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AN ASSESSMENT OF LPG TANKER OPERATING REGULATIONS IN THE PORT OF VANCOUVER, B.C.

by

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ABSTRACT

In recent years, the Port of Vancouver has emerged as a major transshipment centre for a broad range of hazardous materials. This, in turn, has led to growing public concern over the problems associated with the large-volume production, storage, and movement of dangerous commodities in populated areas.

The shipment of liquefied petroleum gas (LPG) by means of refrigerated oceangoing gas tankers is considered to be one of the potentially most dangerous aspects of the hazardous materials trade in the Port of Vancouver. In this regard, the thesis examines the qualitative relationship between the regulatory standards governing the safe movement of LPG carriers in the Port of Vancouver, and those in effect in selected urban gas ports in Europe (Canvey Island, U.K.; Europoort, Holland; and Le Havre, France) and the United States (Boston, Massachusetts and Los Angeles, California).

By means of comparative assessment, the research isolates a number of instances where local gas tanker operating standards do not compare favourably in terms of substances, scope, or applicability with the requirements in force in the five control ports. In those instances where the Vancouver regulations are deficient to the extent that they are deemed to constitute an unnecessary risk to public safety, the research rationalizes the need to upgrade local requirements to a level which either meets, or exceeds the consensus standard for the control ports.

The thesis addresses in some detail such related items as the properties, characteristics, and potential hazards associated with the marine transportation of LPG and LNG; the composition and operating history of the

world liquefied gas tanker fleet, including an overview and assessment of the safety record of this fleet; and the basic structure of the international marine trade in liquid gases. Moreover, the research identifies a number of additional public safety issues pertaining to the production, storage, and transportation of hazardous materials generally in the Port of Vancouver, and suggests a strategic evaluation process whereby these concerns might reasonably be addressed, and either mitigated or resolved. In this latter regard, the thesis makes several broad-based recommendations ranging from the need for a federal inquiry to address the overall implications of the hazardous materials question as it relates to the Port of Vancouver, to a suggestion that the National Harbours Board's responsibility for port safety should be transferred to the Canadian Coast Guard in order to eliminate the possibility of a serious conflict of interest situation arising between the Board's marketing and safety concerns.

Although the research is primarily directed to circumstances occurring in the Port of Vancouver, much of the information contained in the thesis is likely to have valid application in other Canadian ports which are either currently engaged in the marine transfer of hazardous materials, or are anticipating the possible establishment of such a trade in the foreseeable future.

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The responsibility for any errors, misinterpretations, or omissions rests solely with the writer.

Joseph C. Marston, Jr.

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1.0 INTRODUCTION

1.1 Evolution of the Local Hazardous Materials Trade

The lower mainland area* of southwestern British Columbia, in its capacity as a major seaport and rail terminus, has had a long association with the handling and shipment of a wide assortment of dangerous commodities. The introduction of the Hooker Chemical chlorine manufacturing plant in North Vancouver during the mid-1950s, however, marked an important turning point in terms of both the nature and direction of the dangerous goods trade locally. Prior to that time, the movement of especially hazardous substances through the area had usually been limited to fairly small consignments. Moreover, with perhaps the exception of the residual production of small amounts of toxic or explosive substances in conjunction with the petroleum refining process at any of the several area refineries, the lower mainland was not viewed as a significant manufacturer of dangerous goods. The Hooker Chemical plant substantially altered that impression by signifying a permanent, large scale chlorine storage/production presence within the settled limits of the community. The Hooker operation also contributed to the generation of many more local road, rail, and marine movements of hazardous materials (such as chlorine and caustic soda) than had previously been the case.

During the course of the next two decades (1957-1977), the region experienced a steady, but unspectacular, growth in the hazardous materials

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*For the purposes of this thesis, the term "lower mainland" shall be viewed as synonomous with the Greater Vancouver Regional District (G.V.R.D.), a geopolitical unit comprised of 14 municipalities (including the City of Vancouver) and three electoral areas. The regional district covers an area of some 2 600 km^2, and has an estimated population of approximately 1.1 million (1976 Census).

trade. Increased demand from industrial concerns on Vancouver Island and elsewhere along the coast for commodities such as chlorine, propane, and sulphuric acid served to enhance the Port of Vancouver's position as a rail/marine transshipment interface for a variety of hazardous chemical and petrochemical products. Additionally, two new deepwater petrochemical terminals were brought on line during this period - Trans Mountain Pipeline Company's liquefied petroleum gas (LPG) facility in Burnaby in 1966, followed by the introduction of Vancouver Wharves Limited's North Vancouver methanol terminal a few years later.

The period 1977-82 has seen a dramatic shift away from the sporadic pattern of growth which characterized the local trade in hazardous commodities throughout the 'sixties and much of the 'seventies. The rapid evolution of the petrochemical industry in western Canada, combined with the development of new large volume markets in Japan and other Pacific Rim countries, has generated considerable pressure to improve and expand the deepwater petrochemical terminal infrastructure on the west coast. Since 1979 alone, the lower mainland has experienced the construction of one major new petrochemical transshipment facility by Dow Chemical (Canada) Ltd., and has witnessed significant capital investment by Vancouver Wharves and Canadian Occidental Petroleum Ltd. (formerly Hooker Chemical) for the purpose of upgrading their respective methanol and chlorine/caustic soda terminal operations. Furthermore, recent proposals by British Columbia Hydro to construct a liquefied natural gas (LNG) peak shaving plant near the eastern end of Burrard Inlet, and by Canterra Energy Ltd. to build a world-scale petrochemical production facility in the vicinity of the Fraser River estuary, suggest that the production and movement of dangerous goods will continue to figure prominently in the debate over the mid- to long-term growth alternatives available to the lower mainland area.

1.2 A Regional Perspective on the Dangerous Goods Issue

The manufacture, storage, and safe carriage of dangerous goods has emerged as an important public issue within the Greater Vancouver Regional District (G.V.R.D.) in recent years. The origins of the current high level of community interest in this topic can perhaps best be traced back to two significant events which transpired during the summer of 1978. The first, occurring on 29 August 1978, involved a collision between a freight train hauling 41 tankcars loaded with highly inflammable LPG and three runaway boxcars in Vancouver's East End. Although several of the gas tankers were derailed, none was ruptured and their cargoes remained intact.

It is difficult to estimate the extent to which public safety might have been jeopardized had this collision resulted in the escape of a large volume of gas. Officials speculated at the time that the ignition of vented gas from a ruptured tankcar could have led to an explosion or, for that matter, a chain reaction of explosions involving several or all of the LPG units which comprised the train.[1] The accident did present a sufficient hazard to prompt police and fire authorities to urge residents living within a four block radius of the collision site to temporarily evacuate the area.

In order to gain a sense of perspective as to the destructive potential inherent in this accident, while bearing in mind that both circumstances and subsequent effects would be likely to vary widely from one LPG incident to the next, it is worthy of note that the explosion of a single derailed tanker containing some 9 000 litres of LPG killed 15 people in Waverly, Tennessee during February of 1978.[2] By contrast, each tankcar in the Vancouver accident contained approximately 128 000 litres of gas, for a total trainload capacity in excess of 5 million litres.[3] In view of the large volume of gas involved, and given the close proximity of the derailment to suburban residential neighbourhoods, one cannot escape the conclusion that Vancouver was indeed fortunate to avoid a major disaster.

Less than a month later, on 25 September 1978, a 450 litre canister containing liquid chlorine fell from the rear of a truck on Main Street. The canister ruptured upon impact, releasing some 300 litres of toxic chlorine gas into the atmosphere before the leak could be brought under control.[4] In terms of volume, the amount of gas vented was small. Nevertheless, no fewer than 78 persons were hospitalized with a variety of complaints ranging from minor skin and eye irritations to more serious respiratory complications.

Notwithstanding the grave nature of the previously described accidents, it must also be emphasized that several important lessons have been learned from these experiences. The chlorine spill, in particular, was instrumental in bringing to light a number of deficiencies within the local emergency planning/response process. Moreover, it served to underscore in a most dramatic fashion the serious nature of potential problems arising from the largely unregulated day-to-day movement of dangerous goods on lower mainland streets and rail lines. In a practical sense, the G.V.R.D. and a number of its member municipalities have since attempted to address many of these shortcomings, and have made progress in terms of both improving internal emergency response capabilities and, perhaps more importantly, reducing the likelihood of serious road accidents involving the transportation of hazardous commodities in the future. This has been achieved primarily through the introduction of workable new vehicle safety standards and operating regulations (such as more frequent vehicle inspections, limiting trucks carrying specified dangerous cargoes to certain routes and certain hours of travel, etc.), and by improving the existing channels of communication between local government agencies and private industry. Evacuation planning, too - an item which received limited attention in the past - has emerged as a topic of considerable concern to G.V.R.D. politicians and planners alike, as they endeavour to formulate and improve upon comprehensive and mutually compatible emergency evacuation strategies for the lower mainland.

The preceding public safety initiatives, while valuable in their own right, are nevertheless symptomatic of the widespread regulatory practice of upgrading existing design or operational safety requirements only after a serious accident has occurred. In most cases, these accidents were neither totally unanticipated, nor were they unavoidable. Unfortunately, this type of reactive response to risk management is particularly evident in instances where the probability of a major accident is very small, but the potential effects upon public safety in the event of such an accident would be extremely severe. It is, therefore, encouraging to note that several local communities have adopted a much more proactive approach to addressing the many public safety problems posed by the various aspects of the lower mainland hazardous materials trade. The City of Vancouver, for example, has waged a lengthy campaign to remove all activities involving the large-scale storage and shipment of dangerous commodities within the community. For some time, city council's primary objective in this regard has been to convince the Canadian Pacific Railway to discontinue the practice of storing railcars loaded with toxic and inflammable substances on the periphery of the downtown commercial core. Thus far, C.P. Rail has refused to comply with the city's request and, in view of the fact that railway lands fall under the jurisdiction of the federal Railway Act, council has been powerless to force the issue. During the fall of 1981, however, C.P. Rail's real estate development arm, Marathon Realty, requested approval from the city to construct a $100 million office/retail complex on the waterfront. City council has refused to approve the project unless C.P. Rail agrees to halt the shipment of hazardous materials through the waterfront precinct.[5]

The District of North Vancouver, which accommodates a wide variety of hazardous materials-oriented industrial activities, recently adopted a similar position on the problem as that established by the City of Vancouver, although under somewhat different motivating circumstances. In recent years, the growing public debate over the dangerous goods controversy has spawned a number of essentially single purpose community interest groups. Among the most prominent of these has been the North Shore-based Chemical Hazards Alert Committee (C.H.A.C.), which was formed in early 1980 for the purpose of conveying the position that the Canadian Occidental chlorine plant in North Vancouver constituted an unacceptable safety risk to area residents and, as such, should be removed from the community. Although C.H.A.C. has yet to realize this fundamental goal, the organization was nonetheless instrumental in persuading the District of North Vancouver to sponsor a Community Hazards Task Force, the mandate of which was to address the broad spectrum of contentious issues pertaining to the production, storage, and transportation of hazardous materials on the North Shore, and to subsequently prepare appropriate strategic responses designed to either mitigate or eliminate serious risks. Due largely to the findings and recommendations of the task force, the district council, in October of 1981, placed a ban on the introduction of new high risk chemical and petrochemical industries to the community, and, in conjunction with other levels of government, agreed to examine ways and means of eventually removing the Canadian Occidental plant from the North Shore.[6]

In a related vein, Canterra Energy Ltd., in its recent (spring 1982) bid to secure approval to construct a large new petrochemical plant in the Lower Mainland, endeavoured to solicit public input relative to all aspects of the proposal.

While a number of local government and industrial institutions have, in certain instances, chosen to address hazardous materials-related concerns in a reasonably open and forthright manner, it would be incorrect to assume that this practice has been universally endorsed. Historically, there has existed a tendency on the part of both industry and government regulatory agencies to downplay the significance of the potential health and safety concerns associated with many hazardous products. Many organizations involved with the routine production, movement, or regulation of dangerous commodities continue to adhere to the convenient dictum that "it won't happen here" as a means of discounting the likelihood of a serious chemical or petrochemical accident. This philosophical approach periodically (although less frequently than in the past) manifests itself in an extreme form through the intentional witholding from the public of information regarding either the proposed construction of a potentially controversial facility catering to the hazardous materials trade or the substantial revision of an existing operation. The purpose is to avoid damaging conflicts with groups or individuals holding strongly divergent attitudes to those of the project sponsors. On occasion, the manoeuvre works to the benefit of the proponent, as evidenced by the recent (1979-80) construction of a Dow Chemical Company storage and transshipment terminal on National Harbours Board property in the District of North Vancouver. The Dow facility handles three separate bulk chemical products - ethylene dichloride (EDC), a source of polyvinyl chloride plastic resin; ethylene glycol, used in the manufacture of anti-freeze; and caustic soda solution, which is required by the pulp/paper and aluminum processing industries. Although all three substances, for reasons of toxicity, corrosiveness, or inflammability, require special handling procedures, ethylene dichloride, in particular, could present a serious threat to public safety in the event of a major spill. In addition to being highly inflammable, EDC, when heated to decomposition, produces deadly phosgene gas similar to that deployed in trench warfare during the First World War. It is also a known cancer causing agent in animals, and is suspected of being carcinogenic to humans.[7]

Despite the acknowledged hazardous nature of these materials, Dow Chemical made little, if any, effort to inform the public as to the nature of the project until <u>after</u> all of the necessary regulatory permits had either been issued or approved in principle.[8] Moreover, the government agencies closest to the proposal - that is, the District of North Vancouver and the National Harbours Board - remained equally silent throughout the project approval process. In this manner, it was virtually assured that any immediate public criticism of the project would be both limited in scope and easily manageable.

An item of equal concern was the relative ease with which Dow secured project approval from various regulatory agencies at all levels of government. For instance, at no time was a detailed social impact analysis ever requested, or undertaken. Hence, a number of important questions remain unanswered, including:

a) why did Dow Chemical elect to construct a facility designed to store large volumes of highly inflammable and toxic chemical materials in the midst of a densely populated urban area?

b) could a vessel loaded with EDC or other toxic chemical compounds effect a quick, orderly, and safe departure from the terminal docking area in the event of a serious shipboard or shoreside fire, given the limited room for manoeuvreability at the Dow berth and the dangerous tidal conditions in the vicinity of the Second Narrows? and

c) in the event of a disaster scenario involving a major uncontrolled EDC pool fire at the terminal and an onshore windflow, to what extent would the generation of toxic gases present a threat to local residents, and what contingencies have been prepared to mitigate any related impacts?

It must be stressed that Dow Chemical, while exercising questionable ethical judgement by witholding information on the project until the necessary regulatory permits had been secured, was by no means operating outside the law. In this regard, part of the problem rests both with the government regulatory agencies for failing to recognize the need for greatly improved public disclosure standards, and with legislators for not <u>insisting</u> upon it. Thus, the general public has traditionally been in such a position as to exercise, at best, only limited influence over those decisions pertaining to the siting and construction of major hazardous materials-oriented operations within the community. Moreover, the standards, guidelines, and procedures governing the operation of these facilities tend to have been established in the absence of any meaningful public input, despite the fact that it is invariably local area residents who will incur the most serious consequences in the event of a severe breakdown or deficiency in the operational safety framework.

1.3 Purpose of Study

1.3.1 Study Environment

The trend towards increasing public interest on matters having to do with the hazardous materials trade generally, and the corresponding emphasis upon both emergency planning and improved risk management and avoidance techniques, is by no means a regional phenomenon. Highly publicized events such as the Love Canal toxic chemical dump controversy in Niagara Falls, New York, the Three Mile Island, Pennsylvania nuclear reactor accident, or, in Canada, the 1979 derailment of a freight train carrying toxic and explosive products near Mississauga, Ontario have served to engender a much stronger sense of public awareness as to the scope and nature of the problem than had previously existed.

One of the more noteworthy characteristics of the current pattern of local interest in the dangerous goods issue, however, is that public attention in the Greater Vancouver area has remained focussed almost exclusively upon the land-based aspect of the hazardous materials trade. The marine transportation of hazardous substances, with fewer individual cargo movements than its road or rail counterparts, and a correspondingly lower accident probability, has largely avoided the mainstream of local debate.

It is important to bear in mind that the Port of Vancouver has, since the Second World War, emerged as an important storage and marine distribution centre for a broad range of dangerous chemical and petrochemical products. In this regard, the seaborne movement of toxic, corrosive, and inflammable commodities within the port precinct, by virtue of the generally large volumes of material involved, represents one of the greatest, but generally least recognized, threats to public safety locally. Of particular concern are the frequent bulk movements of chlorine (by barge from the Canadian Occidental plant in North Vancouver), methanol (by chemical tanker from the Vancouver Wharves terminal, North Vancouver District), ethylene dichloride (by chemical tanker from the Dow Chemical terminal, North Vancouver), assorted dangerous chemicals (by rail barge from the C.P. Rail berth in downtown Vancouver), and LPG (by refrigerated gas tanker from the Trans Mountain Pipeline Company export terminal in Burnaby.)*

An accidental large volume discharge of any one of the above-noted commodities resulting from a serious shipping mishap in the Port of Vancouver could, under various circumstances, jeopardize the lives of many thousands of people working or residing within close proximity to the shores of Burrard Inlet.

1.3.2 Hypothesis

In November of 1979, the Office of the Harbour Master, Port of Vancouver stated that "...(shipping) safety standards in the Port of Vancouver reflect -- to the extent humanly and reasonably possible -- local, regional and national concerns, and can be compared favourably with similar international

*For a partial list of hazardous materials carriers which have visited the Port of Vancouver since 1 January 1981, refer to Appendix I.

experience."[9] These remarks were issued in direct response to an earlier letter to the Harbour Master expressing serious concern over both the quality and adequacy of local operational safety regulations governing the passage of deepsea liquefied petroleum gas (LPG) carriers through the Port of Vancouver.[10]

The purpose of this thesis, then, will be to test the validity of the Harbour Master's statement (hypothesis) of 22 November 1979 as it applies to the imposition of navigational safety constraints for LPG carriers operating in the Port of Vancouver, against those regulations in effect for LPG and LNG* carriers in several comparable European and American gas ports.

Within this context, the principal objectives of the research will be to:

a) examine and assess the problems/hazards associated with the marine transportation of inflammable liquefied gases in general, and through congested or heavily populated port precincts in particular;

b) conduct a detailed review of the safety record of both LPG and LNG carriers since 1964, with an emphasis upon the period 1979-1982;

c) review and, where possible, rationalize the regulatory responses to the potential problems or hazards identified in "a" (above), as reflected by the legislation and special operating requirements/ procedures which are applicable to deepsea vessels engaged in the transportation of either LPG or LNG within the confines of the selected urban gas ports in Europe and North America;

d) undertake a comparative analysis of the regulations/legislation in force for the above-noted ports, and to identify any areas where the Port of Vancouver appears to be clearly deficient in maintaining gas tanker operating standards at a level equivalent to, or esceeding, those in effect in the majority of the other gas ports examined; and

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*Although LPG and LNG display somewhat different characteristics from one another in terms of physical composition, transportability, flammability, explosiveness, etc., it is common practise in American gas ports to apply special navigating requirements equally to both LPG and LNG carriers.

e) provide specific recommendations designed to upgrade regulatory deficiencies in the Port of Vancouver (as defined in "d" above) to a level at least equivalent to the accepted or identifiable standard in place for the other gas ports examined.

As a point of clarification, the above-noted objectives relate only to the actual physical movement of liquefied gas carriers in the Port of Vancouver, not to such affiliated items as the siting or safe operation of shoreside liquefied gas terminals, or the regulatory standards in place for other hazardous materials carriers (such as chemical tankers) operating within the port. Nevertheless, during, and subsequent to, the data collection and analysis phases of the exercise, numerous other hazardous materials concerns were brought to the author's attention. Passing reference is made to many of these issues throughout the course of the text. While a lack of time, financial resources, and technical expertise precluded an in depth examination of these items, Section 6.2 of the report, entitled "Supplementary Observations/Recommendations", attempts to summarize some of the more important concerns, and to provide a general framework for addressing these issues in the near future.

1.3.3 Rationalization of the Research

LPG tankers involved in the Vancouver-Japan trade have been variously described as "...the single most hazardous vessel(s) that move( ) regularly through the Port of Vancouver..."[11] and as presenting "...a risk equal to that of Canadian Oxy's chlorine barge."[12] While the issue as to whether or not LPG carriers do, indeed, represent the most serious shipping threat to public safety (there is, in fact, a strong argument to be made that the rapidly escalating parcel chemical tanker trade in Vancouver poses the greatest local shipping safety concern in terms of the size and number of chemical tankers serving the port, and by the often mixed nature of their

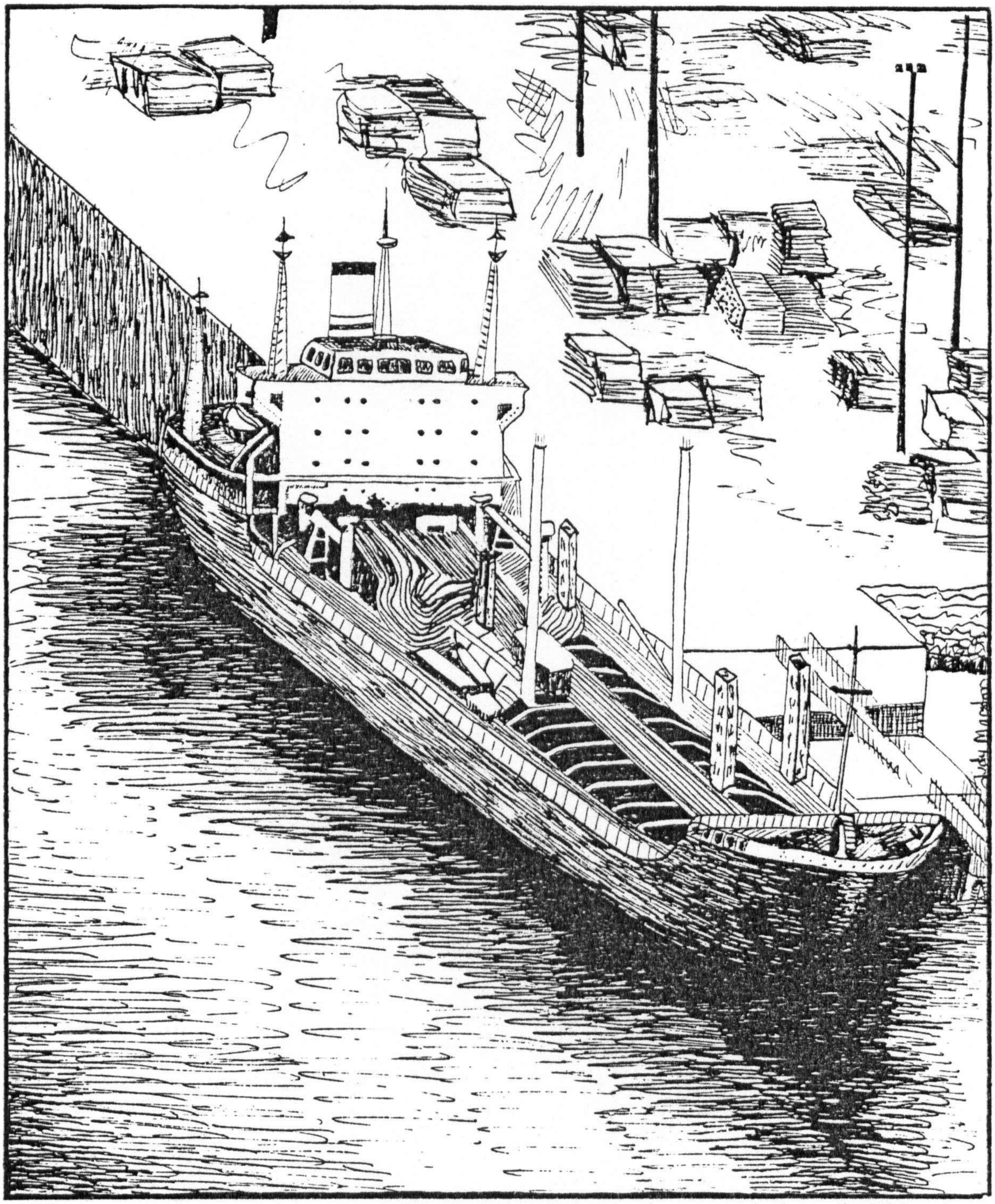

Figure 1.1 Chemical Tanker Hamakaze

cargoes), it is widely recognized within the shipping community that LPG, by virtue of its inflammable and potentially explosive nature, is a particularly dangerous commodity requiring special handling and shipment precautions in excess of those normally applied to more conventional cargoes.

The problem facing port officials is one of establishing an appropriate regulatory balance between the economic and public safety concerns of the community. In this regard, the case supporting greater regulatory intervention in the administration of the deepsea LPG trade locally is based upon the precept of reducing the likelihood of a serious accident involving a gas tanker to an "acceptable" level. The task of determining a "publicly acceptable" level of accident risk, however, is one which will always be open to widespread individual interpretation. In its most extreme form, acceptable risk may be defined as zero risk - a condition which could be brought about by either banning gas tankers from the port entirely, or by introducing such economically prohibitive regulatory constraints as to render the shipment of LPG from Vancouver unprofitable. Significantly, there is evidence of the "zero risk" philosophy having had considerable impact upon decisions to either prohibit, or forego, gas port development in at least two documented instances. The explosion of an empty LNG storage tank on Staten Island in 1973 subsequently led to a complete ban on LPG and LNG marine terminal development in the Port of New York.[13] In Europoort, Holland, British Petroleum and Shell (Netherlands) recently withdrew their joint proposal to construct a major new LPG import facility, citing the high cost of safety measures as a contributing factor to the decision.[14]

On the other hand, the case for limiting regulatory intervention is based largely upon economic considerations. Specifically, the Trans Mountain Pipeline Co. LPG production and overseas export program, either directly or indirectly, provides jobs throughout British Columbia, contributes to local and regional tax bases, and, arguably, supports national financial objectives by adding to Canada's favourable foreign trade surplus with Japan. The introduction of economically prohibitive regulations could seriously jeopardize any or all of these positive aspects of the Trans Mountain LPG operation.

Given that Trans Mountain has operated its Westridge LPG export terminal without serious incident since 1966, and that the company is legally entitled to continue to operate from the Westridge facility, it would seem that any recommendations emanating from this thesis which would support the immediate exclusion of liquefied gas carriers from the port would be both premature and largely inappropriate. In light of the preceding observation, it is assumed for the purposes of the research that:

- liquefied gas carrier movements in the Port of Vancouver can be managed safely and efficiently within a certain range of constraints;

- in view of the acknowledged hazardous nature of LPG, the operating requirements currently in effect for liquefied gas carriers in the Port of Vancouver shall represent the <u>minimum</u> acceptable standards, and will not be diminished in terms of scope, applicability, or enforcement, irrespective of the outcome of the research;

- in the absence of definitive standards relative to the constitution of an acceptable level of public risk, the gas tanker operating regulations in effect in Vancouver will be measured against similar requirements in several other world gas ports, and in those instances where it can be reasonably demonstrated that the quality or substance of specific regulations governing gas tanker operations locally do not compare favourably with those in force in the majority of other ports examined, the majority response shall be viewed as the "accepted" standard for local implementation.

In this manner, it is hoped that the findings and conclusions of the research will serve as a rational basis upon which to implement a program of recommendations designed to both protect and enhance public safety concerns in the port (at least to the extent that they might be affected by the marine transportation of LPG) without seriously jeopardizing the profitability of the Westridge terminal operation.

1.3.4 Control Port Selection Criteria

In addition to Vancouver, a total of 10 separate European and American gas port operations were examined in detail. The purpose of the port selection process was to identify gas ports which display many of the basic physical or legislative characteristics which are common to the Port of Vancouver in order that a meaningful comparative assessment of gas tanker operating requirements might be undertaken.

Table 1.1 Physical/Legislative Considerations

Characteristic / Port	Urban Terminal Location	Terminal Access via City Core	Lengthy, Restricted Access Route	> 10 Gas Tanker Visits/Year	Congested Port Precinct	Man-Made Obstructions to Navigation	Fragmented Legislative Control	Joint Port Safety/Marketing Mandate	TOTAL
Boston, MA	●	●	●	●	●	●			6
Cove Point, MD			●	●					2
Elba Island, GA	●		●	●		?			3
Los Angeles, CA	●	●	●		●				4
New York, NY	●		●		●	●			4
Canvey Island, U.K.	●		●	●	●			?	4
Europoort, Holland	●			●	●		●	●	5
Le Havre, France	●	●		●	●				4
Porsgrunn, Norway	●		●	●	?		?	?	3
Zeebrugge, Belgium	●	●			●	?	?	?	3

Those ports displaying four or more characteristics common to the Port of Vancouver - including the essential criterion that the gas terminal must be situated in an urban setting - were selected to form the basis for regulatory comparison with Vancouver. The single exception was the Port of

New York which, despite the existence of both the facilities to serve the deepsea liquefied gas trade and an approved Coast Guard operating plan for LPG and LNG, has chosen to exclude gas carriers for a variety of political and public safety reasons.

Thus, the foreign gas ports which will be examined in greater detail include:

Boston, Massachusetts
Los Angeles, California
Canvey Island, U.K.
Europoort, Holland
Le Havre, France

1.3.5 Methodology

1.3.5.1 Compilation of Background Material

Purpose: To gather support documentation relative to:

- the properties, characteristics and potential hazards associated with LPG and LNG;
- the composition and operating history of the world liquefied gas tanker fleet, including the safety record of this fleet;
- liquefied gas tanker design and safety considerations;
- the basic market characteristics of the international marine trade in liquefied gases, and the nature of its attendant service infrastructure;
- special legislative and regulatory provisions pertaining to all aspects of the LPG and LNG trades, but emphasizing the marine transportation component;
- the attitudes, perceptions, and opinions of private industry, government regulatory agencies, and the general public as they relate to the LPG/LNG safety question; and
- issues pertaining to any other significant aspect of the production, storage, and transportation of hazardous materials generally.

Sources: i) Literature Review

- government documents
- government legislation and regulations
- technical and shipping journals
- newspapers
- industry-sponsored project information brochures
- published literary accounts dealing with the LPG and LNG industries
- marine safety manuals governing the handling of LPG and LNG carriers
- academic/technical papers on the topic of risk analysis/risk management theory

ii) Professional Contacts

A detailed list of organizations contacted in conjunction with the research is included in Section C of the Bibliography.

1.3.5.2 Field Investigation

Purpose: In order to gain a broader perspective on the marine LPG/LNG trade, the potential hazards associated therewith, and the nature of the legislative/ regulatory responses to those hazards, field research was conducted in several European countries during the spring of 1980. The field investigation addressed the following:

a) Consideration: Review and rationalization of regulatory standards in overseas ports.

Response: Meetings were held with representatives from the Ports of Rotterdam and Le Havre to discuss, in detail, the nature and perceived adequacy of the special LPG/LNG shipping requirements in effect in these harbours.

b) Consideration: Examination of LPG/LNG tanker construction industry.

Response: Visits to two of the world's foremost builders of liquefied gas carriers - Kockums Shipyards of Malmö, Sweden and Moss Werft of Moss, Norway - were arranged in order to obtain greater insight into both the special technical considerations inherent in the construction of liquefied gas tankers, and the economic state of the LPG/LNG shipping industry as a whole.

c) Consideration: Assessment of risk analysis and impact forecasting techniques as they relate to the marine shipment of LPG and LNG.

Response: The Norwegian ship classification society Det norske Veritas, and the consultant engineering firm SOGREAH, which operates the Port Revel Marine Research and Training Centre near Grenoble, France provided valuable background information relative to LPG/LNG risk analysis techniques and ship handling characteristics, respectively.

1.3.5.3 Analysis

Conceptual Framework

The establishment of regulations designed to govern the safe siting, construction and operation of large scale liquefied gas import/export terminals has historically been influenced by two general analytical concepts - qualitative assessment (based upon practical experience, professional judgment, and a logical interpretation of the available data); and statistical forecasting techniques involving accident probability analysis and hazard impact modelling.

The application of risk analysis as a means of assisting in the determination of appropriate regulatory standards for high risk commercial development projects dates back more than two decades. In 1957, the Brookhaven National Laboratory produced a controversial report entitled "Theoretical Possibilities and Consequences of Major Accidents in Large

Nuclear Power Plants" (more commonly known as the WASH-740 study). WASH-740 represented something of a breakthrough in that it legitimized the use of risk analysis as a valid accident and impact forecasting tool within the context of public sector projects.

It was not until the mid-1970's that risk analysis began to emerge as a recognized aid in determining the suitability of specific gas terminal development proposals. Prior to that time, regulatory officials in most established gas ports had tended to overlook the probability of a major LPG or LNG accident occurring, or the likely effects (impact) resulting from such events. Instead, the regulatory emphasis remained more or less in accordance with the enforcement of established construction and management procedures, augmented by any special operating provisions which may have been deemed necessary, given the nature of the cargoes in question.

Today, risk analysis forms an integral part of the LNG and LPG approvals process in most, if not all, western nations. Nevertheless, in spite of the many technical and methodological improvements which have evolved since the days of the WASH-740 report, risk analysis itself remains the object of considerable controversy. Many of the shortcomings associated with risk analysis as it applies to the LNG industry are cited in the book "Frozen Fire" by Lee N. Davis. In particular, Davis concentrates on a number of problems inherent in two separate LNG risk analysis studies undertaken during the mid-1970's. The first, prepared in 1974, examines the probability of a major LNG shipping accident at proposed terminals at both Staten Island and Providence, Rhode Island.[16] The report has been criticized by William B. Fairley, a former Harvard professor of statistics, on the basis that it makes many unsupported and unrealistic assumptions in the absence of a detailed common data base.[17]

The second study was prepared in 1976 by Science Applications Inc. (SAI) for the purpose of determining the potential risks associated with the operation of a proposed LNG terminal in California. Davis questions the validity of the analysis, citing the rather limited list of identified "initiating events" which could lead to serious shipboard or terminal accidents.

According to Davis, among the potential initiating events not included in the SAI risk assessment were the following:[18]

- No component rate failure data (ice clogging valves, instrument malfunctions, etc.);
- High winds, tornadoes, storm waves, tsunamis, flooding;
- Earthquakes
- Chance of moored LNG carrier being struck by another vessel;
- Ship groundings, explosions, sinkings, etc.
- Accident at nearby hazardous materials installation spreading to LNG terminal;
- LNG road tanker accidents;
- Human error;
- Sabotage;
- Emergency cargo jettison from LNG carrier.

There is no doubt that many of the initiating events identified by Davis as having been either discounted or overlooked in the SAI report can lead (and, in some instances, have already led) to serious accident situations involving LNG.

In view of the fact that both the New York/Providence and California risk analyses were among the earliest such applications to circumstances involving LNG terminals and shipping activities, one might reasonably anticipate problems of a methodological or interpretative nature, based upon a lack of historical precedent or specific knowledge of the issues. However, it is significant to note that B.C. Hydro recently commissioned a California firm, Energy Resources Company (ERCO), to undertake a risk analysis on Hydro's proposed Sasamat LNG peak shaving plant, situated some 20 kilometres east of Vancouver. The ERCO analysis concluded that:

> ...only a number of types of events are plausible which could cause (a major spill of LNG). These events are aircraft impact on the tank or an earthquake exceeding the tank design. Based on the design of the proposed facility, events such as meteorite impact, operational failure of the tank or a severe windstorm (tornado) are of such low probabilities to render them insignificant. Only large jet aircraft were found to possess the required weight and speed to cause a penetration and collapse of the planned tank... Although a major earthquake has a relatively high probability of occurrence, it is not considered as an initiating event because the tank would be designed to withstand the Safe Shutdown Earthquake. The design considers the maximum credible earthquakes for the area.[19]

Once again, such plausible initiating events as human error, acts of sabotage, or design, engineering, and construction faults have been completely discounted. Recent discussions with representatives of Hydro's Gas Engineering Division indicate that the company is cognizant of the apparent deficiencies in the ERCO study, and will attempt to either rectify the situation or limit the significance of the analysis in terms of the overall project justification process.[20]

The second important component of risk analysis, in addition to determining the probability of an accident, is forecasting the potential impact of the event upon the surrounding community. The impact is generally measured in terms of loss of life, physical damage, depreciated property values, or loss of productivity. As a rule, impact modelling tends to be less precise than is establishing the probability of a serious accidental event. This is particularly true with regard to forecasting the nature and probable effects of a large volume accidental discharge of LPG or LNG on public safety. The amount of practical research undertaken to date on liquefied gas spill characteristics vapour cloud dispersion patterns has been limited. Among the organizations most actively involved with the study of controlled discharges of LNG and LPG have been the United States Coast Guard (on various occasions at the U.S Naval Weapons Centre, China Lake, California), Shell Oil (aboard the LNG carrier Gadila in 1973, and at Maplin Sands, Essex during the summer of 1980), and the Government of France (near Fos-sur-Mer during the early 1970's). Two significant features emerge which are common to all of the above-noted tests. Firstly, in most instances the volume of gas discharged seldom exceeded 20 cubic metres. The largest controlled discharge involved the jettisoning of 193 cubic metres from the British LNG carrier Gadila.[21] In relative terms, this amount represented just over 1% of the carrying capacity of any one of Gadila's five 15 000 cubic metre cargo tanks. Significantly, the United States Coast Guard has indicated that, initially, the maximum credible accidental spill aboard an LNG carrier would involve the discharge of the contents of one tank - or, in this instance, 15 000 cubic metres.[22] In order to apply the test results to a credible situation level, they must be enhanced substantially - a process which, in itself, is dependent upon considerable qualitative judgment and professional conjecture. Thus, in the absence of any hard data on large spill behaviour, scientists are forced to speculate on the validity of their own spill dispersion modelling techniques.

The second noteworthy characteristic of controlled discharge and ignition tests involving liquefied gases is that the emphasis has always been upon LNG, rather than LPG. In fact, of the four gas discharge testing programs mentioned in the preceding paragraph, only the U.S. Coast Guard and Shell Oil (at the Maplin Sands test site) have undertaken controlled LPG release experiments. In each instance, the LPG tests have been secondary to simultaneously- conducted LNG discharge monitoring programs, a factor which has been acknowledged by the U.S. Coast Guard.[23] The net result is that, while the spill characteristics for volumes of LNG up to about 20 cubic metres have been fairly well documented, the same is not true for LPG. Hence, the link between small and large LPG spill characteristics is even more dependent upon conjecture than is the case for LNG. The problem is compounded by the fact that few risk analysis applications pertaining to the marine transportation of LPG have been undertaken to date.

Clearly, there remain a number of serious limitations with regard to the application of risk analysis methods to large-scale liquefied gas terminal and shipping operations. Significantly, in the absence of a wholly reliable quantitative methodology, the United States Coast Guard...

> ...does not use a formalized risk analysis procedure in which the probabilities of accident and major cargo release for each type of accident are quantified and combined with a damage estimate to obtain a numerical value of risk for comparison with other risks encountered by the public. The capability for such a rigourous technique is under development for general use with all hazardous materials and all water transportation systems but, at present, a qualitative approach is used in which cargo hazards and accident risks are considered and expert judgment used to determine proper preventive measures.[24]

<u>Analytical Approach</u>

The rationale for undertaking the research is based upon the key underlying assumptions that:

a) loaded or partially-loaded gas carriers represent a substantially greater threat to public safety than do conventional cargo ships;

b) loaded or partially-loaded gas carriers operating within the confines of a restricted harbour, irrespective of the quality of the safety regulations in force, cannot be rendered totally immune from the possibility of a potentially catastrophic accident;

c) the imposition of new, or upgraded, safety requirements can serve to reduce the likelihood of a serious accident occurring.

Each of the preceding assumptions is either tacitly or explicitly recognized in virtually every liquefied gas port in the world, as evidenced by the common practice of imposing special operating constraints on liquefied gas carriers. The degree to which gas carriers are perceived to present a safety risk to the community is reflected by the extent to which additional regulations have been introduced. In the majority of world gas ports - and this is especially true for LPG ports - the regulations governing the safe movement of gas carriers have traditionally been based more upon sound professional and technical judgment than upon risk analysis or impact assessment studies.

The overriding objective of this thesis is to ensure that the level of regulatory response to the perceived public safety hazards posed by the movement of liquefied gas carriers in the Port of Vancouver either meets, or exceeds, the consensus regulatory standards for specific operational safety requirements in place in the control ports described in Section 1.3.4. In five of the six gas ports which have been examined in detail, the existing shipping regulations have evolved solely on the strength of qualitative assessment techniques based upon professional judgment.* In the interests of establishing a common, comparable information base, it is suggested that the undertaking of a detailed risk analysis for the Port of Vancouver would serve little purpose unless similar studies were conducted for Boston, Los Angeles, Canvey Island, and Le Havre. Severe cost and data collection constraints render this latter consideration impractical within the context

*The exception was the ill-fated Shell/B.P. LPG terminal proposal for Europoort, which was subjected to a risk analysis and impact assessment program. The results of these studies are not available.

of this research. Thus, the comparative assessment of liquefied gas port regulations conducted herein will be based upon the "rational man" analytical approach which has long been adhered to by the U.S. Coast Guard and other port regulatory agencies around the world.

FOOTNOTES - CHAPTER 1.0

1 "Four run for lives under train accident" The Province, 30 August 1978, p. 11.

2 Ibid.; and Beak Consultants, Chemical Hazard Evaluation of the Maplewood Chemical Industry (Vancouver: 1978), p. 127.

3 "'Damn lucky it didn't blow,' say crew on propane train," The Vancouver Sun, 29 August 1978, p. A1.

4 "Volrich calls for strict curbs as gas fells 78", The Vancouver Sun, 26 September 1978, p. A1; and "Chlorine gas cloud in city sends 32 to hospital", The Province, 26 September 1978, p. 1.

5 "Council advised to put the whip to CP Rail giant", The Province, 30 October 1981.

6 "Hazards cleanup given green light", North Shore News, 21 October 1981.

7 N. Irving Sax, Dangerous Properties of Industrial Materials (New York: Van Nostrand Rheinhold Company, 5th ed., 1979), pp. 658-659; and National Institute of Occupational Safety and Health, Registry of Toxic Effects of Chemical Substances 1978 (Washington: U.S. Department of Health, Education and Welfare, January 1979), p. 529.

8 "Dow Chemical Plant 'Safe'", The (North Shore) Citizen, 28 March 1979, p. 1.

9 Letter from Captain T. Elworthy, Assistant Harbour Master, Port of Vancouver, to J. Marston, dated 22 November 1979.

10 Letter from J. Marston to Captain H. Vondette, Harbour Master, Port of Vancouver, dated 16 November 1979.

11 "Payload turns tanker into floating bomb", The Vancouver Sun, 14 November 1979.

12 Community Hazards Task Force, North Vancouver Community Hazards Task Force - Final Report (North Vancouver: November 1980), p. 11.

13 Based upon information contained in a letter from Mr. Paul Roshkind, Manager, Marketing Services, Port of New York and New Jersey to J. Marston, dated 4 January 1980.

14 "Controversial LPG plan at Europoort wins approval," Lloyd's List, 9 November 1981.

15 United States (Atomic Energy Commission), Theoretical Possibilities and Consequences of Major Accidents in Large Nucleur Power Plants", March 1957.

16 Theodore W. Horner and Ecosystems Inc., "Probability Assessment of LNG Ship Accidents in the New York and Providence Harbors", Report to the Federal Power Commission, Bureau of Natural Gas, 1974, as cited in Lee N. Davis, Frozen Fire (San Francisco: Friends of the Earth, 1979), pp. 135-138.

[17] William B. Fairley, "Evaluating the 'small' probability of a catastrophic accident from the marine transportation of liquefied natural gas", Statistics and Public Policy (Reading, Mass.: Addison-Wesley Publishing Co., 1977), pp. 340-346.

[18] Information on SAI risk assessment obtained from California State Legislature, Assembly Subcommittee on Energy, Liquefied Natural Gas, Hearings July 1976 (Sacramento, 1977), pp. 43-83, 568-571, as cited in Davis, op. cit., pp. 139-140.

[19] Energy Resources Co. Inc., Risk Analysis on Sasamat Site Gas Storage Plant (Torrance: November 1981).

[20] Interview with Mr. C. Miller, B.C. Hydro (Gas Engineering Division), 25 August 1982.

[21] Davis, op. cit., pp. 42-44.

[22] U.S. Coast Guard (Department of Transportation), Liquefied Natural Gas and Liquefied Petroleum Gas - Views and Practices (Washington, D.C.: circa February 1980), p. 13.

[23] U.S. Coast Guard, op. cit., pp. 30-32; and "Shell to release and ignite LNG at Maplin Sands", Lloyd's List, 2 May 1980.

[24] U.S. Coast Guard, op. cit., p. 8.

2.0 TRANSPORTATION OF HAZARDOUS MATERIALS BY MARINE MODE: LEGISLATIVE STRUCTURE

2.1 Marine Terminal Siting Considerations

Significantly, and somewhat ironically, given the high degree of media exposure afforded the long-standing controversy surrounding the dual question of oil tanker safety and oil port development on the west coast, the gradual (and continuing) evolution of the hazardous materials trade in the Port of Vancouver has gone largely unnoticed and, as such, unquestioned by the general public. The irony is complete when one considers that many of the substances which are now routinely transported by coastal and deepsea vessels on the waters of Burrard Inlet - including LPG, liquid chlorine, methanol, and ethylene dichloride - would normally represent a greater potential hazard to public safety in the event of a major uncontrolled discharge than would a large spill of crude oil.

There are several reasons why this situation has been allowed to develop, foremost among which is the basic nature of the administrative structure for the Port of Vancouver. Jurisdiction over the port is vested primarily with a single federal agency - the National Harbours Board (N.H.B.). The Board is, to varying degrees, responsible for such diverse functions as port marketing, security, terminal management, the promulgation and enforcement of ship and shoreside operational safety regulations, and harbour planning and development. It is also the largest single administrator of developed and readily developable waterfront property on Burrard Inlet - property which is legally exempt from local or provincial land use restrictions due to its federal ownership status. Because of this extraordinary span of operational control, the Board is in a position to exercise a considerable amount of (direct and indirect) influence over the dissemination of public information relative to virtually every aspect of port business, including those having to do with the trade of hazardous materials.

A second important consideration has been the historical absence of any mandatory provision in Canadian law whereby the proponents of potentially high impact harbour development projects (such as the construction of a hazardous materials storage and transshipment depot) would automatically be required to inform the public as to the nature of the scheme, and to solicit public feedback on the proposal prior to receiving final project approval. This is in direct contrast to the American experience where, under the terms of the National Environmental Policy Act (NEPA, 1969), the public right to examine major development proposals is guaranteed from an early stage in the approval process. Moreover, safeguards have been built into the American legislation to ensure that final project approval will not be forthcoming until such time as the project sponsor is judged by government regulatory agencies to have taken suitable measures to mitigate all legitimate public concerns.

Finally, in the absence of specific requirements to the contrary, there has been a general reluctance on the part of many actors involved in local port development - particularly development relating to the storage and handling of dangerous materials - to inform the public as to the nature of these activities. Regrettably, this practice is not restricted solely to private operations, but is tacitly endorsed by a number of government bodies having a vested financial interest in the development of the harbour, including the Harbours Board and, from time to time, various waterfront municipalities. The recent Dow Chemical experience, as described in Section 1.2, graphically underscores these limitations.

Nevertheless, the fact remains that government agencies at all levels do, to varying degrees, possess the inherent legislative authority to control the siting and operation of facilities engaged in the production, storage, and distribution of dangerous goods. The extent to which these regulatory powers can be effectivey applied in terms of both serving and protecting the best interests of the public, however, will be wholly dependent upon a thorough knowledge on the part of the appropriate regulatory agencies as to the nature and range of the hazards presented by the plant/terminal operation, and upon an uncompromising commitment to ensuring the highest standards of community safety. Unfortunately, while the necessary authorities required to regulate activities involving dangerous materials are, by and large, in place, due to the often subjective nature as to what constitutes a "hazard" to the community, and to what degree, the extent to which rules governing these operations are applied and enforced within the context of the existing legislative structure is often open to broad interpretation. It is the contention of the thesis that, as a consequence of these interpretative deficiencies, the quality of regulations governing certain hazardous materials operations within the Port of Vancouver (including those affecting the marine transportation of LPG and other chemical/petrochemical products) are, either unwittingly or by design, insufficient to ensure an adequate level of public safety when compared with the regulatory standards governing similar activities in other western industrialized nations.

2.2 Pertinent Hazardous Marine Terminal Siting Legislation

2.2.1 Federal Legislation

2.2.1.1 Navigable Waters Protection Act[1]

The Navigable Waters Protection Act (NWPA) is administered by the Ministry of Transport. One of the principal objectives of this Act is to regulate

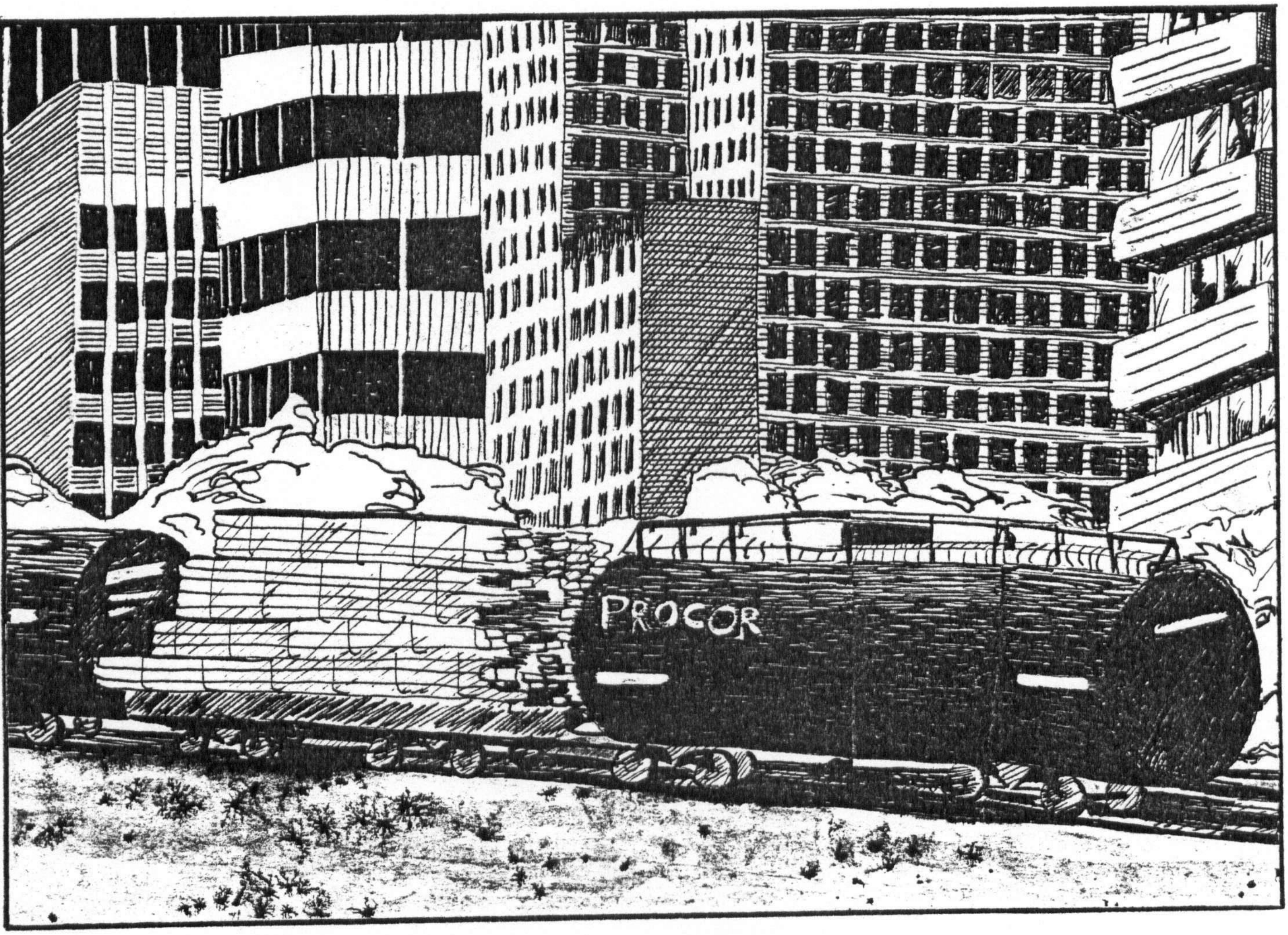

Figure 2.1 Hazardous Materials on Vancouver Waterfront

construction within designated Canadian navigable waters. In this respect, Section 10(1) of the Act states that:

> ...the Governor-in-Council may make such orders as he deems expedient for navigation purposes respecting any work to which this Part applies...

While no specific reference is made in the Act to the regulation of vessels transporting hazardous materials, the NWPA is a key element in the successful application of the Canadian Coast Guard's "voluntary" Termpol Code (see Section 2.2.1.2). That is to say, while the Termpol Code is not a mandatory requirement in the strictest sense of the word, failure on the part of a gas or oil terminal proponent to provide the basic information requested in the Termpol Code may cause Coast Guard officials to withold necessary permits for the construction of marine works associated with the proposal, as required under the terms of the NWPA.

2.2.1.2 Termpol Code[2]

The Termpol Code evolved during the mid-1970's in response to public concern over major oil port proposals on Canada's east and west coasts. In 1979, the Code was amended to include LNG and LPG marine terminal proposals.

Essentially, the Termpol Code is a voluntary process whereby the proponents of marine oil or gas terminals are requested to submit to the Coast Guard a detailed assessment as to the nature of the project, particulars on the construction and physical lay-out of the facility, an indication as to the type and volume of marine traffic which will be generated, a risk analysis, and a statement of major potential impacts and mitigating measures.

The Termpol Code is administered by the Canadian Coast Guard. The proponent submissions, however, are reviewed by an appointed committee of experts from various federal departments and agencies, under the chairmanship of a Coast Guard representative.

To date, only one liquefied gas proposal - the Arctic Pilot Project (for details refer to Appendix IV) has undergone the full Termpol assessment. The project was deemed acceptable by the Termpol committee, subject to compliance with certain fundamental recommendations.[3] Two other proposals, the Rimgas LNG project and the Western LNG project (for details refer to Appendix IV) are currently being reviewed by a Termpol committee.

It is further speculated that the Termpol Code will be extended in the near future to include proposed chemical and petrochemical port development, as well.

The Termpol Code cannot be retroactively applied to terminal operations which are already in place.

2.2.1.3 Environmental Assessment and Review Process (EARP)[4]

The Environmental Assessment and Review Process was introduced in 1973 for the purpose of ensuring that:

a) environmental effects are taken into account early in the planning of new federal projects, programs, and activities;

b) an environmental assessment is carried out for all projects which may have an adverse effect on the environment before commitments or irrevocable decisions are made; and

c) the results of these assessments are used in planning, decision-making and implementation.

The responsibility for administering EARP rests with the Federal Environmental Assessment Review Office (FEARO), which is ultimately accountable to the Minister of the Environment.

There are two key considerations to bear in mind when examining EARP. First, it is applicable only to projects that are initiated by federal departments or agencies, that involve federal property, or where federal funding assistance has been solicited. Second, the process in place is based on the concept of self-assessment. In other words, federal departments and agencies are responsible for assessing the environmental consequences of their own projects, or those which they sponsor, and for deciding on the anticipated environmental significance of the proposal. In the event a department/agency decides that the environmental impact is likely to be insignificant, no further analysis will be required. For the most part, projects are either screened out of the EARP process, or are subjected to mitigating strategies at the departmental level. However, projects which are deemed to present an environmental impact potential that cannot be effectively mitigated at the departmental level are submitted to a formal Environmental Assessment Panel. This panel is normally comprised of between four and six experts (from within and without the federal civil service) whose responsibility it is...

> ...to review the environmental consequences of a specific project and its alternatives, and to evaluate the significance of the environmental impacts that might result from implementing the project.

Under the direction of the Panel, the proponent department will be required to sponsor a detailed Environmental Impact Statement - a document which will subsequently form the basis for the Panel review, and act as a sounding board for public opinion. Both the terms of reference for the Impact Statement, and the actual document itself, will be made available to the public prior to any recommendations being submitted relative to whether or not the project should proceed. Subsequent to this information having been distributed, the Panel will arrange to meet with the public in order to receive briefs from any individuals or groups who wish to express their opinions on the matter. Based upon the combined results of the Impact Statement, the public input, and any other information which may be considered appropriate, the Panel will prepare and submit its final recommendations on the project to the Minister of the Environment. The recommendations are not binding.

To date, none of the proposed west coast liquefied gas or petrochemical terminal projects have been formally linked to the EARP process. However, in the event federal lands are involved in conjunction with one or more of these projects (as may be the case with National Harbours Board land at Prince Rupert), it is likely that review panels will be appointed.

2.2.1.4 Fisheries Act[5]

Section 2 of the Fisheries Act defines "Canadian fisheries waters" as:

> ...all waters in the fishing zones of Canada, all waters in the territorial sea of Canada and all internal waters of Canada.

Under the heading of "Injury to fishing grounds and pollutions of waters", the Act expressly forbids the introduction of "...chemical substances, or drugs, poisonous matter...or any other deleterious substances or thing... (into) any waters frequented by fish..." (Section 33(2)).

Furthermore, the Governor in Council is, under the provisions of the Act, vested with the authority for introducing regulations respecting the obstruction and pollution of waters frequented by fish (Section 34(h)).

Thus, chemical or petrochemical terminal proposals which could, under certain circumstances, result in the (controlled or uncontrolled) discharge of substances deemed by the Governor in Council to be potentially deleterious to fish must first secure approval from the Department of Fisheries & Oceans.

2.2.1.5 National Harbours Board Act[6]

Section 14 of the National Harbours Board Act defines the basic terms by which the Board can influence or control hazardous materials terminal site selection in NHB ports:

> 14(1)the Governor in Council may make by-laws...for the direction, conduct and government of the Board and its employees, and the administration, management and control of the several harbours, works and property under its jurisdiction including:
>
> (b)...the leasing or allotment of any harbour property under the administration of the Board...
>
> (c) the regulations of the construction and maintenance of wharves, piers, buildings or any other structures within the limits of the harbours, and anything incidental thereto.
>
> (f) the transportation, handling or storing under the administration of the Board or any private property within any harbour under the jurisdiction of that Board of explosives or other substances that, in the opinion of the Board, constitute or are likely to constitute a danger or hazard to life or property.

Failure on the part of a proponent to comply with such regulatory provisions as may be deemed necessary by the Board with respect to the siting, construction, or operation of a proposed hazardous materials facility within an NHB port could result in the Board's refusal to authorize the construction of the project.

2.2.2 Provincial Legislation

2.2.2.1 Pollution Control Act[7]

Under Section 3 of the Pollution Control Act*, the Director of the Waste Management Branch, Department of Environment, is vested with the power and duty to:

a) determine what qualities and properties of water, land or air constitute a polluted condition;

b) prescribe standards regarding the quality and character of the effluent or contaminant which may be discharged into any waters, land or air;

c) appoint advisory or technical committees deemed necessary to inform the board with regard to matters referred by the board; and

d) carry out specified references or instructions made to the board under Section 2(3).

The principal objective of the Act is to ensure that:

> ...no person shall...discharge or cause to permit the discharge of effluent or other waste material on, in or under land or into waters without a permit or approval from the director (Section 4(1)).

In this regard, it is once again incumbent upon the proponent to ensure that the requirements of the Act and its regulations are met in ever respect prior to a permit being issued.

Failure on the part of a proponent to either a) secure the necessary permit; or b) comply with the provisions of the permit once it has been issued could result in a fine "...not exceeding $10,000 or imprisonment for

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The Pollution Control Act is scheduled to be replaced during the fall of 1982, subject to the proclamation of the provincial Waste Management Act. The recent (1981) introduction of the Environment Management Act (which is also administered by the Department of Environment) assumed some of the functions formerly vested with the Pollution Control Act, including the responsibility for hearing appeals resulting from decisions made under the Pollution Control Act.

a term not exceeding one year, or to both, and if the offence is of a continuing nature, to a fine not exceeding $500 for each day the offence is continued...(Section 25).

2.2.2.2 Fire Services Act[8]

Under the provisions of Section 59(1) and 59(2) of the Fire Services Act, the Lieutenant Governor in Council may:

a) regulate manufacturing or trades dangerous in causing or promoting fire;

b) regulate the manufacture, storage, carriage, sale and disposal of combustible, explosive or flammable matter; and

c) adopt the whole or part of the standards for the Canadian Gas Association, the National Fire Code of Canada, and any other code, or standard on fire standards and fire safety, and to amend a code or standard adopted under this paragraph.

Thus, the Provincial Fire Commissioner's concurrence and approval relative to siting, construction, and fire fighting/prevention systems must be secured in conjunction with the construction of marine facilities designed to handle combustible, inflammable, or explosive materials.

2.2.2.3 Utilities Commission Act[9]

In British Columbia, the construction or operation of any regulated energy project can only be undertaken with the joint concurrence of the Minister of Energy, Mines and Petroleum Resources and the Minister of Environment (Section 19). In certain instances, an application for an "energy project certificate" or a modified "energy operating certificate" may be referred to the Utilities Commission for review prior to the necessary certificate being authorized (Section 19(1) (a) and (b)). The referral may be made on the grounds of the complexity of the application, or upon the grounds of public safety or economic concerns. In those instances where an application for an energy project certificate is referred to the Commission for review...

> ...the Commission shall hear the application in public hearing in accordance with terms of reference specified jointly by the Minister of Energy, Mines and Petroleum Resources and the Minister of Environment, and on conclusion shall submit a report and recommendations to the Lieutenant Governor in Council (Section 20(1)).

Several west coast LNG marine terminal proposals are presently before the Minister of Energy, Mines and Petroleum Resources awaiting a decision as to whether or not they will be referred to the Utilities Commission. Moreover, it has been speculated that B.C. Hydro's Sasamat LNG terminal proposal could be submitted to the Commission in the near future, largely on the strength of the public controversy generated by the project.

2.3 Legislation Pertaining to the Bulk Shipment of Hazardous Materials By Marine Mode

2.3.1 Federal Legislation

The regulation of the bulk shipment of hazardous materials by ship falls under the jurisdiction of the Government of Canada. The organizations primarily responsible for the promulgation and enforcement of special operating provisions for hazardous materials carriers are the Ministry of Transport (under the terms of the Canada Shipping Act), the National Harbours Board (under the National Harbours Board Act), and the various federally-appointed Harbours Boards. This thesis is primarily concerned with the Canada Shipping Act and the NHB Act.

2.3.1.1 Canada Shipping Act[10]

Several aspects of the Canada Shipping Act relate either directly or indirectly to the regulation of vessels transporting hazardous materials in Canadian waters. For example, in a broad sense the Act governs the circumstances whereby Canadian ships' officers, crews, and coastal pilots are licensed. The quality of these licensing procedures, in turn, should reflect upon the quality of Canadian marine personnel - a feature which could have an affect upon the safe management and operation of vessels carrying dangerous goods in Canadian waters. Similarly, responsibility for the establishment and maintenance of navigation aids plus the provision of vessel traffic management services enhance the overall level of operational safety for hazardous materials carriers, as well as other vessels.

Of particular significance to the regulation of vessels transporting dangerous goods is Part VIII of the Act, entitled "Safety". Part VIII deals with the provision of steamship inspection services for domestic and foreign vessels trading in Canadian waters. In this regard, Section 450 of the Act (under the heading "Dangerous Goods"), provides the Governor in Council with the authority to establish regulations for hazardous materials carriers on such matters as:

- packing/stowing of cargo
- quantities to be carried
- locations aboard vessels where dangerous goods may be stored
- marking
- handling procedures
- powers of steamship inspectors
- other requirements, as necessary

The actual practice of inspecting such specialized hazardous materials carriers as parcel chemical tankers and liquified gas tankers requires techiques which are unique in the shipping world. As a rule, these techniques are not generally developed on a nation by nation basis. Instead, they evolve as a reuslt of joint international co-operation through the auspices of such bodies as the International Maritime Consultative Organization (IMCO). Canada, as a participating member of IMCO, has adapted inspection techniques and standards for various types of hazardous materials carriers into the Canadian steamship inspection process. These special inspection requirements are, in turn, reflected within the regulatory authorities vested in Part VIII.

The role of the Canada Shipping Act, particularly as it relates to the movement of hazardous materials carriers in the Port of Vancouver is more clearly defined in Section 4.2.2.

2.3.1.2 National Harbours Board Act[11]

The responsibility for establishing safe navigational procedures for vessels operating within NHB ports rests not with the Canadian Coast Guard, but rather with the Board itself. This authority is described as follows:

> 14(1) The Governor in Council may make by-laws...for the direction, conduct and government of the Board and its employees, and the administration, management and control of the several harbours, works and property under its jurisdiction including:
>
> a) the regulation and control of each and every matter in connection with vessels and aircraft navigating the harbours and their mooring, berthing, discharging or loading or anything incidental thereto; and
>
> b) the regulation of all plant, machinery or appliances, whether floating or not, for loading or unloading vessels, including the power to prescribe that none shall enter any harbour or remain in it without the permission of the Board...

For a detailed account of the special regulations in effect for hazardous materials carriers in the Port of Vancouver, refer to Section 4.2.2.

FOOTNOTES - CHAPTER 2.0

1 Government of Canada, Navigable Waters Protection Act, Revised Statutes of Canada - 1970, Chapter N-19.

2 Government of Canada, Code of Recommended Standards for the Prevention of Pollution in Marine Terminal Systems (Ottawa: Canadian Coast Guard, 22 February 1977).

3 Government of Canada, Arctic Pilot Project - Termpol Assessment (4 vols.) (Ottawa: Coast Guard, 1981).

4 Government of Canada, A Guide to the Federal Environmental Assessment and Review Process (Ottawa: Fisheries & Environment Canada, February 1977); and interviews with representatives of the Federal Environmental Assessment and Review Office, Vancouver, B.C.

5 Government of Canada, Fisheries Act, Revised Statutes of Canada - 1970, Chapter F-14.

6 Government of Canada, National Harbours Board Act, Revised Statutes of Canada - 1970, Chapter N-8.

7 Province of British Columbia, Pollution Control Act, Revised Statutes of British Columbia - 1979, Chapter ___; and interviews with representatives of the provincial Waste Management Branch, Victoria.

8 Province of British Columbia, Fire Services Act, Revised Statutes of British Columbia - 1979, Chapter 133.

9 Province of British Columbia, Utilities Commission Act, Assented to 22 August 1980.

10 Government of Canada, Canada Shipping Act, Revised Statutes of Canada - 1970, Chapter S-9, plus amendments.

11 Government of Canada, National Harbours Board Act, Revised Statutes of Canada - 1970, Chapter N-8.

3.0 MARINE SHIPMENT OF LPG AND RELATED COMMODITIES

3.1 Evolution of the Liquefied Gas Tanker Trade

Liquefied petroleum gas, or LPG, is the generic term commonly applied, either singly or in combination, to members of a specific group of chemical compounds falling within the lower molecular weight range of the hydrocarbon spectrum. The principal components of LPG would normally be either propane or butane. However, depending upon the source and nature of the gas mixture, it is possible for other compounds such as propylene or isobutane to emerge as dominant constituents within a particular gas sample. Because the characteristics and practical applications of the gas may vary considerably with the mixture, LPG is known under a variety of popular names, including propane, butane, propylene, pyrofax, or simply "bottled gas".

LPG is derived from two principal sources - both as a byproduct of the wellhead separation of natural gas (methane and ethane) from liquid petroleum hydrocarbons, and through the refinery fractioning of crude oil and the further processing of petroleum distillates. In practical terms, it has proven to be a durable, clean burning fuel source having a wide range of domestic, commercial, and industrial applications worldwide.

At ambient temperature (15° C) and normal atmospheric pressure, the individual chemical components of LPG would exist in a gaseous state.

However, one of the salient features of LPG, and certainly the one which has served most effectively to put it on an economically competitive footing with more traditional, non-gaseous fuel sources, is that it can be readily reduced to a liquid state for easier storage and transportation through the processes of cooling and/or pressurization. In its liquid condition LPG occupies approximately 1/250th of its volume as a gas.

Although commercial gas liquefaction has long been practiced in a variety of forms, it was not until after the First World War that a concerted effort was made to apply the technology to the constructon of liquid gas tankships.* The earliest gas carriers were, by and large, small pressurized tankers having a cargo capacity of less than 1 500 cubic metres. Most had been designed to serve the growing European inter-coastal LPG trade.

During the 1950's, gas tanker technology became increasingly sophisticated. A number of vessels which came on line during this period possessed the dual capacity for both pressurizing and partially refrigerating their cargoes. Moreover, new tanker designs were being developed for the purpose of addressing the special problems and considerations associated with the carriage of bulk liquid gases other than LPG - notably ammonia, vinyl chlorides, and liquefied natural gas (LNG).

In 1959, a new era of liquefied gas transport was christened with the successful trans-Atlantic crossing of the world's first experimental LNG carrier, the Methane Pioneer, from Lake Charles, Louisiana to the British

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*The first LPG carrier was the British tanker Megara, which was built in 1926 for the Anglo-Saxon Oil Company. The ship served the West Indies/Europe trade, carrying oil and propane, the latter in riveted cylindrical pressure vessels. The Megara was scrapped in 1955, although her tanks are reportedly still being used for land storage.1

Gas Corporation terminal at Canvey Island, near the mouth of the River Thames. Ths historic voyage of the Methane Pioneer, a converted dry cargo vessel, was doubly significant in that it marked the introduction of the concept of cryogenic* engineering to the construction of a ship's cargo containment and transfer system.

The importance of this event should not be allowed to pass without a few brief observations on the ocean carriage of LNG generally. Like LPG, LNG is comprised of lower molecular weight hydrocarbon compounds - primarily methane and ethane. In its liquid state it occupies just 1/600th of its volume as a gas. However, unlike LPG, it does not lend itself well to liquefaction simply through the application of sufficient pressure. The critical point of LNG is -83° C, which means that it cannot be liquefied at any temperature above -83° C, irrespective of pressure. Liquefaction by direct refrigeration involves cooling the gas to its boiling point of approximately -162° C, a costly and complex procedure. Thus, engineers faced with the prospect of designing a practical LNG containment system suitable for long-haul shipboard deployment were left with basically three alternatives - specifically, to develop either:

a) a non-pressurized, active refrigeration/re-liquefaction system;

b) a system combining elements of both active refrigeration and pressurization similar to the technique which had been successfully applied to the construction of small LPG tankers; or

c) a passive, non-pressurized system of cargo refrigeration based upon the principle of efficient insulation.

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*The term cryogenics refers to the branch of physics which deals with the study of low temperature phenomena generally occurring at temperatures below -150°C.

Neither Alternative "a" nor Alternative "b" has ever proven wholly acceptable from either an economic or an operational standpoint. Instead, the owners of the Methane Pioneer (and, for that matter, of virtually every LNG carrier built since) chose to incorporate a design system based upon Alternative "c" - passive refrigeration through insulation. Under this option, gas which has been cooled to its liquid state at a shoreside liquefaction plant is subsequently pumped into the ship's specially insulated tanks.[2] Each tank, operating much in the manner of a huge thermos, is designed to maintain the cargo in a super-cooled liquid state for extended periods of up to several months by effectively restricting normal internal heat gain. Due to the extremely cold temperatures involved in the storage of LNG, special engineering techniques and metal fabricating materials (including highly resilient aluminum and nickel steel alloys which will retain their ductility at low temperatures) must be employed - both factors of which contribute substantially to the final cost.

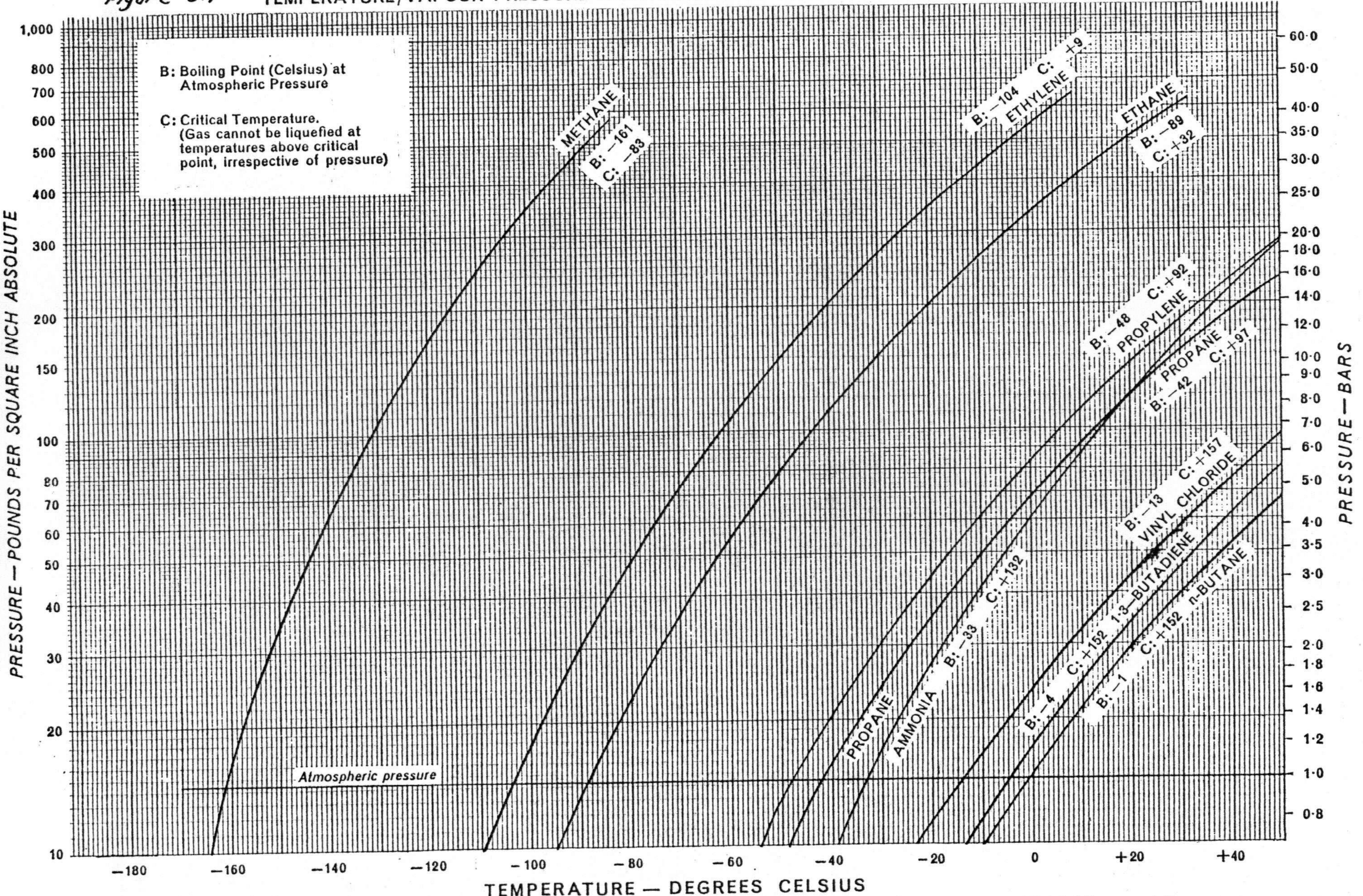
Because LNG is, by its very nature, constantly striving to return to its gaseous state, as the cargo gradually (an inexorably) warms up to beyond its vapour point, the phenomenon of "boil-off", or vapourization, occurs. In modern vessels, boil-off consumes about 0.2% of the total cargo daily - or roughly 200-250 cubic metres of gas per day for a standard 125 000 cubic metre capacity LNG carrier.[3] Cargo boil-off is normally re-directed to the engine room where it is used to augment the vessel's conventional fuel supply.

In contrast to the widespread interest generated throughout the international shipping community during, and subsequent to, the inaugural voyage of the Methane Pioneer, the development of a practical cargo containment system whereby LPG could be economically transported over long distances and/or extended periods of time created little fanfare outside the immediate industry. Even so, by 1962 the first ocean-going refrigerated LPG carriers incorporating a self-contained cargo re-liquefaction capacity (similar to that which had been deemed unsuitable for LNG transport) were in service.

The new LPG design philosophy drew extensively from the recently compiled body of knowledge pertaining to the marine transport of LNG. Accordingly, both technologies displayed many basic similarities. For example, each emphasized the fundamental premise that optimum tank efficiency could only be recognized through the effective insulation of the cargo containment system. Furthermore, each system incorporated a broad range of specialized shipboard safety features to offset the enormous hazard potential created by the volatile nature of their cargoes.

Notwithstanding these and other common design characteristics, from the standpoint of storage and transportability LNG and LPG differ from each other in one very important respect. The principal physical advantage of LPG over LNG is that all of its constituent parts will be reduced to a liquid state at a temperature of -48° C and one atmosphere of pressure. This compares with a liquefaction temperature for LNG of -162° C at atmospheric pressure (see "Temperature/Vapour Pressure Relationship for Selected Ship-Borne Gases," p. 50). Hence, the physical constraints associated with LPG tanker construction, while substantially more demanding than for conventional shipbuilding practice, are by no means as restrictive as those involving LNG. Thus, there are significant cost savings to be realized through the application of "cold temperature", as opposed to "cryogenic" engineering techniques. LPG cargo containment systems, for

Figure 3.1 TEMPERATURE/VAPOUR PRESSURE RELATIONSHIP OF SELECTED SHIP-BORNE GASES*



* Curves constructed by application of Antoine equation, using data from "Selected Values of Properties of Hydrocarbons and Related Compounds", American Petroleum Institute Research Project 44, Thermodynamics Research Centre, Texas A. & M. University, and from "Advances in Chemistry Series: No. 22" (1959) published by the American Chemical Society.

example, utilize special low temperature steel, rather than the substantially more expensive aluminum and 9% nickel steel alloys widely employed in LNG construction. The non-cryogenic techniques used in LPG construction also enable a wider range of mechanical systems applications than is economically (or, in many instances, technically) practical in cryogenic engineering. It is for this reason that shipboard re-liquefaction of gas boil-off becomes a viable option for LPG carriers, while it is not from the standpoint of LNG tanker construction.

In recent years, the gas tanker industry has experienced a number of severe marketing difficulties due, in part, to spiralling ship construction and operating costs, uncertain long-range supply and demand requirements for gas, political instability, and, increasingly, to serious social and environmental misgivings over the safety of liquefied gas carriers and terminal facilities. This is particularly true of the LNG tanker trade, where the general pattern of growth over the past 10 years has displayed many of the distinct characteristics associated with the oil tanker boom/bust period of the 1960's and early 1970's, although on a much smaller scale. In fact, as of January 1980, the world LNG tanker fleet consisted of only 54 vessels, with 17 others scheduled for delivery by 1982. However, the average cargo capacity per vessel increased from 27 400 cubic metres in 1964* to more than 84 000 cubic metres in 1980.[4] Of perhaps even greater significance is the fact that all 17 LNG carriers on order at the beginning of 1980 had cargo capacity ratings of 125 000 cubic metres or more.[5]

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*The average capacity figures for 1964 exclude the Methane Pioneer and the Pythagore, both of which were used primarily for experimental, rather than commercial, LNG carriage.

The preceding statistics, while seemingly portending a bright economic future for LNG, are somewhat misleading. Unlike crude oil, the basic international transportation infrastructure for both LNG and LPG is relatively underdeveloped, and is restricted to comparatively few well-established overseas trade routes. This can be attributed to the limited availability of specialized gas liquefaction (loading) and receiving terminals around the world. The historical tendency within the gas industry has been to construct a specific number of vessels designed to serve each individual route on a long-term basis. Thus, there is little room for excess tanker capacity.

Nevertheless, by the summer of 1980 a considerable glut of surplus LNG tanker capacity had begun to accumulate, thus illustrating the extremely fragile nature of the production/delivery chain associated with the introduction of new overseas gas tanker trade routes. Perhaps the most vulnerable link in this chain is that of the shipbuilding component. In order to meet production schedules, vessels must be ordered several years in advance - often while the project is still in the conceptual planning stages. However, political unrest in various producing countries such as Iran, and an increasing trend and towards more stringent regulatory standards for both liquefied gas carriers and the siting of onshore terminals in many western consuming nations, has led to several projects being either delayed or cancelled. As a result, a number of LNG carriers are now laid up in various parts of the world.

Uncertainty surrounding the futures of two major LNG development proposals, in particular, has served to upset the delicate supply/demand balance which has long characterized the international LNG takner market. The much discussed Pac-Indonesia trade, calling for the delivery of Indonesian LNG to California, has experienced lengthy delays as a result of both pricing disputes between the United States and Indonesia, and regulatory difficulties at the proposed Point Conception, California receiving terminal site. It now seems unlikely that the Pac-Indonesia project will come onstream before the late 1980's.[6] Similarly, excessive costs have delayed the start-up of the massive Bonny LNG project in Nigeria. The Bonny proposal will involve the eventual shipment of Nigerian gas to receiving terminals in western Europe and the eastern United States.

Collectively, the Pac-Indonesia and Bonny projects could eventually require some 23-25 new LNG carriers, most of which have not yet been ordered.[7] Several firms, however, in anticipation of a strong LNG market during the 1980's, proceeded with orders to construct a number of new gas carriers, even in the absence of any firm long-term charter commitments to transport LNG. The Swedish shipbuilding giant, Kockums of Malmo, for example, invested heavily in the construction of two 133 000 cubic metre capacity LNG carriers during the mid-1970's. Kockums had originally expected to sell its interest in these vessels long before their completion. Unfortunately, in its initial market demand forecasts, the company failed to take into account the myriad of economic, environmental, and political problems which have recently beset the LNG industry. In the virtual absence of an open LNG tanker market, Kockums was unable to divest itself of either tanker until 1981, when one of the vessels was purchased by German interests.[8] The second tanker remains unsold, and would seem destined for an obscure fate in extended lay-up.

Kockums is by no means the only company to have experienced serious fleet marketing difficulties. The twin 122 000 cubic metre tankers <u>Gastor</u> and

Nestor, which were purpose-built in 1976 and 1977 respectively to serve the proposed Pac-Indonesia run, have been permanently moored near Dunoon, Scotland since they were delivered.[9] One of the world's largest LNG fleet operators, El Paso Natural Gas, was forced to lay up as many as seven vessels at a time during 1980 and 1981, pending the resolution of a gas pricing dispute between Algeria and the United States.[10]

One of the few positive notes to emerge from this aspect of the industry in recent years concerns the 131 500 cubic metre Belgian LNG carrier Methania. Built initially to serve the proposed LNG trade between Algeria and Belgium, she was transferred directly from the builder's yard to a remote fjord near Haugesund, Norway when it became evident that the Zeebrugge, Belgium gas receiving terminal would not be completed on time. However, during the summer of 1981, interim arrangements were finalized whereby Methania will commence trading between Algeria and Montoire, France in the fall of 1982, pending the scheduled completion of the Zeebrugge terminal in the mid 1980's.[11]

In contrast to the LNG tanker market, the sea-borne LPG trade has remained comparatively stable, if unspectacular, over the years. The LPG shipping industry is divided into two distinct components. The coastal trade is comprised primarily of small pressurized and semi-refrigerated vessels having a cargo capacity of less than 5 000 cubic metres. As of January 1980, the 368 vessels falling within this category accounted for 72% of the total number of LPG carriers, but only 9% of the worldwide LPG tanker capacity.[12] The deepsea LPG fleet, on the other hand, is made up almost exclusively of fully-refrigerated vessels in excess of 5 000 cubic metres capacity. The 145 or so vessels which constitute the deepsea fleet have a combined cargo capacity of almost 5.4 million cubic metres, or roughly

600 000 cubic metres more than the total capacity for the existing LNG fleet.[13]

Characteristically, ocean-going LPG carriers have tended to be somewhat smaller than their LNG counterparts. Whereas vessels in excess of 100 000 cubic metres account for some 71% of all LNG tanker capacity, less than 4% of the deepsea LPG cargo capacity is contained in vessels of 100 000 cubic metres or greater.[14] Instead, the preferred size for modern refrigerated tankers is in the range of 50-75 000 cubic metres.

The future of the liquefied gas trade - over the short term, at least - is by no means clear. While it is acknowledged that the market potential for both natural and petroleum gas fuels is excellent, the political reliability and public acceptability of the marine delivery concept remains a serious point of contention in many quarters throughout the world. The revolution in Iran, for instance, has led to the indefinite suspension of plans to export LNG from the huge Pars offshore gas field in the Persian Gulf to the United States. Similarly, social and environmental concerns over the safety of liquefied gases have resulted in lengthy delays to the proposed construction of major gas receiving terminals at Europoort, Holland (LPG), Zeebrugge, Belgium (LNG), and Point Conception, California (LNG).

3.2 LPG IN VANCOUVER

In spite of the problems currently facing many LPG and LNG development proposals, the majority of existing liquefied gas delivery systems involving tankers have functioned successfully and, for the most part, without serious mishap over the years. One such operation has been the long-standing Vancouver-Japan LPG trade.

Figure 3.2 Westridge
Terminal, Burnaby, B.C.

Because of a chronic shortage of domestic energy resources, Japan has long depended upon overseas liquefied gas importation to supplement its burgeoning fuel requirements. In order to satisfy its growing demand for LPG over the years, Japan has seen fit to enter into a number of long-term international agreements for the purpose of securing guaranteed overseas gas supplies. Canada, with its enormous potential to produce and export LPG on a large volume basis, became a partner to one of the earliest gas trade arrangements, and in 1966 the first major liquefied gas exporting terminal on the west coast - Trans Mountain Pipeline Company's Westridge Terminal in Burnaby, B.C. - went into full commercial operation. During the intervening 16 year period, Westridge has exported on the order of 7.0 million cubic metres (or approximately 44.0 million barrels) of LPG to Japan.[15]

The basic delivery concept has changed little since the Westridge facility began exporting LPG in the mid 1960's. Liquefied propane is transported to the terminal in pressurized rail tankcars from Alberta. Upon arrival at Westridge, the propane is refrigerated and pumped into two 27 800 cubic metre (175 000 barrel) capacity insulated storage tanks, where it is maintained at a temperature of approximately -45°C.

On an average of once every five to six weeks, a refrigerated gas tanker arrives at Westridge to take on a consignment of LPG destined for markets in Japan. Between 1966 and the spring of 1982, the Westridge terminal was served almost exclusively by the 38 000 cubic metre capacity LPG carrier Yamahide Maru. The Yamahide Maru has since been replaced on a permanent basis by the Nichizan Maru, a recently-completed gas tanker of approximately 40 000 cubic metres capacity. Whereas the Yamahide Maru was representative of the first generation of refrigerated ocean-going LPG carriers, the Nichizan Maru reflects the present state of the art in terms of Japanese gas tanker design technology. She is expected to add a new dimension to the safe and efficient movement of LPG between Canada and Japan.

While comparatively small by present standards, both the Yamahide Maru and the Nichizan Maru are nevertheless capable of accommodating the equivalent of some 300 standard sized (127-130 cubic metre capacity) railcarloads of liquefied gas, or roughly 22 200 tonnes of propane (specific gravity 0.583).

3.3 The Issues

3.3.1. Background

Perhaps the greatest contrast between LPG and LNG has not so much to do with their respective physical or chemical properties as it does with the distinctly different manner in which the general public routinely perceives each product. In the United States, the public was made aware of the volatile nature of LNG as long ago as 1944, when a storage tank at a peak shaving facility in Cleveland, Ohio ruptured, spilling some 4 200 cubic metres of LNG into the adjoining streets and sewer system. The subsequent fire and explosions killed 130 people, injured scores of others, and devastated a 12 hectare area of the city.[16] The total damage estimate approached the $7 million mark. The Cleveland accident effectively put an end to further LNG development in the United States for more than 20 years.

By the late 1960's LNG was again being widely considered for use in peak shaving facilities throughout the country, especially in the heavily populated northeast. Once more, however, the gas industry experienced a serious setback when, in February 1973, a supposedly empty LNG storage tank on new York's Staten Island exploded, killing 40 workers who had been engaged in repairing its cryogenic liner.[17] Although the tank had actually been drained some 10 months earlier, sufficient pockets of undetected residual gas remained to cause the massive concrete dome to be blown almost 10 metres into the air.[18]

Unlike the Cleveland disaster, the Staten Island explosion did not result in a reinstatement of the moratorium on LNG development, although it is significant to note that both loaded LNG and LPG ships have been prohibited from entering the Port of New York since the incident.[19] Furthermore, the accident has served to bring the LNG industry under far more careful scrutiny by both government regulatory bodies and concerned citizens groups alike than would probably have been the case had the explosion not occurred. In recent years, a number of existing and proposed gas receiving terminal operations in such major centres as Boston, Los Angeles, and, of course, New York have been subjected to much criticism over the serious public safety problems inherent in the transportation and storage of LNG. The trend towards increased citizen participation in the LNG safety debate has yielded several positive results. The latest LNG terminals to become operational in the United States - one at Cove Point, Maryland and another near Savannah, Georgia - are situated in comparatively underpopulated areas, and are surrounded by extensive buffer zones to discourage public encroachment on the facility grounds. Equally significant has been the recent decision on the part of the State of California to restrict LNG terminal development to the isolated Point Conception area, some 100 kilometres northwest of Los Angeles.

By contrast, LPG has never evoked the same sense of public concern as that generated by the LNG controversy. Professor James Fay has explained the different public perceptions of LNG and LPG in the United States in the following manner:

> At both state and federal levels, LNG is regulated as a form of natural gas whose distribution and sales fall within the scope of public utility law. The process of granting permits under these laws necessarily requires a substantial review of safety, environmental, and pricing issues. The procedures open up to public scrutiny the evaluations of public safety impact undertaken by applicants and regulatory agencies, and permit intervention in the regulatory process by citizens groups or individuals who might be exposed to risk. Because of the direct involvement of government agencies, controversies over LNG facilities frequently (if not invariably) become political issues.
>
> In contrast, LPG distribution is no more regulated than is the distribution of any other petroleum product of equivalent flammability. Provided the usual construction and operating standards for vehicles and storage facilities are observed, no overall regulatory evaluation of LPG facilities, including safety and environmental effects, is required by law. Because such requirements are absent, little public information exists on LPG risks and public controversy over facilities is almost non-existent.[20]

Professor Fay's observations are more clearly underscored when one considers that the recent state decision to restrict future LNG terminal developments to a single geographical area within California does not apply to the siting of LPG terminals. Thus, in view of the fact that many government regulatory agencies, both in the United States and elsewhere, do not appear to equate the hazards associated with LPG equally with those of LNG, it is perhaps not surprising that the general public tends to perceive the widespread domestic use of such convenient and readily accessible products as liquefied propane and butane with a sense of both familiarity and acceptance.

Assuming that the rather detailed and, in some instances, quite extraordinary precautionary measures which have been imposed by many nations upon companies engaged in the transportation and storage of LNG are wholly justifiable from the standpoint of ensuring an appropriate standard of public safety, one is prompted to question whether or not LPG does actually present as great a potential threat to health and safety as LNG. There is, in fact, a sizeable body of opinion within both academic and government circles to suggest that LPG is, in many respects, at least as dangerous as LNG. A recent study by the Oceanographic Commission of Washington State states that:

> ...under certain conditions, LPG can be more hazardous than LNG. For example, unlike LNG, there is no doubt that unconfined vapor clouds of LPG can explode. When stored under pressure, there is some possibility of a boiling liquid expanding vapor explosion (BLEVE). Since LPG vapor is heavier than air, the vapor cloud from an LPG spill will not become buoyant like the LNG cloud, and a trapped LPG gas pocket might take longer to disperse. LPG vapor also has lower flammable limits..., which means that the vapor cloud from an LPG spill must be more diluted than an LNG vapor cloud before it is non-flammable. Finally, LPG has about 20 percent more energy for a given volume of liquid than does LNG.[21]

James Fay, in a comparative assessment of LNG and LPG risks, concludes that:

> ...compared to LNG, LPG risk analysis for large systems is less developed. The few studies made to date lead to the conclusion that LPG systems are at least as risky, and possibly much more risky, than equivalent LNG systems.[22]

As noted previously, the liquefied gas controversy has been equated almost exclusively with the LNG issue. This has been especially true in North America. Furthermore, in spite of its having been in widespread commercial use for a considerably longer period of time than LNG, the body of literature dealing with LPG-related hazards is small by comparison. Recognizing these historic limitations, the United States Coast Guard - which, more than any other government agency, has been responsible for both legitimizing the need for stronger gas tankship operating regulations and for providing the fundamental models upon which to base these regulations - has recently indicated that it will place a greater emphasis upon future research into the special considerations associated with the sea-borne carriage of hazardous materials other than LNG - notably LPG, ammonia, and sulphuric acid.[23] This is not to suggest that the Coast Guard has, in the past, been negligent in its rulemaking capacity for these or other dangerous commodities. On the contrary, in the absence of sufficient background data on the spill or ignition characteristics of LPG, at least, the Coast Guard has chosen to approach the vessel safety question in a manner which can only be described as prudent and responsible by applying special (LNG-oriented) gas tanker operating regulations equally to both LNG and LPG carriers (see Chapter 4.0). Other countries such as Japan (which has had a long tradition of liquefied gas importation) and Holland (which has recently embarked upon an important new era of increased LPG importation and distribution) are anxious to ensure that safety standards for ocean-going gas carriers operating in their territorial waters are at least as stringent as those which are now in effect in American ports.

The LPG industry itself has been particularly successful in maintaining a low public profile over the years. That this has been so, however, is perhaps more of a credit to the effectiveness of the industry's public relations programs than to its overall safety record, which has been much worse than that of the LNG industry. Lee Davis, in her account of the LNG safety issue entitled "Frozen Fire", chronicles no fewer than 23 confirmed (and six unconfirmed) LPG accidents between 1943 and 1978 which resulted in deaths. By contrast, Ms. Davis identifies only four separate LNG-related accidents during this same period which resulted in loss of life, including the previously mentioned Cleveland fire of 1944 and the 1973 Staten Island explosion.[24] In total, at least 483 deaths were attributable to the above-noted LPG accidents, as opposed to 177 for the LNG accidents (170 of which resulted from the Cleveland and Staten Island disasters alone).

The Davis figures require further elaboration. Firstly, LPG does have a broader range of uses, and is more widely distributed by means of road and rail tanker than is LNG. Accordingly, one must logically expect a higher incidence of LPG accidents involving these particular facets of the industry. Furthermore, by the author's own account, the accident lists contained in "Frozen Fire" are by no means all-encompassing.

On the other hand, considering that Ms. Davis' primary interest was with LNG rather than LPG, and given that the LNG industry is both more strictly regulated and more localized in a geographical sense, it is not unreasonable to assume that the accident statistics compiled in "Frozen Fire" reflect a more accurate and comprehensive picture of the LNG accident situation than they do for LPG. It is quite conceivable, then, that many incidents involving LPG - particularly those occurring in countries where accident reporting procedures are, at best, rudimentary - have gone unannounced in the past. As a concluding remark, it is significant that none of the LNG-related accidents reported in "Frozen Fire" after the Staten Island disaster of 1973 resulted in a single death. During the period February 1973 to July 1978 (the date of the last recorded incident in the book), however, no fewer than 17 confirmed (and 3 unconfirmed) LPG accidents involving loss of life have been detailed.

Admittedly, the preceding figures are inconclusive, and should be viewed with some caution pending a detailed assessment of the circumstances surrounding each separate incident. Nevertheless, the substantial discrepancies in the relative safety records for each product would appear to indicate serious deficiencies in terms of the quality and effectiveness of worldwide LPG regulatory procedures.

3.3.2 LPG Hazard Assessment

LPG-related hazards fall into two broad categories - those having to do with the effects of cold temperatures on steel or human tissue, and those having to do with the highly inflammable nature of the product. Of the two, cold temperature hazards are generally felt to present less of a direct threat to public health or safety. In the event a quantity of LPG is accidentally spilled onto an untreated "mild" steel surface, it is possible that the metal could suffer from the phenomenon known as brittle fracture - or loss of ductility due to exposure to low temperatures. The severity of the brittle fracture would be dependent not only upon the amount of LPG spilled and the extent to which it is distributed over the untreated surface, but also upon the composition of the spilled gas and the temperature at which it was being stored. Thus, one would anticipate that the likelihood of serious brittle fracture occurring would be less in the event of a spill of normal butane stored at or near its boiling point of -1° C than it would for an equivalent spill involving propane refrigerated to -42° C. Another potential cold temperature-related hazard is that of frostbite, which can result from even brief exposure of human tissue to LPG.

The most serious problems associated with LPG, however, are related to its inflammability. In the absence of oxygen, LPG is a relatively safe, stable product which is not prone to violent chemical reactions. For this reason, it is stored and transported in closed, oxygen-free containment systems. Unfortunately, it is not always possible to maintain LPG in a controlled state of oxygen deprivation. Thus, in the event of a large volume accidental discharge into the atmosphere, at least two important changes in the make-up of the LPG would take place. Firstly, the escaping liquid would immediately endeavour to return to its natural vapour state in what would be tantamount to a massive, uncontrolled boil-off. Secondly, the resultant vapour, upon coming in contact with oxygen in the atmosphere would quickly be transformed into an unstable, highly combustible gas mixture. The explosive limits for propane range from 2.1% (by volume) to 9.5%; for normal butane, from 1.8% to 8.5%. In other words, when propane vapour mixes with air at a ratio of 2.1 - 9.5% gas to air, it is capable of burning upon ignition.

Assuming that the escaping LPG is not ignited immediately, a large vapour cloud (or plume) would form, and would drift downwind until either dissipating, or encountering a suitable ignition source. Depending upon the gas to air ratio of the vapour cloud at the point of contact with a potential ignition source, the cloud could be set on fire by as little as a burning cigarette or even an errant electric spark. Ignition of the vapour cloud would normally result in an intense, high temperature flashback fire - possibly to the initial source of discharge. Under certain circumstances, however, unconfined LPG vapour clouds have been known to explode upon ignition.[25] According to the U.S. Coast Guard:

> If...detonation (a violent, forceful explosion) were to occur, the damage would be greater than that of a deflagration (simple burning). A deflagrating vapor cloud is probably fatal to those within the cloud and outside buildings but is not a major threat to those beyond the cloud, though there will be burns from thermal radiation.... In comparison, a detonation is not only fatal to those inside the cloud but also due to the overpressures developed, can be harmful outside the cloud boundaries.[26]

The vapour cloud problem is compounded by the fact that LPG, being heavier than air, disperses more slowly than many lighter gas compounds. Moreover, because of its weight, LPG vapour tends to collect in low lying pockets where it can remain in explosive concentrations for extended periods of time.

To date, comparatively little is known about the specific mobility or flashback characteristics associated with a massive LPG discharge, such as might be expected to occur in the event of a major shipping accident. Similarly, empirical studies undertaken in the United States and elsewhere concerning the possible distribution limits of inflammable LNG vapour clouds have been the topic of much controversy within the scientific community. As recently as 1976, independent estimates of the distance to the end of the inflammable zone for a plume resulting from a hypothetical 100 000 cubic metre LNG spill ranged from 5.2 kilometres (U.S. Federal Power Commission projection) to 203 kilometres (based upon the calculations of MIT Professor James Fay).[27] The enormous discrepancy in these figures reflected the limited amount of research which had been undertaken to that time in the area of liquefied gas plume behaviour, especially as it related to large gas spill situations.

While modelling techniques have improved since 1976, "...there is no consensus as to which (gas dispersion) model is the best, especially when used to simulate spill of 25 000 m^3 of LNG for which no experimental results are available."[28] This is borne out by the results of four recent models which were used to forecast the probable dispersion of a hypothetical 25 000 cubic metre LNG spill under identical circumstances. As can be seen in Table 3.1, the resulting cloud dimensions and cloud travel patterns differ significantly from one another:

Table 3.1 A Comparison of Results of Four Models Describing the Dimensions of the LFL Extent of a Cloud Following a 25 000 m^3 LNG Spill

			Distance (Kilometres)			
Dimension	Stability	Wind m/s	Germeles Drake	Eidsvik	Colen- brander	E&E (Dome)
Maximum Down- wind Travel	F	3	6.3	6.5	8.0	21.9
	D	2	4.1	6.3	7.4	13.0
Maximum Cloud Width	F	3	1.0	7.8	12.8	1.0
	D	2	1.0	6.3	11.8	1.0
Maximum Cloud Length	F	3	0.8	0.6	3.3	2.0
	D	2	0.8	0.6	1.8	2.0

Source: The Termpol Co-ordinating Committee's Assessment Report on Dome Petroleum Limited's Proposal to Construct and Operate a Liquefied Natural Gas Marine Terminal at Grassy Point, Port Simpson Bay, B.C. (Vancouver: Canadian Coast Guard, May 1982), as extracted from the Environmental Assessment and Risk Analysis Sub-Committee Report.

Davis, however, cites one particularly noteworthy instance during 1973 when Shell Oil scientists conducted a series of controlled gas discharge experiments from the LNG carrier Gadila in the Bay of Biscay.[29] During the largest test, some 193 cubic metres of LNG were jettisoned from Gadila over a 10 minute period in winds ranging from 4 to 11 knots. The subsequent gas plume extended downwind over a distance of 2250 metres. The inflammable zone was estimated at approximately 700 metres.

Because both LNG and LPG vapour clouds share the common characteristic of being able to travel over considerable distances to an ignition source, it is not unreasonable to assume that a somewhat similar result might have been recorded if LPG, rather than LNG, had been deployed during the Gadila experiment. In fact, this supposition is supported by at least one theoretical study by the United States Office of Technology Assessment:

Table 3.2 Spills on Water
(Under Worst Weather Conditions)

	LNG		LPG	
Spill Quantity (Tons)	Max. Half-Width (Ft.)	Max. Extent (Miles)	Max. Half-Width (Ft.)	Max. Extent (Miles)
100	340	1.5	320	1.4
1000	860	4.5	800	3.9
10000	2020	12.0	2000	11.0

Source: United States Senate, Liquefied Natural Gas: Safety, Siting, and Policy Concerns (Washington: June 1978), p. 45.

It is generally acknowledged that the greater the volume of liquefied gas released in a spill, the greater the distance the resultant vapour plume could theoretically travel to a point of ignition.[30] The volume of gas discharged during the Gadila experiment was comparatively small, amounting roughly 1½ railcarloads. By contrast, the unscheduled rupturing of even a single tank aboard an ocean-going LPG carrier could lead to the potential discharge of up to many thousands of cubic metres of gas over a relatively short period of time, depending upon the nature and location of the hull penetration. Under this type of worst case situation, and in the extremely unlikely event that the escaping LPG does not ignite immediately at the point of the tank rupture, the potential formation of a vapour cloud of up to several kilometres in length must be viewed as a real possibility.

Generally speaking, however, in the event of a high impact shipping accident (such as a collision with another vessel or structure, grounding, or act of sabotage) resulting in an uncontrolled large volume discharge of LPG, the debate over vapour cloud characteristics would almost certainly be reduced to a purely academic level. The friction heat and/or static charges generated during such an event would normally be sufficient to ignite the escaping gas vapours instantaneously.

Based upon numerous smaller scale LPG explosions involving road tankers, railcars, and storage facilities, and upon limited LNG fire experience, it is possible to speculate as to the probable form which a major ship-based LPG fire might take. Typically, liquefied gas would pour out of the rupture, much of it vapourizing upon entry into the atmosphere. The rest, remaining temporarily in a cold, liquid state, would quickly spread over the surface of the water. Upon ignition, a huge vertical column of flame would be produced, and the fire would rapidly extend to the outer extremities of the "pool" of liquefied gas which had formed on the water. The ultimate outward spread of the fire would be directly dependent upon such influencing factors as wind speed and direction, tidal conditions, and the rate of volume discharge of gas from the holed tank.

The cardinal rule for fighting liquefied gas fires is to avoid extinguishing the blaze until the source of the leak has been effectively sealed off. Failure to follow this procedure will almost certainly result in repeated vapour cloud flashback and re-ignition of the pool. To all intents and purposes, then, the only practical way to handle a large shipboard gas fire caused by a tank rupture is to allow it to burn itself out. Unfortunately, while this might be a theoretically acceptable procedure for tackling a gas-fuelled fire aboard a vessel at sea, it would leave much to be desired when applied to a congested, physically restricted harbour situation. Under certain circumstances, it has been estimated that a fire aboard an ocean-going LPG carrier could burn for many days or, in theory, even months.[31] Furthermore, once the fire takes hold, the hazard potential increases markedly. Characteristically, gas fires tend to burn at very high temperatures. At the height of the 1944 LNG fire in Cleveland, for example, flame temperatures reportedly reached as much at 1650° C, and the intense radiant heat generated by the conflagration ignited buildings 650 metres distant.[32] Significantly experimental flame temperatures recorded for both butane and propane have been marginally higher than for methane, the principal component of LNG. During tests conducted by the U.S. Coast Guard, flame temperatures of up to 1875° C have been recorded for methane, as oposed to temperatures of 1895° C and 1925° C for butane and propane respectively.[33] Thus, a fire aboard an LPG carrier in a harbour such as Vancouver (where the minimum north-south width between the First Narrows and the Second Narrows is only 200 metres and the maximum is seldom more than 2000 metres) could lead to extensive indirect shoreside combustion. The prospect of a massive mid-harbour LPG conflagration takes on an added dimension when one considers the wide range of toxic and combustible materials which are routinely stored in railcars and tank farms on both sides of Burrard Inlet, including chlorine, propane, ethylene dichloride, methanol, sulphuric acid, and many others.

Another inherent shortcoming with the "let it burn" approach to LPG fire management is that the longer the fire burns, the greater the risk that those cargo tanks which did not rupture during the initial impact may collapse from heat-induced structural failure. In the only comparable maritime accident involving LPG - that is, the 1974 collision between the Liberian-registered freighter Pacific Ares and the Japanese LPG/naphtha carrier Yuyo Maru - the Yuyo's naphtha tanks were breached upon impact and ignited instantly. Initially, no fewer than 11 fire fighting vessels were dispatched to deal with the fire. However, due to the intense heat generated by the burning naphtha, the fireboats were unable to get near enough to the Yuyo to bring the flames under control.[34] Nevertheless, through a combination of sound design, good luck, and constant water cooling by attending fireboats, the Yuyo's LPG tanks remained intact throughout.[35] Nothwithstanding the rather fortuitous circumstances which prevented the Yuyo's LPG tanks from collapsing, the very real threat of heat-induced tank failure should by no means be discounted.

All of this leads to an interesting point of conjecture. If a loaded LPG carrier was involved in serious, tank-penetrating collision in Burrard Inlet, could systematic failure of those cargo tanks which had not been initially damaged be avoided? Obviously there is no concrete answer to this question. There are, however, certain factors which would tend to distinguish an accident involving the Nichizan Maru from the one which consumed the Yuyo Maru. For instance, a cargo fire aboard the Nichizan Maru would be fueled by propane, which burns at a higher temperature than the naphtha which was involved in the Yuyo Maru disaster. Secondly, the Port of Vancouver, with only one fireboat at its disposal, would almost certainly be unable to contain a major shipboard LPG fire. This latter limitation would be further compounded should the City of Vancouver ever choose to follow through on its periodic threat to withdraw the fireboat from service completely due to rapidly escalating costs and an unwillingness on the part of other local municipalities and harbour agencies to contribute to the fireboat's upkeep and operating expenses.[36] The loss of the fireboat under these circumstances would seriously inhibit any attempt to mount a co-ordinated offensive against an LPG fire, and would effectively remove the one functional unit which is best trained and equipped to deal with such an emergency. Ironically, at a time when the trend towards increased shipborne movements of all manner of hazardous materials is on the upswing in the port, one might argue that the real issue at hand should not be focussed upon the possible withdrawal of the existing fireboat from service, but whether or not more specially-designed emergency response vessels are actually required.

The question of whether undamaged LPG tanks could be prevented from rupturing in the event of a serious mid-harbour gas fire remains moot. Nevertheless, the previously-discussed factors of limited local emergency response capability and the use of propane, instead of naphtha, as the principal fuelling agent, suggest that the likelihood of systematic tank failure in the event of a fire aboard a loaded gas carrier in Burrard Inlet would be greater than it was for the Yuyo Maru. The impact of such a tank failure in a crowded harbour setting would be enormous; the effects possibly catastrophic.

3.3.3 The Gas Tanker Safety Record

3.3.3.1. Phase I - 1964-1978

In the face of often severe public criticism, gas tanker proponents have long maintained that LNG and LPG carriers are among the safest, most accident-free vessels afloat. Prior to the late 1970's, industry officials were quick to point out that only one "total loss" accident involving a gas tanker had ever occurred. That, of course, was the ill-fated Yuyo Maru, which burned out of control for some 19 days after colliding with the freighter Pacific Ares in November of 1974. The Yuyo Maru was eventually sunk by Japanese naval gunfire on 28 November 1974 after it had been determined that the vessel's cargo of LPG and naphtha could continue to burn for up to several months.

Nevertheless, it would be erroneous to presume that, aside from the Yuyo Maru disaster, the gas tanker safety record has remained unblemished throughout. In fact, recent comments by Captain Alberto Allievi, gas and chemical shipping safety co-ordinator for Esso Europe, suggest that quite the opposite has been true. Captain Allievi indicates that between 1964 and 1977, some 376 gas carriers of fewer than 5000 cubic metres capacity experienced a total of 394 vessel casualties - or 2.34 casualties per month. Large gas carriers (that is, those in excess of 5000 cubic metres) suffered an average of 1.2 casualties per month during this period.[37]

Unfortunately, the article from which Captain Allievi's comments were extracted ("Smaller gas carriers bigger casualty risks," Lloyd's List, 10 April 1981) is, for the purposes of this study, deficient in two very important respects. Firstly, it provides little insight into the specific nature or severity of the casualties in question. In marine insurance terms, a vessel "casualty" could constitute anything from a relatively minor incident which would not compromise the safety of either the vessel or its crew, to a total loss situation (such as that experienced by the Yuyo Maru). Secondly, the article fails to distinguish between incidents involving LPG carriers as opposed to LNG carriers.

A review of several published accounts dealing primarily with the LNG safety issue revealed 29 separate incidents involving LNG carriers, but only six involving LPG carriers, during the period 1964-1978.* Among the mishaps chronicled for this period were several experienced by the world's first LNG carriers - the Aristotle (formerly the Methane Pioneer), and the 27 400 cubic metre sister ships Methane Princess (1964) and Methane Progress (1964). All of these vessels have, from time to time, proven to be disturbingly susceptible to a host of mechanical malfunctions and serious errors in human judgment, as illustrated by the following series of events which befell Aristotle during a single 24-month period in the mid-1960's:[38]

November 1966:	Damage to main bearing results in mid-ocean breakdown requiring 53 days to repair.
Date unspecified, 1967:	Cylinder liner breaks. Two cargo pumps subsequently damaged.
September 1968:	Stranded for 61 hours off coast of Mexico following grounding. Sustains minor bottom damage and requires tug assistance to refloat.
November 1968:	Loses rudder in storm north of Azores. Towed to Boston for repairs.

Both the Methane Princess and Methane Progress have, at various times, experienced cargo containment system disorders ranging from "cold spots" on the inner hull (caused by construction defects in the cryogenic insulation) to more serious structural cracking.[41] In 1974, the Methane Progress was reportedly laid up for more than 70 days while repairs were made to her steering gear following a grounding episode at Arzew, Algeria.[42] In December of the same year, she was rammed in the stern by the British coaster Tower Princess.[43] Fortunately, the accident was well removed from the cargo tanks and there was no spillage of LNG.

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*For a more detailed chronology of reported incidents involving liquefied gas carriers from 1964 to 1982, refer to Appendix II (for LPG tanker casualties) and Appendix III (for LNG tanker casualties).

Another noteworthy incident which occurred during the 1964-1978 period involved the small Swedish gas carrier Claude. In the fall of 1968, while carrying some 900 cubic metres of liquefied butane, Claude collided in fog with a British freighter off Southampton, England. The following account of the accident is from Noël Mostert's Supership:

> "Seconds after the collision," Captain Bayley writes (in Safety at Sea International, J.C.M.), "the pilot of the Claude found himself alone on the bridge of the stricken ship, the rest of the crew having jumped into the fog-shrouded water. The gas tanker's engine was left turning with a slight reverse pitch on the propeller! The pilot knew nothing of the cargo beneath him, but figuring that the crew knew what was best for their own skins, he too abandoned ship." The abandoned Claude drifted back the way she had come, assisted by her propeller and the tide, and went aground. The drama however did not end there. The ship was towed to a refinery and a Portuguese gas ship was chartered to take off the Claude's cargo. During the transfer operation one of the hoses sprang a leak and a "vast cloud of gas was carried on the wind towards the refinery and the city of Southampton.
>
> "In a fine display of panic...the Portuguese tanker steamed away, ignoring the rupturing of hoses and pipelines, inestimably increasing the risk of explosion. The rapid evaporation of the liquid gas caused ice to form and volunteers working without gas masks...had a hard job to close the valves left open by the departing gentlemen of Portugal."[42]

The Claude episode was one of the first to draw public attention to the hazards associated with the marine carriage of bulk liquefied gases. It also served to illustrate, with considerable emphasis, the extent to which the human factor can have a serious, even debilitating, effect upon the safe operation of any vessel. Even so, the total volume of gas involved was small by present shipping standards and, accordingly, the damage potential somewhat limited in terms of physical scope.

In addition to the incidents already described in this chapter, gas carriers were involved in a variety of episodes between 1964 and 1978, including collisions (Euclides - 1974; LNG Challenger - 1977 and 1978; Lincolnshire - 1977; and Khannur - 1978), groundings (Euclides - 1974), shipboard fires (Milli - 1974), and, in at least one instance, breaking adrift from secure moorage during storm-force winds and severe tidal conditions (LNG Aries - 1978).

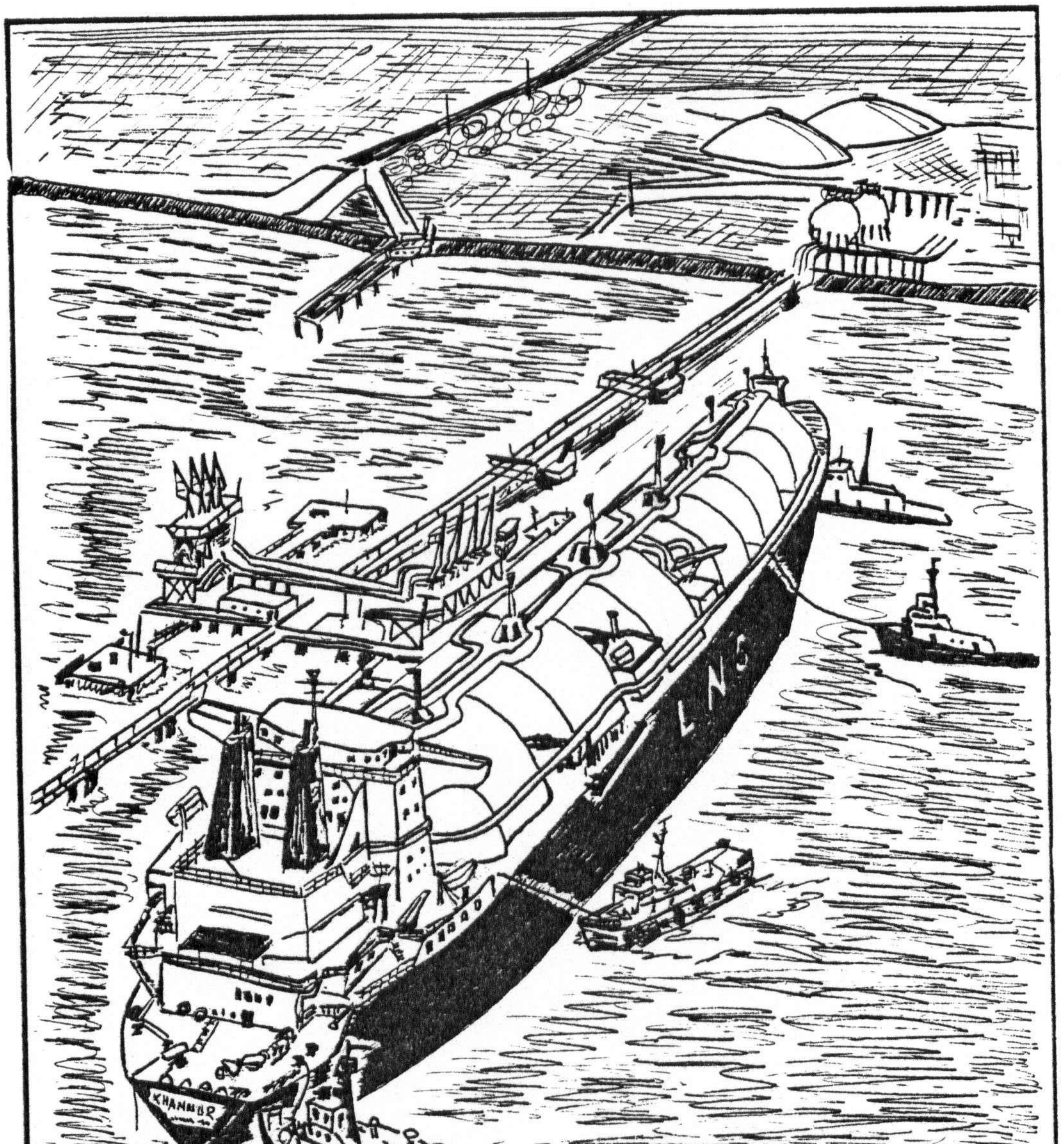

Figure 3.3 LNG Carrier Khannur at Sodegaura, Japan

3.3.3.2 Phase II - 1979-1982

The preceding findings for the period 1964-1978 are disconcerting in two respects. Firstly, they represent only a fraction of the more than 400 gas tanker casualties referred to by Captain Allievi of Esso Europe for the corresponding period. Furthermore, only six of the 35 incidents documented involved LPG carriers. Small and large LPG carriers have traditionally outnumbered LNG carriers by a very wide margin. In fact, in 1966 operating LPG carriers outnumbered LNG carriers by a ratio of 29 to 1 (145 LPG carriers to 5 LNG carriers); by 1977, the ratio stood at approximately 11 to 1 (441 LPG carriers, as opposed to 39 LNG carriers).[43] This would tend to suggest that either a) LNG tankers have had a significantly higher accident rate than LPG carriers, or b) the researchers who compiled gas tanker accident statistics during the 1960's and 1970's were biased towards incidents involving LNG carriers and, as such, tended to overlook all but the most serious LPG tanker mishaps. The latter explanation would seem to be the more appropriate of the two. However, in the absence of detailed information to support this hypothesis, a daily analysis was conducted of all LPG and LNG accident reports filed with Lloyd's List between 28 June 1979 and 28 February 1982 - a total of 32 months. The findings of this investigation are especially interesting in that they appear to cast serious doubt upon the long-held claim that liquefied gas carriers are inherently safer and, hence, less susceptible to serious mishaps than other types of cargo ships.

During the course of the review period, 85 incidents of note involving LPG carriers were identified, as opposed to 23 LNG casualties.* The results of the review for each category of vessel (LPG and LNG) are as follows:

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*Note: Approximately 10% of the total number of LPG and LNG casualties identified were removed from the analysis due to the clearly insignificant nature of the event.

Table 3.3: LPG Incidents of Note
28 June 1979 - 28 February 1982

Casualty Type

Casualty Status	G	C	T	L	W	M	S	F	E	Total
O	0	5	0	0	0	5	1	0	0	11
◐	4	7	2	2	3	7	2	2	0	29
●	13	1	2	2	3	8	3	1	0	33
●●	2	0	0	1	0	0	0	4	2	9
●●●	1	0	1	0	1	0	0	0	0	3
Total	20	13	5	5	7	20	6	7	2	85

Source: *Lloyd's List*, various editions

Table 3.4: LNG Incidents of Note
28 June 1979 - 28 February 1982

Casualty Type

Casualty Status	G	C	T	L	W	M	S	F	E	Total
O	1	4	0	0	0	1	0	0	0	6
◐	0	1	0	1	2	4	0	0	0	8
●	0	0	1	0	0	0	1	1	0	3
●●	3	0	0	0	0	0	0	0	0	3
●●●	0	0	3	0	0	0	0	0	0	3
Total	4	5	4	1	2	5	1	1	0	23

Source: *Lloyd's List*, various editions

Explanation of Symbols for
Tables 3.3 and 3.4 (above):

A. Status of Casualty Symbols

O Minor incident - little or no damage

◒ Incident of undetermined status

● Serious incident, but not critical to vessel or crew safety

●● Very serious incident - imminent danger to safety of vessel, crew, and/or public

●●● Total loss of vessel

B. Casualty Type Symbols

G - grounding

C - collision or contact with another vessel or obstacle (such as a pier, bridge, etc.)

T - damage to cargo containment system

L - damage to cargo handling system

W - weather damage

M - damage to the vessels mechanical or electrical system

S - steering/propeller damage

F - fire

E - explosion

Prior to examining the results of Tables 3.3 and 3.4 (above) in greater detail, a few words of explanation as to how these tables were derived is in order. The "casualty type" classifications are essentially self-explanatory and, as such, require little further elaboration. The "casualty status" classifications, on the other hand, represent an attempt to categorize incidents based on the perceived degree of severity attributable to each mishap. In many instances, there was insufficient information presented in the daily Lloyd's List casualty reports to enable a meaningful judgment as to the severity of a particular mishap. These incidents of undetermined status are noted thusly "●", and account for approximately 34% of the total number of LPG accidents recorded, and 35% of the LNG accidents recorded. The perceived differentiation between minor incidents (O) and serious incidents (●) is perhaps open to the broadest interpretation. This is particularly true under such "casualty type" categories as groundings, collisions, and mechanical/electrical system disorders. For example, under the heading "groundings", the position has been taken that a situation in which a vessel briefly touches bottom, but does not remain hard aground and does not incur bottom damage as a result, should be viewed as a minor incident. On the other hand, during any instance whereupon a vessel grounds, and subsequently remains stranded for a period of time, the episode will be viewed, at the very least, as a serious incident, even if the ship is deemed to have suffered no appreciable damage as a result of the accident.

With regard to incidents involving collisions between two or more vessels, low speed "contact" casualties resulting in superficial or cosmetic damage only (classified as minor incidents) are distinguished from more significant incidents involving hull penetration or internal damage to the gas carrier or other vessel (classified as serious, at the very least).

On the matter of mechanical or electrical system disorders, the criterion of mobility has been used as the distinguishing feature between serious and minor incidents. That is, if a vessel is rendered immobile as a result of an engine malfunction and requires towing assistance to reach port, the incident would be viewed as serious. Conversely, if a vessel experiences a mechanical or electrical disorder, but is still able to proceed under its own power, the incident would be considered minor (unless, of course, there are significant and well-documented extenuating circumstances to suggest otherwise).

The very serious classification (●●), simply stated, applies to circumstances in which, as a result of mishap, the safety of a vessel, its crew, or, in some instances, the general public has been placed in a position of great jeopardy. In most, although not all, cases the presence of LPG or LNG aboard a vessel in distress may be the distinguishing characteristic between a serious and a very serious incident. In fact, in at least six (and possibly seven) of nine very serious LPG accidents identified during the 1979-1982 review period loaded gas tankers were involved. Similarly, of three very serious LNG accidents, two involved loaded vessels (see Table 3.5 - Page 81).

Lastly, for the purposes of this thesis, total loss casualties (●●●) refer to those situations wherein a vessel, by reason of misadventure or some form of technical limitation, is rendered permanently unable to transport liquefied gases. In this respect, the total loss category is somewhat misleading in that it need not involve the actual sinking of a vessel. In fact, of six LPG and LNG total losses identified between 1979 and 1982, only two involved vessel sinkings. Moreover, in both instances the sinkings were undertaken deliberately. The LPG carrier Babounis Costas was scuttled off the coast of Nigeria in December of 1979, some two months after experiencing severe leaking problems near Lagos. The LPG carrier Gaz East, which capsized in high winds off the French Riviera during October of 1980, was subsequently sunk by the French navy because it presented an unacceptable risk to shipping and public safety.

Table 3.5: Very Serious Casualties: Impact Assessment for the Period 28 June 1979 - 28 February 1982

Date	Vessel (Type)	Cargo (m^3)	Nature of Mishap	Loss Of Life	Injured	Evacuated
29 June 79	E.P. Paul Kayser (LNG)	99 500	Grounding	Nil	Nil	?
18 Sept 79	Jatai (LPG)	Empty	Explosion	1	4	Nil
28 Dec 79	Butaseis (LPG)	1 200	Fire	Nil	Nil	Nil
21 Jan 80	Regitze Tholstrup (LPG)	400	Grounding	Nil	Nil	Local Area
25 Jan 80	Rudi M. (LPG)	Empty	Fire	1	4	Nil
17 Aug 80	Cetane (LPG)	?	Explosion	Nil	?	Nil
12-14 Sept 80	Mary Else Tholstrup (LPG)	630	Grounding & Explosion	Nil	2	Nil
12 Dec 80	LNG Taurus (LNG)	125 000	Grounding	1	Nil	Nil
24 Apr 81	Prins Maurits (LPG)	Empty	Fire & Explosion	Nil	2	Nil
16 May 81	Gaz Fountain (LPG)	38 500	Fire	Nil	Nil	Nil
31 May 81	Olav Trygvason (LPG)	4 100	Discharge Spill	1	2	Nil
17 Dec 81	E.P. Columbia (LNG)	Empty	Grounding	Nil	Nil	Nil
			TOTALS	4	14	

Source: Lloyd's List, various editions.

Of the 108 combined LPG and LNG casualties recorded in Tables 3.1 and 3.2, those falling under the very serious and total loss categories should be viewed with particular concern in that they represent, with few exceptions, the greatest threat to vessel and crew safety. While the basic circumstances surrounding each of these incidents are described in Appendices II and III, a brief review of some of the more significant gas tanker accidents to have occurred since 1978 is warranted. For example, there is the spectre of a serious fire aboard the LPG carrier Gaz Fountain, loaded with some 38 500 cubic metres of propane and butane, or the capsizing and subsequent sinking by the French navy of the ill-fated tanker Gaz East and its cargo of 2000 cubic metres of liquefied butane. Furthermore, one should not overlook the tremendous burden of responsibility assumed by the crews of these vessels. The uniquely hazardous nature of unconventional liquefied gas cargoes must surely add an extra dimension of pressure on even the most seasoned mariners. Captain Peter Winkler of the Algerian LNG carrier Larbi Ben M'hidi offered the following comments to Vancouver Sun reporter Alan Daniels during a November 1980 shipboard interview at Boston, Massachusetts:

> The most dangerous time is during discharge...If a pipe breaks, if a valve was suddenly shut off ashore and there was a surge of pressure which fractured a pipe, enough LNG would be spilled on deck before the emergency shut off could be operated that the deck would crack open. The LNG would fall onto a tank below and it would also rupture. In such a case a fire would be a certainty because there are enough hot points to set it burning. A fire in one tank could not be fought and because of the heat the other tanks would certainly be melted and all would go. The disaster, in a crowded metropolitan area, would be unimaginable.[44]

On the morning of 12 December 1980, the American liquefied gas tanker LNG Taurus, inbound for Tobata, Japan ran aground near Moji, off the west coast of Honshu. LNG Taurus was loaded with some 125 000 cubic metres of LNG at the time of the accident, which occurred during poor weather conditions.[45] On 15 December 1980, the vessel's master, Captain C.L. Peterson, anguished over an accident for which he accepted full responsibility, committed suicide in his stateroom while his vessel was still aground, although apparently in no immediate danger.[46]

However, the one incident which symbolizes both the best and worst of the liquefied gas tanker safety argument involved the 29 June 1979 grounding of the 125 000 cubic metre capacity LNG carrier El Paso Paul Kayser. The Liberian-registered E.P. Paul Kayser, loaded with some 99 500 cubic metres of Algerian LNG, was outbound in fog through the Strait of Gibraltar when she ran aground off the Spanish coast while apparently attempting to avoid collision with another ship.[47] The grounding occurred while the E.P. Paul Kayser was travelling at service speed (18 knots), and resulted in a massive 170-metre long penetration of her outer hull.[48] Eventually, some 95 000 cubic metres of cargo was removed to her sister ship the El Paso Sonatrach in what constituted, up until that time, an unprecedented ship-to-ship gas transfer manoeuvre. The E.P. Paul Kayser was refloated on 4 July 1979, and was subsequently towed to St. Nazaire, France in order to effect repairs which would take almost two years to complete.

Prior to examining some of the more significant safety implications associated with the E.P. Paul Kayser accident, one must first draw attention to the fact that the cargo containment system successfully withstood the enormous impact of the grounding. This, in itself, is a great tribute to the vessel's designers (Gaz/Transport, Paris) and her builders (Chantiers de France, Dunkerque). Nevertheless, in spite of the substantial technological advances which have been made over the past decade with regard to gas tanker design and safety, the E.P. Paul Kayser episode services to once again underscore the critical importance of the human factor. In the absence of a detailed account of the events leading up to the grounding of the E.P. Paul Kayser, many questions remain unanswered. However, if the limited details of the accident which have been presented in such normally reliable publications as Lloyd's List, Clarkson's Liquid Gas Carrier Register, and Marine Engineering/Log are correct, one might reasonably presume that the E.P. Paul Kayser was travelling well in excess of what would normally be considered a safe speed, given the prevailing (foggy) weather conditions, the proximity of the vessel to land, and the general state of congestion which exists in the Strait of Gibraltar, one of the world's busiest waterways. Under these circumstances, it would be difficult to conclude that the grounding was not attributable, in large measure, to a very serious error in judgment on the part of the master of the E.P. Paul Kayser.

In retrospect, had the above-described accident involved an older vessel, or one of lesser design quality than the E.P. Paul Kayser, the results may have been much worse. More importantly, if a severe grounding such as the one which disabled the E.P. Paul Kayser can happen, there is little to suggest that, as a result of human error or mechanical failure, a high speed collision involving one, or possibly even two, large gas carriers could not occur. In the event of such a collision, the likelihood of deep tank penetration would normally be considered much greater than it would in a grounding accident. A recent study by the Norwegian classification society, Det norske Veritas, indicates that a 10 000 deadweight ton (dwt) vessel colliding broadside with a stationary 125 000 cubic metre LNG carrier employing the Kvaerner-Moss spherical tank containment design (which is considered to be theoretically one of the most impact resistant of all gas containment systems) could penetrate the cargo tank wall at a speed of approximately 11 knots, assuming that the point of impact occurred at or near mid-tank - that is, at the point where the sphere is closest to the hull.[49] The report further theorizes that a 50 000 dwt vessel colliding with a Kvaerner-Moss design gas carrier under identical circumstances could pierce the cargo containment wall at only 6 knots. Another, less optimistic, analysis prepared by the firm of Arthur D. Little, Inc. indicates that a 38 000 dwt vessel colliding at a 90° angle with a berthed 120 000 cubic metre LNG carrier incorporating the Technigaz/Conch Ocean membrane containment design would have sufficient forward momentum to cause a gas spill at only 3.4 knots.[50]

Both the norske Veritas and Arthur D. Little studies apply to LNG, rather than LPG, carriers. There are, however, several considerations which would suggest that LPG carriers would, in fact, be more susceptible to low speed hull penetration in the event of a collision than would their LNG counterparts. For example, whereas the vast majority of LNG carriers are double hulled, most LPG carriers are not.[51] Furthermore, LNG tanks are designed to accommodate cargoes at cryogenic temperatures, whereas LPG tanks are not. Accordingly, the stress analysis requirements for LPG tanks, as established by the International Maritime Consultative Organization (IMCO) codes for new and existing gas carriers, are less stringent than for LNG tanks.[52] In the only comparable real-life collision event involving a liquefied gas carrier, the 16 000 dwt Pacific Ares was travelling at an estimated 4-7 knots when she penetrated the hull of the LPG/naphtha tanker Yuyo Maru in Tokyo Bay.[53]

That there have not been more gas tanker accidents on the scale of the Yuyo Maru disaster is, in itself, quite remarkable. However, as more large gas carriers are introduced, and as the existing fleet becomes progressively older, the probability of a major accident occurring will increase.

Undoubtedly, technological advances in ship construction, navigational aids, and the development of superior cargo containment designs will provide upcoming generations of vessels with an added dimension of safety. Nevertheless, the grounding of the El Paso Paul Kayser clearly demonstrates that technological innovation cannot, in itself, completely offset the potential manifestations of the one truly weak link in the hazard prevention chain - and the one which, for that matter, cannot be effectively legislated out of existence - human error. It has been estimated that fully 80% of all marine accidents are based upon at least a measure of human error or negligence.[54]

Under these rather foreboding circumstances, the medium range outlook for gas tanker safety can perhaps best be summed up in the words of Captain Richard Simonds of the U.S. Coast Guard:

> We've just been plain lucky so far. A major incident must occur. We're just waiting. It's a question of when, not if.[55]

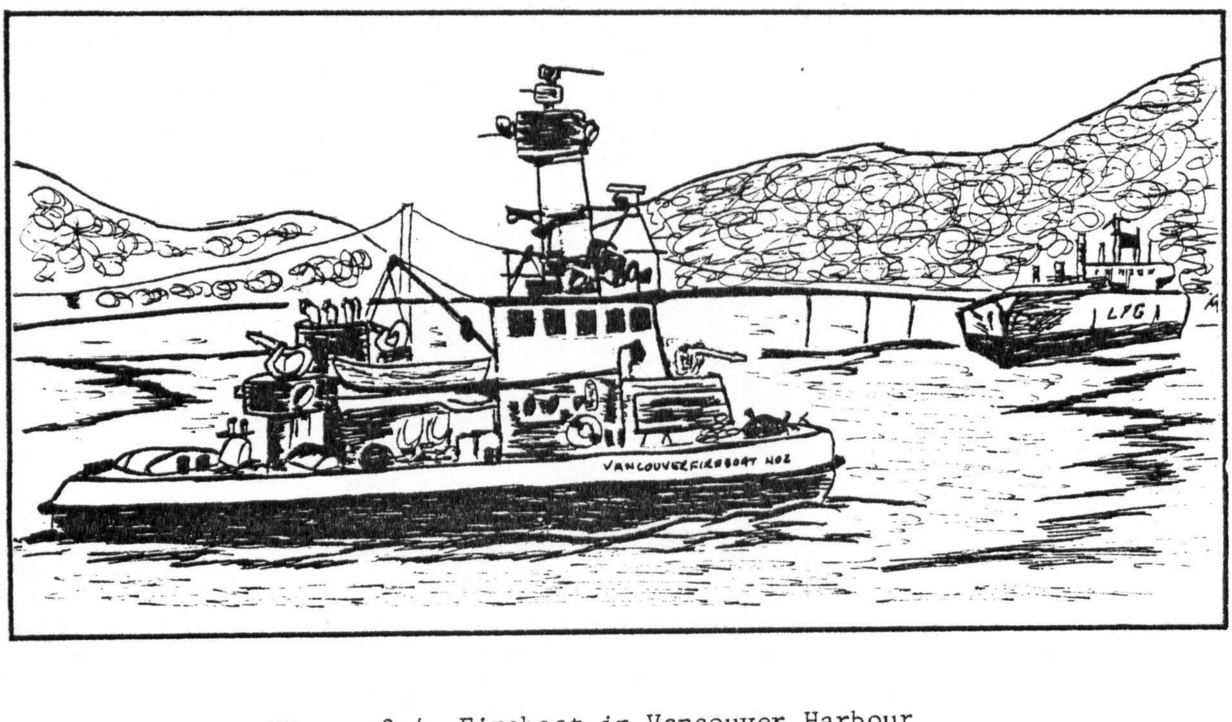

Figure 3.4 Fireboat in Vancouver Harbour

FOOTNOTES - CHAPTER 3.0

1 "Special Report - Gastech '81", Lloyd's List, 20 October 1981.

2 Since the first LNG tankers were introduced more than two decades ago, more than 20 different insulated LNG containment systems have been proposed. Basically, these systems can be grouped into three main categories: 1) free standing tanks (i.e. self-supporting structural entities which do not form an integral part of the hull structure, and do not contribute to hull strength); 2) membrane tanks (which are non-self-supporting tanks in the form of compartments bounded by the ship's hull structure, and lined with insulation and primary and secondary barriers); and 3) semi-membrane tanks (which are a hybrid of both free-standing and membrane tank designs). For an excellent introduction to the variouis LNG cargo containment systems presently in use or in the conceptual design stages, refer to Charles Zeien and William Dubarry Thomas, "Ship Containment Systems," Seminar on Natural Gas from the Arctic by Marine Mode: A Preliminary Assessment (Ottawa: 1977), pp. 91-107.

3 Lee N. Davis, Frozen Fire (San Francisco: Friends of the Earth, 1979), p. 45.

4 H. Clarkson & Company Limited, Liquid Gas Carrier Register - 1980 (London: H. Clarkson & Company Limited, 1980), p. 16.

5 Ibid., p. 17.

6 "More obstacles for Pac-Indonesia orders", Lloyd's Shipping Economist, Vol. 3, No. 2 (February 1981), p. 36.

7 Lloyd's Shipping Economist, Vol. 3, No. 2 (February 1981), pp. 34-36.

8 H. Clarkson & Company Limited, Liquid Gas Carrier Register - 1981 (London: H. Clarkson & Company Limited, 1981), p. 144.

9 "Ocean's figures might even surprise the optimists", Lloyd's List, 19 June 1981.

10 "The El Paso Effect", Lloyd's Shipping Economist, Vol. 3, No. 2 (February 1981), p. 5; and "El Paso fleet is laid up for sale", Lloyd's List, 26 January 1981; and Lloyd's List, 9 April 1981.

11 "Kockums order to reconstruct CMB gas carrier", Lloyd's List, 19 June 1981.

12 H. Clarkson & Co. Ltd., op. cit. (London: 1980), p. 16.

13 Ibid., p. 16.

[14] As of 1 January 1980 the world LNG fleet contained 27 vessels in excess of 100 000 m^3 capacity, with 17 more ships in this category on order for delivery by 1982. By contrast, only two LPG carriers are in the 100 000 m^3 category - the Esso Westernport (101 000 m^3) and the Esso Fuji (100 200 m^3). The largest LPG tanker scheduled for delivery to the end of 1982 will have a capacity of 83 000 m^3. Ibid., p. 22 and p. 28.

[15] Trans Mountain Pipeline Company Ltd., Annual Reports 1975-1981 (Vancouver: 1976-1982).

[16] Davis, op. cit., p. 269.

[17] Richard G. Wooler, Marine Transportation of LNG and Related Products (Cambridge, MD: Cornell Maritime Press, 1975), pp. 88-97.

[18] Peter van der Linde, Time Bomb (Garden City: Doubleday & Company, Inc., 1978), p. 26.

[19] Based upon information contained in a letter to the author from Mr. Paul Roshkind, Manager, Marketing Services, Port Authority of New York and New Jersey, dated 4 January 1980.

[20] James A. Fay, "Risks of LNG and LPG", as extracted from Annual Review of Energy - 1980, p. 5:92.

[21] Oceanographic Institute of Washington, LNG and LPG Hazards Management in Washington State (Seattle: December 1978), p. 1-8.

[22] Fay, op. cit., p. 5:101.

[23] U.S. Coast Guard (Department of Transportation), Liquefied Natural Gas and Liquefied Petroleum Gas - Views and Practices (Washington, D.C.: circa February 1980), p. 32.

[24] Davis, op. cit., pp. 269-282.

[25] Oceanographic Institute of Washington, op. cit., p. VII - 7; and U.S. Coast Guard, LNG and LPG - Views and Practices, p. 11.

[26] U.S. Coast Guard, LNG and LPG - Views and Practices, p. 11.

[27] F.W. Murray et al, Hazards Associated with the Importation of Liquefied Natural Gas (Santa Monica: Rand Corporation, 1976), p. 48.

[28] The Termpol Co-ordinating Committee's Assessment Report on Dome Petroleum Limited's Proposal to Construct and Operate a Liquefied Natural Gas Marine Terminal at Grassy Point, Port Simpson Bay, B.C. (Vancouver: Canadian Coast Guard, May 1982), from the Environmental Assessment and Risk Analysis Sub-Committee Report, p. 9.

[29] Davis, op. cit., pp. 42-43.

30 U.S. Coast Guard (Department of Transportation), Predictability of LNG Vapor Dispersion from Catastrophic Spills onto Water: An Assessment (Washington, D.C.: April 1977), pages 24, 50, and 80.

31 van der Linde, op. cit., p. 23.

32 Ibid., p. 13; and Davis, op. cit., p. 35.

33 U.S. Coast Guard, LNG and LPG - Views and Practices, p. 7.

34 "34 feared lost in fiery ship explosion," The Vancouver Sun, 9 November 1974, p. 1.

35 Based upon an account of the Yuyo Maru disaster by the Japanese Maritime Safety Agency, as reported in Davis, op. cit., pp. 79-80; and van der Linde, op. cit., pp. 17-23.

36 "Fear of inferno in Vancouver haunts experts", The Vancouver Sun, 2 September 1980.

37 "Smaller gas carriers bigger casualty risks", Lloyd's List, 10 April 1981.

38 van der Linde, op. cit., pp. 64-65.

39 Robert P. Curt et al, Marine Transportation of Liquefied Natural Gas, (King's Point, NY: a report produced under the auspices of The National Maritime Research Center, 1973), p. 178; and Wooler, op. cit., pp. 25-31.

40 P.L.L. Vrancken and J. McHugh, "Twelve Years Operating Experience with Methane Princess and Methane Progress", LNG-5 (Dusseldorf: 1977), Session VI, Paper 6, Part II, as described in Davis, op. cit., p. 52 (footnote #11).

41 Davis, op. cit., p. 70.

42 Based upon an extract from an article by a Captain Bayley in Safety at Sea International (date undetermined), as reported in Noel Mostert, Supership (New York: Warner Books, Inc., 1976), pp. 372-373.

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44 "Cargo has a city holding its breath", The Vancouver Sun, 15 November 1980, p. A10.

45 "LNG carrier aground with explosive cargo", Lloyd's List, 13 December 1980.

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47 Lloyd's List, 29 June 1979.

48 H. Clarkson & Co. Ltd., op. cit. (London: 1980), p. 4.

49 From an unpublished report prepared by Det Norske Veritas, as reported in Davis, op. cit., p. 74.

50 Arthur D. Little, Inc., "The Collision Resistance of the Ben Franklin", cited in General Accounting Office, Liquefied Energy Gases Safety, Vol. III, p. 519, as reported in Oceanographic Institute of Washington, op. cit., p. II-II.

51 Comptroller General of the United States, Report to the Congress - Liquefied Energy Gases Safety (Washington: 31 July 1978), Vol. 1, p. 6-6.

52 Ibid., p. 6-6.

53 Based upon an account of the Yuyo Maru disaster by the Japanese Maritime Safety Agency, as cited in van der Linde, op. cit. p. 19.

54 Oceanographic Institute of Washington, op. cit., p. II-6.

55 Captain Richards Simonds, USCG, as quoted in van der Linde, op. cit., p. 65.

4.0 THE PUBLIC SAFETY IMPERATIVE: A REVIEW OF SPECIAL REQUIREMENTS FOR LIQUEFIED GAS CARRIERS OPERATING IN SELECTED WORLD PORTS

4.1 Overview

Due to the unique nature of their cargoes, liquefied gas carriers began to attract special attention among ship insurers, classification societies, and government regulatory agencies long before the Methane Pioneer embarked upon her historic trans-Atlantic voyage from the U.S. Gulf Coast to Canvey Island back in 1959. Recognizing the enormous hazard potential inherent in the sea-borne carriage of liquefied gases generally, these and other organizations, through the auspices of the U.N.-affiliated Intergovernmental Maritime Consultative Organization (IMCO), have been instrumental in contributing to the gradual evolution of a sound code of minimum standards governing both the construction of new gas tankers and the retrofitting of existing ones.[1] A few nations - notably the United States - have seen fit to re-define many of these standards, at least to the extent that they relate to domestic flag vessels, in order to further reduce the associated operational risk factor.* Similarly, several countries have endeavoured to upgrade existing manning standards for liquefied gas carriers through the application of specialized officer and crew training requirements.

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* Recently, the U.S. Coast Guard refused to certify three 127 800 cubic metre capacity LNG carriers under construction at Avondale Shipyards in New Orleans for the El Paso Marine Company. Coast Guard inspectors discovered cracks in the polyurethane insulation surrounding the vessels' cargo tanks. The builder was unable to isolate the cause of the problem, nor was it possible to modify the hull structure to incorporate a new cargo containment system. In October 1980, a group of insurance companies agreed to pay El Paso $300 million in the largest marine insurance settlement in history. The three vessels were eventually sold, and were scheduled to be converted into dry bulk carriers. In December of 1981, one of the ships, El Paso Columbia, ran aground off the coast of Nova Scotia while under tow for Halifax, where she was to be temporarily laid up. The future of El Paso Columbia is now in doubt.[2]

The critical phase in the operational cycle of a gas tanker occurs when it is in port - that is, during the arrival, loading/unloading, and departure stages. It is at this point - particularly during the arrival and departure intervals - that the vessel is most vulnerable to the potential effects of both human error and mechanical failure. According to Captain W.S.G. Morrison of the Canadian Coast Guard, "...about 80% of the accidents to ships occur in...restricted waterways and harbours."[3] Such external factors as harbour congestion, lack of familiarity with the layout of the port, pilot control, tidal conditions, and weather, to name but a few, may all contribute, to a greater or lesser degree, to this generally increased state of vessel susceptibility to mishap. It must also be recognized that if the level of risk to the vessel is likely to be heightened in port, then so too is the potential level of impact upon the surrounding community in the event of a serious shipboard accident. Accordingly, most port and harbour authorities around the world have chosen to introduce extraordinary operating regulations which are solely applicable to liquefied gas carriers. The remaining portion of this chapter will examine these regulations as they relate to several North American and European ports, and will briefly attempt to assess some of their relative merits and shortcomings.

4.2 Canada

4.2.1 Current Situation Assessment

Vancouver is presently the only deepwater port in Canada which is engaged in the overseas shipment of liquefied gases on a regular, large volume basis. However, it is widely speculated that further gas port development will occur on Canada's eastern, western, and Arctic coasts within the coming decade. For a detailed description of the major proposals which have been announced to date, refer to Appendix IV.

4.2.2 Vancouver

The Port of Vancouver is favoured with one of the finest natural deepwater harbours in the world. Extending some 25 kilometres eastward from the First Narrows (the singular point of ocean access) to Port Moody, B.C., the harbour ranges in width from roughly 200 metres at Gosse Point to as much as 2600 metres in the main port area (see maps, pp. 94-95).

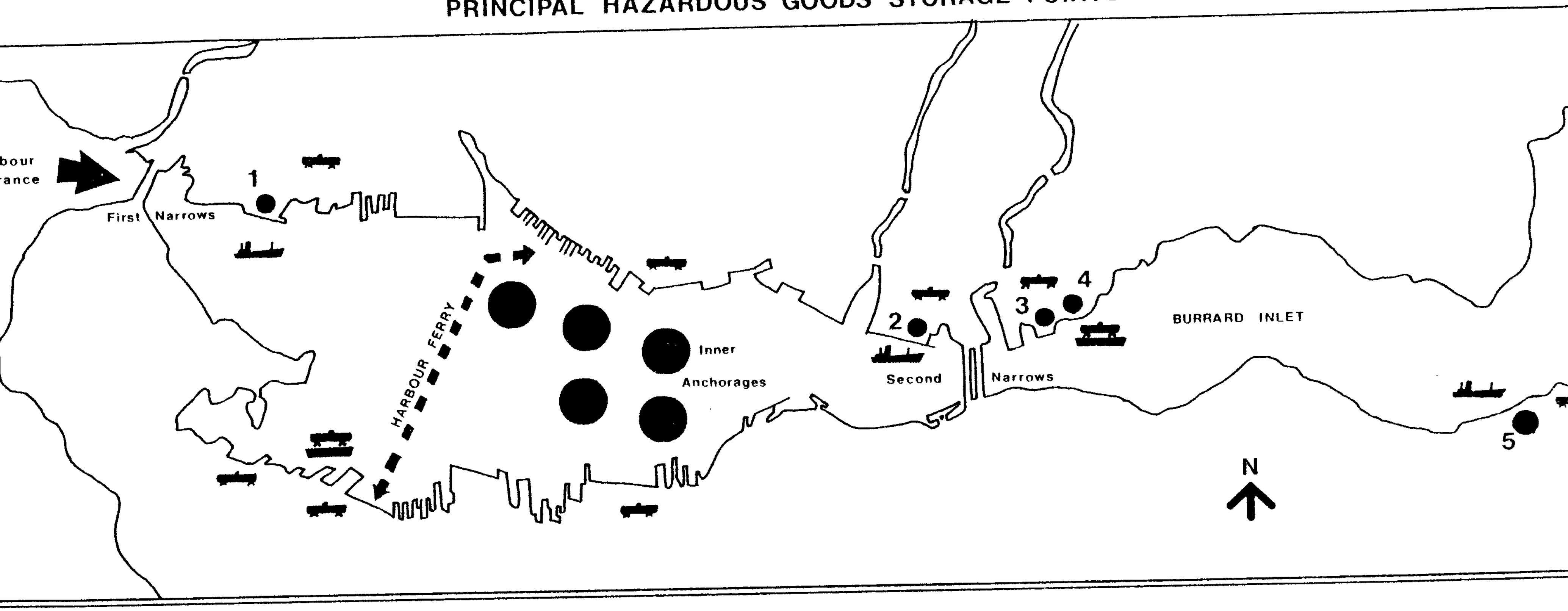
In spite of its length and fjord-like configuration, the harbour is remarkably free of natural obstructions to navigation. The principal exceptions are in the vicinity of the First and Second Narrows, where the navigable fairway for ocean-going vessels constricts appreciably. Tidal conditions are generally more pronounced in the Narrows than elsewhere. This is particularly true for the Second Narrows, where tidal velocities of up to 5.5 knots are not uncommon.[4]

In terms of fixed man-made obstructions, the Second Narrows railway bridge has been the greatest source of concern to mariners over the years. On 12 October 1979, the outbound freighter Japan Erica collided with the bridge in dense fog, thereby disrupting rail service to the north shore of Burrard Inlet for almost five months. This action prompted the Harbour Master's office to issue strict new shipping regulations for the area, the substance of which will be more fully addressed later in this section.

Perhaps the least desirable aspect of the port in terms of its physical structure has been the historical tendency among many industries catering to the hazardous materials trade to locate on the eastern side of the Second Narrows. In fact, most local marine shipments of LPG, chlorine, and petroleum products originate from terminals situated between the Second Narrows and Port Moody. Vessels wishing to gain access to, or egress from,

PORT OF VANCOUVER:

PRINCIPAL HAZARDOUS GOODS STORAGE POINTS



LEGEND

● **Chemical/Petrochemical Terminals:**

1. VANCOUVER WHARVES (Methanol)
2. DOW CHEMICAL (Ethylene Dichloride, Caustic Soda, Ethylene Glycol)
3. CANADIAN OCCIDENTAL-HOOKER (Chlorine and others)
4. ERCO INDUSTRIES (Sodium Chlorate)
5. TRANS MOUNTAIN PIPELINE (LPG)

Deepwater Berth

Railcar Holding Area

Barge Facility

0 1 km

Figure 4.1

PORT OF VANCOUVER:
LAND USE PATTERN

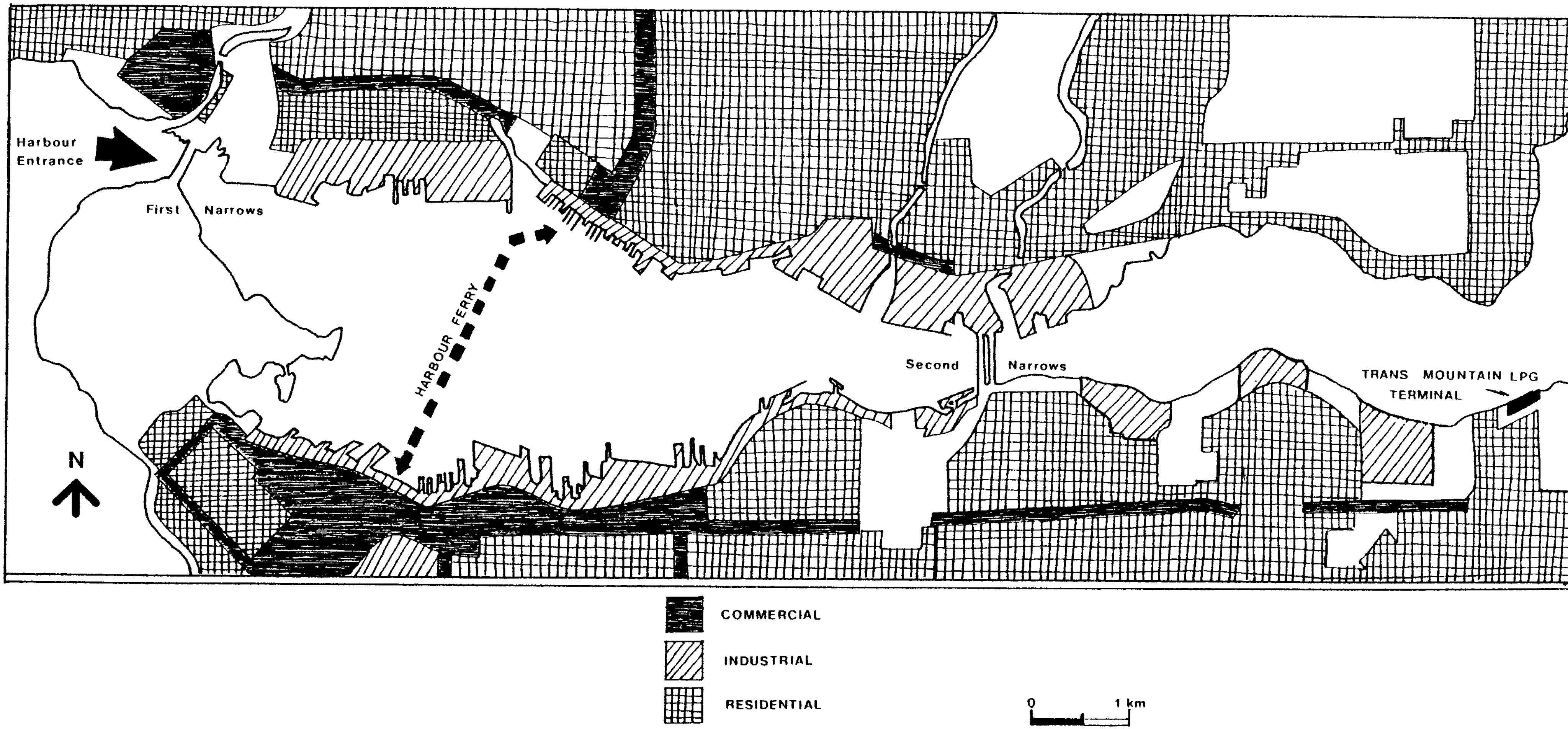


Figure 4.2

these facilities have no alternative but to pass through the heart of the busiest port on the west coast, as well as the restricted waters of the First and Second Narrows. Clearly, this is a less than ideal situation, as it exposes the vessel and, by extension, a potentially large segment of the Lower Mainland population, to among the highest levels of operational risk in the harbour.

The task of reducing the hazards associated with the sea-borne carriage of dangerous goods in the port rests primarily with two federal agencies - the Canadian Coast Guard and the National Harbours Board. Coast Guard involvement takes two distinct forms - one regulatory, the other advisory. The Ship Safety Branch of the Coast Guard is responsible for ensuring that construction, manning, and operating standards for vessels functioning in Canadian waters are in conformity with the provisions of the Canada Shipping Act, as well as any international conventions on maritime safety to which Canada is a contracting member. Unfortunately, due to the large number of visits by foreign-flag vessels to British Columbia ports annually, and to limited staff resources within the Ship Safety Branch, it is not possible for Coast Guard officials to personally examine each incoming vessel. Instead, a substantial proportion of all shipboard inspections by Coast Guard marine surveyors are, by necessity, conducted on a more or less ad hoc basis, or at the request of qualified individuals (such as coast pilots) who have reason to believe that a particular vessel is in contravention of Canadian shipping regulations.* Under these circumstances, it is

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*The major exceptions to this practice are oil and, more recently, chemical tankers which, based upon special pollution prevention regulations introduced under the authority of Section 730 (2) of the Canada Shipping Act (Certificates evidencing compliance), are required to undergo mandatory inspections at least every two years. Liquefied gas carriers, by virtue of the essentially non-polluting nature of their cargoes, are exempt from these regulations.

conceivable that a liquefied gas carrier could serve the Port of Vancouver on a regular basis for an extended period of years without ever being subjected to a detailed inspection by Canadian authorities.

The other means whereby the Coast Guard can effectively exercise a certain degree of influence over harbour safety is through its Vessel Traffic Management (VTM) service. Locally, the traffic management system has four primary objectives:[5]

1) to establish viable traffic routes;
2) to establish two-way communication with all commercial vessels operating within, or at the approaches to, the harbour in order to provide full information on traffic and conditions;
3) to establish radar surveillance of the port; and
4) to manage traffic in a safe and effective fashion.

The service has been in operation since the mid-1970's, and has doubtless played an instrumental role in maintaining Vancouver's reputation as one of the world's safest ports, in spite of a continuing tendency towards growth in terms of both vessel size and the number of vessel movements within the port precinct. If the system is to be faulted for any reason, it would have to be on the basis that it has not yet been allowed to reach its optimum potential. At present, the service is advisory only, and must rely upon the voluntary co-operation of all pilots and ships' crews in order to be most effective. Although the vast majority of vessels operating within the sphere of influence of the VTM system, both locally and elsewhere on the coast, do co-operate fully in this respect, there are occasional instances where vessels fail to establish proper contact with the traffic management centre. In an era of increasingly regimented marine traffic routing, the presence of non-conforming vessels is a major source of concern, particularly in a crowded harbour area where manoeuvring room is generally at a premium.

The ultimate authority to regulate shipping in the Port of Vancouver, however, rests with the National Harbours Board. As stated in Section 59 of the N.H.B. Operating By-law:

> ...every vessel (in the Port of Vancouver) is subject to the orders of the Board in respect of its draught, location, speed and direction, and in respect of its means and methods of movement.[6]

The Harbour Master, on behalf of the Board, is charged with the overall responsibility for administering both the standard shipping regulations as prescribed in the Operating By-Law, plus any further discretionary safety measures which he may wish to introduce under the authority of the By-law. Accordingly, his powers in the matter of harbour management and safety are substantial.

The provisions of the Operating By-law as they relate to marine safety are, for the most part, reasonably broad in terms of scope, application, and interpretation. Derived largely from accepted international shipping practices, they establish the essential terms under which <u>all</u> vessels must operate in the harbour. Due to their almost universal applicability, many of the provisions of the By-law are actually operating "guidelines", rather than hard and fast "regulations". In this regard, and despite the fact that Part IV of the By-law deals with explosives and other dangerous cargoes, there is little in the document reflecting the special needs or considerations of such non-conventional hazardous commodity carriers as chemical or liquefied gas tankers.

Nevertheless, the By-law does provide the necessary regulatory foundation upon which the Harbour Master may introduce further, more specific, operating requirements should he deem it necessary to do so. A recent example of this, and one which, coincidentally, has done more to reduce the overall level of operational risk involving liquefied gas carriers functioning within the harbour area, has been the institution of strict new navigating rules for the Second Narrows. The decision to significantly upgrade vessel operating procedures in the area came as a direct result of the October 1979 collision involving the railway bridge and the cargo ship Japan Erica. The first deepsea vessels to pass through the Narrows following the accident were subjected to a number of hastily-assembled operating requirements governing such aspects as tidal restrictions, tug escorts, speed limits, and visibility standards. During the course of the next two years, the Second Narrows rules were reviewed and upgraded on a fairly regular basis until, in December of 1981, the Harbour Master issued permanent Standing Orders for the area. The Standing Orders are contained in a detailed, 19-page document covering a diverse range of conditions and operating procedures.

The highlights of the rules, at least to the extent that they are likely to apply to gas tanker traffic, can be summarized as follows:[7]

Part I - Interpretation:

Section 1. In these Orders:

"MRA" means the Second Narrows Movement Restriction Area and comprises that area enclosed within lines drawn 000° from the fixed light on the northeastern end of Terminal Dock to the North Vancouver Shoreline at Neptune Terminals and a line drawn 000° from Berry Point Light (approximately 1.5 miles east of the CN Bridge on the South Shore of Vancouver Harbour) to the North Shore on the opposite side of the channel.

Part III - Restricted Periods and Conditions

Periods

Section 3.(1) Deep sea vessels intending to transit under the Second Narrows Bridges shall do so during periods of operation established either side of high and low water slack with deepsea vessels transiting under the Second Narrows Bridges at slack water or stemming the current.

(3) Transits at times other than those specified in subsection (1) shall be made only where the Master and pilot consider it safe and where permission of the Harbour Master is obtained prior to the transit.

4. During the periods of operation referred to in section 3, transit priority will be given, in the following order, to:

(a) deep sea vessels carrying dangerous goods;

(b) all other deep sea vessels

(c) small craft carrying dangerous goods; and

(d) all other small craft, vessels and tows.

Wind

7.(1) No vessel shall attempt to transit the MRA where wind conditions are such that difficulty in manoeuvring may be experienced as a result of light vessel draught and/or high freeboard factors.

Visibility

8.(1) No deep sea vessel, or small craft carrying dangerous goods, intending to pass under the Second Narrows Bridges, shall transit through the MRA unless there is a clear visibility range at the CN Bridge of at least 1.5 miles to the east and 1 mile to the west (defined limits of the MRA).

Part IV - Control and Procedures

Section 9.(1) Vessel Traffic Management Centre (VTMC) procedures, including clarance and operating procedures, as outlined in the said "Notices to Mariners" are mandatory for all the following vessels that are intending to transit the MRA in either direction or move within the MRA:

(a) a vessel of 20 metres (65.6 feet) or more in length;

(b) a towing vessel of 8 metres (26.2 feet) or more in length;

(c) a towing vessel of less than 8 metres...in length that is towing one or more vessels or floating objects that have an aggregate extreme breadth of 20 metres ... or more; or an aggregate overall length, measured from the stern of the towing vessel to the stern of the last vessel or object towed, of 30 metres (98.4 feet) or more;

(d) an air cushion vehicle of 8 metres ... or more in length when on or over the water.

(4) The Harbour Master shall be advised of the proposed transit time, as early as possible, of all vessels referred to in paragraphs (a), (b) and (c) of Section 4, and at least 12 hours prior to the proposed transit, and of any changes thereto.

Part V - Transit Speed

Section 10. Except for reasons of emergency, or to avoid damage to the Second Narrows Bridges, no deep sea vessel shall proceed within the MRA at a transit speed in excess of 6 knots.

11.(1) Deep sea vessels intending to transit under the Second Narrows Bridges which are unable to maintain a transit speed of 6 knots or less, or are unable to safely navigate at 6 knots or less, shall:

(a) remain at berth or anchorage, or

(b) proceed to a remain at a designated berth or anchorage, until the arrangements specified in subsection (2) are made to assist such vessel in its movement.

(2) The arrangements refered to in subsection (1) include:

(a) a minimum of 3 tugs, each of 1500 B.H.P. or greater,

(b) a restricted transit time at or near slack water, and

(c) prior approval of the Harbour Master.

Part VI - Clear Narrows

Section 13.(1) A Clear Narrows is required for:

(a) LPG/LNG tankers

Part VII - Method of Operation

Section 15.(1) No deepsea vessel intending to transit the MRA shall:

(a) commence its transit until a deep sea vessel transiting in the opposite direction has completed its transit; or

(b) enter the MRA until any preceding deep sea vessels transitting in the same direction have cleared the Second Narrows Bridges by a minimum distance of 2 cables (0.2 nautical mile).

Part VII - Attendant Tugs

Section 17.(1) Except as specifically exempted by the Harbour Master, deep sea vessels, other than non self-propelled barges of 6,500 tonnes displacement or greater, intending the transit under the Second Narrows Bridges shall employ a minimum of 2 tugs, which tugs shall remain in close attendance from at least 5 cables (0.5 nautical mile) before the Second Narrows Bridge until such vessels have cleared the Second Narrows Bridges by a minimum of 2 cables...

(2) The total bollard pull of the tugs referred to in subsection (1) shall be equivalent to that set out in Appendix B which pull is determined on the basis of the deadweight tonnage of the vessel being assisted.

(3) Where the deadweight tonnage of a deep sea vessel exceeds that provided for in Appendix B, the Harbour Master may require tugs in addition to the minimum number and, in any event, approval of the Harbour Master is required prior to the proposed transit.

APPENDIX B

Design Ship Tonnage/Tug H.P. Compatibility

Design Ship Tonnage (DWT)	No. of Tugs	BHP	Bollard Pull Per Tug/Total	
6 000	2	400	7.5 T	15.0 T
10 000	2	550	8.0 T	16.0 T
20 000	2	700	10.5 T	21.0 T
30 000	2	900	15.0 T	30.0 T
40 000	2	1200	18.5 T	37.0 T
50 000	2	1650	22.0 T	44.0 T

The Harbour Master has come under some public criticism from the shipping industry since first introducing special navigating measures for the Second Narrows following the Japan Erica incident in 1979. In particular, industry representatives have stated that the mandatory tug escort requirement adds substantially to the shipowner's round trip costs through the port, thereby providing an economic advantage to terminals situated to the west of the Second Narrows.[8] Furthermore, it has been suggested that tug escorts would not be particularly effective in an emergency situation unless they are secured by lines to the larger vessel.

In partial response to these claims, it is suggested that, for LPG carriers at least, the provision of a mandatory tug escort, while admittedly increasing the cost of the transit, would not provide terminal operators to the west of the Second Narrows with any kind of economic advantage, as there are no facilities to the west of the bridge capable of accommodating LPG carriers. On the matter of the second question, it is acknowledged that escorting tugs, whether secured or not, would be of little practical value in certain instances. The escort question is, nevertheless, very much open to debate. On 10 February 1980, through an apparent mix-up in instructions, both the inbound British salt carrier Argyll and the outbound Greek freighter Star Centaurus met unexpectedly in the vicinity of the Second Narrows. Although the incident occurred prior to the introduction of the new rules, interim measures which had been brought into effect immediately after the Japan Erica episode in October of 1979 did provide for a mandatory tug escort through the Narrows. In the words of Pacific Pilotage Authority Chairman Peter Evans, "...with the help and great effort of (assisting tugs), the Argyll was moved to the north side of the channel sufficiently to clear the way for Star Centaurus, although a close-quarters passing did result."[9]

In a related type of incident several years earlier, the fully-laden American tanker Arco Sag River lost its steering capability in Rosario Strait, near Cherry Point, Washington. Again, attending tugs (as required for large oil tankers operating in coastal waters east of Port Angeles, Washington) managed to keep the temporarily disabled vessel on a proper heading until steering had been restored.[10]

While the primary objective of the new regulations is to protect the railway bridge from further mishap, by definition they also represent an important step in improving the level of public protection from the risks associated with the operation of ships transporting high impact hazardous materials through the port. It is, in fact, the strongly held contention of this thesis that many of the special safety measures now in effect for the Second Narrows area should logically be extended to include the entire harbour precinct, at least to the extent that they would be applicable to vessels transporting particularly dangerous commodities such as chlorine, ethylene dichloride, and, of course, LPG. At present, the mandatory imposition of speed limit restrictions, tug escorts, and clear passage requirements are dropped once a vessel has cleared the Second Narrows MRA, irrespective of the nature of its cargo.

In addition to the special rules cited for the Second Narrows, the Harbour Master has also imposed several discretionary safety requirements which relate directly to liquefied gas carriers. The Nichizan Maru, for example, is only permitted to transit the port during daylight hours, and with a clear channel through both the First and Second Narrows, unless otherwise advised by the Harbour Master.

4.3 United States

4.3.1 Current Situation Assessment

Since the early 1970's, the United States has emerged as a major importer of liquefied gases from overseas sources - notably Algeria. During the course of the past decade several American ports have, at one time or another, received tanker shipments of gas, including Boston (LNG and LPG), Providence, Rhode Island (LPG), Cove Point, Maryland (LNG), Elba Island, Georgia (LNG), Los Angeles (LPG), and Cherry Point, Washington (LPG), Houston, Texas (LPG), and Philadelphia, Pennsylvania (LPG).* The sole American liquefied gas exporting facility is situated at Kenai, Alaska from whence Cook Inlet natural gas has been regularly shipped to Japan since 1969 aboard the Liberian-registered tankers Arctic Tokyo and Polar Alaska.

The administrative structure for regulating marine operations in American gas ports differs from Vancouver in one fundamental regard. In Vancouver, the National Harbours Board is responsible for both port marketing and marine safety. In view of the enormous public and political pressure placed upon local NHB officials to constantly improve the economic performance of the port, the possibility of ship safety requirements being sacrificed in order to promote the economic interests of the port should not be discounted.

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*The Ports of Philadelphia LPG terminals are actually located at Paulsboro, New Jersey (the Mantua butadiene terminal) and Girard Point, Pennsylvania (the Gulf Oil butane terminal). Both facilities fall under the jurisdiction of the Captain of the Port, Philadelphia.

In the United States, the likelihood of such a potential conflict of interest situation developing is remote, as the U.S. Coast Guard, with no vested economic interest in the operation of any port, is totally responsible for implementing and enforcing marine safety regulations in all coastal ports and waterways. The task of marketing and managing the financial affairs of each port within the regulatory constraints established by the Coast Guard rests with the individual port authority.

In recent years, it has become standard practice in American gas ports for the Coast Guard to introduce operations plans specifically designed to govern the movement of liquefied gas carriers. Many of the regulatory provisions contained in each individual LPG/LNG operations plan are common to all of the American ports examined for the purpose of this thesis, including the following items:[11]

1) the master of any vessel carrying LNG/LPG as cargo shall notify the Captain of the Port (COTP) at least 72 hours in advance of the vessel's arrival in port;

2) prior to the vessel's arrival in port, the master of the gas carrier must furnish the Coast Guard with a standard statement similar to the following:

   "To the best of my knowledge and belief there are no casualties to this vessel, its machinery, or navigational equipment which might affects its seaworthiness or ability to navigate within the harbour of ______________________. I further state that all cargo handling and gas detection equipment is in proper operating condition."[12]

3) foreign-flag gas carriers must be in possession of a valid Letter of Compliance issued by the Coast Guard prior to initial entry into American territorial waters. Vessels registered in the United States must carry a valid Certificate of Inspection;

4) every incoming liquefied gas carrier shall be subjected to a detailed shipboard inspection by qualified Coast Guard personnel prior to commencing cargo transfer operations. A serious, uncorrectable deficiency noted by the safety inspection party which could create a hazard to the vessel or the surrounding area would be sufficient cause to order the vessel to return to international waters, or to take other action as directed by the COTP; and

5) a qualified Coast Guard monitoring team must be on hand at all times throughout the cargo transfer phase (exception - Ports of Philadelphia).

Due to the unique physical and structural composition of each port, no two operations plans are exactly alike. Hence, from a navigational perspective, individual plan restrictions concerning such items as pre-entry clearance requirements, vessel speed, weather conditions, traffic management procedures, or the provision of escorts may vary from one port to the next. In a broad sense, however, operations plans tend to fall into two fairly distinct categories. Firstly, there are those which govern gas tanker operating procedures in the vicinity of terminals such as Cove Point, Maryland and Elba Island, Georgia, both of which are situated in readily accessible, yet relatively underpopulated areas. The second group of plans relate to instances where either the gas terminal is located in the midst of a metropolitan port, or where a gas carrier must traverse a busy, densely populated stretch of waterway in order to gain access to the terminal. The regulations governing gas tanker movements (as defined in the various operations plans) are generally less stringent under the former circumstances, as the gas carrier does not present as great a threat to either public safety or shipping.

By definition, Vancouver has little in common with the isolated, single purpose gas ports at Cove Point or Elba Island. Accordingly, the report will not dwell further upon the special shipping regulations in force at either site. Instead, the basic problems likely to be encountered locally with regard to the safe management of liquefied gas tanker traffic more closely resemble those which could be reasonably anticipated in the highly developed port cities of Boston and Los Angeles.

4.3.2 Boston

The Port of Boston has been associated with the overseas liquefied gas trade since 1970, when the Panamanian-registered LNG carrier Aristotle (formerly the Methane Pioneer) delivered the first consignment of Algerian gas to the new Boston Gas Company receiving terminal at Commercial Point.[13]

Boston occupies a unique position among the gas ports examined in this thesis in that the community accommodates three separate liquefied gas terminals within its boundaries. In addition to Boston Gas, both Distrigas (LNG) and Exxon (LPG) constructed large import receiving facilities at Everett, on the north bank of the Mystic River, during 1971 and 1972 respectively (See Map. p. 109.). Of the three, however, only the Distrigas and Exxon terminals were expressly designed to accommodate large ocean-going gas carriers.* The Boston LNG/LPG operations plan is primarily concerned with managing deepsea gas tankers destined for these two facilities.

Unlike Vancouver, which has rarely been visited by gas tankers other than the Yamahide Maru or, more recently, the Nichizan Maru, Boston has hosted many different LNG and LPG carriers over the years. Furthermore, whereas LPG carriers tend to visit Vancouver on a more or less regular basis throughout the year, the Boston gas tanker trade is of a more seasonal nature, averaging perhaps two visits per month during the winter, and few, if any, throughout the remainder of the year. Each port will normally receive on the order of 10 to 15 gas tanker calls annually.

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*The Boston Gas facility at Commercial Point, because of berthing and channel draught limitations, is largely restricted to the handling of coastal barge traffic or the occasional small LNG tanker.

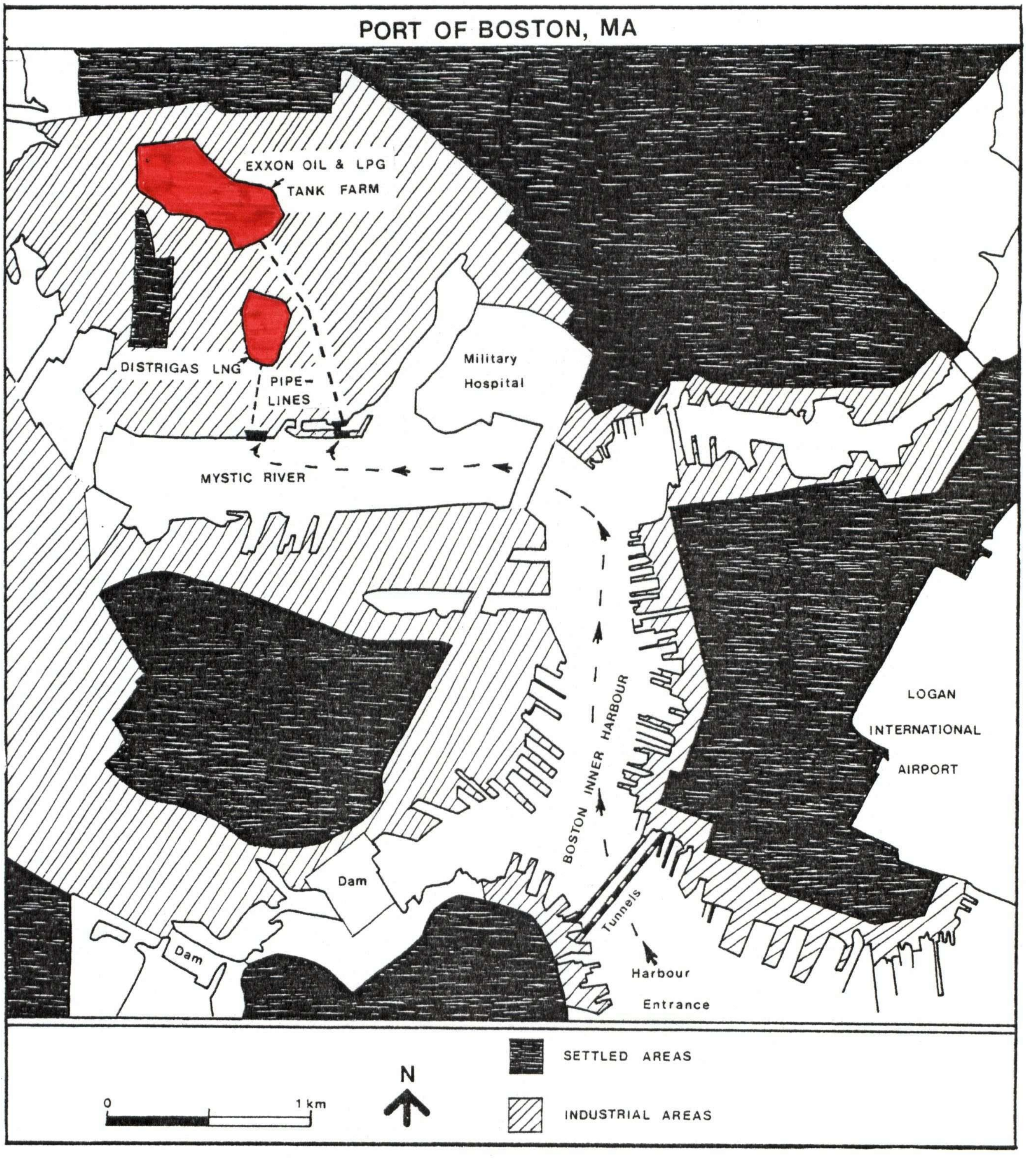
PORT OF BOSTON, MA
EXXON OIL & LPG TANK FARM
DISTRIGAS LNG
PIPE-LINES
Military Hospital
MYSTIC RIVER
BOSTON INNER HARBOUR
LOGAN INTERNATIONAL AIRPORT
Dam
Dam
Tunnels
Harbour Entrance
SETTLED AREAS
INDUSTRIAL AREAS
N
0
1 km

Figure 4.3

The sea approach to the Exxon and Distrigas terminals is, in some respects, similar to the approach into the Westridge LPG terminal in Burnaby. For instance, access to either the Everett, Massachusetts or Burnaby, B.C. gas facilities requires a lengthy harbour transit by way of an often narrow navigable channel.* The channel width problem is compounded in Boston by the fact that vessels destined for Exxon or Distrigas must make several pronounced course adjustments, including one of approximately 90° at the entrance to the Mystic River. The single most dominant characteristic common to both ports, however, is that vessels wishing to gain access to local deepwater gas terminal facilities must negotiate the central harbour precinct, while at the same time skirting the downtown core of each city. In this regard, the vessel routing system into (and out of) the Everett and Burnaby facilities would likely place more people at potential risk in the event of a gas tanker accident than any of the other ports examined.

In order to offset the locational shortcomings associated with the Everett gas terminals, the U.S. Coast Guard introduced its initial operations plan for the Port of Boston as long ago as 1971. Over the years, the plan has been constantly amended and upgraded in response to changes in both public attitude and gas tanker technology. In so doing, it has come to be widely regarded as the model upon which many other ports have based their gas tanker operating regulations.

The Port of Boston operations plan is divided into four segments - notification and arrival; harbour transit; cargo discharge; and departure.

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*The Port of Vancouver harbour transit for liquefied gas carriers is approximately 15 kilometres (from First Narrows Bridge to Westridge), as opposed to 8 kilometres in Boston.

This thesis, however, will concentrate upon the salient features of Phase II - harbour transit - and only to the extent that the rules apply to deepsea liquefied gas carriers destined for the Exxon and Distrigas terminals at Everett.

Upon completion of a mandatory pre-entry vessel inspection, and assuming that the Coast Guard has granted the gas tanker permission to enter the port, the following regulations automatically come into force, unless waived by the Captain of the Port:[14]

a) transit must occur during daylight hours only for loaded or partially loaded vessels;

b) a vessel shall not commence transit unless the minimum visibility is at least two miles. Should visibility deteriorate to less than two miles while the vessel is underway, the following measures shall be taken:

   i) if still in Broad Sound, the vessel shall not enter port;

   ii) if entering the harbour inbound for Everett and not yet past the Fort Point Channel, notify Coast Guard and proceed back to Broad Sound;

   iii) if entering the harbour inbound for Everett and already past the Fort Point Channel, notify Coast Guard and continue to berth;

   iv) if outbound from Everett, notify Coast Guard and continue outbound.

c) no liquefied gas carrier shall transit the harbour unless accompanied by a Coast Guard escort vessel;

d) loaded or partially loaded vessels in excess of 60 000 cubic metres capacity will be attended by a minimum of five tugs, two of which must be of 3000 h.p. or greater, and the remaining three of 1200 h.p. or greater. Loaded or partially loaded vessels of less than 60 000 cubic metres will be attended by a minimum of three tugs, including two of 3000 h.p. or greater, and the third of 1200 h.p. or greater. The tugs will meet the incoming vessel at the eastern end of President Roads and be utilized as needed throughout the vessel's transit of Boston Harbour. During the docking/undocking operation the tugs will be strategically positioned, consistent with the Master's sound judgment, and based upon consultation with the docking master/pilot. Tugs will meet outbound vessels at the berth and attend to their needs until they have cleared President Roads;

e) whenever a loaded or partially loaded liquefied gas carrier is in transit of Boston Inner Harbour, no other vessel will be permitted to get underway without the expressed authorization of the Captain of the Port. Permission to transit will be granted on a case by case basis using the concept of a "moving safety zone". That is, the vessel requesting permission to transit the harbour must remain at least two nautical miles ahead, or one nautical mile astern, of the gas tanker. Traffic movement will be limited to the same direction as the gas carrier in order to avoid passing situations.

N.B. Vessels under 100 gross tons and towboats without tow may transit the harbour without the prior consent of the Captain of the Port, provided they are capable of navigating safely outside the main shipping channel.

f) during the transit of a liquefied gas carrier, the maximum allowable speed for any vessel operating within the moving safety zone will be eight knots; and

g) no aircraft will be permitted to overfly a liquefied gas carrier while in the Port of Boston. Furthermore, no aircraft wishing to photograph an LPG or LNG tanker will be permitted to operate within 1000 feet of that vessel.

The preceding regulations represent only a small portion of the total number of special requirements for liquefied gas tankers operating in the Port of Boston. Even so, they reveal several interesting features which could have a significant bearing upon the future implementation of additional operating requirements for vessels transporting hazardous chemical or petrochemical substances within the Vancouver harbour precinct. The Boston rules clearly emphasize that the U.S. Coast Guard's primary commitment is to ensuring a high level of public safety, not to the special marketing interests of the local gas industry. More importantly, though, both the Exxon and Distrigas operations at Everett have successfully adapted to any additional economic constraints resulting from the introduction of these extraordinary operational safety requirements. This is borne out by the fact that Boston continues to function as a major liquefied gas importing centre.

4.3.3. Los Angeles

The Port of Los Angeles is by no means an important liquefied gas terminal on the scale of either Boston or Vancouver. In fact, according to Ms. J. Natow of the Los Angeles Port Authority, as of November 1979 the port had received fewer than half a dozen deepsea gas tankers in its entire history.[15]

Nevertheless, the Coast Guard has elected to introduce a comprehensive LPG tanker operations plan which, in some instances, is even more stringent than the Boston plan. The reasons for this are essentially twofold. Firstly, as with Boston, access to the Petrolane LPG offloading facility in Los Angeles can be gained only by transiting the narrow, 220 metre wide Main Channel. The passage through the Main Channel to the 450 metre wide Inner Harbor Turning Basin covers a distance of approximately 4 kilometres. Upon arrival at the Inner Harbor Turning Basin, the tanker must negotiate a 90° turn to port. The Petrolane

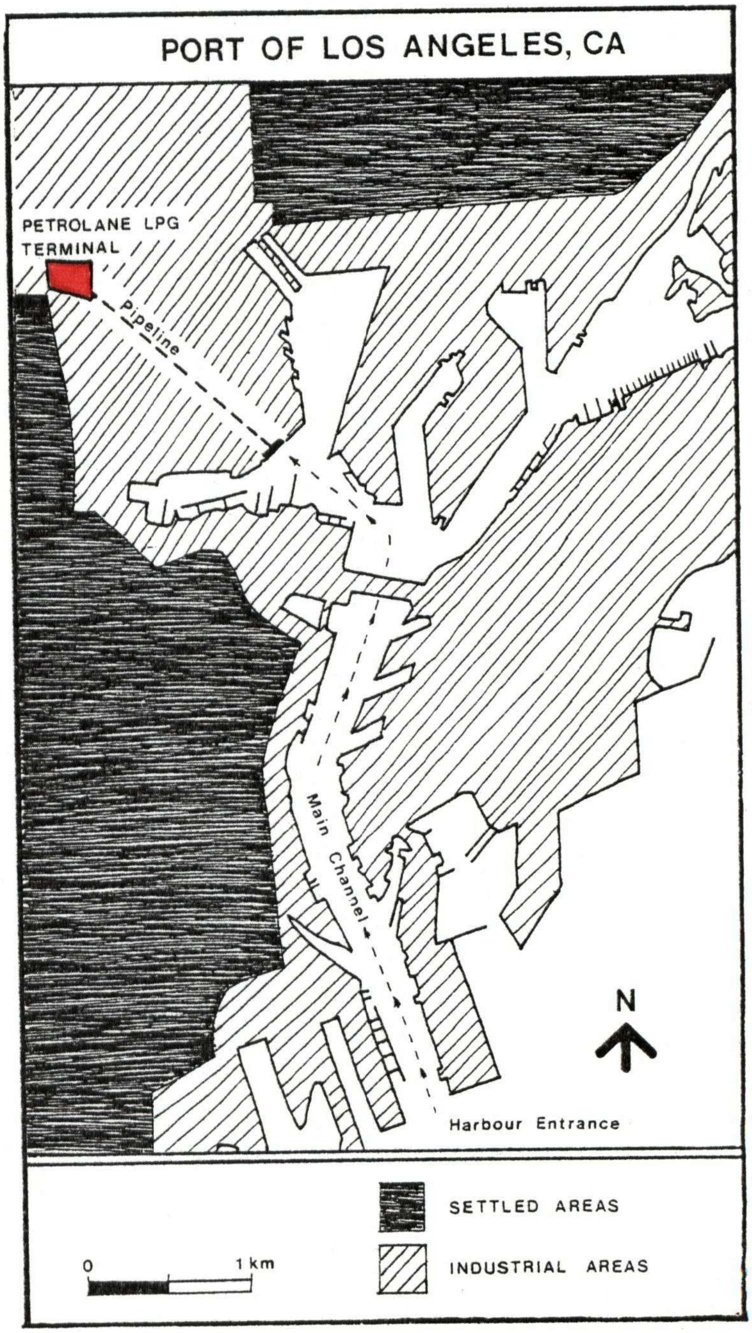

Figure 4.4

wharf, designated as Berth 120, Port of Los Angeles, is situated roughly one kilometre to the northwest of the turning basin (See map p.113).

The second important factor governing the strict gas tanker regulations which are in effect in Los Angeles is that the suburban community of San Pedro fronts directly onto the Main Channel. During the mid-1970's, southern California residents were subjected to a lengthy debate over the acceptability of constructing an LNG receiving facility on Terminal Island, situated in the heart of Los Angeles harbour. After much consideration, the proposal (by Western LNG Terminal Company) was rejected, and new state legislation was introduced restricting future LNG terminal development in California to a remote area north and west of Los Angeles.* In the aftermath of the controversy, however, public attention shifted towards the more immediate problem of LPG tankers operating, albeit infrequently, in Los Angeles harbour. The issue reached a head in December of 1978 when it was announced that the 22 000 cubic metre LPG carrier Fernvalley (subsequently re-named Discaria) was scheduled to bring a shipment of Venezuelan gas to Los Angeles during mid-January of 1979. This followed a 17 November 1978 visit to the port by the British gas tanker Cavendish, and prompted some San Pedro residents to demand that the state adopt a similar policy stance with regard to LPG as it had for LNG.[16]

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*On 16 December 1976 Los Angeles city council voted in favour of the Western LNG Terminal Co. proposal. Ironically, the following day, the empty oil tanker Sansinena exploded while berthed at the Union Oil dock in San Pedro harbour. The blast shattered windows up to 32 kilometres away, and left 9 persons dead and 50 injured. The severity of the accident prompted council to reverse its initial decision the following week, and led one member to comment that council had acted "too hastily" on the matter.[17]

The Cavendish visit was the first to the port in roughly two years, and was the initial test of the Coast Guard's new LPG tanker operations plan which had been introduced the previous month (October 1978).

Many of the basic elements contained in the Boston operations plan have been incorporated into the Los Angeles plan.[18] For instance, pre-arrival clearance and inspection procedures are essentially the same at both ports, as is the requirement for a Coast Guard monitoring team to be in attendance at the terminal at all times during the off-loading process. Other regulations differ marginally between Boston and Los Angeles. The minimum acceptable visibility under which a gas carrier may enter the port of Los Angeles, for example, is only one mile, as opposed to two miles in Boston. The nature of the mandatory tug escort requirement also varies between the two ports. In Boston, both the number of tug escorts and their minimum horsepower ratings have been clearly established, based upon the size of the gas carrier. In Los Angeles, the plan states only that a minimum of two tugs (power unspecified) must be in attendance of an LPG tanker transiting the harbour, regardless its size. An interesting provision of the Los Angeles tug escort requirement which is not contained in the Boston plan, however, is that the tugs must be secured to the gas carrier - one at the bow and one at the stern. Finally, there are several important requirements which are unique to the Los Angeles plan. Included among this group are the following

a) Los Angeles Main Channel will be closed to all commercial vessels (excluding small vessels) during transit by the liquefied gas carrier. Under certain circumstances, one-way traffic in the direction of the LPG carrier may be authorized by the Captain of the Port, provided that a minimum distance of one mile is maintained between the LPG tanker and other vessels at all times;

b) no vessels of any kind shall be permitted to occupy Berths 118, 119 or 121 while an LPG carrier is docked at Berth 120, Los Angeles harbour;

c) no vessels other than those representing concerned agencies will be permitted to transit within 100 yards of a moored LPG carrier;

d) seaplanes which use the Main Channel and helicopters which operate in the vicinity, will be notified in advance of an LPG tanker transit of the harbour, and will be directed not to take off, land, or taxi in the channel while the gas carrier is underway; and

e) passage out of the harbour by an empty gas carrier will be made under the same conditions as those set forth for vessels entering the harbour, including mandatory tug and Coast Guard escort requirements.

In addition to the above, Section 2(b) of Phase II (Vessel Transit in Port) of the Los Angeles operations plan makes subtle reference to one aspect of gas tanker safety which, with the exception of the Elba Island, Georgia plan, is not referred to direcly in other U.S. port operations plans - that is, the question of ship and terminal security against attempted acts of sabotage. The Los Angeles plan states that:

> ...a security check will be made of the facility grounds and under the dock, again reporting unusual circumstances to the Captain of the Port. Particular attention shall be paid to unauthorized vessels/vehicles loitering in the area of the facility and dock.

Moreover, Section 3(b) of Phase III further indicates that:

> ...Coast Guard harbour patrol boats will check on the LPG vessel while berthed and report...any and all unusual boat activity in the area and any other circumstances out of the ordinary.

Given the infrequency of gas tanker visits to the port, the Los Angeles regulations reflect a particularly strong sense of public concern over the LPG issue which is perhaps unrivalled anywhere else in the world.

4.4 Europe

4.4.1. Situation Assessment

Since the Canvey Island, U.K. liquefied natural gas receiving facility first went into commercial operation in 1964, several southern and western European nations have also constructed deepwater port facilities for the purpose of accepting large volumes of liquefied gases from offshore sources - notably Algeria and Libya.

Until recently, LNG had been the favoured import commodity over LPG for reasons of both cost and accessibility to supplies. In addition to Canvey, LNG receiving terminals were established at La Spezia, Italy (1969), Le Havre and Fos-sur-Mer, France (1964 and 1971, respectively), and Barcelona, Spain (1969). During the latter half of the 1970's, however, a combination of factors, including changing patterns of use among gas consumers and gas pricing structure revisions, led to a partial demand shift in Europe away from LNG to offshore LPG. This is perhaps best typified by the recent inauguration of an LPG marine delivery service to the petrochemical plants at Rafnes and Herøya, near Porsgrunn, Norway. In coming years, it is estimated that liquefied gas carriers of up to 30 000 cubic metres capacity will make an average of 240 port calls annually to the Porsgrunn area (90 arrivals at Rafnes, and 150 at Herøya).[19]

Elsewhere on the continent, the German Mundogas corporation inaugurated a large new LPG receiving operation at Europoort, Holland during the spring of 1982.[20] The Mundogas terminal is capable of accommodating a maximum throughout of up to 750 000 tonnes annually. Dutch officials have also recently (summer 1981) authorized a major expansion of the Eurogas LPG import facility at Flushing, Holland. Four new 55 000 cubic metre storage tanks will increase existing capacity at Flushing from 20 000 cubic metres to 240 000 cubic metres.[21]

4.4.2. Planning Considerations

In a comparative sense, European port planners have historically maintained a somewhat different attitude towards the fundamental relationship between navigational safety and liquefied gas terminal siting than their North American counterparts. In Canada and the United States, the standard approach throughout the 1960's and most of the 1970's was to minimize the level of potential risk to the gas carrier during the harbour transit phase by means of proper access channel design and maintenance (in terms of width, depth, tidal effects, etc.), vessel traffic management, and, where necessary, through the introduction of additional control regulations. Little direct consideration was given to the possible effects of a serious mid-harbour accident involving a loaded or partially loaded gas tanker upon the local population. Consequently, ports such as Boston, Los Angeles, and latterly Vancouver have increasingly come under criticism on the grounds that, as a result of questionable terminal siting practices in the past, a large segment of the local population has been placed in a position of undue risk during the harbour transit phase of an LNG or LPG tanker.

In Europe, however, in addition to the routine navigational risk reduction measures described in the preceding paragraph, the following policy considerations have traditionally been incorporated into the basic gas terminal siting equation:

a) Liquefied gas carriers shall remain physically removed from major concentrations of population to as great an extent as possible; or

b) where (a) is not always practical, the terminal shall be located at or near the harbour entrance in order to minimize the length of the vessel transit through a populated or heavily congested port precinct.*

The British Gas Corporation LNG terminal at Canvey Island, for example, is situated some 25 kilometres upstream from the mouth of the River Thames in what was, until quite recently, a comparatively underpopulated area. The gas port at Le Havre, France, the proposed LNG receiving terminal at Zeebrugge, Belgium, and a recently-cancelled plan by British Petroleum and Shell Oil to construct a new LPG import facility at Europoort, Holland, on the other hand, are more clearly representative of the planning philosophy described in approach "b" (above). The (actual or proposed) terminal operations in these communities have been situated in close proximity to the respective harbour entrances.

Nevertheless, European gas ports are not without their share of operational safety limitations. For instance, the gas terminals at Canvey and Le Havre, plus the defunct Shell-BP proposal for Europoort, are all situated in the midst of extensive petroleum and petrochemical complexes. This has been done, presumably, in order to take advantage of the economies of agglomeration - particularly as they are influenced by the common usage of specialized service infrastructures. The major shortcoming with this arrangement, however, is that the security of the liquefied gas storage facilities could be seriously jeopardized in the event of an explosion and/or fire at one or more of the neighbouring plants. Conversely, a

*The recent decisions to locate LNG receiving terminals in relatively isolated communities such as Cove Point, Maryland and Elba Island, Georgia, along with the California ruling which restricts LNG terminal development in that state to specified remote areas, suggest that the European approach towards gas terminal siting is, of necessity, gaining favour on this continent.

critical accident at the LPG/LNG facility could touch off a chain reaction of fires/explosions throughout the surrounding area. This concern is especially acute at Canvey Island where, within a space of five kilometres, there is a virtually uninterrupted concentration of industries engaged in the production, storage, refining, and movement of large volumes of hazardous materials, including liquefied gases, crude and refined petroleum products, liquefied ammonia compounds, and explosives. The problem at Canvey is further aggravated by the fact that the surrounding region has become increasingly attractive as a commuter suburb of London in recent years. The permanent population of Canvey Island stood at roughly 33 000 in 1978, as opposed to only 11 000 in 1951.[22] Significantly, the worsening land use conflict between industrial and residential concerns at Canvey Island closely parallels the situation at Burnaby, B.C. where the nearest homes are located within 150 metres of the LPG storage tanks.

As a footnote, in March of 1981 Environment Secretary Michael Heseltine ordered a full inquiry into the safety of the British Gas LNG terminal operation at Canvey Island.[23] The inquiry call was sparked by a government report on the safety aspects of a proposed new oil refinery at Canvey by United Refineries Ltd. According to Mr. Heseltine, the report "...judged that it would be wrong for ... the British Gas terminal to remain sited so close to the resident population unless a foolproof device for the protection of the public could be installed.[24]

The inquiry commenced on 20 October 1981, and is scheduled to continue into 1982, at which time a recommendation on whether or not to close the British Gas terminal will be passed on to Mr. Heseltine by inquiry chairman Robert de Piros.

Neither Le Havre nor the ill-fated Shell-BP gas port proposal for Europoort have been affected by the direct influences of residential encroachment. In each instance, the terminal is remotely situated near the seaward limit of lengthy landfill extensions into the Seine (Le Havre) and Rhine (Europoort) river estuaries. These landfill areas have been set aside exclusively for industrial purposes. Even so, the Shell-BP proposal did generate a great deal of local controversy - particularly among the residents of the nearby community of Hoek van Holland, situated some three kilometres to the north of the terminal.

Another problem which, to varying degrees, is common to all gas ports concerns the exposure of berthed liquefied gas carriers to oncoming marine traffic. Although there have been several reported instances of minor collisions involving moored gas tankers, the potential gravity of this issue has perhaps been most graphically underscored on three separate occasions at Canvey Island - in 1974 when the British coaster Tower Princess collided with the docked LNG carrier Methane Progress; again in 1976 when the Cypriot oil tanker Britt rammed the British Gas Co. jetty at Canvey, coming to rest a short distance from a loaded large-diametre ship-to-shore LNG discharge pipe; and, most recently, in May of 1982 when the coaster Jemrix hit the methane wharf, fracturing a gas pipe which resulted in a minor spill of LNG into the River Thames.[25] Incidents such as these were largely responsible for prompting the designers of the proposed Shell-BP LPG terminal at Europoort to incorporate into the plan a completely enclosed berth which would have all but eliminated the likelihood of a collision while the gas tanker was docked.[26] The fully enclosed berth concept would have also served to contain the immediate spread of any accidental LPG spill.

4.4.3 Le Havre, France

4.4.3.1 Physical Considerations

Access to the Gaz de France LNG terminal at Le Havre involves a more or less direct one kilometre transit through the port's outer harbour (see map, p. 123). Incoming gas tankers must briefly pass within approximately 300 metres of the nearest commercial and residential districts of the community. The actual terminal berth is situated roughly one kilometre from the closest non-industrial areas.

4.4.3.2 Regulatory Considerations

According to information provided by officials at the Port Authority of Le Havre during May of 1980, liquefied gas tankers are required by law to establish radio contact with the vessel traffic centre prior to entering the harbour. This feature is compulsory for all deepsea vessels approaching either Le Havre or the nearby petroleum superport of Le Havre-Antifer.[27] Furthermore, gas carriers must be attended by a tug escort while underway in the harbour.

As in the United States, the responsibility for introducing and enforcing special operating regulations for gas carriers in French ports rests with the federal government - in this instance the Ministry of Maritime Affairs - rather than the individual port authority.

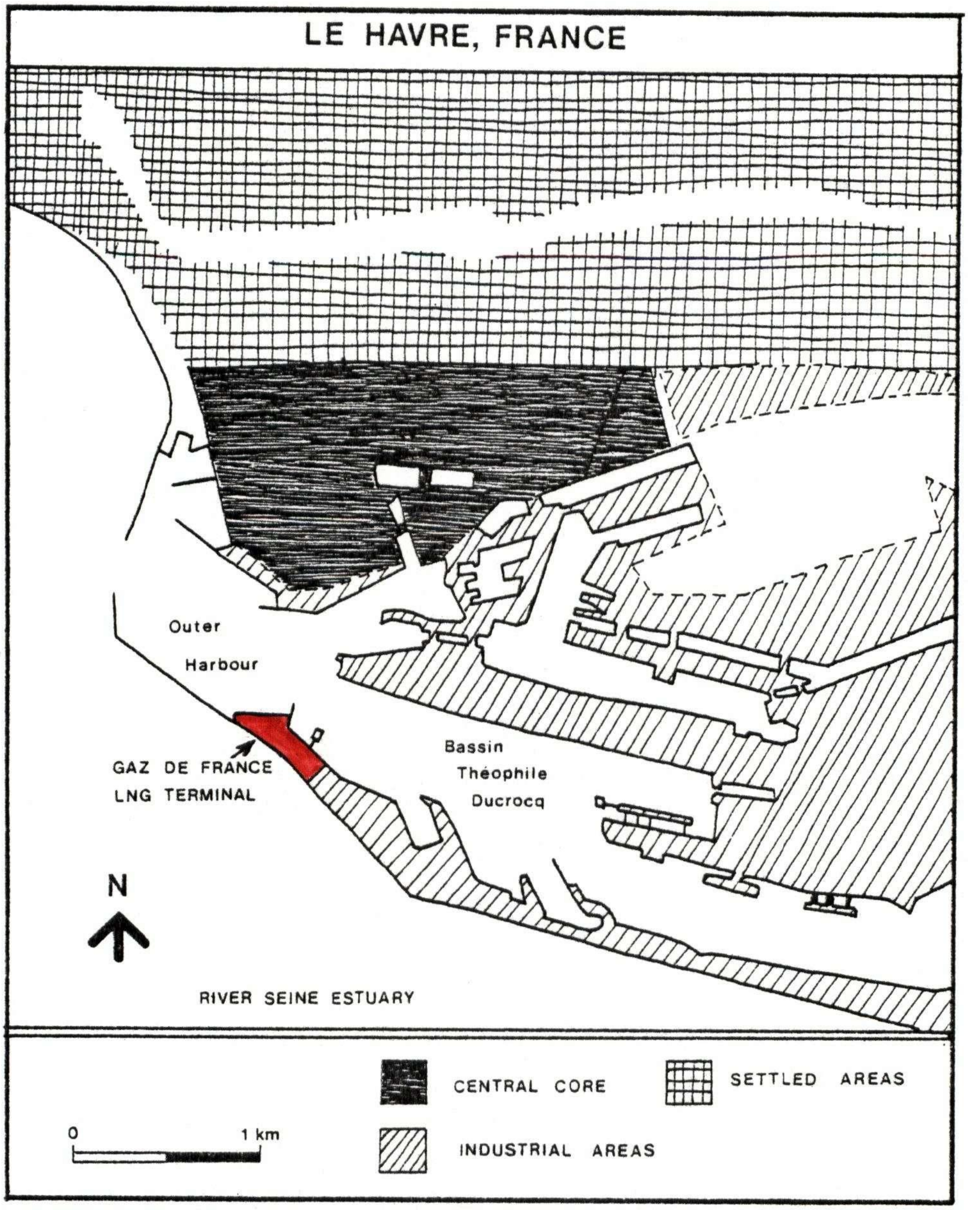
LE HAVRE, FRANCE
Outer
Harbour
GAZ DE FRANCE
LNG TERMINAL
Bassin
Théophile
Ducrocq
N
RIVER SEINE ESTUARY
CENTRAL CORE
SETTLED AREAS
INDUSTRIAL AREAS
0
1 km

Figure 4.5

4.4.4 Europoort, Holland

4.4.4.1 Introductory Note

During the mid-1970's, Shell Oil and British Petroleum put forth a joint proposal to the City of Rotterdam (which administers the Rotterdam-Europoort port complex) to build a major LPG import receiving terminal capable of accommodating vessels of up to 75 000 cubic metres capacity. The terminal was to have been located on BP property situated near the entrance to the North Sea, some three kilometres south of the community of Hoek van Holland (see map, p. 125).

By the spring of 1980, the Port of Rotterdam had endorsed the project in principle, but was witholding final approval pending the resolution of several contentious points, plus the completion of public hearings on the project. Nevertheless, it was apparent that the proposal, as it stood in 1980, had taken into account, and had attempted to rectify, many of the most commonly expressed public concerns relative to the construction of new gas terminals. For this reason, the salient features of the Shell-BP proposal have been addressed in Sections 4.4.4.2. (Physical Considerations) and 4.4.4.3. (Regulatory Considerations).

In November of 1981, Shell-BP announced their intention to abandon plans to construct an LPG terminal at Europoort, officially citing the high cost of safety measures and a generally slackening demand for LPG.[28] A brief review of the circumstances leading up to the Shell-BP announcement to cancel the project, however, would suggest that the official position had been somewhat oversimplified. In fact, problems began to surface as far back as the early months of 1981, when the Dutch government approved the landing of large volumes of LPG at both Flushing and Europoort, instead of just Europoort.[29] Representatives from the City of Rotterdam and the

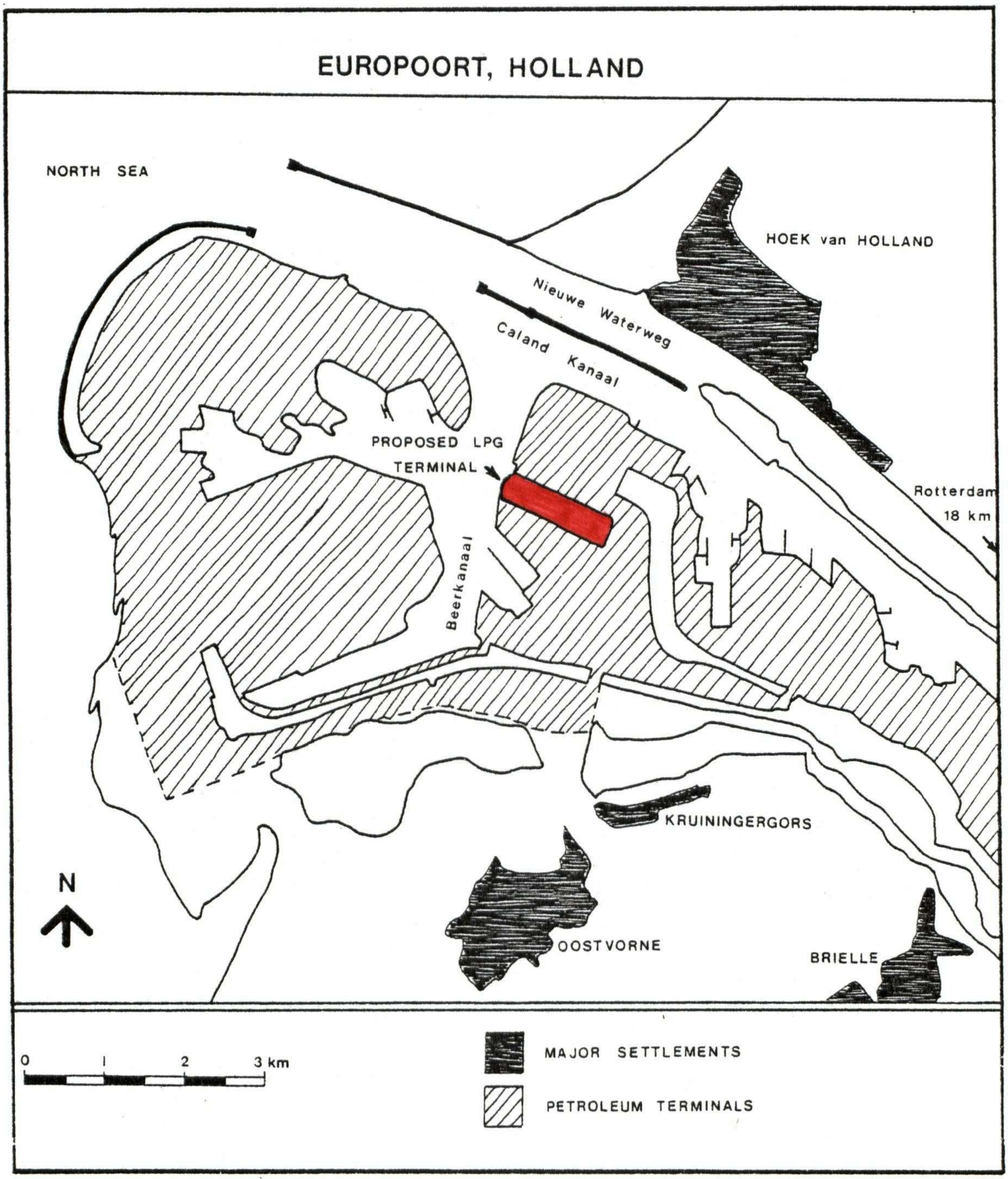
EUROPOORT, HOLLAND
NORTH SEA
HOEK van HOLLAND
Nieuwe Waterweg
Caland Kanaal
PROPOSED LPG TERMINAL
Rotterdam 18 km
Beerkanaal
KRUININGERGORS
N
OOSTVORNE
BRIELLE
0 1 2 3 km
MAJOR SETTLEMENTS
PETROLEUM TERMINALS

Figure 4.6

Province of Zuid-Holland accused the federal government of pursuing a confusing policy on the matter. At the same time, Shell announced that the need for a major terminal at Europoort had been reduced as a result of the government's decision, which would enable Shell to supply its Europoort facilities with gas landed at Flushing.[30] Rotterdam authorities expressed concern that LPG would be transported from Flushing to the Shell and BP operations at Europoort by means of increased rail and coastal shipping movements, with all of the attendant safety risks. Furthermore, civic officials feared that the Port of Rotterdam would lose much of the Shell-BP terminal's proposed annual throughput of 1.5 million tonnes of LPG - to the extent that the city offered to pay Fls. 20 million of the estimated Fls. 60-70 million construction cost for the project.[31]

By August of 1981, in the absence of a firm commitment from Shell and BP to proceed with the project, and increasingly experiencing the effects of a severe global economic downturn, Rotterdam authorities agreed to relax a previous condition that the oil companies would have to construct a separate, enclosed berth for the discharge of LPG.[32] Apparently these concessions were not enough, as Shell and BP ultimately scrapped the project in November of 1981. Significantly, one week after the collapse of the Shell-BP proposal, Rotterdam city council approved another proposal, this one by Mundogas, to tranship LPG directly from oceangoing gas carriers to coastal and inland vessels. The Mundogas terminal, like the Shell-BP proposal, is situated in the Maasvlakte district of the Europoort refinery complex. The facility is capable of handling a throughput capacity of some 750 000 tonnes per annum. Details of the special operating requirements applicable to deepsea LPG carriers serving the new Mundogas terminal are unavailable. However, it is unlikely that they differ substantially from the regulations which had been proposed for the Shell-BP operation (see Section 4.4.4.3 - Regulatory Considerations).

4.4.4.2 Physical Considerations - Shell-BP Proposal

The Shell-BP gas reception facility was to have been situated some six kilometres inside the harbour precinct. However, despite a somewhat longer harbour transit than is required for Le Havre, the Europoort proposal displayed several distinct locational advantages over its French counterpart. Foremost among these was the fact that loaded gas tankers would, at no time, have been required to come within 2500 metres of the nearest commercial or residential areas. Moreover, as previously indicated, the actual site chosen for the terminal was situated approximately three kilometres from the closest centre of population, Hoek van Holland. While this precaution would not, in itself, have constituted an absolute guarantee of public safety in the event of a serious mishap, the existence of a minimum three-kilometre radius buffer zone, especially in a country where the availability of open or underpopulated space is at a tremendous premium, indicates a significant commitment on the part of the project planners to the fundamental premise that liquefied gas terminals should be kept physically remote from the general public to as great an extent as possible.

4.4.4.3 Regulatory Considerations - Shell-BP Proposal

The highlights of the proposed special gas tanker operating regulations for vessels serving the proposed Shell-BP terminal were as follows:[33]

a) inbound gas carriers would be required to establish radio contact with the Port of Rotterdam well in advance of arrival in order to secure clearance to enter the harbour;

b) fully- or partially-loaded gas tankers would not be permitted entry into the harbour during periods of limited visibility or in high wind conditions (standards to be established);

c) present regulations, which require loaded oil and gas tankers to assume a compulsory tug escort once the vessel has entered the harbour, would be modified to the extent that the tug escort would be picked up some two or three kilometres west of the harbour entrance.

(N.B. A preliminary report entitled LPG in Europoort, produced by the project sponsors in 1978 or 1979, suggested that incoming LPG tankers would be attended by two tugs - one attached at the bow, and the other at the stern.)[34]

d) a harbour patrol boat would be assigned to each incoming gas carrier for the purpose of maintaining a clear navigable channel ahead of the tanker throughout the harbour transit phase

(N.B. As of May 1980, it had not been established whether the port would introduce a "moving safety zone" concept similar to that in effect in Boston, or the shipping channel closure technique practiced at Los Angeles)

e) gas tankers operating either within the confines of, or the approaches to, the Port of Rotterdam would be required to have both a coastal and a river pilot on board at all times;

f) liquefied gas carriers would be required to maintain radio contact with the vessel traffic service while underway in the port.

4.4.5 Canvey Island, U.K.

4.4.5.1 Physical Considerations

Outwardly, Canvey Island would appear to have the most in common with the Port of Vancouver from a terminal siting perspective. In both instances, the respective gas terminals are situated many kilometres from the open sea. Similarly, when constructed during the early 1960's there was little in the way of concentrated suburban residential development in the immediate vicinity of either facility (although this condition has since reversed itself in each case).

There are, however, several important considerations which set Vancouver and Canvey apart from one another. Firstly, whereas the maximum width of Burrard Inlet seldom exceed 2500 metres at any point, the River Thames between the British Gas Corporation jetty at Canvey and the Former Seaward Limit of the Port of London, some 22 kilometres downstream, never constricts to less than 2500 metres (see map, p. 130). In fact, the minimum width of the river between Canvey Point (the easternmost extremity of Canvey Island) and the Former Seaward Limit is approximately six kilometres. Because the Thames deepsea shipping channel is, for the most part, geographically situated in mid-river, liquefied gas tankers are assured a minimum buffer of at least two kilometres on either side between the vessel and the coastline for all but the last five kilometres of the journey into the Canvey terminal.

The second significant difference between the two ports stems from the fact that the harbour transit through the Port of Vancouver places tens, perhaps even hundreds, of thousands of people who live or work along the shores of Burrard Inlet at risk. The coastal population residing along the River Thames between Canvey and the Former Seaward Limit, on the other hand, is neither as large nor as densely concentrated as in Vancouver. This feature, combined with the knowledge that loaded gas tankers approaching the British Gas terminal are generally smaller and, in a physical sense, further removed from the immediate coastal population than is the case in Vancouver, suggests that Canvey-bound gas carriers present less of a direct threat to public safety than do liquefied propane tankers during their regular

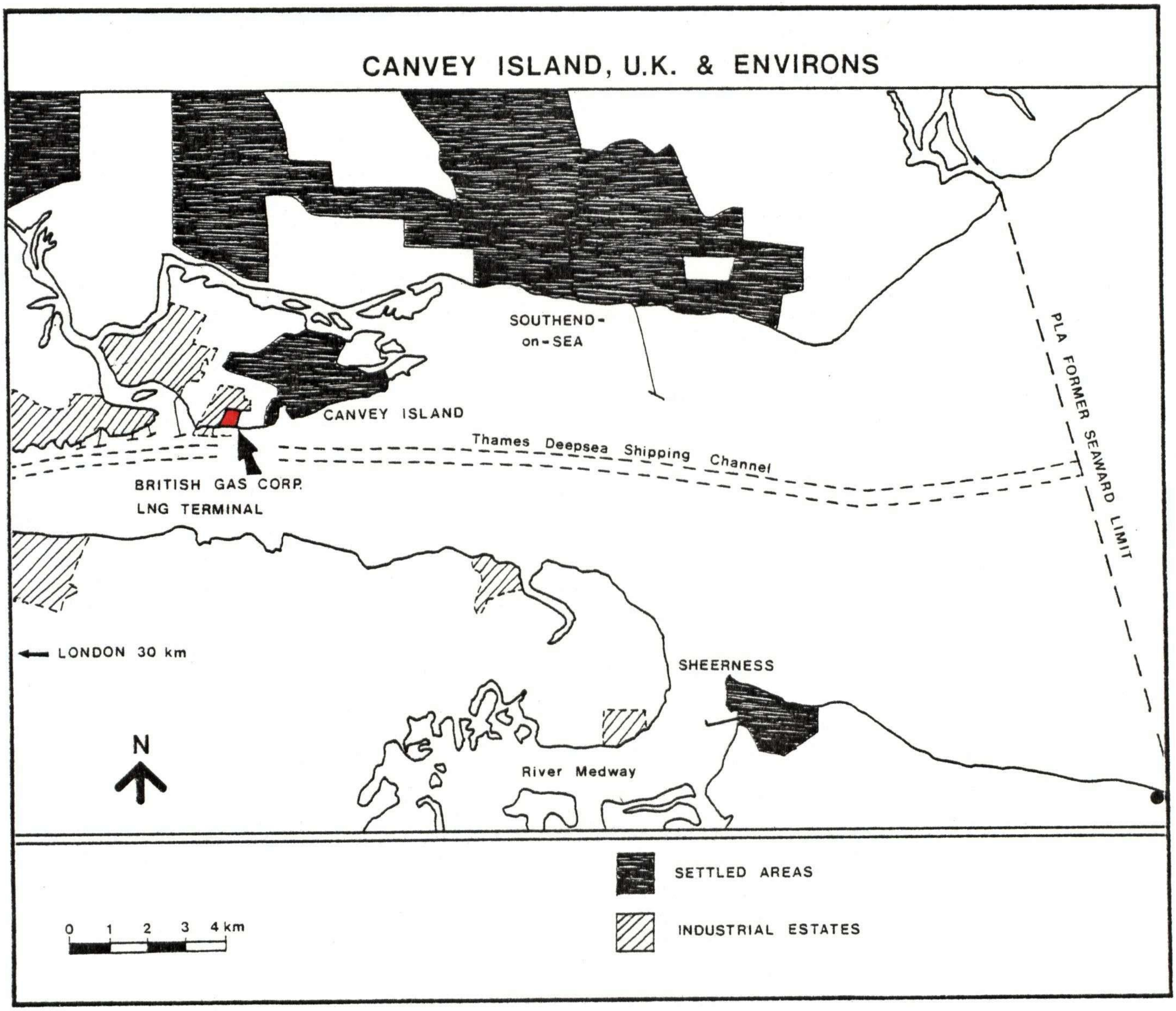
CANVEY ISLAND, U.K. & ENVIRONS
SOUTHEND-on-SEA
CANVEY ISLAND
Thames Deepsea Shipping Channel
BRITISH GAS CORP. LNG TERMINAL
PLA FORMER SEAWARD LIMIT
LONDON 30 km
SHEERNESS
N
River Medway
SETTLED AREAS
INDUSTRIAL ESTATES
0 1 2 3 4 km

Figure 4.7

transits of Burrard Inlet.*

A final point to consider is that liquefied gas tankers operating in the lower reaches of the Thames are not required to contend with such potential hazards as cross-harbour commuter ferries, deepsea vessels moored either within, or in close proximity to, the navigable fairway, or railway and automobile bridges, all of which are distinct navigational concerns in the Port of Vancouver.

4.4.5.2 Regulatory Considerations

Liquefied natural gas carriers functioning within the Port of London have, for a number of years, been governed by a special operating by-law.[35] However, contrary to recent regulatory experience in the United States where the tendency on the part of the coastal state has increasingly been one of exercising greater "hands on" control over actual ship operations, the London LNG by-law has been drafted in such a fashion as to leave the vessel master's authority more or less intact. Thus, while inbound gas carriers are required to secure Harbour Master's clearance to both enter and move within the port, and while they are bound to observe a number of special precautions concerning vessel berthing and cargo offloading procedures, gas tankers are not affected by such constraints as the mandatory provision of escorts, tug assistance during docking, shipping lane closures, or the institution of moving safety zones.

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*The two vessels which regularly service the Canvey Island LNG terminal - that is the Methane Progress and the Methane Princess - have cargo capacities on the order of 27 400 m^3. The cargo capacity ratings for the three most recent LPG carriers to visit Westridge Terminal in Burnaby (prior to 31 August 1982) were as follows:

Yamahide Maru	-	38 160 m^3
Tatsuno Maru	-	50 670 m^3
Nichizan Maru	-	40 000 m3 (estimated)

The apparent reluctance on the part of Port of London officials to introduce more stringent operating regulations for liquefied gas tankers undoubtedly stems from a combination of factors ranging from a long-standing sense of British maritime tradition to the rather questionable hypothesis that, since the port has experienced no serious gas tanker accidents in 18 full years of operation, there is no perceived need to upgrade existing standards. As with Vancouver, Port of London officials, either, unwittingly or otherwise, appear to have established their regulations on the assumptions that:

a) individual gas tankers will not be placed in hazardous circumstances as a result of either mechanical failure or human error;

b) gas tanker safety will not be jeopardized as a result of mechanical failure or human error on <u>other</u> vessels; and

c) in the unlikely event a gas tanker is involved in a serious accident, the structural integrity of the cargo containment system will remain intact throughout.

History may, in fact, bear out the preceding assumptions. However, as has been indicated elsewhere in this thesis, regulatory agencies in the United States and on the European continent have widely rejected this approach to rulemaking on the basis that it fails to incorporate sufficient back-up safety measures capable of responding in an effective manner to any initial emergency situation which may result should either of assumptions "a" or "b" (above) prove incorrect. For example, the presence of escorting tugs could prove invaluable in the event a liquefied gas carrier sustains a loss of power or rudder malfunction in a constricted or congested area. The introduction and enforcement of a moving safety zone, by the same token, would serve to virtually eliminate the possibility of a major collision between vessels, for whatever reason(s).

Another disturbing feature on the part of the Port of London Authority (PLA) has been its tendency to introduce sometimes loosely worded operating guidelines which are open to broad interpretation by individual masters and pilots and which, by definition, would almost certainly prove difficult to enforce. For instance, PLA Notice to Mariners 8 of 1980 (issued in January 1980) states that all vessels operating between Sea Reach No. 7 and West Blyth Buoys (i.e. in the immediate vicinity of Canvey Island) "...shall proceed at a moderate speed when passing berths where specified vessels with cargoes of LNG, LPG, Ammonia or Explosives are present or manoeuvring in the vicinity...", and furthermore that specified vessels "...shall, when above Sea Reach No. 7, at all times proceed at moderate speed."[36] The operative term in both instances is "moderate speed" which, in turn, has been defined by the PLA as being "...not more than 8 knots through the water, or minimum speed necessary for adequate control and safe navigation, whichever is greater."[37] Accordingly, while 8 knots is a "suggested" maximum speed, the wording of the definition is such that any vessel could be operated at speeds in excess of 8 knots should the master deem it necessary to maintain proper control. This somewhat interpretive approach towards navigational rulemaking is in direct contrast to the strict, precisely-defined safety regulations which have become the hallmark of American gas tanker regulatory experience.

FOOTNOTES - CHAPTER 4.0

1 For further details see Intergovernmental Maritime Consultative Organization, Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (London: The Organization, 1976); and Intergovernmental Maritime Consultative Organization, Code for Existing Ships Carrying Liquefied Gases in Bulk (London: The Organization, 1976).

2 Lloyd's List, see editions 4 October 1980 and 18 and 19 December 1981.

3 Captain W.S.G. Morrison, as quoted in West Coast - A Digest of Evidence presented to the West Coast Oil Ports Inquiry (Vancouver: prepared by Westwater Research Centre, 1977), p. 28.

4 Fisheries and Oceans, Sailing Directions - British Columbia Coast (South Portion), (Ottawa: Fisheries and Oceans Canada - Scientific Information and Publications Branch, 1979), Vol. 1, eleventh edition, p. 188.

5 Transport Canada, The Modern Tale of the Timeless Seas (Vancouver: Canadian Coast Guard, circa 1976), p. 3.

6 Government of Canada, National Harbours Board Operating By-law (Ottawa: Queen's Printer for Canada, 1978), section 59.

7 Port of Vancouver, Second Narrows MRA Standing Orders (Vancouver: National Harbours Board, 1 December 1981), pp. 1-19.

8 "Tug escorts 'will raise' cost of Narrows transits", The Vancouver Sun, 25 March 1980.

9 "Near-misses plague Second Narrows", The Province, 11 March 1980.

10 "Tanker loses steering", The Vancouver Sun, 27 November 1977.

11 Based upon information extracted from U.S. Coast Guard liquefied gas tanker operations plans for Boston, Massachusetts; Los Angeles, California; Providence, Rhode Island; Elba Island (Savannah), Georgia; Cove Point, Maryland; and Philadelphia, Pennsylvania.

12 Quotation extracted from U.S. Coast Guard (Department of Transportation), Port of Los Angeles - Liquefied Petroleum Gas Operations/Emergency Plan (Los Angeles: October 1978), Part III, Section A, Subsection 1a, p. 3. It should be noted that the actual wording of the disclosure may vary marginally from one port to the next, although the substance of the text remains essentially the same.

13 Background information on the evolution of Boston as a gas port extracted from a letter addressed to the writer from Mr. R. Moriconi, Assistant Port Director - Traffic, Massachusetts Port Authority, dated 14 December 1979.

14 U.S. Coast Guard (Department of Transportation), *The Port of Boston - LNG-LPG Vessel Management Plan and Emergency Plan* (Boston: U.S. Coast Guard Marine Safety Office, 1 August 1979), pp. I-2 to I-4, p. I-II-1, and p. I-II-1.

15 Based upon telephone conversation between writer and Ms. J. Natow, Port of Los Angeles, 28 November 1979.

16 "Tanker scheduled to bring second LPG shipment", *Los Angeles Times*, circa December 1978.

17 Davis, *op. cit.*, p. 158.

18 Unless otherwise indicated, all information pertaining to gas tanker regulations in the Port of Los Angeles has been derived from U.S. Coast Guard (Department of Transportation), *Port of Los Angeles - Liquefied Petroleum Gas Operations/Emergency Plan* (Los Angeles: October 1978).

19 T.K. Jennssen, "Risk Analysis of LPG Transportation in the Porsgrunn Area", *Veritas* (Oslo: Det norske Veritas), Vol. 24, No. 94, December 1978, p. 9.

20 *Lloyd's List*, 26 April 1982.

21 "Progress on LPG terminal", *Lloyd's List*, 10 August 1981.

22 Health & Safety Executive, *Canvey: Summary of an investigation of potential hazards from operations in the Canvey Island/Thurrock area* (London: Her Majesty's Stationary Office, 1978), p. 2.

23 *Lloyd's List*, 25 March 1981.

24 *Ibid.*, 25 March 1981.

25 Lee M. Davis, *Frozen Fire* (San Francisco: Friends of the Earth, 1979), pp. 275-276; and *Lloyd's List*, 21 May 1982.

26 BP Raffinaderij Nederland N.V. and Shell Nederland B.V., *LPG in Europoort* (Rotterdam?: public information brochure released circa 1978 or 1979), p. 9.

27 Based upon interviews between the writer and representatives of the Port Autonome du Havre, Le Havre, France, 26 May 1980.

28 "Controversial LPG plan at Europoort wins approval", *Lloyd's List*, 9 November 1981.

29 "Rotterdam row over landing policy", *Lloyd's List*, 19 March 1981.

30 *Ibid.*, 19 March 1981.

31 *Ibid.*, 19 March 1981.

32 "Rotterdam anxious for LPG start-up", *Lloyd's List*, 8 August 1981.

[33] Preliminary information on the proposed gas tanker regulations for Europoort furnished by Mr. Peter Noë, Research Project Manager, Port of Rotterdam during a conversation with the writer, 30 May 1980, except as otherwise indicated.

[34] BP Raffinaderij Nederland N.V. and Shell Nederland B.V., *op. cit.*, p. 9.

[35] Port of London Authority, *By-laws made by the Port of London Authority with respect to the importation, exportation and handling of liquid methane in the port of London* (London: P.L.A., circa November 1965).

[36] Port of London Authority, *Notice to Mariners 8 of 1980 - Precautions to be Observed by Vessels* (London: P.L.A., 30 January 1980).

[37] *Ibid.*

5.0 CONCLUSIONS

It is apparent that two fairly distinct schools of thought have emerged among the port regulatory agencies examined in this thesis concerning the matter of navigational safety requirements for liquefied gas carriers. On the one hand, there are those who would advocate strong regulatory intervention on the part of the host nation, as has clearly been the case in both the United States and, more recently, Holland. The essence of this philosophy is to diminish the inherent risk factor to the lowest possible level short of excluding gas tankers from the port entirely.

By contrast, authorities at both the Port of London and the Port of Vancouver have traditionally tended to avoid direct regulatory intervention wherever possible. As a result, the special gas tanker operating requirements in effect for both the lower Thames region and Vancouver harbour are noticeably lacking in terms of substance, scope, and clarity when contrasted with such communities as Boston, Los Angeles, or Rotterdam/ Europoort.

It must therefore be concluded that the hypothesis tested - that "...safety standards in the Port of Vancouver reflect -- to the extent humanly and reasonably possible -- local, regional and national concerns and can be compared favourably with similar international experience..."[1] - cannot be supported on the strength of the evidence presented, at least to the extent that it applies to the safe passage of liquefied petroleum gas carriers through the port. In actual point of fact, given such constraints as the size and configuration of the harbour, the volume and nature of shipping traffic in the port, and the geographical location of the Westridge terminal, local LPG safety standards in such areas as tug escort requirements, vessel inspection and clearance procedures, speed limit restrictions, or the imposition of mandatory safety zones around liquefied gas carriers bear little resemblance to those in effect in the majority of the American or European gas ports examined.

Table 5.1 Comparison of Special Regulations in Effect During Harbour Passage of LPG/LNG Tankers

Port: / Standard	Boston	Los Angeles	Europoort	Le Havre	Canvey Island	Vancouver
1. Frequent gas tanker safety inspections by host nation	*	*	?	?	?	
2. Mandatory tug escort	*	*	*	*		Second Narrows Only
3. Harbour speed limit restriction	*	?	*	*	*	Second Narrows Only
4. Moorage prohibited in or near navigable fairway	*	*	*	*	*	
5. Safety zone around moving gas carrier	*	*	*	?		
6. Mandatory provision of harbour master escort	*	*	*	?		
7. Aircraft movement restrictions	*	*	?	?	?	
8. Daylight passage only (loaded vessels)	*	*	*	?		*
9. Visibility restrictions	*	*	*	?	*	*
10. Special bylaw or operations plan	*	*	?	*	*	
11. Vessel traffic management system			*	*	*	*

It is conceivable that the Assistant Harbour Master's statement of November 1979 was based, either in whole or in part, upon any of three separate assumptions/considerations:

A) A geniune, but mistaken, belief that gas tanker rules were, indeed, on a par with other world ports.

B) The assumption that, since there have been no reported gas tanker accidents to date in the Port of Vancouver, the existing safety standards must be adequate and, therefore, at least equivalent to those in effect in other ports.

There are several flaws in this argument, which reflects a serious misinterpretation of historic events, both locally and internationally. Fairley and others have suggested that risk analysis based upon limited, accident free operating histories should be viewed with caution.[2] The Port of Vancouver has experienced perhaps 400 (inbound and outbound) LPG tanker transits during the past 16 years, or roughly 25 transits per year. That there have been no serious gas tanker accidents during that period does not necessarily establish a "significant" probability factor, and should not be construed as indicating that, based upon previous operating experience, there is a zero probability of an LPG accident occurring in the harbour. In actuality, it is more realistic to assume that the probability of a major accident occurring at some time in the future is equal to some range of values, irrespective of the previous operating record. The preceding comments should be further tempered by the fact that, of 45 serious, very serious, and total loss LPG tanker casualties between 28 June 1979 and 5 February 1982 (as identified in Appendix II), at least 18 occurred in, or in close proximity to, populated harbour areas. Based upon information provided in Clarkson's Liquefied Gas Carrier Register - 1981, it is estimated that the world LPG tanker fleet during this period constituted some 1400 tanker operating years:[3]

Table 5.2 LPG Tanker Operating Years
28 June 1979 - 28 February 1982

Year	a) World LPG Tanker Fleet	b) Portion of Year Under Consideration	c) Tanker Years (a X b = c)
1979	500	6 months (6/12)	250
1980	528	12 months (12/12)	528
1981	568	12 months (12/12)	568
1982	570 (est.)	1 month (1/12)	48
		Total	1394

Thus, the incidence of serious LPG tanker accidents in or near populated harbour areas during this period amounted to approximately one casualty for every 78 tanker years.

It is possible that the shipping regulations presently in place may, thus far, have had little bearing whatsoever on the safe passage of gas carriers through the Port of Vancouver. A combination of good seamanship, strict adherence to the navigational rules of the road, and the absence of any extraordinary operating circumstances may, in fact have precluded the likelihood of a serious accident occurring on any of the 200 or so previous gas tanker visits to the port. The question remains, however, as to whether or not the existing standards would be sufficient to deter a major, possibly catastrophic, accident from occurring in the event of a serious equipment malfunction or error in judgment. It is the contention of this thesis that they would not be adequate.

The 12 October 1979 incident involving the freighter Japan Erica more fully underscores the shortcomings associated with the "adequacy of the existing standards" argument. Prior to that date, it is reasonable to assume that shipping regulations in force for the Second Narrows might also have been considered both appropriate and effective, based upon the previous ship safety record for the area. However, on the evening of 12 October, the outbound Japan Erica collided with the Second Narrows Railway Bridge during a period of dense fog and, in so doing, inflicted heavy damage to the bridge's lift span. In a brief moment, the basic inadequacies of the Second Narrows Operating regulations were exposed in the worst possible light. In simplest terms, the Japan Erica should not have been permitted to sail under the prevailing fog conditions on the night of 12 October. Clearly, the shipping regulations in effect at that time were not sufficiently rigourous to compensate for the poor quality of seamanship displayed by the master and pilot aboard the Japan Erica.

C. Port authorities may consciously have resisted introducing more appropriate operating standards for gas tankers on the basis that the Port of Vancouver is responsible for the dual, and not entirely compatible, portfolio of port marketing and harbour safety.

Under these circumstances, there exists the very real concern that port officials, in an effort to either attract new businesses or retain existing ones, may choose to place marketing considerations ahead of public safety concerns. The hasty manner by which strict new shipping regulations were introduced for the Second Narrows area following the Japan Erica accident lends considerable support to the preceding observation. It is a matter of public record that Dr. Hugh Horner, formerly of the Canadian Wheat Board made "...very strong representations..." to the National Harbours Board prior to the re-opening of the Second Narrows railway bridge in February of 1980 in an attempt to gain assurances that stringent measures would be taken to ensure that the bridge would not be hit again.[4] The Harbours Board responded to Mr. Horner's overtures by introducing the most comprehensive mandatory operating regulations currently in force in the harbour (See Section 4.2.2).

While the recent introduction of special navigation rules for the Second Narrows - at least to the extent that they apply to vessels transporting hazardous materials - does, in a sense, reflect the goals of this thesis, it must not be overlooked that the primary objective of the new regulations is not so much to increase the level of public safety in the vicinity of the Second Narrows as it is to protect both the structural integrity of the railway bridge and the economic interests in serves. That the NHB appears to perceive its commitment to ensuring a high level of public safety as secondary to the preservation of economically strategic properties is illustrated by the fact that once a ship transporting dangerous materials (such as LPG) has cleared the Second Narrows, the principal elements of active vessel protection (including tug escorts, speed restrictions, and clear channel requirements) are immediately dismissed. Significantly, an outbound gas tanker traversing Vancouver's main harbour (that is, the harbour area situated to the west of the Second Narrows) would routinely expect to encounter such potential hazards to navigation as passing deepsea vessels, large cargo ships moored at any of the five critically located mid-harbour anchorages, tug and barge traffic, coastal and cross- harbour ferry movements, extensive seaplane activity, and numerous small commercial and recreational craft. In the event of a serious mid-harbour gas tanker accident occurring between the First and Second Narrows, it is arguable that, depending upon the location and nature of the mishap, a greater number of lives would almost certainly be placed ar risk than would be the case for an identical accident occurring within the strictly controlled limits of the Second Narrows. Thus, while there is a compelling rationale from a public safety perspective to upgrade the quality of gas tanker operating standards throughout the remainder of the port, the Harbours Board has done little in the way of responding to this challenge.

Regardless of the official corporate reasoning behind the Port of Vancouver's decision to implement LPG navigational safety rules which do not compare favourably with those in force in other gas ports, certain recent events suggest that port officials may find themselves in an increasingly compromised position should they continue to adhere to the current regulatory philosophy as it relates to the bulk storage and marine transport of dangerous goods. In order to put this statement into proper context, one might briefly consider B.C. Hydro's recent proposal to construct an LNG peak shaving plant near Sasamat Lake, some 20 kilometres east of Vancouver. The Hydro proposal calls for the construction of a 70 000 cubic metre capacity LNG storage facility for the purpose of supplying natural gas during periods of peak energy demand. The Sasamat site was selected over several others on the strength of purportedly superior engineering, public safety, and environmental characteristics. Natural gas would be piped to the Sasamat plant, where it would be liquefied and subsequently stored until required. The plan would not require the movement of LNG by either marine or rail mode.

However, despite the comparatively underpopulated nature of the area, and notwithstanding Hydro's stated intention to incorporate the highest design standards into the project, the public reaction against the proposal was sufficiently intense to cause the company to thoroughly re-assess the practicality of locating at the Sasamat site. The proposal is presently on indefinite hold, pending an improvement in the general economic climate.

In contrast, the Westridge LPG terminal operation in Burnaby is affected by a number of severe locational and operational disadvantages which are not inherent in the Hydro proposal. For instance, Westridge is unfavourably situated in close proximity to residential neighbourhoods, and is not separated from these areas by an effective neutral buffer zone. It has been estimated that between 1000 and 2000 people reside within a 600 metre radius of the Westridge facility.[5] Furthermore, Westridge is dependent upon rail and marine delivery systems, both of which require lengthy transits through densely populated areas, and are more susceptible to the risk of serious life-threatening accidents than are pipelines. Finally, as noted in Section 3.3.1 of this document, LPG is, in many respects, considered to be a more dangerous commodity to handle than LNG.

In view of these circumstances, it is not difficult to understand why port officials have been reluctant to draw public attention to the existence of a large volume overseas LPG trade operating out of Vancouver. By so doing, they would undoubtedly run the risk of incurring a serious public backlash. Moreover, the introduction of strict new operating regulations for gas tankers at this time might only serve to emphasize that the existing requirements are inadequate. On the other hand, failure to upgrade existing standards could also result in severe repercussions in the event of either a serious gas tanker incident in the port. In any event, public trust in the operating methods of the Port of Vancouver could be substantially, and justifiably, undermined.

In the wake of events such as the Japan Erica episode, there can be little doubt that a major, life-threatening accident involving a liquefied gas carrier could occur in the Port of Vancouver, given the appropriate circumstances. Furthermore, it would be wrong to presume that the likelihood of such an accident occurring could ever be totally eliminated as long as the port continues to serve the deepsea liquefied gas tanker trade. Nevertheless, the accident risk factor could be reduced significantly through the introduction of more stringent regulations, both in terms of substance and enforcement. That the Yamahide Maru has now been permanently replaced by the Nichizan Maru should be viewed as the inauguration of a new era in gas tanker operations in the port, and as an opportunity to upgrade existing regulatory standards to a recognized world level prior to, rather than after, a serious mishap has occurred.

5.1 Recapitulation

In summary, it is concluded that:

- in terms of inflammability/explosiveness, the hazard potential inherent in the marine transportation of LPG by ocean-going gas carriers is as great as, if not greater than, that of LNG, and should be recognized accordingly in terms of the application and enforcement of appropriate special in-harbour operational safety regulations;

- the special operating requirements presently in force in the Port of Vancouver for vessels transporting LPG do not compare favourably with similar regulatory circumstances in either the United States or Western Europe.

- liquefied gas carriers operating within the confines of Vancouver's Burrard Inlet are routinely exposed to a wide variety of navigation hazards ranging from shipping congestion to potential conflicts with seaplane activity. With few exceptions, the Port of Vancouver has failed to introduce special safety measures which are both cognizant of the dangerous nature of LPG and which are designed to mitigate the inherent hazard potential associated therewith;

- it is conceivable that a loaded or partially-loaded liquefied gas tanker could be involved in a serious harbour accident due to mechanical failure or human error (either aboard the gas carrier or another vessel);

- it would be difficult, if not impossible, to contain a major shipboard LPG fire in the Port of Vancouver due to a critical local shortage of appropriate marine emergency response equipment. This situation would be exacerbated in the event the City of Vancouver chooses to withdraw the only existing fireboat from service entirely; and

- the effects of a serious mid-harbour LPG fire and/or explosion could be catastrophic to both public health and property, depending upon such variable factors as the time and location of the accident, and upon prevailing tidal and weather conditions.

FOOTNOTES - CHAPTER 5.0

1 Letter from Capt. T. Elworthy, Assistance Harbour Master, Port of Vancouver, to J. Marston, 22 November 1979.

2 William B. Fairley and Frederick Mosteller, Statistics and Public Policy (Reading, Mass.: Addison-Wesley Publishing Company, 1977), pp. 331-353; and F.W. Murray et al, Hazards Associated with the Importation of Natural Gas (Santa Monica: The Rand Corporation, 1976), pp. 5-6.

3 H. Clarkson & Company Limited, Liquid Gas Carrier Register - 1981 (London: H. Clarkson & Company Limited, 1981), p. 25.

4 "Bridge safeguards urged", The Province, 17 February 1980.

5 Canadian Transport Commission, Railroad Transport of Dangerous Goods in the Greater Vancouver Region (Vancouver: May 1982), p. 53.

6.0 RECOMMENDATIONS

6.1 Primary Recommendations - LPG Tanker Operational Safety

In the interests of improved public safety, it is concluded that the operating standards for both LPG and LNG tankships functioning within the confines of the Port of Vancouver should be upgraded to a level more or less equivalent to those in force in the American and continental European gas ports examined in the research. In order to achieve this objective, it is recommended that the following special regulatory provisions for deepsea liquefied gas carriers should be brought into effect forthwith:

A. Inspection Requirements

A detailed shipboard inspection of every incoming liquefied gas carrier should be undertaken by qualified Canadian Coast Guard personnel prior to the commencement of cargo transfer operations. The mandatory inspection requirement should not be waived for frequent visitors to the port. Loaded or partially-loaded vessels should be inspected prior to the vessel entering the Port of Vancouver, while empty vessels that are certified to be gas free should be inspected while at berth or local anchorage.

Rationale:

There have been a number of documented instances where shipboard inspections by U.S. Coast Guard teams have determined serious gas detection system malfunctions on liquefied gas carriers. In 1973, the Norwegian LPG tanker Havis was refused permission to unload in Boston Harbour when it was discovered that the vessel's gas detection alarm could not be shut off.[1] The pressure relief valves had been improperly set by the crew, rather than by an internationally certified team, as required.

In February 1977, an unnamed LPG carrier was ordered to leave the port of Providence, Rhode Island when the gas detection system apparently malfunctioned. According to the Coast Guard Marine Safety Office, Providence, the vessel spent several days offshore while attempting to remedy the problem. Apparently unable to do so, it eventually departed without discharging its cargo.[2]

The strongest supporting rationale for the pre-cargo transfer inspection process, however, comes from Coast Guard officials in Boston and Philadelphia. Kenneth A. Rock of the Marine Safety Office, Boston, stated recently that "...experience at (Boston)...has shown that approximately 15-20% of liquefied gas vessels entering this port on their initial visit are delayed off port due to malfunctioning equipment or incomplete documents. Approximately 10% of liquefied gas vessels entering on a regular trade are delayed offport."[3]

Captain D.B. Charter, Captain of the Port, Philadelphia, has added that "...in the past two years we have not denied entry to any...(liquefied gas) ship. We have, however, had to send a ship to anchorage to further cool cargo before allowing it to transfer and refused operations of two vessels without the required span gas.*

*"Span gas" is gas certified to contain 30% of the explosive limit for LPG and LNG, and is used to test gas detection equipment.

This...is why we feel it is important to inspect these ships every port visit. The gas detection system, span gas, alarms and firefighting equipment are items that can change during transit. They are also vital to the safety of the vessel and port. We have had a vessel come into port with an icing problem on their quick closing valves which wasn't discovered until the Coast Guard... inspection."[4]

B. Attending Tugs

Loaded or partially-loaded oceangoing LPG and LNG carriers operating within the confines of Burrard Inlet or its contiguous navigable waters should, while underway, be attended at all times by a compulsory escort of at least two tugs. The mandatory escort area should include all navigable waters situated to the east of the First Narrows Bridge.

Escort tug horsepower and bollard pull standards should correspond with those established in Appendix B of the Port of Vancouver's Second Narrows MRA Standing Orders, dated 1 December 1981 (See Section 4.2.2., p. 100 of this thesis).

Rationale:

Mandatory tug escort requirements are common to all of the American and continental European gas port examined. The availability of adequately powered and highly manoeuvrable tug escorts could prove invaluable in various emergency situations which could arise during the harbour transit of a gas carrier. Among the most plausible emergency events in which tug assistance could be beneficial would be loss of steering, loss of power or a gas tanker being placed on a collision course with another vessel or obstacle.

C. Speed Restrictions

Except under emergency circumstances, as determined by the master or pilot, loaded or partially-loaded LPG and LNG carriers operating within the mandatory escort area (as described in Recommendation "B"), should maintain a speed not in excess of 6 knots, exclusive of those areas in the port where lower maximum speed limits are in force.

Rationale:

The proposed 6 knot maximum speed requirement, like the proposed tug escort requirement listed in Recommendation "B", is a direct extension of the standards currently in place for the Second Narrows MRA. In this regard, the tug escort and vessel speed limit standards are compatible with one another in order to ensure optimum escort effectiveness.

It is acknowledged that the maximum safe operating speed for a liquefied gas carrier (under escort) in the open harbour might reasonably be higher than for the restricted Second Narrows area. However, power requirements for attending tugs listed in Recommendation "B" would have to be amended accordingly in order for the escort to remain effective at higher speeds, as it would require greater energy to either stop or change the heading on a large travelling at a speed of 8 knots than it would for the same vessel travelling at 6 knots.

It is suggested that the issue of establishing appropriate long-term tug escort and speed limit requirements (Recommendations "B" and "C") should be afforded particular attention by the Joint Technical Committee (described in Recommendation "H").

D. Inner Anchorage Moorage

No vessels should be permitted to moor at Inner Anchorages A through E, Port of Vancouver, during either the inbound or outbound passage of a loaded or partially-loaded liquefied gas carrier.

Rationale:

The existence of moored deepsea vessels in the midst of the main harbour area of the Port of Vancouver represents an unnecessary impediment to the safe navigation of a large gas tanker. Through proper scheduling, it should be possible to ensure that Inner Anchorages A through E will remain vacant during the main harbour passage of deepsea gas carriers, thereby eliminating a potential threat to ship safety.

E. Safety Zone

Loaded or partially-loaded liquefied gas carriers transitting the port should do so within a moving safety zone in order to avoid potentially dangerous crossing or passing situations with other large vessels. The safety zone should extend three kilometres ahead of the gas carrier, and two kilometres astern at all times. No other vessels underway in the port would be permitted to encroach upon this safety zone. Outside the safety zone, vessels in excess of 100 gross tons would not be allowed to transit the harbour during the passage of a gas carrier without the expressed permission of the Harbour Master.

Rationale:

The imposition of a moving safety zone would substantially reduce the likelihood of a collision involving the gas carrier and another large vessel within the confines of the harbour, especially in high speed crossing and (oncoming) passing situations. Furthermore, in the event of another large vessel accidentally encroaching upon the safety zone, the gas carrier, along with its attendant tug escort, would likely be afforded sufficient opportunity to manoeuvre out of danger.

The moving safety zone has an added economic advantage over a total harbour closure (such as that which is imposed for the Los Angeles Main Channel during the passage of loaded gas carriers) in that it will have little effect upon traffic proceeding in the same direction as the gas carrier. Oncoming vessels could be disadvantaged to a somewhat greater degree should they wish to enter port during the outbound passage of a loaded gas carrier. It is suggested, however, that such inconveniences could be kept to a minimum, if not eliminated entirely, with proper vessel movement scheduling.

F. NHB Escort

The Harbour Master's Office should assign a patrol vessel to accompany loaded or partially-loaded liquefied gas carriers while underway within the mandatory escort area (as described in Recommendation "B"). The NHB escort would be expected to take up normal station several hundred metres ahead of the gas carrier.

Rationale:

The NHB escort would be responsible for ensuring the integrity of the moving safety zone, and for enforcing all other vessel traffic regulations pertaining to the safe passage of the gas carrier.

In the event of a serious, or potentially serious, situation arising aboard the gas carrier, the master of the escort vessel would be responsible for contacting the Harbour Master immediately, and for providing strict traffic control and other assistance in the vicinity of the gas carrier, as required.

G. Aircraft Restrictions

The Harbour Master's Office should notify the harbour air traffic control centre at least 24 hours in advance of any scheduled transit of Burrard Inlet by a loaded or partially-loaded gas carrier. No seaplane landing/takeoffs should be permitted until the gas tanker is at least two kilometres past the designated aircraft movement area. Furthermore, no aircraft should be permitted to fly within a 1000 metre radius of any loaded, partially-loaded, or unloaded liquefied gas carrier, either moving or stationary.

Rationale:

Steadily increasing aircraft movements within the Port of Vancouver have been characterized in recent years by several serious accidents and the introduction of a separate air traffic control centre for the harbour precinct. Given the extensive amount of aircraft activity in the port area, combined with the fact that liquefied gas carriers engaged in the transit of the harbour must encroach upon active seaplane landing/take-off zones, the possibility of a serious airplane or helicopter accident involving a gas carrier cannot be discounted. It is therefore concluded that the imposition and enforcement of more stringent, but readily manageable, aircraft movement restrictions as described in Recommendation "G" will serve to enhance the overall level of public safety in the port precinct.

H. Review and Implementation

The recommended operating requirements "A" through "G" should be brought into force immediately on an interim basis under the authority of the Harbour Master's Standing Orders.

Subsequent to the introduction of these proposed interim measures, a Joint Technical Committee comprised of representatives from the National Harbours Board, the Canadian Coast Guard, the Pacific Pilotage Authority, the towboat industry, and the marine division of the Vancouver Fire Department should be formed for the purpose of:

i) reviewing and, as necessary, amending Recommendations "A" through "G";

ii) preparing a detailed LPG/LNG tanker operations plan, based upon the U.S. Coast Guard model; and

iii) establishing a comprehensive LPG/LNG emergency response plan for the Port of Vancouver.

Rationale:

Recommendations "A" through "G" represent a preliminary attempt to upgrade gas tanker safety requirements in the Port of Vancouver to a widely recognized - and generally accepted - world standard for urban gas ports. Nevertheless, while the basic concept inherent in each recommendation is, from the perspective of the research, essentially inviolate, it is acknowledged that the specific terms of their individual application, as established in Section 6.1, could, under certain circumstances, be open to varying degrees of professional interpretation.

For instance, while the imposition of a mandatory tug escort requirement is common to all of the American and continental European gas ports examined, the composition of the escort and the minimum power ratings for attending tugs differ markedly from one port to the next. This is evident upon a brief examination of tug escort requirement as they would apply to the 40 000 cubic metre capacity, 29 800 dwt Nichizan Maru in four North American gas ports:

Port	# of Tugs	H.P.	Bollard Pull	Tug Secured to LPG carrier
Boston	3	2 @ 3000 H.P. 1 @ 1200 H.P.	unspecified unspecified	no
Los Angeles	2	unspecified	unspecified	yes
Philadelphia	1	unspecified	unspecified	no
Vancouver*	2	2 @ 900 H.P.	15.0 T each	no

Similarly, gas carrier speed restrictions at these ports vary as follows:

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*Assumes application of existing Second Narrows MRA standards

Port	Maximum Speed
Boston	8 knots
Los Angeles	?
Philadelphia	10 knots
Vancouver*	6 knots

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* Assumes application of existing Second Narrows MRA standards.

Given the technical complexity of the debate, it is concluded that the responsibility for refining the long-term gas carrier operating speed and tug escort standards for the Port of Vancouver must rest with a competent committee of marine professionals who are fully conversant with the problem. The interim standards, as described in Recommendations "B" and "C", would remain in force, subject to the review findings and conclusions of the Joint Technical Committee.

The preparation of a detailed operations plan and emergency response plan would be expected to evolve logically from the just-described preliminary standard upgrading process.

6.2 Supplementary Observations/Recommendations

Liquefied gas tanker safety is only one of many dangerous commodity-related issues involving the Port of Vancouver which have yet to be satisfactorily resolved. For example, the port has experienced a marked increase in the frequency of visits by "parcel" chemical tankers since the inauguration of Dow Chemical's new Lynnterm facility in North Vancouver during 1980. An average of between one and two chemical tankers now call into Vancouver every week.

The term "parcel" tanker applies to vessels which have been specifically designed to carry several different chemicals at once in small consignments, or parcels. The 31 000 dwt Liberian tankers Stolt Sincerity and Stolt Pride, both of which are occasional visitors to the Port of Vancouver are capable of accommodating upwards of 40 separate chemicals in bulk liquid form.[5]

Under certain circumstances, and depending upon the nature, volume, and array of chemical substances on board, it is conceivable that a serious harbour accident involving a chemical tanker could present as great a threat to public safety as that posed by a gas tanker fire or explosion. Furthermore, since there is no set cargo mix of chemicals from one tanker to the next, emergency response forces would be hard-pressed to identify and implement the optimum contingency plan in the event of an accident.

Despite the preceding concerns, local regulations governing the movement of chemical tankers in the port tend to be less stringent than those which pertain to liquefied gas carriers. For instance, the "daylight passage" requirement which has been applied to gas tankers for a number of years is routinely waived for chemical tankers. It is not uncommon for loaded chemical carriers to depart the harbour after darkness and without the benefit of a proper tug escort.

Yet another significant area of local concern, and one which has taken on increasingly controversial overtones of late, involves the siting of terminal facilities designed to handle hazardous materials. The terminal siting issue came to a head in February of 1980 following the public release of a confidential study chronicling many of the potential dangers associated with the Canadian Occidental Petroleum (Hooker Chemical Division) chlorine plant and the nearby Erco Industries sodium chlorate production facility in North Vancouver.[6] A subsequent report prepared for North Vancouver District council by volunteer members of the Community Hazards Task Force in November of 1980 isolated further safety inadequacies associated with the production and shipment of hazardous materials on the North Shore of Burrard Inlet, and recommended "...that the municipal government, in concert with the federal and provincial governments, seek a means by which the Canadian Oxy facility can be relocated from the North Shore."[7]

The Canadian Occidental issue, however, is only part of a much larger dilemma. In spite of local efforts to have the Canadian Occidental operation removed from the community the fact remains that the hazardous materials trade within the port precinct - and especially on the North Shore - has increased dramatically in recent months. The 1980 completion of Dow Chemical's new ethylene dichloride storage terminal less than a kilometre to the west of the controversial Canadian Occidental plant is a typical case in point.

In a related matter, on 22 December 1980 North Vancouver District council approved the construction of a new 18 million litre capacity methanol storage tank at the Vancouver Wharves site near the harbour entrance. The new tank augments Vancouver Wharves' existing 27 million litre methanol storage capacity on the property. By coincidence, the application was approved by council the same day a railway tankcar containing methanol - a light, inflammable, and toxic liquid - caught fire following an accident at British Columbia Railway's main switching yard in North Vancouver, not far from the Vancouver Wharves terminal.[8]

Land use conflicts also figure prominently in the terminal siting issue. This is especially true at Trans Mountain Pipeline's Westridge terminal in

Burnaby, where the nearest homes are situated within 150 metres of the LPG storage tanks. In the event of a major uncontrolled propane fire or explosion at the terminal, there is every reason to believe that the safety of those persons residing on or near the western and southern perimetres of the Westridge site would be placed in serious jeopardy.

Westridge is by no means unique in this regard. In fact, a number of gas terminals in other parts of the world, including Boston (LNG and LPG), Los Angeles (LPG), and Canvey Island, U.K. (LNG) are situated within 500 metres of settled areas. However, in light of increased public concern over the liquefied gas storage issue, it is unlikely that any new terminal proponents would either wish, or be permitted, to locate in the midst of a populated community. Recent experience at both Cove Point, Maryland and Elba Island, Georgia where the new LNG receiving terminals are situated several kilometres from the nearest settled areas, tends to support this observation. Michael Bell, president of Melville shipping, the marine component of the Arctic Pilot Project, further adds that "...if you had (a gas spill) here in Montreal and it caught alight, people would run for their lives ; but our approach is that there is no bloody way we are going to have a (liquefied natural gas) terminal near a major population centre."[9]

Unfortunately, unlike the newer terminals in Europe and the United States, the land use interface at Westridge is well-established and, over the medium term at least, largely irreversible. Prohibitive legal and financial considerations would almost certainly preclude any attempt on the part of the government to either close down the Westridge operation prematurely, or to impose upon Trans Mountain Pipeline a special requirement calling for the creation of a public safety zone around the terminal - that is, assuming the minimum acceptable dimensions of such a buffer zone could be reasonably established.

In the meantime, though, Trans Mountain and other local firms engaged in the large volume production, storage, and handling of hazardous materials must be encouraged to improve upon all aspects of emergency response planning, ranging from the upgrading of existing accident detection systems to the introduction of new and more effective spill containment and fire control technologies. Furthermore, companies such as Trans Mountain, Canadian Occidental, Dow Chemical and others will have to take a more active position on the matter of both informing the community as to the nature of the products being handled and to the emergency response procedures which must be observed by members of the public in the event of a serious plant accident. In this respect, a broad-based public education program designed to advise the average citizen as to his/her role within the context of several different disaster scenarios involving hazardous materials should be jointly prepared by government and industry, and made available to the general public on a regular basis.

The transportation of hazardous materials by road and rail, too, continues to present local authorities with a number of largely unresolved public safety concerns. In spite of attempts on the part of many regional agencies to upgrade the quality of regulations governing the movement of vehicles transporting specified dangerous goods - especially since the September 1978 chlorine spill on Main Street - there would appear to exist considerable room for further improvement. In recent months, Greater Vancouver has experienced several serious motor vehicle accidents involving such materials as oxygen and acetylene, propane, naphtha, and caustic soda.[10]

The circumstances surrounding the regulatory control of rail traffic differ markedly from those affecting motor vehicles. Railway transport is governed largely by the federal Railway Act and the National Transportation Act. Accordingly, local levels of government exercise little jurisdication over the rail movement of dangerous goods through populated communities. To better illustrate this, the City of Vancouver has, on several occasions in recent years, attempted to convince the Canadian Pacific Railway to abandon the practice of storing railcars laden with hazardous materials along the city's downtown waterfront.[11] Nevertheless, on any given day one can still find a wide range of tankcars carrying corrosives, liquefied gases, and other toxic materials which are completely incompatible with adjacent high density urban commercial and residential functions.

A similar situation exists on the north shore of Burrard Inlet, although on a somewhat less dramatic scale, as the physical separation between the railyards and the closest high density population centres is generally greater than on the south (downtown) side of the Inlet. Even so, at least four separate rail accidents involving ethylene dichloride (26 March), caustic soda (25 July), anhydrous ammonia (18 September), and methanol (22 December) were reported on the North Shore during 1980.[12]

The last incident, in which a tankcar loaded with highly inflammable methanol caught fire during a switching accident, was of particular concern to emergency crews in that it occurred in close proximity to another car containing LPG.[13] Although the LPG tanker was subsequently removed from the danger zone, the methanol fire did spread to five other cars containing pulp and paper. In view of the ever increasing volumes of hazardous materials being shipped by rail through North Shore communities, there is little reason to believe that the frequency of accidents involving dangerous chemicals will diminish in coming years unless dramatic new measures are introduced to control the situation.

The Nichizan Maru represents but a single element in the overall LPG production/delivery chain. As such, it is a comparatively simple task to identify and implement effective measures to improve the level of operational safety for that particular vessel within the port precinct. The problem of upgrading the general level of safety within the broad context of the entire hazardous materials trade in the Port of Vancouver, on the other hand, is significantly more complex. Locally, the situation has been allowed to deteriorate in the face of such variables as badly fragmented legislation, confused and often conflicting lines of government responsibility, a lack of common policy direction and co-ordination at all levels of government and among member municipalities within the Greater Vancouver Regional District, and sometimes questionable project evaluation and approvals processes. In the continued absence of a comprehensive strategic plan which has been specifically designed to both identify and resolve hazardous materials-related concerns before they have had an opportunity to become entrenched, the community will be forced into a position of having to react to serious events only after they have occurred. The Japan Erica incident, while not involving hazardous materials, is representative of the reactive philosophy currently adhered to by many local regulatory bodies.

While it is beyond the scope and technical capacity of this report to address these and other dangerous materials issues in detail, it is, nevertheless, recommended that the following measures should be instituted at an early date in order to establish the essential decision making framework for the purpose of improving the regulation of the hazardous materials trade in the Port of Vancouver:

a) A federally-sponsored enquiry commission comprised of recognized experts in the fields of managing and regulating the production, storage, and transfer of hazardous materials, and vested with the authority to subpoena witnesses and documents as required, should be appointed for the purpose of investigating all aspects of public safety in the port as they relate to the local dangerous goods trade. The commission would be responsible for:

   i) identifying areas of immediate concern to public safety, and establishing suitable short- and long-term response strategies for either mitigating or eliminating the associated element of public risk;

   ii) isolating deficiencies within the existing regulatory structure, and recommending appropriate measures designed to make the regulatory process both more responsive and responsible; and

   iii) categorizing hazardous materials and the various operational components associated with their production, storage, and transfer on the basis of the level of inherent risk to the general public, and isolating those materials and/or operations which, in the opinion of the committee, are judged to possess a sufficiently high hazard potential to render them both incompatible with more conventional urban functions, and therefore unacceptable within the context of their existing geographical settings.

   The enquiry process should be open to the general public, and should include adequate provision for representatives of the public at large to voice their concerns on any relevant aspect of the hazardous materials issues.

b) A jointly-sponsored federal/provincial task force comprised of senior government representatives, and designed to work in close conjunction with the enquiry commission described in "a" (above), industry officials, and appropriate public interest groups should be formed in order to establish a rational, viable, and mutually acceptable relocation strategy and time schedule for those operations described in "a-iii"(above) as being incompatible with conventional urban functions. Included within the task force terms of reference should be the provision for identifying suitable alternate locations on the coast which more appropriately reflect such fundamental siting criteria for these particular industrial functions as physical remoteness from centres of population, seismic stability, and safe, economical road, sea, and rail access.

c) In the interest of improving the level of maritime safety in the Port of Vancouver, the federal Minister of Transport should examine the feasibility/practicality of:

   i) transferring the position and duties of the Office of the Harbour Master, Port of Vancouver, from the National Harbours Board to the Canadian Coast Guard in order to consolidate the responsibility for both coastal and harbour marine safety under the auspices of a single agency, and to thereby remove any public doubt over potential conflict of interest situations arising between the marketing and safety concerns of the NHB; and

   ii) introducing a compulsory reporting system whereby all vessels in excess of 20 metres in length, and all tugs with tows, would, at various designated points within the harbour, be required to advise the Vessel Traffic Centre by radio as to their position, speed, destination, or any other pertinent information requested by the Coast Guard.

d) In view of the fact that the Port of Vancouver operates on a 24-hour per day basis, and given that the Office of the Harbour Master is the focal point for the co-ordination of shipping operations and marine emergency response procedures within the harbour, an officer of at least the rank of Assistant Harbour Master should be <u>on duty at all times</u>.

e) Federal and provincial project review capabilities should be expanded and strengthened to ensure that all high impact potential development proposals involving hazardous materials are subjected to a detailed social and environmental impact analysis, and that the public will be guaranteed an opportunity to provide input into any of these proposals through the institution of a compulsory hearings process prior to government project approval being awarded.

f) For all liquefied gas carriers in excess of 5000 cubic metres capacity, and all bulk chemical tankers in excess of 5000 tons dwt, the Office of the Harbour Master should provide a detailed manifest of cargo to be loaded or unloaded in the Port of Vancouver to the following agencies:

   i) Canadian Coast Guard:
      •Regional Marine Emergency Office
      •Vessel Traffic Management Centre

   ii) City of Vancouver:
      •Fire Department
      •Emergency Office

iii) Burnaby Fire Department

iv) North Vancouver District Fire Department

v) North Vancouver City Fire Department

vi) Port Moody Fire Department

vii) West Vancouver Fire Department

The required information should be forwarded to the above-noted agencies at least 24 hours prior to the arrival of the gas or chemical carrier at the Port of Vancouver.

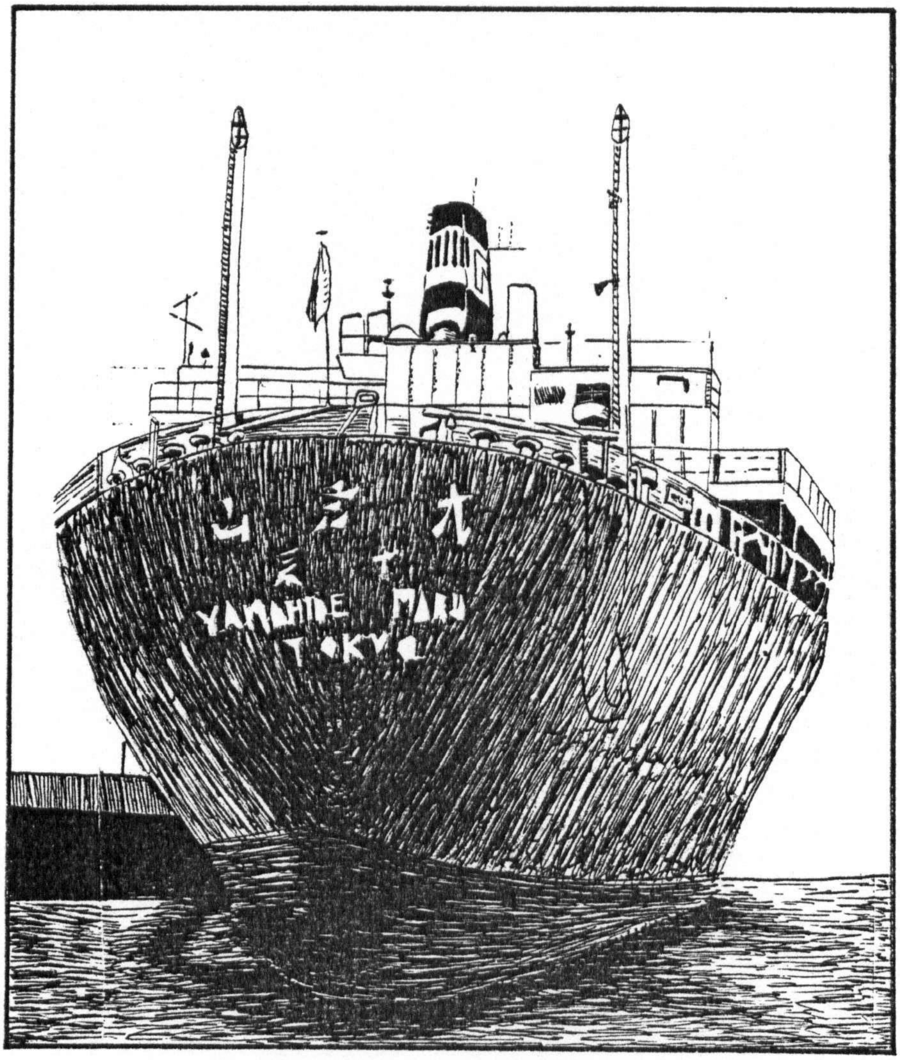

Figure 6.1 LPG Carrier Yamahide Maru at Westridge Terminal

FOOTNOTES - CHAPTER 6.0

1 van der Linde, op. cit.,, p. 140

2 Based upon telephone interview with Lt. Grenier, USCG Marine Safety Office, Providence, RI, 5 September 1980.

3 Letter from K.A. Rock, USCG Marine Safety Office, Boston to J. Marston, undated (circa 31 August 1982).

4 Letter from Capt. D.B. Charter, Captain of the Port, Philadelphia, d/16 August 1982.

5 H. Clarkson & Company Limited, The Tanker Register - 1980 (London: H. Clarkson & Company Limited, 1980).

6 "North Van ends 20-month blackout on Beak report", The Vancouver Sun, 26 February 1980, p. A3; and Beak Consultants, op. cit.

7 Community Hazards Task Force, Final Report (North Vancouver: a report commissioned by the District of North Vancouver, November 1980, p. 30.

8 "Methanol Storage Okayed", The Vancouver Sun, 23 December 1980; "Chemical fire closes bridge", The Vancouver Sun, 23 December 1980; and "Methanol: First the fire, next comes bulk storage", (North Shore) Sunday News, 28 December 1980, p. A3.

9 "LNG tankers to smash through ice", The Vancouver Sun, 19 November 1980, p. A18.

10 "Deadly tank trailer corralled", The Vancouver Sun, 18 November 1981; "Eleven Chemical spills in 1980", North Shore News, 25 March 1981; and "Vancouver Firemen..." The Vancouver Sun, photo caption, 30 April 1981, p. A1.

11 "Most dangerous in Canada", The Vancouver Sun, 27 November 1979; and "Volrich's 'time bomb' plan blasted", The Province, 27 February 1980.

12 "Eleven chemical spills in 1980", North Shore News, 25 March 1981.

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C. LIST OF AGENCIES CONTACTED

- Government of Canada:

  Canadian Coast Guard
  Environment Canada
  Federal Environmental Assessment and Review Office
  Port of Vancouver (National Harbours Board)
  National Energy Board

- Government of British Columbia:

  British Columbia Utilities Commission
  B.C. Hydro (Gas Engineering Division)
  Ministry of Environment (Waste Management Branch)

- City of Vancouver:

  Emergency Program Office
  Vancouver Fire Department

- District of North Vancouver Fire Department

- United States Coast Guard:

  Marine Safety Office, Boston, Massachusetts
  Marine Safety Office, Cove Point, Maryland
  Marine Safety Office, Los Angeles, California
  Marine Safety Office, Savannah, Georgia
  Marine Safety Office, Seattle, Washington
  Captain of the Port, Philadelphis, Pennsylvania
  Captain of the Port, Providence, Rhode Island

- Port of Boston

- Port of Los Angeles

- Port of New York/New Jersey

- Port Autononome du Havre

- Port of London Authority

- Port of Rotterdam

- University of British Columbia (Vancouver)

- University of Victoria (Victoria, B.C.)

- Pacific Marine Training Institute (Vancouver)

- B.C. Research (Vancouver)

- Oceanographic Institute of Washington (Seattle)

- SOGREAH * (Grenoble, France)
- Det norske Veritas (Oslo)
- Lloyd's of London (London)
- Rivtow Straits Ltd. (Vancouver)
- Moss Werft (Moss, Norway)
- Kockum's Shipyards (Malmo, Sweden)

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* Administrators of the Port Revel Marine Research and Training Centre.

APPENDIX I

A Partial List of Visits by
Hazardous Materials Carriers to
the Port of Vancouver between
1 January 1981 and 31 August 1982*

*The information presented in Appendix I was based upon a frequent review of local shipping movements as presented in The Province and The Vancouver Sun newspapers, Canadian Coast Guard Vessel Traffic reports, and visual observations. The Appendix does not lay claim to being a complete record of hazardous materials carrier movements in the Port of Vancouver during the period in question.

TERMINAL: Westridge Terminal (Burnaby)

PRODUCT: Liquefied Petroleum Gas (Propane)

Duration of Visit	Vessel	Registry	Year Built	DWT	Cap'y (m^3)
1981					
31 Jan.	Yamahide Maru	Japan	1966	29 059	38 160
1-2 Feb.	Yamahide Maru	Japan	*	*	*
6-8 Mar.	Yamahide Maru	Japan	*	*	*
8-10 Apr.	Yamahide Maru	Japan	*	*	*
11-12 May	Yamahide Maru	Japan	*	*	*
1-3 July	Yamahide Maru	Japan	*	*	*
4-5 Aug.	Yamahide Maru	Japan	*	*	*
8-9 Sept.	Yamahide Maru	Japan	*	*	*
19-20 Oct.	Yamahide Maru	Japan	*	*	*
1982					
3-5 Mar.	Yamahide Maru	Japan	*	*	*
15-17 Apr.	Yamahide Maru	Japan	*	*	*
8-9 May	Tatsuno Maru	Japan	1967	38 628	50 670
4-6 June	Nichizan Maru	Japan	1982(?)	29 786	App. 40 000
6-7 July	Nichizan Maru	Japan	*	*	*
9-10 Aug.	Nichizan Maru	Japan	*	*	*

*Indicates that vessel information has already been provided.

TERMINAL: Lynnterm (North Vancouver)

PRODUCTS: Ethylene Dichloride; Ethylene Glycol; Caustic Soda Solution

Duration of Visit	Vessel	Registry	Year Built	DWT	# of Cargo Tanks
1981					
2 Jan.	Asakaze(?)	Japan	1980	16 982	?
6 Jan.	Marine Chemist	U.S.	1970	35 949	11
14 Jan.	Unknown	?	?	?	?
2 Feb.	Marine Chemist*	U.S.	*	*	*
18-19 Feb.	Hamakaze	Japan	1980	16 617	?
24-25 Feb.	Asakaze	Japan	*	*	*
26-27 Feb.	Marine Chemist	U.S.	*	*	*
12-13 Mar.	Risanger	Norway	1976	27 582	42
2-3 Apr.	Hamakaze	Japan	*	*	*
6 Apr.	Fujihoshi Maru	Japan	1976	14 435	21
9-10 Apr.	Osco Stripe	Norway	1974	33 415	27
22-24 Apr.	Matsukaze	Japan	?	?	?
25-26 May	Marine Chemist	U.S.	*	*	*
26-27 May	Hamakaze	Japan	*	*	*
4-5 June	Matsukaze	Japan	*	*	*
5 July	Hamakaze	Japan	*	*	*
10 July	Marine Chemist	U.S.	*	*	*
22-23 July	Bow Spring	Norway	1976	27 616	38
30-31 July	Asakaze	Japan	*	*	*
19-21 Aug.	Bruse Jarl	Norway	1974	32 060	34
24-26 Aug.	Matsukaze	Japan	*	*	*
1-2 Sept.	Osco Sierra	Norway	1974	33 415	27
9-10 Sept.	Asakaze	Japan	-	-	-
18-20 Sept.	Bow Fortune	Norway	1975	27 511	42
1-2 Oct.	Formosa One	Liberia	?	?	?
21-22 Oct.	Osco Sierra	Norway	*	*	*
1982					
5-6 Jan.	Hamakaze	Japan	*	*	*
26-27 Jan.	Asakaze	Japan	*	*	*

*Indicates that vessel information has already been provided.

Duration of Visit	Vessel	Registry	Year Built	DWT	# of Cargo Tanks
1-2 Feb.	Fujinami	Japan	?	?	?
12-14 Feb.	Hamakaze	Japan	*	*	*
15 Feb.	Marine Chemist	U.S.	*	*	*
23-24 Feb.	Matsukaze	Japan	*	*	*
9 Mar.	Asakaze	Japan	*	*	*
24-25 Mar.	Osco Sierra	Norway	*	*	*
31 Mar.	Marine Chemist	U.S.	*	*	*
1 Apr.	Marine Chemist	U.S.	*	*	*
4 Apr.	Hamakaze	Japan	*	*	*
6 Apr.	Matsukaze	Japan	*	*	*
17-18 Apr.	Fujihoshi Maru	Japan	*	*	*
26-27 Apr.	Hakko Minerva	Japan	1979	6304	?
30 Apr.	Jo Clipper	Norway	?	?	?
1 May	Jo Clipper	Norway	*	*	*
8 May	Asakaze	Japan	*	*	*
21 May	Matsukaze	Japan	*	*	*
29-30 May	Hamakaze	Japan	*	*	*
7-8 June	Fujihoshi Maru	Japan	*	*	*
10-11 June	Osco Stream	Norway	?	?	?
26 June	Matsukaze	Japan	*	*	*
10-11 July	Hamakaze	Japan	*	*	*
13-14 July	Marine Chemist	U.S.	*	*	*
15 July	Fujihoshi Maru	Japan	*	*	*
7 Aug.	Asakaze	Japan	*	*	*
8-9 Aug.	Golar Petrotrade	Liberia	1975	32 060	34
15 Aug.	Tsokaze	Japan	1980	16 628	?
16 Aug.	Botany Troubador	?	?	?	?
23 Aug.	Hamakaze	Japan	*	*	*
26-29 Aug.	Formosa One	Liberia	*	*	*

TERMINAL: Vancouver Wharves (North Vancouver)

PRODUCT: Methanol

Duration of Visit	Vessel	Registry	Year Built	DWT	# of Cargo Tanks
1981					
20 Feb.	Hamakaze	Japan	1980	16 617	?
16-17 Mar.	Alberta Glory	Japan	1979	8 858	15
3-5 Apr.	Fujihoshi Maru	Japan	1976	14 435	21
27-29 Apr.	Ocean Victoria	Panama	?	?	?
6 May	Alberta Glory	Japan	*	*	*
8-10 June	Ocean Victoria	Panama	*	*	*
18-19 June	Alberta Glory	Japan	*	*	*
3-4 July	Hamakaze	Japan	*	*	*
10 July	Matsukaze	Japan	?	?	?
15-17 July	Ocean Victoria	Panama	*	*	*
4-5 Aug.	Alberta Glory	Japan	*	*	*
17-20 Aug.	Ocean Victoria	Panama	*	*	*
4-6 Sept.	Asakaze	Japan	1980	16 982	?
14-15 Sept.	Shiokaze	Japan	?	?	?
20-21 Sept.	Alberta Glory	Japan	*	*	*
21-22 Sept.	Ocean Victoria	Panama	*	*	*
3-4 Oct.	Formosa One	Taiwan	?	?	?
26-27 Oct.	Asakaze	Japan	*	*	*
29-30 Oct.	Ocean Victoria	Panama	*	*	*
1982					
7-8 Jan.	Ocean Victoria	Panama	*	*	*
14-16 Feb.	Ocean Victoria	Panama	*	*	*
17-18 Feb.	Alberta Glory	Japan	*	*	*
10 Mar.	Asakaze	Japan	*	*	*
30-31 Mar.	Ocean Victoria	Panama	*	*	*
6 Apr.	Hamakaze	Japan	*	*	*
7 Apr.	Matsukaze	Japan	*	*	*
15-16 Apr.	Fujihoshi Maru	Japan	*	*	*
17-18 Apr.	Stolt Pride	Liberia	1976	30 822	46

*Indicates that vessel information has already been provided.

Duration of Visit	Vessel	Registry	Year Built	DWT	# of Cargo Tanks
6-7 May	Ocean Victoria	Panama	*	*	*
25-26 May	Alberta Glory	Japan	*	*	*
31 May	Hamakaze	Japan	*	*	*
6-7 June	Fujihoshi Maru	Japan	*	*	*
13-14 June	Ocean Victoria	Panama	*	*	*
17-20 June	Stolt Sincerity	Liberia	1976	30 822	46
24-26 June	Fuji Nami	Japan	?	?	?
27-29 June	Matsukaze	Japan	*	*	*
12 July	Hamakaze	Japan	*	*	*
12-13 July	Fujihoshi Maru	Japan	*	*	*
3-5 Aug.	Senyo Glory	Japan	1982	?	?
7-10 Aug.	Stolt Span	Liberia	1970	23 450	36
15-17 Aug.	Bow Flower	Norwegian	1975	31 500	30
18 Aug.	Isokaze	Japan	1980	16 628	?
19-20 Aug.	Alberta Glory	Japan	*	*	*
24 Aug.	Ocean Victoria	Panama	*	*	*

TERMINAL: Miscellaneous

Duration of Visit	Vessel	Type	Registry	Year Built	DWT	Terminal
1981						
2-4 Mar.	Carlinka	Tanker	?	?	?	Gulf Oil Bby.
17 Mar.	Shiokaze	Chemical	Japan	?	?	Neptune
4-5 Apr.	Hamakaze	Chemical	Japan	1980	16 617	Neptune
23 June	Shiokaze	Chemical	Japan	*	*	Neptune
13 July	Matsukaze	Chemical	Japan	?	?	Neptune
31 July	Maaskroon	Chemical	Belgium	1976	32 235	Vanterm
1 Aug.	Maaskroon	Chemical	Belgium	*	*	Vanterm
29-30 Aug.	Isokaze	Chemical	Japan	1980	16 628	Neptune
1982						
7 Jan.	Hamakaze	Chemical	Japan	*	*	Neptune
11-25 Mar.	Hoegh Shield	LPG	Norway	1969	8 700	Burrard-Yarrows
5 Apr.	Hamakaze	Chemical	Japan	*	*	Vanterm
5 Apr.	Matsukaze	Chemical	Japan	*	*	Neptune
28-31 May	Mundogas Atlantic	LPG	Liberia	1969	8 784	Burrard/Yarrows
30-31 May	Isokaze	Chemical	Japan	*	*	Vanterm
1-5 June	Mundogas Atlantic	LPG	Liberia	*	*	Burrard/Yarrows
1 June	Isokaze	Chemical	Japan	*	*	Vanterm
27-28 June	Shiokaze	Chemical	Japan	*	*	*
14 July	Fujihoshi Maru	Chemical	Japan	1976	14 435	Neptune
14-15 July	Ocean Victoria	Chemical	Panama	?	?	Centennial
23 Aug.	Ocean Victoria	Chemical	Panama	*	*	Centennial
24 Aug.	Hamakaze	Chemical	Japan	*	*	Neptune
25-26 Aug.	Hamakaze	Chemical	Japan	*	*	B.C. Sugar

*Indicates that vessel information has already been provided.

APPENDIX II CHRONOLOGICAL LIST OF MISHAPS INVOLVING LPG CARRIERS

Status of Casualty Symbols

0	Minor incident - little or no damage
◐	Incident of undetermined status
●	Serious incident, but not critical to vessel or crew safety
●●	Very serious incident - imminent danger to safety of vessel, crew, and/or public
●●●	Total loss of vessel

APPENDIX II CHRONOLOGICAL LIST OF MISHAPS INVOLVING LPG CARRIERS

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
Fall 1968	Claude	Sweden	1 yr.	1511	Nr. Southampton, U.K.

PARTICULARS: Claude collides with inbound British freighter. Crew abandons ship, which subsequently runs aground. A Portuguese LPG carrier is later chartered to remove the butane cargo. However, a discharge hose springs a lack, sending a cloud of inflammable vapour towards Southampton. Volunteers are called in to board Claude and close valves.

STATUS: ● SOURCE: Noël Mostert, Supership, pp. 372-373.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
1973 (unspecified)	Havis	Norway	3 yrs.	15 285	Nr. Boston, Mass.

PARTICULARS: Norwegian LPG carrier Havis refused entry into Port of Boston when it is determined by U.S. Coast Guard inspectors that the vessel's gas detection alarm system cannot be shut off. The pressure relief valves had been improperly set by the ship's crew, rather than by an internationally certified team, as required.

STATUS: ● SOURCE: P. van der Linde, Time Bomb, p. 65

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
June 1974	Milli	?	?	?	Grangemouth, Scotland

PARTICULARS: While in port, Milli begins to leak propane through faulty valve. Vapour catches fire, touching off minor explosion. Authorities close port, fearing major conflagration. Repair team eventually seals leaking valve. One person killed.

STATUS: ●●

SOURCE: Lee Davis, Frozen Fire, p. 274

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
09 Nov. 1974	Yuyo Maru	Japan	8 yrs.	80 000	Tokyo Bay, Japan

PARTICULARS: LPG/naphtha carrier Yuyo Maru collides with cargo ship Pacific Ares, rupturing naphtha tanks and causing massive shipboard fire. Still burning out of control after two weeks, vessel is sunk by Japanese navy. Thirty-three persons killed.

STATUS: ●●●

SOURCE: Davis, Frozen Fire, p. 275

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
Feb. 1977	Unnamed	?	?	?	Nr. Providence, R.I.

PARTICULARS: Unnamed LPG carrier refused entry into Port of Providence by U.S. Coast Guard, pending repairs to faulty gas detection system. After several days at anchorage offshore, vessel departs U.S. waters with cargo still aboard, apparently unable to repair detection system malfunction.

STATUS: ●

SOURCE: Lt. Grenier, USCG Marine Safety Office, Providence, Rhode Island, 5 Sept. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
07 June 1977	Lincolnshire	Britain	5 yrs.	31 290	Bahrain

PARTICULARS: LPG carrier Lincolnshire is reported to have collided with LNG carrier LNG Challenger while the latter is moored. LNG Challenger sustains damage to starboard quarter and engine room. No report of damage to Lincolnshire.

STATUS: ●

SOURCE: Davis, *Frozen Fire*, p. 277

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
28 June 1979	Gas Al Burgan	Kuwait	1 yr.	72 100	Suez Canal

PARTICULARS: Sustains extensive hull damage following grounding in Suez Canal. Repairs deferred by owners to July 1980.

STATUS: ●

SOURCE: Lloyd's List, 12 & 30 July 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
10 July 1979	Garinda	Britain	1 yr.	54 220	Nr. Buenos Aires

PARTICULARS: Inbound for Buenos Aires in partly loaded condition, Garinda runs aground at kilometre 5 of the South Entrance Channel. Vessel refloated 0740 hours, 12 July 1979. Surveyor reports no serious damage to hull of Garinda.

STATUS: ●

SOURCE: Lloyd's List, 12 & 13 July 1979

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
23 July 1979	Faraday	Britain	8 yrs.	31 215	Unspecified

PARTICULARS: Vessel reports turbo-blower damage while docked at La Ciotat, Spain.

STATUS: O SOURCE: Lloyd's List, 23 July 1979

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
31 Aug. 1979	Caribe I	Panama	18 yrs.	879	Rio Haina

PARTICULARS: During hurricane 'David', MV Kalliope breaks away from mooring. Vessel blows across harbour, coming in contact with LPG carrier Caribe I. Caribe I reported to have suffered severe structural damage and water in engine room.

STATUS: ● SOURCE: Lloyd's List, 7 & 12 Sept. 1979

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
06 Sept. 1979	Lincolnshire	Britain	7 yrs.	31 290	Buenos Aires

PARTICULARS: Lincolnshire reported to have contacted French LPG carrier Atlante. Both vessels sustain superficial damage.

STATUS: ◒ SOURCE: Lloyd's List, 8 Sept. 1979

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
06 Sept. 1979	Atlante	France	6 yrs.	53 400	Buenos Aires

PARTICULARS: See previous reference to LPG carrier Lincolnshire.

STATUS: ◒ SOURCE: Lloyd's List, 8 Sept. 1979

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
14 Sept. 1979	Ogden Bridgestone	Panama	6 yrs.	74 580	Unspecified

PARTICULARS: Stern gland found to be leaking. Vessel drydocked Sakaide, Japan in order to effect necessary repairs.

STATUS: 0

SOURCE: Lloyd's List, 15 Sept. 1979

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
18 Sept. 1979	Jatai	Brazil	1 yr.	4 100	Bilbao, Spain

PARTICULARS: Jatai, while under construction at Tomas Ruiz de Velasco Shipyard, experiences explosion aboard vessel. Vessel sustains substantial damage. One workman killed, and four others injured.

STATUS: ●●

SOURCE: Lloyd's List, 21 Sept. 1979 and 15 Oct. 1979

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
30 Sept. 1979	Babounis Costas	Greece	33 yrs.	670	Nr. Lagas, Nigeria

PARTICULARS: Vessel reported at anchor off Lagos, Nigeria when leakage noticed. Babounis Costas subsequently beached, and engine room flooded. On 6 December 1979, ship refloated, taken out to sea, and deliberately sunk.

STATUS: ●●● SOURCE: Lloyd's List, 9 Oct. 1979 and 14 Feb. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
04 Oct. 1979	9 de Octubre	Peru	20 yrs.	318	Nr. Macapa, Brazil

PARTICULARS: Vessel grounded some 50 kilometres from Macapa; near the mouth of the Amazon River. The 9 de Octubre is refloated at 0530 hours, 11 October 1979, only to ground again five minutes later. Portion of vessel's oil and LPG cargo subsequently offloaded into barges on 13 October 1979. Ship refloated following day with tug assistance. Surveyor reports no apparent serious hull damage.

STATUS: ● SOURCE: Lloyd's List' 12, 13, 15, & 16 Oct. 1979

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
29 Oct. 1979	Emiliano Zapata	Mexico	9 yrs.	3 380	Tuxpan, Mexico

PARTICULARS: Seawater leakage through holes in #2 starboard double bottom discovered. Serious damage to #2 cargo tank insulation and inert gas space as a result of vertical movement by #2 cargo tank (by either ice action or flotation). Vessel requires extensive repairs to pumping system, cargo tank, liquefaction plant, insulation, etc.

STATUS: ●

SOURCE: Lloyd's List, 28 Nov. 1979

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
Nov. 1979	Hampshire	Britain	5 yrs.	52 650	Mississippi River

PARTICULARS: While en route New Orleans to Turkey, with 34 000 tonnes ammonia, Hampshire reports serious cracking and shell plate damage. Speculation that damage related to grounding incident in Mississippi River (date unspecified). Vessel unable to enter Valletta, Malta harbour on 19-20 November 1979 due to bad weather. Crew forced to effect emergency hull repairs while vessel at sea.

STATUS: ●

SOURCE: Lloyd's List, 20, 21, & 24 Nov. 1979

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
Nov. 1979	Hilli	Liberia	4 yrs.	126 227	Unspecified

PARTICULARS: LPG/LNG carrier Hilli requests survey at Singapore (26 March 1980) concerning a reported failure of cargo tank insulation the previous November. No further details available.

STATUS: ◐

SOURCE: Lloyd's List, 27 March 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
Circa 15 Nov. 1979	Rudi M	Panama	13 yrs.	826	Unspecified

PARTICULARS: Vessel arrives London after having sustained serious damage to cargo tank insulation due to LPG saturation. Extensive repairs required. Vessel declared compromised constructive total loss.

STATUS: ●●●

SOURCE: Lloyd's List, 18 Jan. 1980

INVOLVING LPG CARRIERS

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
11-12 Dec. 1979	Claude	Panama	12 yrs.	1 511	English Channel

PARTICULARS: Vessel sustains heavy weather damage while en route Antwerp to Milford Haven, U.K. Two wash bulkheads collapsed in #4 tank. Repairs effected at Le Havre, March 1980.

STATUS: ●

SOURCE: Lloyd's List, 14 March 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
12 Dec. 1979	Gay Lussac	Panama	10 yrs.	40 232	Marcus Hook, Penn.

PARTICULARS: Vessel grounded while on part loaded passage inbound for Marcus Hook, Pennsylvania. Various bottom damage incurred. Repairs to be deferred until routine drydocking in Europe, early 1980.

STATUS: ◒

SOURCE: Lloyd's List, 11 Jan. 1980 and 2 May 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
28 Dec. 1979	Butaseis	Span	20 yrs.	1 414	Nr. Brixham, U.K.

PARTICULARS: Crews quarters catch fire while vessel off Brixham. Vessel loaded with butane. Crew of 18 abandons ship, which is subsequently towed to remote location. Fire burns for two days before being brought under control. Serious damage to wheelhouse, storerooms, crew's accommodation. Butaseis denied entry into Plymouth harbour after fire due to concern for public safety. Cargo remained intact throughout.

STATUS: ●●

SOURCE: *Lloyd's List*, 29 & 31 Dec. 1979 and 2 & 12 Jan. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
28 Dec. 1979	Pythagore	Panama	12 yrs.	14 258	Aegean Sea

PARTICULARS: Vessel reported grounded 28 December 1979 in Aegean Sea while en route (loaded) from Odessa to the United States eastern seaboard. Pythagore surveyed afloat at Philadelphia, 17 January 1980. Minor hull damage identified. Vessel's owners' intentions unknown, but considering loading cargo of ammonia in Mexico, destined for Europe. Pythagore likely to be drydocked in Spain to effect repairs.

STATUS: ◒

SOURCE: *Lloyd's List*, 17 Jan. 1980 and 1 Feb. 1980

INVOLVING LPG CARRIERS

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
21 Jan. 1980	Regitze Tholstrup	Denmark	17 yrs.	388	Lough Larne, Eire

PARTICULARS: Regitze Tholstrup, with cargo of butane, grounds at entrance to Lough Larne, Eire. Engine room holed. Authorities evacuate local residents. Cargo partially offloaded into road tankers. Vessel refloated.

STATUS: ●● SOURCE: Lloyd's List, 22 & 23 Jan. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
25 Jan. 1980	Rudi M	Panama	14 yrs.	826	London

PARTICULARS: While repairs to insulation saturation being effected (see casualty reference 15 November 1979, this Appendix), fire breaks out aboard Rudi M. One fireman killed; four other injured.

STATUS: ●● SOURCE: Lloyd's List, 26 Jan. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
25 Jan. 1980	Copernico	Chile	17 yrs.	3 428	Nr. Corral, Chile

PARTICULARS: Vessel experiences engine breakdown. Towed to Talcahuano, Chile.

STATUS: ●

SOURCE: Lloyd's List, 29 Jan. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
Circa 06 Feb. 1980	Mundogas America	Liberia	8 yrs.	52 647	Unspecified

PARTICULARS: Owners request survey at New York as a result of damage sustained following contact with tug, date and location unspecified.

STATUS: ●

SOURCE: Lloyd's List, 18 Feb. 1980

INVOLVING LPG CARRIERS

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
17 Feb. 1980	Karama	Dubai	15 yrs.	900	Dubai

PARTICULARS: Vessel sustains minor hull damage following contact with bridge fender.

STATUS: O SOURCE: Lloyd's List, 21 Feb. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
22 Feb. 1980	Katrisa	Greece	12 yrs.	18 422	Mediterranean

PARTICULARS: Experiences main engine damage while en route from Skikda, Algeria to Leghorn, Italy.

STATUS: O SOURCE: Lloyd's List, 20 March 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
29 Feb. 1980	Sunny Fellow	Singapore	12 yrs.	1 526	West coast of Spain

PARTICULARS: Experiences main engine problems while en route for Vigo, Spain

STATUS: ●

SOURCE: Lloyd's List, 3 March 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
04 March 1980	Eva Tholstrup	Denmark	22 yrs.	889	

PARTICULARS: Incurs propeller damage while inbound for Milford Haven, U.K. Nr. Milford Haven, U.K.

STATUS: ●

SOURCE: Lloyd's List, 5 March 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
Circa 17 March 1980	Mundogas Pacific	Liberia	11 yrs.	11 795	Unspecified

PARTICULARS: Surveyor reports #5 and 6 ammonia compressors heavily damaged due to seawater contamination.

STATUS: ●

SOURCE: *Lloyd's List*, 17 March 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
20 March 1980	Gazala	Dubai	16 yrs.	646	Bahrain

PARTICULARS: *Gazala* reports contact with jetty catwalk at Bahrain. Minor hull damage incurred.

STATUS: O

SOURCE: *Lloyd's List*, 25 March 1980

INVOLVING LPG CARRIERS

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
25 March 1980	Garbeta	Britain	15 yrs.	22 765	Mediterranean

PARTICULARS: Garbeta arrives Marseilles 25 March 1980 with heavy weather damage. Vessel sails 8 April 1980 upon completion of damage repairs. Vessel forced to return to Marseilles three days later upon discovery of further damage to double bottoms.

STATUS: ●   SOURCE: Lloyd's List, 14 April 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
28 March 1980	Razi	Iran	13 yrs.	70 900	Ras Tanura, Saudi Arabia

PARTICULARS: Vessel sustains damage to #3 cargo pump. Permanent repairs deferred until May 1980.

STATUS: ●   SOURCE: Lloyd's List, 17 April 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
01 April 1980	Ultragas	Chile	21 yrs.	1 460	Le Havre, France

PARTICULARS: Ultragas reports damage sustained following contact with Turkish tanker Amiral Fahri Engin. No further details.

STATUS: ◒

SOURCE: Lloyd's List, 3 April 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
circa 12 April 1980	Gambhira	Britain	11 yrs.	14 103	Nr. Bombay

PARTICULARS: Vessel reports cracks in LPG compressor cylinder block. Time and date unspecified.

STATUS: ◒

SOURCE: Lloyd's List, 12 April 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
05 May 1980	Antilla Cape	Netherlands Antilles	12 yrs.	29 540	Unspecified

PARTICULARS: Antilla Cape reports #2 and 3 generator failures, broken piston, and failure of the main engine cooling water system.

STATUS: ●   SOURCE: Lloyd's List, 07 May 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
19 May 1980	Mundogas Pacific	Liberia	11 yrs.	21 795	Caribbean

PARTICULARS: While en route from Panama Canal to Maracaibo, Venezuela vessel reports breakdown of main engine aft turbo-blower, plus port and starboard generator breakdowns.

STATUS: ●   SOURCE: Lloyd's List, 5 June 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
27 May 1980	Northern Arrow	Liberia	2 yrs.	75 610	Dubai

PARTICULARS: Vessel reports flooding in No. 3 void space - requests survey. Northern Arrow in loaded condition.

STATUS: ●   SOURCE: Lloyd's List, 29 May 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
30 May 1980	Gaz Pioneer	Panama	15 yrs.	4 163	Alexandria, Egypt

PARTICULARS: Gaz Pioneer reported in collision with Panamanian freighter Ocean Ace. Both vessels sustain minor contact damage.

STATUS: 0   SOURCE: Lloyd's List, 11 June 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
Circa 05 June 1980	Ultragas	Chile	21 yrs.	1 460	Unspecified

PARTICULARS: Vessel reports propeller damage. No further details.

STATUS: ●

SOURCE: Lloyd's List, 5 June 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
10 June 1980	Sunny Girl	Singapore	13 yrs.	900	Nr. Whitby, England

PARTICULARS: While some 5 kilometres southeast of Whitby, England, vessel reports engine room fire. Fire brought under control quickly. Sunny Girl empty following discharge of cargo at Tees, England.

STATUS: ●

SOURCE: Lloyd's List, 12 June 1980

INVOLVING LPG CARRIERS

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
24 July 190	Ogden Bridgestone	Panama	7 yrs.	74 560	Unspecified

PARTICULARS: Vessel experiences damage to main engine turning gear. Owner requests survey, Kobe, Japan.

STATUS: 0

SOURCE: *Lloyd's List*, 25 July 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
06 August 1980	Claude	Panama	13 yrs.	1 511	Le Havre, France

PARTICULARS: While completing discharge at Le Havre, water hose breaks, spraying main switchboard and several alternators. No major damage identified.

STATUS: 0

SOURCE: *Lloyd's List*, 9 August 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
17 Aug 1980	Cetane	Philippines	3 yrs.	250	Manila Bay

PARTICULARS: Explosion aboard Cetane while in Manila Bay, Philippines. Four out of ten crew members injured. Vessel reported abandoned prior to explosion.

STATUS: ●● SOURCE: Lloyd's List, 19 August 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
26 Aug 1980	Gaz Progress	Panama	14 yrs.	3 038	Ravenna, Italy

PARTICULARS: While leaving berth and moving slowly astern, Gaz Progress contacted tanker Assunta Ravenna. Assunta Ravenna pushed back - incurs some bow and steering damage. Gaz Progress sustains minor hull damage.

STATUS: ◐ SOURCE: Lloyd's List, 29 Aug. 1980 and 2 Sept. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
07 Sept. 1980	Mundogas Pacific	Liberia	11 yrs.	21 795	Coatzacoalcos, Mexico

PARTICULARS: Main engine turbo-blower badly damaged while vessel entering Coatzacoalcos inner harbour. Mundogas Pacific in ballast at time of accident.

STATUS: ● SOURCE: Lloyd's List, 18 Oct. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
12 Sept. 1980	Mary Else Tholstrup	Denmark	15 yrs.	629	Coast of Ireland

PARTICULARS: Mary Else Tholstrup, while en route from Milford Haven, Wales to Whitegate (near Cork); Eire in loaded condition grounds on Irish coast. Vessel towed to Cork - pumped out by attending tug. Sister ship Ulla Tholstrup arrives Cork morning of 13 Sept. 1980 in order to off-load Mary Else Tholstrup. During initial hook-up operations between the two vessels, explosion occurs aboard Mary Else Tholstrup. Two crew members burned.

STATUS: ●● SOURCE: Lloyd's List, 13 & 16 Sept. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
16 Sept. 1980	Discaria	Liberia	11 yrs.	22 240	Various

PARTICULARS: Between 16 Sept. 1980 and 23 Oct. 1980, Discaria experiences several instances of engine damage (e.g. alternator damage, 16 Sept. and 23 Oct.; emergency generator damage, 16 Sept.; and cylinder damage, 16 Oct.). While at Dubai, owners request survey. More engine damage identified. On 3 Nov. 1980, vessel experiences complete electrical system breakdown while loading. Vessel towed to anchorage to effect repairs to alternators.

STATUS: ●

SOURCE: Lloyd's List, 3 & 5 Nov. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
18 Sept. 1980	Mundogas Pacific	Liberia	11 yrs.	21 759	Mexican coast

PARTICULARS: While en route from Pajaritos, Mexico to Rio Grande, Mexico vessel experiences engine room fire. Ship sustains cylinder liner and piston damage.

STATUS: ●

SOURCE: Lloyd's List, 30 Sept. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
19 Sept. 1980	Marine Eagle	United States	9 yrs.	2 600	Beaumont, Texas

PARTICULARS: Vessel incurs extensive boiler damage as a result of using contaminated fuel oil. Repairs take eight days to complete.

STATUS: ●

SOURCE: *Lloyd's List*, 30 Sept. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
30 Sept. 1980	Petrobras Sudoeste	Brazil	17 yrs.	4 000	Salvador, Brazil

PARTICULARS: Vessel experiences fire in auxiliary engine while at Salvador. Understood that vessel's carbon dioxide fire fighting system failed. Fire extinguished by portable units. No injuries reported.

STATUS: ●

SOURCE: *Lloyd's List*, 3 Oct. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
02 Oct. 1980	Venus Gas	Japan	7 yrs.	2 500	Sulu Sea

PARTICULARS: While en route from Indonesia to Inchon, Korea with cargo of butane gas, Venus Gas runs aground at Asna Island, Sulu Sea. Vessel refloated 7 October 1980, and subsequently towed to Manila for repairs.

STATUS: ●

SOURCE: Lloyd's List, 4, 8, & 16 Oct. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
05 Oct. 1980	Senho Maru	Japan	7 yrs.	1 900	Off Philippines

PARTICULARS: Vessel experiences engine breakdown while en route from Japan to Merak, New Guinea (?). Towed to Manila in ballast for repairs.

STATUS: ●

SOURCE: Lloyd's List, 8 Oct. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
14 Oct. 1980	Gaz East	Greece	?	est. 2000	Nr. Hyeres, France

PARTICULARS: Gaz East capsizes in high winds off French Riviera. Crew of 15 rescued. French navy quarantines area around vessel in view of risk to public safety. Vessel eventually towed out to sea and sunk by navy (using mines placed on hull by divers). Five nautical mile safety zone remained around spot where vessel sunk until 17 October 1980.

STATUS: ●●● SOURCE: Lloyd's List, 14 & 23 Oct. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
29 Oct. 1980	Monomer Venture	Panama	35 yrs.	5 748	Coatzacoalcos, Mexico

PARTICULARS: While at Coatzacoalcos, Mexico vessel drags anchor in heavy storm. Tug dispatched to tow Monomer Venture into deep water until storm abates.

STATUS: ● SOURCE: Lloyd's List, 1 Nov. 1980

INVOLVING LPG CARRIERS

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
30 Oct. 1980	Melrose	Britain	9 yrs.	2 725	S. coast of England

PARTICULARS: Melrose reports engine problems. Vessel proceeding either Plymouth or Falmouth under own power with full load of LPG.

STATUS: 0 SOURCE: Lloyd's List, 31 Oct. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
31 Oct. 1980	Ogden Bridgestone	Panama	7 yrs.	74 580	Unspecified

PARTICULARS: Vessel reported in collision with LPG carrier Petron Gasual. Suffers damage to starboard shell plates, engine rooms, and #1 void space.

STATUS: ● SOURCE: Lloyd's List, 29 July 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
31 Oct. 1980	Petron Gasul	Philippines	18 yrs.	28 857	Unspecified

PARTICULARS: Reported in collision with LPG carrier Ogden Bridgestone (see previous reference)

STATUS: ●

SOURCE: Lloyd's List, 29 July 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
2-3 Nov. 1980	Pythagore	Panama	13 yrs.	14 258	Various

PARTICULARS: Between 2 Nov. 1980 and 29 May 1981, Pythagore experiences following difficulties:
1) 2-3 Nov. 1980 - suffers heavy weather damage (location unspecified)
2) Date unspecified - bottom plate damage (location unspecified)
3) 29 May 1981 - contacts dry dock wall (Genoa, Italy)

Damage: #1 port and starboard side ballast tanks inner structure and inner hull plating fractured numerous locations, allowing partial floading of perlite insulation between ballast and cargo tanks, with 25 mm vertical displacement of cargo tank.
- Various fractures to #'s 2 and 3 port and starboard side ballast tanks (17 in total).
- Lengthy repairs required.

STATUS: ●

SOURCE: Lloyd's List, 17 Aug. 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
05 Nov. 1980	Al Berry	Saudi Arabia	1 yr.	76 700	Suez Canal

PARTICULARS: Vessel grounded Suez Canal. Subsequently refloated with tug assistance. Al Berry surveyed Antwerp, Belgium circa 17 Sept. 1981. Rudder stock found to be twisted 12 degrees off centre, and bent 6 mm between taper ends, with bearing part of rudder badly distorted. Rudder stock beyond repair.

STATUS: ●

SOURCE: Lloyd's List, 7 Nov. 1980 and 17 Sept. 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
07 Nov. 1980	Durward	Singapore	9 yrs.	919	English Channel

PARTICULARS: While en route from England to Zeebrugge, Belgium in ballast, vessel experiences engine failure. Towed to Falmouth for repairs.

STATUS: ●

SOURCE: Lloyd's List, 10 Nov. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
07 Nov. 1980	Ulla Tholstrup	Denmark	19 yrs.	918	S. coast of England

PARTICULARS: Vessel departs Milford Haven, Wales for Oporto, Portugal 6 November 1980. Forced to return Milford Haven the next day after experiencing engine problems. Repairs effected 12 Nov. 1980. Ulla Tholstrup sails for Oporto.

STATUS: ●

SOURCE: Lloyd's List, 13 Nov. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
12 Nov. 1980	Hoegh Skean	Norway	9 yrs.	52 000	Persian Gulf

PARTICULARS: While en route for Ras Tanura, Saudi Arabia, vessel runs aground on Shak Allum Shoal. Hoegh Skean refloated same day - proceeds Bahrain for dry docking and survey. Repairs require estimated 2 to 3 weeks.

STATUS: ●

SOURCE: Lloyd's List, 21 Nov. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
19 Nov. 1980	Mundogas Pacific	Liberia	11 yrs.	21 795	Off coast of Mexico

PARTICULARS: Vessel dry docked San Francisco to repair leaking stern tube seal rings. Problem occurred 21 Oct. 1980 while vessel en route from Salina Cruz, Mexico to Guaymas, Mexico.

STATUS: ◒

SOURCE: Lloyd's List, 24 Nov. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
21 Dec. 1980	Zeilen	Panama	19 yrs.	720	Bahamas

PARTICULARS: Vessel strikes reef at approximate position lat. 24 07 35 N; long. 75 27 05 W. Bow and rudder damage incurred. Crew abandons ship - no injuries. No further details available.

STATUS: ●

SOURCE: Lloyd's List, 29 Dec. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
27 Jan. 1981	Hakusei Maru (#2?)	Japan	15 yrs. (?)	613	Shiono Misaki, Japan

PARTICULARS: Vessel grounded at Shiono Misaki, Japan. Full load LPG (350 t). Sustains serious cracks on double bottom plating, plus flooding in engine room and double bottom tanks. Subsequently refloated and towed to Sakaide, Japan for repairs.

STATUS: ●

SOURCE: *Lloyd's List*, 28 Jan. 1981 and 11 Feb. 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
11 & 13 Jan. 1981	Gammagas	Germany	8 yrs.	5 202	Nr. Buenos Aires

PARTICULARS: 11 February 1981 - vessel grounds in loaded condition near mouth of Parana River, Argentina
12 February 1981 - refloated, but grounds once again due to steering failure.
13 February 1981 - refloated - steering gear found to be inoperative.

- Vessel dry docked circa 24 Feb. 1981 - rudder 95% missing.
- Repair work estimated to take 1-2 weeks.

STATUS: ●

SOURCE: *Lloyd's List*, 28 Feb. 1981 and 19 March 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
circa 23 Feb. 1981	Havis	Norway	10 yrs.	15 285	Mid-Atlantic

PARTICULARS: Vessel develops steering problems en route from Houston to Suez. Damage diagnosed as broken rudder shaft and possible lost rudder. Havis requires tow to Lisbon. Vessel, loaded with 9000 tonnes butane, refused entry into Lisbon. Subsequently towed to Fos, France, where cargo discharged into LPG carrier Northern Arrow circa 21 March 1981. Rudder confirmed lost. Havis scheduled to proceed Marseilles for repairs.

STATUS: ●

SOURCE: Lloyd's List, 24 Feb. 1981 and 19 & 20 March 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
24 Feb. 1981	Discaria	Liberia	11 yrs.	22 240	Unspecified

PARTICULARS: No. 2 void space water detection alarm activated, and damp perlite insulation noted upon inspection. Permanent repairs deferred at that time.

- 21 May 1981 - upon completion of discharge of 11 450 tonnes of propane at Leghorn, Italy, Discaria sails for North Shields, England for dry docking, survey, and repairs.

STATUS: ●

SOURCE: Lloyd's List, 21 May 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
? March 1981	Monagas	?	?	?	Bay of Biscay

PARTICULARS: While en route from Le Havre to Bilbao, Spain, vessel sustains damage to #1 hold cargo derricks due to heavy weather.

STATUS: ●

SOURCE: *Lloyd's List*, 11 & 19 March 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
circa 14 April 1981	Jame Cook	Tonga	9 yrs.	1 580	Caribbean

PARTICULARS: Vessel sustains broken crank shaft while en route from Maracaibo, Venezuela to Bahamas in loaded condition. Subsequently towed to unnamed U.S. east coast port for repairs.

STATUS: ●

SOURCE: *Lloyd's List*, 15 & 22 April 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
15 April 1981	Gas Gemini	Liberia	3 yrs.	77 960	Unspecified

PARTICULARS: Gas Gemini loses propeller blade. Under tow to Yokahama. No further details available.

STATUS: ●

SOURCE: Lloyd's List, 15 April 1981.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
24 April 1981	Prins Maurits	Netherlands	New	3 200	Dutch coast

PARTICULARS: While on maiden voyage, Prins Maurits experiences engine room fire and explosion some 50 kilometres north of Ijmuiden, Holland. Vessel in ballast. Two crew members hurt - vessel suffers serious damage.

STATUS: ●●

SOURCE: "Two hurt in blast on new LPG carrier", Lloyd's List, 25 April 1981.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
16 May 1981	Gaz Fountain	Panama	?	est. 38 000	Nr. Cherchell, Algeria

PARTICULARS: While en route Kalamai, Greece to Buenos Aires, vessel experiences serious engine room fire. Ship loaded with 7646 tonnes propane and 15 605 tonnes butane. Most crew abandon ship. Vessel eventually towed to Lavera, near Fos, France, where cargo off-loaded into LPG carrier Garala. Preliminary inspection reveals serious engine room damage.

STATUS: ●●

SOURCE: Lloyd's List, 18 & 19 May 1981, and 15 July 1981.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
22 May 1981	Bridgestone Maru III	Japan	15 yrs.	46 720	Rio de la Plata

PARTICULARS: Vessel runs aground while en route from Buenos Aires to Singapore. Upon being refloated, diver reports no serious hull damage.

STATUS: ●

SOURCE: Lloyd's List, 27 May 1981.

INVOLVING LPG CARRIERS

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
May 1981 (unspecified)	Gandara	Britain	5 yrs.	22 500	Unspecified

PARTICULARS: Nos. 1 and 3 cylinder liners badly cracked.

STATUS: O

SOURCE: *Lloyd's List*, 30 May 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
July 1981 (unspecified)	Magellan	Tonga	14 yrs.	900	South Pacific

PARTICULARS: Vessel suffers main engine breakdown. Towed to Suva, Fiji for repairs.

STATUS: ●

SOURCE: *Lloyd's List*, 16 July 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
13 July 1981	Eirik Raude	Norway	14 yrs.	6 170	Caribbean

PARTICULARS: 11 July 1981 - vessel reports loose rudder.
13 July 1981 - while underway, rudder falls off. Vessel towed to Willemstad, Curacao for survey. Upon completion of survey, vessel towed to Punta Camacho for partial discharge of cargo (propylene oxide).
17 July 1981 (?) - Erik Raude arrives Wilemstad under tow for repairs (i.e. replacement of rudder and stock).
- upon completion of repairs, vessel to proceed Plaquemine, Louisiana to complete discharge of cargo.

STATUS: ●

SOURCE: Lloyd's List, 20 Aug. 1981 and 10 Sept. 1981.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
24 July 1981	Discaria	Liberia	12 yrs.	22 240	Unspecified

PARTICULARS: Vessel experiences main engine cylinder damage. No further details.

STATUS: ●

SOURCE: Lloyd's List, 26 July 1981.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
31 July 1981	Olav Trygvason	Norway	6 yrs.	4 100	Sines, Portugal

PARTICULARS: During discharge opertaion, cargo unloading arm becomes disconnected, resulting in ethylene spill. Two crew members burned; one shoreside worker killed.

STATUS: ●●

SOURCE: Lloyd's List, 4 August 1981.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
18 Sept. 1981	Shogi Maru #8	Japan	2 yrs.	800	Coast of Japan

PARTICULARS: Vessel in collision with coastal chemical tanker Toho Maru #8 (175 g.r.t.) off Aijima Light, Japan. Toho Maru #8 sunk. No report of damage to Shogi Maru #8.

STATUS: ●

SOURCE: Lloyd's List, 19 Sept. 1981

INVOLVING LPG CARRIERS

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
04 Oct. 1981	Al Berry	Saudi Arabia	2 yrs.	76 700	

PARTICULARS: Contacts quay wall of Boudouin Lock. Returns to Mercantile Drydock to effect repairs.

STATUS: 0

SOURCE: Lloyd's list, 6 & 7 Oct. 1981.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
20 Oct. 1981	Texaco Colon	Panama	15 yrs.	?	Nr. Paramaribo, Surinam

PARTICULARS: Vessel runs aground off Paramaribo, Surinam. No further details available. (NB. Texaco Colon is an oil tanker which carries LPG in #2 centre tank only.)

STATUS: ●

SOURCE: Lloyd's List, 22 Oct. 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
06 Nov. 1981	Joule	Britain	16 yrs.	11 200	Maracaibo, Venezuela

PARTICULARS: Vessel grounds near Maracaibo in loaded state. Joule subsequently refloated after transfer of portion of cargo to Norwegian LPG carrier Tordenskiold.

STATUS: ●

SOURCE: Lloyd's List, 18 Nov. 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
26 Dec. 1981	Garinda	Britain	5 yrs.	53 000	Unspecified

PARTICULARS: As a result of heavy weather, vessel suffers cracks to lower double bottom hopper tanks and wing tanks, plus crack on cofferdam plating. Contents of upper No. 4 starboard wing tank leaked. Internal repairs require gas freeing in order to undertake hot work, but drydocking not necessary.

STATUS: ●

SOURCE: Lloyd's List, 19 Jan. 1982.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
11 Jan. 1982	Faraday	Britain	11 yrs.	31 215	Unspecified

PARTICULARS: Vessel experiences severe damage to 3 cargo gas compressors.

STATUS: ●

SOURCE: Lloyd's List, 22 & 28 Jan. 1982

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
15 Jan. 1982	Sarrat	Philippines	19 yrs.	13 196	?

PARTICULARS: Sarrat ashore during strong winds, with full load of LPG. Vessel subsequently settled in trench with a 60° port list. Experiences flooding and engine room damage, as well as hull damage. As of 22 February 1982 vessel still aground.

STATUS: ●

SOURCE: Lloyd's List, 18 & 28 Jan. 1982, 4 & 24 Feb. 1982

INVOLVING LPG CARRIERS

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
20 Jan. 1982	Petrogaz	Greece	17 yrs.	353	Levkas Island, Greece

PARTICULARS: While preparing to berth at Levkas Island to discharge cargo, vessel runs aground. Experiences extensive exterior structural damage, plus rudder damage. Vessel towed Piraeus (?) for repairs.

STATUS: ●

SOURCE: Lloyd's List, 23 Jan. 1982 and 4 Feb. 1982

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
5 Feb. 1982	Mossovet	Soviet Union	3 yrs.	75 000	Sea of Marmara

PARTICULARS: Vessel in collision with Turkish merchant vessel in Sea of Marmara. Mossovet unable to stop, strikes small military jetty. Vessel sustains minor damage. Loaded with cargo of ammonia at time of accident, which occurred during period of poor visibility.

STATUS: 0

SOURCE: Lloyd's List, 6 & 7 February 1982.

APPENDIX III CHRONOLOGICAL LIST OF MISHAPS INVOLVING LNG CARRIERS

Status of Casualty Symbols

O	Minor incident - little or no damage
◒	Incident of undetermined status
●	Serious incident, but not critical to vessel or crew safety
●●	Very serious incident - imminent danger to safety of vessel, crew, and/or public
●●●	Total loss of vessel

APPENDIX III CHRONOLOGICAL LIST OF MISHAPS INVOLVING LNG CARRIERS

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
25 Dec. 1964	Methane Progress	Britain	New	27 400	Arzew, Algeria

PARTICULARS: Fire in forward vent riser causes six-hour delay in loading operations. Fire caused by lightning strike.

STATUS: ●　　　SOURCE: Davis, *Frozen Fire*, p. 269

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
May 1964 (unspecified)	Methane Progress	Britain	1 yr.	27 400	Unspecified

PARTICULARS: Faulty valve causes localized LNG spill. LNG flows into drip pan beneath tank, but overflows when water is poured into pan. Causes minor cracking in deck plating.

STATUS: ●　　　SOURCE: Davis, *Frozen Fire*, p. 269

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
May 1965 (unspecified)	Jules Verne	France	New	25 500	Arzew, Algeria

PARTICULARS: Cargo tank guages malfunction during loading operation. LNG overflow occurs, resulting in cracks to cargo tank cover and deck stringer plate.

STATUS: ●

SOURCE: Davis, Frozen Fire, p. 270

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
Sept. 1968 (unspecified)	Aristotle	Panama	?		Off Mexican coast

PARTICULARS: Vessel runs aground and incurs bottom damage. Aristotle stranded for 61 hours before being refloated with tug assistance.

STATUS: ●

SOURCE: Davis, Frozen Fire, p. 270

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
Nov. 1968 (unspecified)	Aristotle	Panama			Mid-Atlantic

PARTICULARS: Vessel loses rudder during storm. Towed to Boston for repairs.,

STATUS: ●

SOURCE: van der Linde, Time Bomb, p. 65

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
Dec. 1968 (unspecified)	Methane Princess	Britain	4 yrs.	27 400	Canvey Island, U.K.

PARTICULARS: Vessel strikes British Gas Co. jetty at Canvey Island. Methane Princess suffers minor superstructure damage. Repairs necessary to jetty loading arm.

STATUS: ◐

SOURCE: Davis, Frozen Fire, p. 270

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
17 Nov. 1969	Polar Alaska	Liberia	New	71 500	en route Kenai, Alaska

PARTICULARS: Membrane wall of No. 1 cargo tank is ruptured when cable tray breaks loose inside tank.

STATUS: ●

SOURCE: Davis, Frozen Fire, p. 270

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
13 Dec. 1969	Polar Alaska	Liberia	New	71 500	Unspecified

PARTICULARS: While attempting to repair damaged tank membrane, crew accidentally overpressurizes void space behind membrane wall with nitrogen, causing it to bulge into the tank. Repairs deferred until April 1970. Tank not used.

STATUS: ●

SOURCE: Davis, Frozen Fire, p. 271

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
02 Sept. 1970	Arctic Tokyo	Liberia	1 yr.	71 500	Off coast of Japan

PARTICULARS: Outbound from Japan, crew detects traces of gas outside No. 1 cargo tank. Later investigation reveals the cause as excess cargo sloshing in heavy weather. Sloshing causes membrane wall to bend in four places, and put ½ inch crack in one weld seam. Repairs deferred until scheduled drydocking, May 1972.

STATUS: ●

SOURCE: Davis, Frozen Fire, p. 271

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
30 May 1971	Methane Princess	Britain	7 yrs.	27 400	Canvey Island, U.K.

PARTICULARS: Liquid nitrogen loading line opens, resulting in spill of nitrogen onto foredeck. Accident results in some cracks in deck plating. Cause: relief valve had been improperly set to lower than specified pressure during annual survey.

STATUS: ●

SOURCE: Davis, Frozen Fire, p. 271

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
01 Aug. 1971	Esso Brega	Italy	2 yrs.	41 000	La Spezia, Italy

PARTICULARS: Pressure inside 50 000 cubic metre LNG storage tank abruptly begins to rise, venting clouds of vapour into atmosphere. Plant officials close the operation and initiate emergency procedures. LNG carrier Esso Brega is towed out of harbour. Ultimately, some 300 cubic metres of gas escapes before the internal tank pressure subsides of its own accord. Cause of accident: A phenomenon known as "rollover" in which violent mixing occurs when quantities of LNG (or, in theory, LPG) of different density, composition and temperature are brought together.

STATUS: ●●

SOURCE: Davis, Frozen Fire, pp. 271-272.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
1971 (unspecified)	Methane Princess	Britain	7 yrs.	27 400	Canvey Island, U.K.

PARTICULARS: Methane Princess sustains serious cracks to inner hull, necessitating lengthy repairs.

STATUS: ●

SOURCE: Davis, Frozen Fire, p. 272.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
31 Oct. 1971	Methane Progress	Britain	7 yrs.	27 400	Unspecified

PARTICULARS: Liquid nitrogen storage tank aboard Methane Progress is overfilled, cracking main and secondary deck plating.

STATUS: ◒

SOURCE: Davis, Frozen Fire, p. 272

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
1971 (unspecified)	Descartes	France	New	50 000	Boston, U.S.A.

PARTICULARS: Vessel experiences gas leak from aft cargo tank due to faulty connection between tank dome and membrane wall. Ship's crew reportedly purges area with inert nitrogen gas, but fails to disclose problem to U.S. Coast Guard.

STATUS: ●

SOURCE: Davis, Frozen Fire, p. 272.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
1972 (unspecified)	Methane Progress	Britain	8 yrs.	27 400	Unspecified

PARTICULARS: Vessel laid up for extended period in order to effect repairs to inner hull and to cracks caused by storage of LNG at cryogenic temperatures.

STATUS: ● SOURCE: van der Linde, *Time Bomb*, p. 140

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
04 June 1974	Massachusetts (Barge)	United States			Unspecified

PARTICULARS: Ordnance coupling fractures, resulting in small spill of liquid nitrogen. Main and canopy decks cracked.

STATUS: ● SOURCE: Davis, *Frozen Fire*, p. 274.

INVOLVING LNG CARRIERS

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
16 July 1974	Massachusetts (Barge)	United States			Unspecified

PARTICULARS: Nitrogen purge valve is overpressurized during loading operations, resulting in 40 gallon discharge. Canopy deck cracked.

STATUS: ●

SOURCE: Davis, *Frozen Fire*, p. 275

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
Aug. 1974 (unspecified)	Euclides	Italian	3 yrs.	4 000	Terneuzen, Holland

PARTICULARS: Vessel in collision with another ship - sustains superficial damage to bulwark plating.

STATUS: 0

SOURCE: Davis, *Frozen Fire*, p. 275

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
Nov. 1974	Euclides	Italian	3 yrs.	4 000	

PARTICULARS: Vessel runs aground, resulting in substantial hull and propeller damage.

STATUS: ●

SOURCE: Davis, Frozen Fire, p. 275.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
06 Dec. 1974	Methane Progress	Britain	10 yrs.	27 400	Canvey Island, U.K.

PARTICULARS: British coaster Tower Princess, steaming off course, rams Methane Progress while latter berthed at British Gas Corp. jetty. No spillage occurs.

STATUS: ●

SOURCE: Davis, Frozen Fire, p. 275

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
Dec. 1974 (unspecified)	Methane Progress	Britain	10 yrs.	27 400	Arzew, Algeria

PARTICULARS: Vessel runs aground, and in so doing sustains severe rudder damage. Out of service for 72 days.

STATUS: ●

SOURCE: Davis, Frozen Fire, p. 275

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
10 Sept. 1976	Gimi	Liberia	New	126 277	Stavanger, Norway

PARTICULARS: Fire days prior to christening, vessel experiences serious fire in No. 2 cargo tank, where workers are welding tank sections together. Spark from welding torch ignites styropor insulation - fire spreads rapidly. Seven workers hospitalized. All of the insulation in the tank has to be either replaced or reworked.

STATUS: ●●

SOURCE: Davis, Frozen Fire, pp. 276-277

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
14 May 1977	Hilli	Liberia	2 yrs.	126 227	Chiba, Japan

PARTICULARS: On maiden voyage, Hilli is towed away from Chiba terminal upon discovery of bolts and residual pieces of metal in the vessel's discharge lines. Ship remains at sea for a month while discharge pipes are warmed up in order that all foreign objects can be removed.

STATUS: ●

SOURCE: Davis, Frozen Fire, p. 277

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
07 June 1977	LNG Challenger	Britain	3 yrs.	87 600	Bahrain

PARTICULARS: While moored, vessel is struck by LPG carrier Lincolnshire. LNG Challenger sustains damage to starboard quarter and engine room.

STATUS: ●

SOURCE: Davis, Frozen Fire, p. 277

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
11 Jan. 1978	LNG Aries	United States	1 yr.	125 000	Canvey Island, U.K.

PARTICULARS: Vessel breaks adrift from British Gas Corp. jetty during storm force winds and flood tide conditions. Vessel drags anchor across navigable fairway.

STATUS: ●

SOURCE: Davis, Frozen Fire, pp. 277-278

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
June 1978	Descartes	France	7 yrs.	50 000	near Boston, U.S.A.

PARTICULARS: Vessel reports abnormally high concentrations of gas in the inner barrier space of No. 3 cargo tank. Affected area purged with inert liquid nitrogen.

STATUS: ◒

SOURCE: Davis, Frozen Fire, p. 278

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
28 July 1978	Hilli	Liberia	3 yrs.	126 277	Abu Dhabi

PARTICULARS: Vessel reported as having sustained propeller damage.

STATUS: ●

SOURCE: Davis, Frozen Fire, p. 278

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
14 Aug. 1978	Khannur	Liberia	1 yr.	126 360	Straits of Singapore

PARTICULARS: Vessel reported in collision with cargo ship Hong Hwa. No further details.

STATUS: ●

SOURCE: Davis, Frozen Fire, pp. 278-279.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
26 Aug. 1978	LNG Challenger	Britain	4 yrs.	87 600	Bahrain

PARTICULARS: LNG Challenger struck by floating crane Magnus IX, which is under tow. LNG Challenger sustains two holes and a lage dent when port anchor flukes are driven into hull.

STATUS: ●

SOURCE: Davis, Frozen Fire, p. 279

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
1979 (unspecified)	Larbi Ben M'Hidi	Algeria	2 yrs.	129 500	

PARTICULARS: Vessel laid up for extended period in order to repair cracks in cargo tanks, and to strengthen welds which secure cargo tank to inner hull.

STATUS: ●

SOURCE: "LNG tankers smash through ice", The Vancouver Sun, 19 Nov. 1980, p. A18

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
29 June 1979	El Paso Paul Kayser	Liberia	4 yrs.	125 000	Strait of Gibraltar

PARTICULARS: While outbound in fog through Strait of Gibraltar, E.P. Paul Kayser runs aground at a speed of 18 knots while attempting to avoid another vessel. Impact tears a 170-metre gas along hull of the vessel, which is laden with some 99 500 cubic metres of LNG. Remarkably, cargo tanks remain intact. In a hitherto unperformed operation, 95 000 cubic metres of LNG are removed from E.P. Paul Kayser to sister ship El Paso Sonatrach, enabling vessel to gain sufficient buoyancy to be refloated. Repairs to E.P. Paul Kayser, take almost two years to effect, at an estimated cost of some $20 million.

STATUS: ●●

SOURCE: H. Clarkson & Company Limited, Liquid Gas Carrier Register 1980, p. 4; Lloyd's List, 1 & 5 July 1979, 22 Nov. 1980, and 16 May 1981; and telephone conversation between writer and Lt. Robin Crusse, USCG, Cove Point, Maryland, 19 Nov. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
19 July 1979	Methane Progress	British	15 yrs.	27 400	Unspecified

PARTICULARS: Vessel experiences fire within insulating material between aft bulkhead of No. 3 cargo and cofferdam. Fire extinguished in fairly short order. Repairs require 2 weeks to complete.

STATUS: ●

SOURCE: Lloyd's List, 23 & 24 July 1979.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
07 Sept. 1979	LNG Capricorn	United States	1 yr.	125 000	Unspecified

PARTICULARS: Vessel sustains minor contact damage to bulbous bow as a result of contact incident with tug B. Lancang II.

STATUS: 0 SOURCE: Lloyd's List, 15 Sept. 1979

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
08 June 1980	El Paso Howard Boyd	United States	5 yrs.	126 540	Hampton Roads, Virginia

PARTICULARS: Vessel reports suspected grounding damage after breaking adrift from moorage at Hampton Roads. Surveyor reports no damage found. (NB. E.P. Howard Boyd had been in lay up at Hampton Roads since 15 April 1980 due to contractural impasse between Algeria and United States over LNG pricing structure).

STATUS: 0 SOURCE: Lloyd's List, 19 June 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
02 July 1980	LNG Leo	United States	2 yrs.	125 000	Japan

PARTICULARS: Mooring lines parted during strong winds while vessel discharging. LNG Leo shifts, reuslting in damage to pier and several chiksan arms.

STATUS: ●

SOURCE: Lloyd's List, 5 July 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
07 July 1980	LNG Libra	United States	1 yr.	125 000	Unspecified

PARTICULARS: Vessel experiences flooding damage in forward pump room. Emergency fire pump motor and fuel oil transfer pump motor damaged during incident.

STATUS: ●

SOURCE: Lloyd's List, 19 July 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
10 July 1980	Geomitra	British	5 yrs.	77 131	Unspecified

PARTICULARS: Reports damage to port diesel generator. No further details.

STATUS: 0

SOURCE: Lloyd's List, 22 July 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
03 Oct. 1980	LNG Libra	United States	1 yr.	125 000	Celebes Sea

PARTICULARS: Vessel suffers propeller shaft damage while en route to Japan in loaded condition. Vessel towed to Davao Bay, Philippines. Cargo transferred to LNG Leo, circa 13 Oct. 1980.

STATUS: ●

SOURCE: Lloyd's List, 4, 8, 10 & 14 Oct. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
04 Oct. 1980	Avondale Settlement				New Orleans, U.S.A.

PARTICULARS: U.S. Coast Guard fails to certify three 127 800 cubic metre LNG carriers under construction at Avondale Shipyards for El Paso Marine Company. Coast Guard inspectors discover cracks in polyurethane insulation surrounding vessels' cargo tanks. Builder unable to isolate cause, and unable to introduce new containment system. In October 1980, a group of insurance companies agrees to pay El Paso $300 million in the largest marine insurance settlement in history.

STATUS: ●●●

SOURCE: "Faulty insulation in LNG carriers built at New Orleans", Lloyd's List, 4 Oct. 1980

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
12 Dec. 1980	LNG Taurus	United States	1 yr.	125 000	West coast of Japan

PARTICULARS: While en route to Tobata, Japan with a full cargo of LNG, vessel runs aground near Moji, off west coast of Japan. Water in several ballast tanks - vessel assumes 4° list. Cargo remains intact. Initial attempt to refloat LNG Taurus unsuccessful.

14 Dec. 1980 - vessel's master commits suicide over accident.

16 Dec. 1980 - LNG Taurus refloated with assistance from salvage tug Zwarte Zee and seven harbour tugs.

STATUS: ●●

SOURCE: Lloyd's List 13, 16, 17 & 18 Dec. 1980, and 13 Jan. 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
30 Jan. 1981	LNG Capricorn	United States	3 yrs.	125 000	Unspecified

PARTICULARS: No. 2 turbo generator sustains vibration and journal bearing damage. No further details.

STATUS: ●   SOURCE: Lloyd's List, 3 Feb. 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
12 May 1981	LNG Aries	United States	3 yrs.	125 000	Unspecified

PARTICULARS: Vessel sustains minor contact damage to bulbous bow. Requests survey upon arrival in Japan.

STATUS: O   SOURCE: Lloyd's List, 13 May 1981.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
22 May 1981	LNG Gemini	United States	3 yrs.	125 000	Japan

PARTICULARS: Vessel sustains damage to main and auxiliary (turbine) tubes. No further details.

STATUS: ●

SOURCE: Lloyd's List, 26 May 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
19 June 1981	Larbi Ben M'Hidi	Algeria	3 yrs.	129 500	near Arzew, Algeria

PARTICULARS: Larbi Ben M'Hidi in collision with Greek tanker Ionian Commander off Arzew while both vessels in ballast. Master of Ionian Commander apparently arrested by Algerian officials.

STATUS: ●

SOURCE: Lloyd's List, 23 June 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
19-20 June 1981	LNG Aquarius	United States	3 yrs.	125 000	Unspecified

PARTICULARS: Vessel reports deck plate cracking around dome of No. 5 cargo tank. Although no further details, speculate leak of LNG or liquid nitrogen.

STATUS: ●

SOURCE: Lloyd's List, 10 July 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
Prior 13 Aug. 1981	LNG Aries	United States	3 yrs.	125 000	Bontang, Borneo

PARTICULARS: Vessel sustains minor hull damage following contact incident with tug B. Lancang I. Requests survey upon arrival in Japan.

STATUS: O

SOURCE: Lloyd's List, 13 Aug. 1981

INVOLVING LNG CARRIERS

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
Prior 25 Aug. 1981	LNG Leo	United States	3 yrs.	125 000	Various

PARTICULARS: Vessel sustains following damage:
- turbine damage (circa 20 Aug. 1981)
- damage to rudder bearing at Sakaide (25 Aug. 1981)
- rusted, scored bottom plates as a result of alleged touching bottom at Tobata, Japan (14 Jan. 1981).

STATUS: ●

SOURCE: Lloyd's List, 25 Aug. 1981 and 4 Sept. 1981.

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
30 Sept. 1981	LNG Leo	United States	3 yrs.	125 000	

PARTICULARS: Vessel reports contact incident with tug Osaka. Incurs minor hull damage (one port shell plate in way of ballast tank).

STATUS: 0

SOURCE: Lloyd's List, 3 Oct. 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
Prior 15 Dec. 1981	Genota	British	6 yrs.	77 731	Unspecified

PARTICULARS: Article in Lloyd's List refers to failures in secondary barrier welds aboard Genota. Drydock inspection reveals failures in lower segments of three out of five cargo tanks.

STATUS: ●

SOURCE: "Shell gains experience in gas carrier fuel economy", Lloyd's List, 15 Dec. 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CARGO CAP'Y (M^3)	LOCATION
17 Dec. 1981	El Paso Columbia	United States	1 yr.	127 800	Sable Island, Nova Scotia

PARTICULARS: While en route from Boston, Massachusetts to Halifax, Nova Scotia for lay-up, El Paso Columbia, which is under tow at the time, is blown onto the coast of Sable Island during severe storm. Vessel subsequently refloated circa 28 Dec. 1981. Sustains extensive bottom damage.

STATUS: ●●

SOURCE: Lloyd's List, 18 & 29 Dec. 1981

DATE	NAME OF VESSEL	REGISTRY	VESSEL AGE	CAP'Y (M^3)	LOCATION
21 Jan. 1982	Sophie Schulte	Germany	8 yrs.	2 420	Unspecified

PARTICULARS: Deck mounted cargo gas booster and blower compressor malfunction reported.

STATUS: ●

SOURCE: Lloyd's List, 23 Jan. 1982

APPENDIX IV - CANADIAN GAS PORT PROPOSALS

A) Name : TENNECO PROJECT

Location : Lorneville, New Brunswick

Major Sponsor(s): Tenneco Inc. of Houston, Texas

Proposal : The plan, which was first mooted during the mid-1970's, envisaged the importation of some 45 000 cubic metres of LNG per day from Algeria to Lorneville. The LNG would then be vapourized, and shipped via pipeline to a distribution point at Albany, New York.

Cost (1977 $) : Total project cost estimate, including construction of ships, liquefaction plant in Algeria, and new pipeline in United States: $5 billion.

: Canadian portion only: $500 million

Comments : The proposal ran into difficulty in July of 1977 when Lorneterm LNG Ltd. (a subsidiary of CP Rail), which had been expected to participate with Tenneco in the construction and operation of the vapourization facility, withdrew from the project due to contract disagreements.[2]

Status : Although the National Energy Board of Canada has granted provisional approval to Tenneco for the construction of the Lorneville Terminal and a new 130 kilometre pipeline to the United States border at Woodland, Maine, the project has remained in a state of limbo since 1977.

B) **Name** : ARCTIC PILOT PROJECT[2]

Location : Melville Island, Northwest Territories to an as yet undecided port site in eastern Canada.

Major Sponsor(s): Petro-Canada
Nova, An Alberta Corporation
Dome Petroleum
Melville Shipping

Proposal : The project, which was initiated by Petro-Canada in 1976, calls for the shipment of some 15 000 cubic metres of LNG daily from Melville Island in Canada's High Arctic to either Gros Cacouna, Quebec or the Strait of Canso, Nova Scotia. The liquefied gas will be transported by means of two 140 000 cubic metre capacity Arctic Class 7 icebreaking tankers. Upon arrival at the east coast receiving terminal, the LNG will be pumped into two 100 000 cubic metre insulated storage tanks. It will subsequently be vapourized, and distributed to eastern Canadian markets via pipeline.

Cost (1980 $) : $1.5 billion*

Comments : The A.P.P. is the most advanced proposal to ship LNG by marine mode of the several presently under consideration. It is particularly important in that it will be the prototype for other, more ambitious gas and oil development proposals in the Beaufort Sea/Mackenzie Delta region of the western arctic.

Status : The A.P.P. has been subjected to both the federal Environmental Assessment and Review Process (EARP) and the Canadian Cost Guard's Termpol Code review. In each instance, it was concluded that the project is acceptable within the constraints of environmental preservation and marine safety.

National Energy Board hearings into the technical and economic aspects of the project commenced 2 February 1982.

Anticipated project completion by mid-1980's.

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* The $1.5 billion cost estimate does not include field development and southern receiving terminal construction, the responsibility for which will rest with Panarctic Oils Ltd. and Trans-Canada Pipelines, respectively. Estimated costs for these facets of the development (in 1980 $) are as follows:

Drake Point field development : $138 million
Southern receiving terminal and connecting pipeline: $233 million

C) Name : WESTERN ARCTIC HYDROCARBON DEVELOPMENTS[3]

Location : Mackenzie Delta/Beaufort Sea region of the Northwest Territories and Yukon Territory

Major Sponsor(s): Dome Petroleum
Esso Resources Canada Ltd.
Gulf Canada Resources Inc.

Proposals : Dome, Esso and Gulf are actively involved in offshore oil and gas exploration in the Mackenzie/Beaufort region. At present, a number of alternatives involving pipelines, icebreaking oil/gas tankers, and submarine oil/gas tankers are under active consideration by the proponents. Anticipated markets will likely include eastern Canada, Japan and the United States.

Costs (1980$) : Estimated investment costs for all aspects of Mackenzie/Beaufort region hydrocarbon development by individual proponent as follows:

Dome Petroleum: $44 billion
Esso Resources: $ 1 billion
Gulf Canada : $ 0.7 billion

Comments : Offshore hydrocarbon exploration has been underway in the Mackenzie/Beaufort region for more than a decade. It has yet to be established, however, whether the commercial development of proven and anticipated reserves of oil and gas in the area will be economically viable. In the event a decision is made to ship LNG from the Mackenzie/Beaufort area by icebreaking tanker, the proponents will likely draw heavily from the design, technological, and operational experience of the Arctic Pilot Project. Significantly, Dome Petroleum is responsible for the vessel design component of the A.P.P.

Status : The Federal Environmental Assessment and Review Office (FEARO) established an environmental assessment panel during the fall of 1981 in order to examine the various Mackenzie/Beaufort development proposals. Several public hearings have thus far been held in conjunction with the panel review (which is part of the federal EARP process).

It is unlikely that commercial production of Mackenzie/Beaufort hydrocarbons will commence prior to the end of the decade.

D. Three separate groups have presented to the Province of British Columbia detailed proposals to construct large LNG export terminals on the Canadian west coast. However, due to surplus natural gas limitations, it is unlikely that more than one of these proposals will actually proceed.

D.1 Name : WESTERN LNG PROPOSAL[4]

Location : Preferred location - Grassy Point, B.C. (situated some 33 kilometres north of Prince Rupert)

Major Sponsor(s): Dome Petroleum Ltd.
Trans-Canada Pipelines
Nova, An Alberta Corporation
Missho-Iwai Corp.

Proposal : The Western LNG project involves the construction of a natural gas pipeline to Grassy Point. The gas would then be liquefied and shipped to several Japanese public utility companies by four 125 000 cubic metre LNG carriers.

Cost (1980 $) :

Pipeline to Grassy Point	- $ 450 million
Gas liquefaction plant	- $ 650 million
4 LNG carriers	- $ 750 million
Total	- $1850 million

Status : In 1981, Dome Petroleum submitted its detailed Western LNG proposal to the Province of British Columbia for review. In July of 1982, the province announced its support for the Dome proosal. The project must now obtain approval from the National Energy Board.

The proposal has also been submitted to a federal review committee in accordance with the terms of the Termpol Code.

D.2 Name : CARTER ENERGY LNG PROPOSAL[5]

Location : Prince Rupert, British Columbia

Major Sponsor(s): Carter Energy Ltd.
Noranda Gas Industries
Canadian Hunter Exploration Ltd.
Daewoo Industrial Co. Ltd.
Sumitomo Corp.
Marubeni Corp.

Proposal : The proposal calls for the construction of a 1080 kilometre natural gas pipeline from the British Columbia portion of the Rocky Mountain Deep Basin to Prince Rupert. The gas would be liquefied at Prince Rupert, and shipped to markets in the Orient by means of four 125 000 cubic metre LNG carriers.

Cost (1980 $) :

Gasfield development	- $ 450 million
Pipeline to Prince Rupert	- $ 760 million
Gas Liquefaction Plant	- $ 610 million
4 LNG carriers	- $ 580 million
Total	- $2400 million

Status : The provincial government has rejected the Carter proposal in favour of the Western LNG plan. A spokesman for Carter Energy Ltd. stated in July of 1982 that the company will continue to promote the project at the upcoming National Energy Board hearings.

D.3 **Name** : Rim Gas Project[6]

Location : Preferred location - vicinity of Kitimat, British Columbia

Major Sponsor(s): Petro-Canada
Westcoast Transmission Co. Ltd.
Mitsui and Co. Ltd.

Proposal : The Rim Gas proposal calls for the construction of a natural gas pipeline extension to a west coast gas liquefaction plant (presumably at or near Kitimat). The LNG would then be distributed to markets in Japan (and possibly Korea) aboard four 125 000 cubic metre tankers.

Cost :

Pipeline to Kitimat	- $ 230 million
Gas liquefaction plant	- $ 420 million
4 LNG carriers	- $ 750 million
	$1400 million

Status : The provincial government's decision to back the Western LNG (Dome) proposal has left the Rim Gas project in a state of limbo. Company officials have indicated that they will probably not contest the provincial decision; however, it is likely that Rim Gas will continue to promote the project at least until the Dome proposal has received National Energy Board approval. The proposal has been subjected to a Termpol review.

FOOTNOTES - APPENDIX IV

1 "U.S. sites under study for Tenneco project", Daily Commercial News, 19 July 1977.

2 Information relating to the Arctic Pilot Project was obtained from two company-produced public information brochures entitled Arctic Pilot Project - the first printed in December 1980 and the second in November 1981.

3 Industry, Trade and Commerce, Major Capital Projects Inventory (Ottawa: Department of Industry, Trade and Commerce), Issue 1, October 1981, p. 88 p. 10.

4 Industry, Trade and Commerce, op. cit., p. 1; and "Mega-bids chase gas supplies", The Province, 3 December 1981.

5 Ibid., p. 1; and "Mega-bids chase gas supplies", The Province, 3 December 1981.

6 Industry, Trade and Commerce, op. cit., p. 2; and "2.3 billion LNG plant sought for Kitimat", The Vancouver Sun, 26 November 1981; and "Mega-bids chase gas suppies", The Province, 3 December 1981.