, State of Louisiana, Office of Emergency Planning, Department of Public Works and Louisiana Civil Defense Agency. This comprehensive manual outlines the plans for management of all of the resources of the state. Discussions on economic stabilization, electric power, food supply, petroleum and natural gas, health and medical, industrial production, manpower, water, transportation, housing and community facilities are included.

Emergency and Disaster Planning, Richard J. Healy, New York, John Wiley and Sons, Inc., 1969. The author points out that a vulnerability analysis of

a facility can usually be divided into external and interior categories. A particular item under production might be highly critical, and thus a prime target for destruction. The location of a facility contributes to its vulnerability. Methods of creating an industrial emergency plan and factors needed to be considered related to natural hazards, sabotage and enemy attack are covered. This is a good reference for management and security personnel when planning the protection of facilities.

What Is the Emergency Petroleum and Gas Administration? National Petroleum Council, Washington, D.C., 1972. This booklet describes the Emergency Petroleum Gas Administration (EPGA) and its relationship to the oil and gas industries in the event of a national emergency.

Petroleum and Gas in a National Emergency, National Petroleum Council, Washington, D.C., 1964. The adequacy of government plans to ensure an adequate supply of petroleum and gas in a national emergency to meet military and civilian needs is analyzed.

Emergency Preparedness for Interruption of Petroleum Imports into the United States, National Petroleum Council, Washington, D.C., 1974. This report analyzes the impact of the 1973-74 embargo on the U.S. energy supply/demand situation and on the economy, and reviews the options available to the nation to minimize the results of such an imports denial: increased oil and gas production, reduced consumption, conversion to alternate fuels, and standby security storage of crude oil and refined products.

National Transportation Trends and Choices (to the Year 2000), U.S. Department of Transportation, Document No. 050-000-00124-5, January 1977. This document describes the present transportation system in detail. Future trends are described and public choices identified. Major issues which will soon require public decisions are also outlined.

U.S. Petroleum and Gas Transportation Capacities, National Petroleum Council, Washington, D.C., 1967. The report covers a study of the nation's petroleum and natural gas transportation capacities, including crude oil and petroleum products pipelines, natural gas transmission lines, inland waterways barges, tank cars, and tank trucks. The data represent an inventory of aggregate capacities of these transportation facilities.

Telephone Contacts

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Jack Wagner	Acting Director, Office of Contingency Planning	Federal Energy Administration
George W. Barry	Acting Chief of Emergency Transportation	Department of Transportation
Barry Yaffe	Emergency Task Force	Federal Energy Administration
Ray Madden	Emergency Planning	Maritime Administration

4.3.2 Pipeline Sabotage

Literature

The National Observer, July 4, 1977, p. 1.

Column by Jack Anderson, Tri-City Herald, Pasco, WA, June 29, 1977.

4.4 LEGAL, REGULATORY AND INSTITUTIONAL PROBLEMS

4.4.1 Petroleum Industry Reorganization

Literature

Report of the Committee on the Judiciary, U.S. Senate on S2387, the Petroleum Industry Competition Act of 1976, Report No. 94-1005, 94th Congress, 2nd Session (June 28, 1976).

Report of the Attorney General, the United States Department of Justice, pursuant to Section 19 of the Alaska Natural Gas Transportation Act of 1976 (July 1977).

"The Gasoline Marketing Structure and Refusals to Deal with Independent Dealers: A Sherman Act Approach," W. Nobotny, 16 Arizona Law Review, 465 (1974).

"Petroleum Dismemberment," S. Ritchie, 29 Vanderbilt Law Review 1131 (1976).

Telephone Contacts

<u>Name</u>	<u>Position</u>	<u>Affiliation</u>
John Lamont	Attorney	Lobel, Novins and Lamont, Attorneys

4.4.2 Preemption

Cases

ARCO v. Evans, 7 ELR 20071 (W.D. Wash. 1976), injunction stay continued pending appeal sub. nom., Evans v. ARCO, No. A-456, 45 USLW 3430, docketed, U.S. Sup. Ct., January 5, 1977.

New York City, filing for inconsistency determination, 42 F.R. 41204 (August 15, 1977).

Literature

Note, The Preemption Doctrine: Shifting Perspective on Federalism and the Burger Court, 75 Colum. L. Rev. 623 (1975).

Comment, Preemption Once More: Washington's Tanker Law Enjoined but Stays Afloat, 7 ELR 10012 (January 1977).

4.4.3 Federal Right of Eminent Domain

Literature

"Federal Land Policy and Management Act of 1976," Cong. Record Vol. 122 (1976), Policy and Management Act, PL 94-579, passage in House, September 30,

1976, passage in Senate, October 1, 1976. The Act of 1976 is a major step to modernize public land laws. It authorizes an analysis of the public land laws, the existing statutes and regulations, establishment of procedures to facilitate Congressional overseeing of public land operations and formulation of a new code of regulations for public lands. Department of Interior, Bureau of Land Management and Department of Agriculture, Forest Service are working together to establish uniform public land laws. A portion of these laws pertain to oil and gas pipelines and more uniform regulation is anticipated.

"State Laws Relating to the Authority of Pipeline Companies to Exercise the Right of Eminent Domain," Committee on Public Affairs of the American Petroleum Institute, Association of Oil Pipelines, January 21, 1974. Regulations from all 50 states concerning the authority of common carrier pipeline companies to exercise the right of eminent domain are included in the publication. The variety of individual state regulations can be compared.

"Public Law 93-153, November 16, 1973, An Act to Amend Section 28 of the Mineral Leasing Act of 1920, and to Authorize a Trans-Alaska Oil Pipeline and for Other Purposes." Title I of the public law gave authority to the Secretary of the Interior or appropriate agency head of any federal department or independent federal office or agency to grant rights of way through any federal lands except lands in the National Park System, lands on the Outer Continental Shelf, and lands held in trust for Indians/Indian tribes.

The Need for a National System of Transportation and Utility Corridors, U.S. Department of the Interior, Bureau of Land Management, July 1, 1975. This study was prepared in compliance with the congressional mandate contained in PL 93-153. Five major transportation and utility right of way systems were investigated to determine if there is a need for a national system of common corridors across federal lands, the feasibility of development and when such a development should occur.

Right of Way, "800 Pipeline Condemnation Cases Later," an address given by Howard D. McCloud to the American Right of Way Association on January 11 and April 1974. In the address, McCloud stressed the importance of thorough preparedness of agents in their negotiations for rights of way. The address emphasized the importance of hard work in negotiating rights of way.

Regulatory Requirements Impacting an Interstate Crude Oil Pipeline System, Permit Issuance Study, Volume II, Northwest Federal Regional Council, FEA, March 5, 1977. The study, which used the Northern Tier Pipeline proposal as a case study, analyzed the federal and state agencies' involvement and the approvals required in planning, construction and operation of pipelines with identification of the regulatory requirements.

Telephone Contacts

<u>Name</u>	<u>Position</u>	<u>Affiliation</u>
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Mr. Sam Whitehill	Environmental Affairs Coordinator	Exxon Pipeline Company
Mr. William Huffman	Right of Way Manager	Exxon Pipeline Company
Mr. Lee Johnson	External Affairs Officer	Federal Energy Administration - Region X
Mr. Tom Rodda	Natural Resource Specialist	Department of Interior, Bureau of Land Management
Mr. R. Tom Benson	Executive VP	Universal Fields Services
Dr. David Levan	Associate Director	Department of Transportation, Federal Highway Administration
Mr. Rex Shaffer	Chief Real Estate Appraiser	Southern Pacific Transportation Company
Mr. A. E. Uhl	Project Manager - Pipeline Division	Bechtel, Inc.

4.4.4 Licensing of Deepwater Ports

Literature

Deepwater Port Act of 1974, Public Law 93-267. The purpose of this act is to authorize and regulate the location, ownership, construction, and operation of deepwater ports in waters beyond the territorial limits of the United States.

Ports and Waterways Safety Act of 1972, Public Law 92-340. The purpose of the legislation is to promote the safety and protect the environmental quality of ports, waterfront areas, and the navigable waters of the United States. The act authorizes the Coast Guard to establish and operate vessel traffic services, and systems and controls for waters subject to congested vessel traffic.

Washington State Tanker Law, Chapter 125. The statute requires all oil tankers - American or foreign flag - of 40,000 or more DWT that do not conform to certain design and construction standards to take on tug escorts when navigating Puget Sound. It also requires oil tankers of 50,000 or more DWT to take a state-licensed pilot when navigating the Sound. Oil tankers of more than 125,000 DWT are prohibited from entering the Sound under any circumstances.

The Secretary's Decision on the Deepwater Port License Application of LOOP, Inc. The Secretary's Decision on the Deepwater Port License Application of SEADOCK, Inc., Department of Transportation, December 17, 1976. These documents set forth the decisions of the Secretary of Transportation on the applications submitted by LOOP, Inc., and SEADOCK, Inc. A discussion of the considered issues (such as oil spill liability and antitrust issues) are included, as well as copies of the actual conditional licenses issued.

LOOP Deepwater Port License Application, Final Environmental Impact/4 (f) Statement. U.S. Coast Guard, Office of Marine Environment and Systems, 1976. The impact statement covers the proposed licensing by the Department of Transportation of LOOP, Inc., to own, construct and operate a deepwater port in the Gulf of Mexico about 18 miles off Lafourche Parish, Louisiana. (A similar EIS was prepared concurrently for the proposed SEADOCK, Inc., deepwater port off Freeport, Texas.) The EIS covers many factors relating to the proposed facility, other petroleum-related development, the environment and potential impacts thereon, project and system alternatives, and mitigating measures to reduce impacts.

"Deepwater Port Act of 1974: Some International and Environmental Implications," James H. Grann, Jr., Georgia Journal of International and Comparative Law, Vol. 6:535, 1976. This article consists of an analysis of the Deepwater

Port Act with regard to licensing issues and environmental and international impact. Discussions include the extent of governmental control over deepwater ports as granted by this act and international complications regarding the doctrine of the freedom of the high seas.

Additional Literature

National Transportation Trends and Choices (to the Year 2000), U.S. Department of Transportation, Document No. 050-000-00124-5, January 1977.

U.S. Deepwater Ports, William Hathaway, Transportation Systems Center, 1976-77. Construction of Deepwater Ports, Risk Analysis and Inspection Methods, Engineering Aspects of Oil Transfer Systems.

Brown and Root's Approach to Deepwater Construction, H. W. Gordon, Brown and Root, Inc., Houston, Texas, Pipeline Ind. 43/1/ July 1975.

Petroleum-Transportation-Engineering Development, W. E. Lifson, Exxon Research and Engineering Company, 1974.

Deepwater Port Risk Analysis, Arthur D. Little, Inc., U.S. Department of Transportation, 1976.

Evaluation of Economic Effects of Deepwater Ports, M. B. Schupack, Brown University, U.S. Department of Transportation, 1976.

Economic Aspects of Refinery and Deepwater Port Location in the United States, Volume I, Report, C. P. Schumaier, A. Gezen and M. Kendrick. Office of the Assistant Secretary for Policy, Plans and International Affairs (DOT) May 1974.

Port Collection and Separation Facilities for Oily Wastes. Volume VI. Impact of Offshore Terminals on Contiguous Ports, Richard Forster, J. E. Moyer and M. Lepeau, Haris Inc., Maritime Administration, March 1975.

Cargo Spill Probability Analysis for the Deepwater Port Project, Woodward-Lundgren and Associates, February 1973.

Volume I: Primary Effects of Super Port Development. Volume II: Oil Spill Probabilities and Analysis of Environmental Controls. Volume III:

Secondary Effects of Super Port Development. MIT, State University of New York, University of Delaware, Louisiana State University, Texas A&M, March 1973. Sponsored by National Oceanic and Atmosphere Administration.

Louisiana Superport Studies, Report No. 4 Technical Appendices to Recommendations for the Environmental Protection Plan, Louisiana State University, Baton Rouge, LSU-SG-7404, November 1974.

West Coast Deepwater Port Facilities Study, Appendix A. Petroleum Consumption and Supply, U.S. Army Corps of Engineers, June 1973.

Offshore Terminal Systems Concepts, two volumes, Soros Associates, U.S. Department of Commerce, September 1972.

U.S. Deepwater Port Study, five volumes, Robert R. Nathan Associates, Institute for Water Resources, U.S. Army Corps of Engineers, August 1972.

Preliminary Analysis of the Ecological Aspects of Deep Port Creation and Supership Operation, L. Eugene Cronix, et al., Maryland University, Solomons Natural Resources Institute, October 1971.

Large Capacity Ships in the World Tanker Fleet, A. Ivanor and L. Belyakor, Department of the Navy, Translation-2118, 1966.

Marine Administration Tanker Construction Program, Maritime Administration, U.S. Department of Commerce, Final Environmental Impact Statement, EIS-AA-73-0725-F (NTIS), May 1973.

The Economics of Deepwater Terminals, Division of Ports, Maritime Administration.

Foreign Deepwater Port Developments, Arthur D. Little, Inc., U.S. Army Engineer Institute for Water Resources, September 1971.

Terminal Facilities for Very Large Crude Carriers, H. P. Dewry (Shipping Consultants) Limited, April 1972.

Deepwater Ports, Draft Environmental Impact Statement, U.S. Department of the Interior, Washington, D.C., 1973.

Report on the Gulf Coast Deep Port Facilities, Appendix F, Environmental Assessment, Volume 1, Eastern Gulf, U.S. Army Corps of Engineers, Vicksburg, Mississippi, 1973.

The Coastal Plains Deepwater Terminal Study, Robert R. Nathan Associates and Coastal Zone Resources Corporation, two volumes, prepared for the Coastal Plains Regional Commission, January 1975.

Coastal Effects of Offshore Energy Systems, two volumes, Office of Technology Assessment, United States Congress, OTA-0-37 and -38, November 1976.

Optimum Use of World Petroleum, George W. Cummings, ed., 142 Volume 70, 1974.

Bulk Transportation of Hazardous Materials by Water in the Future, Conference Proceedings, prepared for the U.S. Coast Guard, Report No. CG-D-61-74, July 1973.

"The Supertanker Comes of Age," Ray L. Enderle, Our Sun, Autumn 1974, pp. 12-16.

Large Tankers -- Our Energy Lifelines, American Petroleum Institute, 1977.

Offshore Petroleum Transfer Systems for Washington State. A Feasibility Study, Oceanographic Institute of Washington, Report No. OIW-OCW-7401, December 16, 1974.

<u>Telephone Contacts</u>		
<u>Name</u>	<u>Position</u>	<u>Affiliation</u>
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Ernest Bauer	Chief of Office of Deep-water Ports	DOT
Dave Coslett	Director of Public Relations	SEADOCK

4.4.5 Oil Spill Liability/Compensation Laws

Literature

Marine Oil Transportation Task Force, Interim Report of the Marine Oil Transportation Task Force, January 11, 1977. A comprehensive review of marine safety regulations, recommending action concerning tanker equipment, navigation, standards, manning, liability and enforcement for governmental attention is presented.

A. E. Schumacher and W. J. Petterson, Hull Underwriting and the Changing Technology, July 1973. A statement of the circumstances and situations facing marine underwriters is made. A brief description is given of the "ideal" vessel to underwrite.

House Resolution 6803, Comprehensive Oil Pollution Liability and Compensation Act, passed September 12, 1977. H.R. 6803 was designed to provide a comprehensive system of liability and compensation for oil spill damage and removal costs in the navigable waters of the United States. The system would hold owners and operators of oil discharges liable, provide funds for damage claims, and would supersede duplicate federal and state funds and procedures.

Senate Bill 2083, Oil Pollution Liability and Compensation Act of 1977, submitted for subcommittee hearings on September 12, 1977. S. 2083 is similar to H.R. 6803 in concern over a comprehensive national law governing oil pollution liability and compensation. The Act would not preclude any state from imposing additional requirements or liability for damages and cleanup costs.

Telephone Contacts

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Mr. Arthur McKenzie	Director	Tanker Advisory Center
Ms. Barbara Durke	Director of Legislation	American Institute of Marine Shipping
Captain Shubert	Deputy Chief - Environment Operations	U.S. Coast Guard

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Mr. Chris Jensen	Executive Director	Florida Petroleum Council
Lieutenant Lee	Assistant Coordinator - Coastal Protection Section	Florida Department of Natural Resources
Mr. William Kelly	Manager of Environmental Operations	Atlantic Richfield Co.
Captain Earl	Marine Barge Operation	Exxon Company USA
Mr. Bartlett	Senior Research Engineer	Sun Oil Company

APPENDIX I

SOURCE INFORMATION FOR SECTION 5

APPENDIX I

SOURCE INFORMATION FOR SECTION 5

This appendix contains a bibliography and acknowledges individuals who contributed information on concerns discussed in Section 5. These information sources are listed below according to the section and topic heading used in the body of the report.

5.1 PERCEIVED CONCERNS

5.1.1 Effectiveness of Vessel Traffic Services

Literature

Code of Federal Regulations, "Vessel Traffic Systems," Title 33, Part 161, Subpart B. This is the basic reference on the 1972 Act of Congress which established requirements for VTS in coastal ports and waterways. The passage of a compact version of the Ports and Waterways Safety legislation in July 1972, authorized the Secretary of the Department of Transportation (through the Coast Guard) to establish, operate and maintain vessel traffic services and systems for waterways, ports, and harbors subject to congested vessel traffic.

United States Coast Guard Study Report, "Vessel Traffic Systems Analysis of Port Needs," Department of Transportation, U.S. Coast Guard Headquarters, August 1973. This report is a summation of analyses regarding the relative need for VTS in 22 major ports and waterways. The ports and waterways are listed in the order in which their needs should be addressed.

Traffic Center Manual of the Puget Sound Vessel Traffic Service, U.S. Coast Guard. This is an operating manual for the VTS serving Puget Sound.

Statement by Rear Admiral Anthony F. Fugaro, USCG, before the House Committee on Merchant Marine and Fisheries, Subcommittee on Coast Guard and Navigation, September 21, 1976. This report shows a positive correlation between VTS operation and accident reduction in San Francisco Bay and Puget Sound.

Telephone Contacts

<u>Name</u>	<u>Position</u>	<u>Affiliation</u>
Mr. George Steinman	Chief of Environmental Activities	MARAD/DOC
Dr. Harold Bishop	Chief of Human Factors Branch	TSC/DOT
Commander Nelson	Puget Sound VTS	U.S. Coast Guard
Lt. Bennet	Watch Officer, San Francisco VTS	U.S. Coast Guard
Mr. Don Ryan	Vessel Traffic Specialist, VTS Branch	U.S. Coast Guard Headquarters
Lt. Commander Carl Johnson	R&D Support Manager, VTS Branch	U.S. Coast Guard Headquarters
Commander Hickey	Program Manager, VTS Branch	U.S. Coast Guard Headquarters

5.1.2 Loss of Aging but Crucial Pipeline Links

Literature

Code of Federal Regulations, "Transportation of Liquids by Pipeline," Title 49, Subtitle B, Part 195. Two separate laws, Part I Interstate Commerce Act (Title 49, Chapter 1, U.S. Code) and Explosives and Other Dangerous Articles Act (Title 18, Chapter 39, Sections 831-835, U.S. Code) provided the economic and safety basis for the pipeline regulations. The four subparts include the regulations for pipeline construction, design and accidents.

"Summary of Liquid Pipeline Accidents Reported on DOT Form 7000-1 From January 1, 1976, Through December 31, 1976," Department of Transportation Office of Pipeline Safety Regulation, May 1, 1977. The summary includes the number and percentage of accidents that occurred by cause of accident, commodity involved, and damage incurred. The three major causes of accidents were equipment rupturing line, corrosion and defective pipe seam. Information contained in the summary is useful to DOT and helpful to the pipeline industry to locate safety problem areas.

Project Independence Blueprint, Vol. I, Federal Energy Administration, November 1974.

1976 Educator's Tour, Association of Oil Pipelines, Educator's Conference, Houston, Texas, July 25-28, 1976.

National Energy Transportation, Vol. I, Congressional Research Service, May 1977.

National Transportation Trends and Choices (to the Year 2000), "Pipelines," Department of Transportation, January 12, 1977.

Telephone Contacts

<u>Name</u>	<u>Position</u>	<u>Affiliation</u>
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Mr. Sam Whitehill	Environmental Affairs Coordinator	Exxon Pipeline Company
Mr. A. E. Uhl	Project Manager-Pipeline Division	Bechtel, Incorporated

5.1.3 Inadequately Trained Tank Truck Personnel

Literature

Code of Federal Regulations, 49, Transportation, Part 177, Office of Federal Register, revised as of October 1, 1975. Regulations contained in this section of the code state the precautions that must be observed by the carrier in handling hazardous materials while in transit. These laws apply to the transportation of hazardous materials by both private and common carriers.

Code of Federal Regulations, 49, Transportation, Parts 390-397, Office of Federal Register, revised as of October 1, 1976. This section of the code describes the Federal Motor Carrier Safety Regulations. It includes a discussion of driver qualifications; vehicle parts and accessories necessary for

safe operation; reporting and recording of accidents; hours of service of drivers; inspection and maintenance procedures; and some rules regarding the transportation of hazardous materials.

National Transportation Trends and Choices (to the Year 2000), U.S. Department of Transportation, January, 1977, Document No. 050-000-00124-5. This document describes the present transportation system in detail. Future trends are described and public choices identified. Major issues which will soon require public decisions are also outlined.

Rules and Regulations Governing the Filing of Surety Bonds and Policies of Insurance, Interstate Commerce Commission, Parts 1043 and 1984, revised as of July 1, 1976. These regulations cover minimum amounts of insurance required for common carriers. A list of insurance forms is also included.

Third Annual Report of the Secretary of Transportation on Hazardous Materials Control, Hazardous Materials Transportation Control Act of 1970, Calendar Year, 1972. A comprehensive report on the transportation of hazardous materials during the year 1972. It includes a statistical compilation of accidents and casualties which involved the transportation of hazardous materials, and a list of relevant federal standards in effect or established.

1974 National Truck Characteristic Report, P. Kent and H. Bishop, Planning Services Branch, Office of Highway Planning, Federal Highway Administration, U.S. Department of Transportation, April 1976. This document consists of graphs and tables describing truck weight characteristics. Distribution of trucks by weight and type is also included.

Summary of National Transportation Statistics, William F. Gay, U.S. Department of Transportation, DOT-TSC-OST-76-11, June 1976. This report is a compendium of selected national-level transportation statistics. Included are cost, inventory, and performance data describing passenger and cargo operations of all modes. The report includes basic descriptions of U.S. transportation, such as operating revenues and expenses, and number of vehicles and employees.

1975 Accidents of Motor Carriers of Property, U.S. Department of Transportation, Federal Highway Administration, Bureau of Motor Carrier Safety. This report on accidents which occurred in calendar year, 1975, is based on information submitted by Motor Carriers of Property operating in interstate or foreign commerce. Tables, charts, and graphs are included.

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Ed Gavin	Marketing	Exxon
Don D'Zurilla	Manager of Operations	Union 76 Oil
George Stone	Dispatcher	CF Tanklines
Mrs. Glath	Section of Insurance	ICC
Jean Freeland	Secretary	Utilities and Transportation Commidion
Kenneth Pierson	Deputy Direct	BMCS

5.1.4 Duplicative Petroleum Product Traffic

Literature

Crude Supply Alternatives for the Northern Tier Stages, Bonner and Moore Associates, Inc., Vol. II, Technical Report, prepared for FEA, Contract No. CR-05-60593-00, July 25, 1976. The objective of this study was to assess the feasibility, cost, and potential environmental, social and economic impacts of various alternate supply sources and transportation systems for the Northern Tier area.

Energy in the State of Washington, George Hinman, et al., Energy Policy Council, Seattle, Washington, January 1974. The report includes a brief discussion of the sources and major household uses of energy in Washington. Energy as it relates to the economy of the state is also discussed.

North Slope Crude: Where To? - How?, Federal Energy Administration, Draft Report, September 13, 1976. This study includes a discussion of five proposals for moving Alaskan crude oil. The Transprovincial, Northern Tier and Sohio Pipeline proposals, along with Central American Pipeline Company and unit train alternatives are included.

Mineral Industry Surveys, U.S. Department of the Interior, Bureau of Mines, Washington, D.C. These monthly surveys include many statistics on crude oil and petroleum products in the U.S. production and consumption figures, along with specific transportation information, are presented.

Waterborne Commerce of the United States, Department of the Army Corps of Engineers, Part 5, National Summaries and Part 4, Pacific Region, Calendar Year 1973, 1975. This publication is one of a series containing statistics on the waterborne commerce of the United States. Four of these publications present detailed data on the movements of commodities and vessels at the ports and harbors and on the waterways and canals of the United States, the Commonwealth of Puerto Rico, and the Virgin Islands, and the fifth contains summary data of the nation as a whole.

Telephone Contacts

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5.2 POTENTIAL PROBLEMS UNDER CONTROL

5.2.1 Locational Shifts in Supply Sources

Literature

Crude Supply Alternatives for the Northern Tier States, two volumes, Bonner and Moore Associates, Inc., prepared for FEA, Contract No. CR-05-60593-00, July 1976. The purpose of this study was to assess and compare feasibilities, costs, and potential impacts of various alternate sources and transportation systems for supplying crude oil into the Northern Tier area. Economic, environmental and socio-economic impacts were particularly important considerations.

The impetus for the report was the announced Canadian plan of reducing and eventually eliminating exports of crude oil to the United States. "Supply alternatives" were defined as specific and complete combinations of transportation, port and refining modification facilities.

North Slope Crude Where To? - How?, Draft Report, Federal Energy Administration, prepared for the Energy Resources Council, September 13, 1976. This report is an analysis of the alternatives available for the transportation and disposition of Alaskan North Slope Crude. The following proposals are discussed: Transprovincial Pipeline, Northern Tier Pipeline, Sohio Pipeline, CAPICO (Central American Pipeline Company), and Shipment by Unit Train. Systems are compared by economics, environmental consequences, projected dates of operation, financing prospects and their ability to transport North Slope crude oil. Combination water and land routes are also discussed.

Unit Train Transport of Alaskan Oil from the West Coast to the Midwest Arthur M. Hughes, Chief, Division of Coal Economics and Transportation, Office of Coal, Federal Energy Administration, July 2, 1976. This study involves a detailed comparison of pipeline and unit train methods of moving Alaskan oil excesses to the Midwest. A list of contacts and sources is included.

Alaskan Oil: Alternative Routes and Markets, Charles J. Cicchetti, Resources for the Future, Inc., 1972. This paper compares alternative transportation routes for Alaskan oil before the completion of the Trans-Alaska pipeline. A brief discussion of plans for alleviating West Coast oversupply is also included. Subject matter concentrates on economic issues.

Pipeline Transportation to 1990, B. N. C. Fenton, et al., PACE Company Consultants and Engineers, prepared for the Department of Transportation, January 1976. This report is a forecast of the use of pipelines in the U.S. Pipeline requirements have been estimated by commodity and by function. Growth is predicted to 1990, with changing supply sources and market areas taken into account.

National Transportation Trends and Choices (to the Year 2000), U.S. Department of Transportation, Document No. 050-000-00124-5, January 1977. This document describes the present transportation system in detail. Future

trends are described and public choices identified. Major issues which will soon require public decisions are also outlined.

Project Independence Blueprint, Final Task Force Report, Volume 1, "Analysis of Requirements and Constraints on the Transport of Energy Materials," Transportation Crosscut Group, U.S. Department of Transportation, prepared for the Federal Energy Administration, November 1974. The objective of this study was to determine the degree to which the transportation system will be able to accommodate the goals of Project Independence. An analysis of future needs and capabilities is also included.

The Transportation of Energy Commodities, 1972-1985, Vol. 1, Draft Report, David L. Anderson and David B. Hiatt, Transportation Systems Center, U.S. Department of Transportation, February 1976. This study analyzes transportation requirements for inter-regional commodity movements. Existing energy flow patterns were determined, and new flows through 1985 calculated from these. Economic and political impacts of new flows were examined.

Petroleum Transportation Systems Study. Chapter IV - "Petroleum Demand Forecasts," Robert R. Nathan Associates, Inc., U.S. Army Engineer Institute for Water Resources, Contract No. DACW 31-73-C-0051, April 1975. The overall study, of which this is a part, is concerned with the development of a systems approach to analysis of total economic costs of alternative deepwater port, refinery, and transport combinations for crude oil and refined products. This chapter presents the basic analysis and projection of demand for refined products by state. The goal of the study is to describe and predict petroleum product flows until the end of the 20th century.

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5.2.2 Tanker Size/Safety Relationships

Literature

Large Tankers - Our Energy Lifelines, American Petroleum Institute. A brief report which highlights transportation costs, safety, operation and history of the VLCC.

Our Sun, "The Supertanker Comes of Age," Sun Oil Company, Autumn 1974. An article in this Sun Oil Company publication focuses on the efficiency and size of the VLCC and the lack of a U.S. port to accommodate a VLCC. The article also briefly discusses the safety (the inert gas system) and automation of the supertanker.

"New Concepts for Bulk Cargo Vessels," Horst W. Janecke, Conference Proceedings on Bulk Transportation of Hazardous Materials by Water in the Future, Department of Transportation, U.S. Coast Guard, July 1973. This paper describes new concepts for bulk cargo vessels and summarizes ideas and trends in the marine industry. There is a discussion of the VLCC size-associated problems to be overcome to assure proper operation of the VLCC and to realize the full potential of the associated economic, social and safety benefits.

"Maneuvering Safety of Large Tankers: Stopping, Turning, and Speed Selection," Society of Naval Architects and Marine Engineers. This study examined the effectiveness of devices and procedures used to improve the stopping of large tankers. Effects of parameters such as ship size and speed, loading condition, stern thrust, time lag in reversing, added hydrodynamic resistance and nonhydrodynamic retarding force and tugboats were examined. The results indicate the relevance of ship approach speed to the decision to "crash astern" or to turn; the slight potential gain of different propulsion systems; and the impracticality of special devices used for improvement of stopping performance. Tankers used for the study included: 16,635 DWT, 26,700 DWT, 27,000 DWT, and 191,000 DWT.

"Proposed Procedures for Determining Ship Controllability Requirements and Capabilities," Panel H-10 (Controllability), Society of Naval Architects and Marine Engineers (SNAME), 1975. Another paper by SNAME proposes general

analysis procedures for investigating ship controllability and conditions which limit safe control in restricted waterways. General problem types that require controllability analysis are outlined. Available controllability analysis techniques are described and the combinations of analysis with successful ship experience are stressed.

Maritime Administration Tanker Construction Program, EIS and Vol. I-III Appendices, May 1973. The four volumes are Maritime Administration's final environmental statement in compliance with requirements of the National Environmental Policy Act of 1969. The statement deals with the Tanker Construction Program for each class of contract vessel, gives an analysis of supertankers and their effect on pollution of the oceans and discusses the relationship of spill risk probability to vessel size. The EIS is a voluminous piece of work and considers almost every aspect of the marine tanker pollution subject.

"North Slope Crude. . .Where To? How?," Evaluation of Marine Terminals. Federal Energy Administration, Chapter IV-E, November 18, 1976 (draft). The development of Alaska's petroleum resources is not limited to the construction of the trans-Alaska pipeline. Shipments of petroleum to the West Coast and development of receiving terminals on the West Coast were the focus of this study.

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Mr. Leonard Bassil		Marine Research Board, National Academy of Sciences
Mr. Bill Young	Chief of Marine Plans	Maritime Administration, Department of Commerce
Captain Travis	Retired from Maritime Administration, working under a contract at Kingspoint for CAORF	Joe Puglisi, Maritime Administration, Department of Commerce
Mr. Harold Muth	Industry and Government Relations	American Waterways Operators, Incorporated

5.2.3 Impact of Jones Act on Alaskan Crude Oil Transportation

Literature

National Transportation Trends and Choices (to the Year 2000), Department of Transportation (DOT), January 12, 1977. The DOT publication includes merchant marine data from the Maritime Administration and other sources. The 1976 figures have been used to support this concern.

Energy Transportation Security Act of 1977, House Committee on Merchant Marine and Fisheries Report on Cargo Preference, HR 1037, August 26, 1977. A greater demand for U.S. Flag tankers in 1981 and 1982 than the available supply is shown in a table on page 23. MARAD information reports a tanker deficit between 4.7 and 6.2 million DWT for those years.

"Open Hearings on HR 1037," John M. Murphy, Chairman, subcommittee on Merchant Marine, Committee on Merchant Marine and Fisheries, July 25, 1977. This document specifically discusses the requirements of the use of U.S. flag tankers for U.S. oil imports. It also points out that some objectives of a cargo preference bill would also be accomplished with the tanker Alaskan oil delivery systems to the West Coast, i.e., to strengthen U.S. shipbuilding capacity and increase seafarer and shipyard employment.

Recent Tanker Accidents: Legislation for Improved Tanker Safety, Hearings before the Committee on Commerce, Science and Transportation, United States Senate, Part 2, March 8, 15, 16, and 18, 1977. This report describes five legislative bills designed to improve tanker safety. The increased use of U.S. flag tankers is one of the methods discussed to alleviate the problem of oil pollution by tankers in domestic waters.

Editorial Research Reports, "Tanker Safety," Mary Costello, Vol. 1, No. 9, March 4, 1977. This report is another source for some of the data used in this concern, especially the section entitled Concern Over Oil Tanker Accidents and Proposals to Improve Tanker Safety.

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5.2.5 Deterioration of Rail Trackage and Equipment

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