

# Transportation of Dangerous Goods in the Province of Ontario

JULIUS GORYS

Transportation of dangerous goods has recently been the subject of considerable scrutiny. In general, little is known about the quantity of such substances produced and moved or the degree of risk that exists for the transporters and the general public. The amount of dangerous goods movement, the modal share distribution, the principal issues associated with its transport, the relative frequency of incidents, and the degree of societal risk involved are examined.

The issue of dangerous goods and their transportation has received a great deal of public attention because of the transportation-related incident at Mississauga and the plant-related incidents at Bhopal and Chernobyl. The subject is now frequently in the news.

The principal interest of the Ministry of Transportation in such matters relates to its on-highway safety and regulation mandate. Its involvement is much greater than this, however, given its participation in the recent federal (Gilbert) Task Force on the Movement of Dangerous Goods by Rail in the Toronto area, and its ongoing monitoring and analysis of trends. In addition, the ministry's enforcement strategy includes educating shippers and carriers and ensuring general compliance.

In contrast, the federal government of Canada is responsible for the three other modes, and for shippers and manufacturers. Municipal police form an extension of provincial on-highway enforcement, and are the first responders in the event of an incident.

Dangerous goods can be described as any commodity or product that presents a danger to the environment or to people coming into contact with it. The legal definition of dangerous goods provided in the 1980 *Transportation of Dangerous Goods Act* is any product, substance, or organism included by its nature, or by the regulations in any of the nine classes listed in Schedule 2 of the regulations.

On the order of 3,500 products are listed in the Act. Some have technical names such as chlor-tetra-fluoro-ethane; others have common names—paint, petroleum, chlorine. Dangerous goods are divided into classes and divisions, according to the type of hazard involved. There are nine major categories:

1. Explosives,
2. Gases,
3. Flammable liquids,
4. Flammable solids,
5. Oxidizing substances,
6. Poisonous and infectious substances,

7. Radioactive materials,
8. Corrosive substances, and
9. Miscellaneous products.

## DANGEROUS GOODS QUANTITIES AND TRANSPORT

Substantive statistics on the quantity of dangerous goods produced or transported in Ontario Province are scarce. Much of what exists is derived from federal statistical or monitoring and regulatory agencies and is not necessarily compatible. Inferring from this data, on the order of 39 million tonnes of such goods are transported annually to, from, and within Ontario, and they have a value between \$30 and \$40 billion.

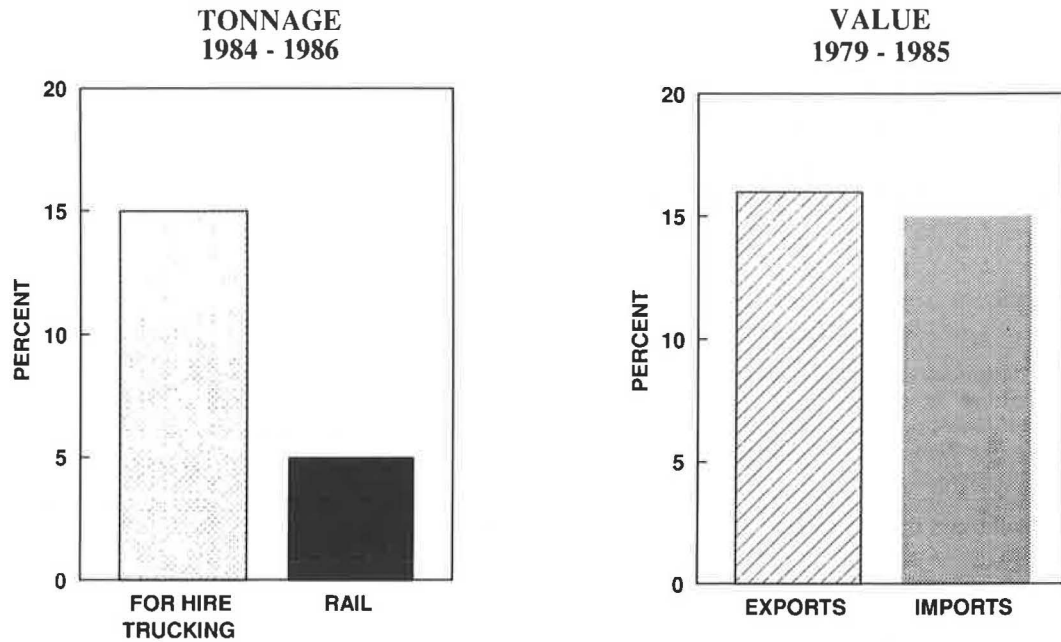
Data from Statistics Canada and Transport Canada suggest that the quantity of dangerous goods being moved has been increasing, commensurate with the economy. Commercial trucking tonnage of such products within Ontario has increased by about 15 percent per year since the end of the recession, while rail tonnage of such commodities has risen by 5 percent per year. The value of Ontario trade in dangerous goods has also been increasing about 15 percent per year (Figure 1).

It is estimated that about 63 percent of the dangerous goods tonnage in the province—some 25 million tonnes—is being hauled by trucks. The rail and marine modes transport 23 and 14 percent of all such tonnage, respectively, while the air mode handles about 1 percent (Figure 2). Transport Canada estimates that for the nation, trucks also transport about 63 percent of all tonnage, compared to only 11 percent for rail.

Within the province, it is not known with certainty whether one mode is assuming greater importance in the overall movement of dangerous goods relative to another. However, a review of federal statistics on Ontario imports and exports suggests that the transportation of dangerous goods is increasingly being handled by trucks.

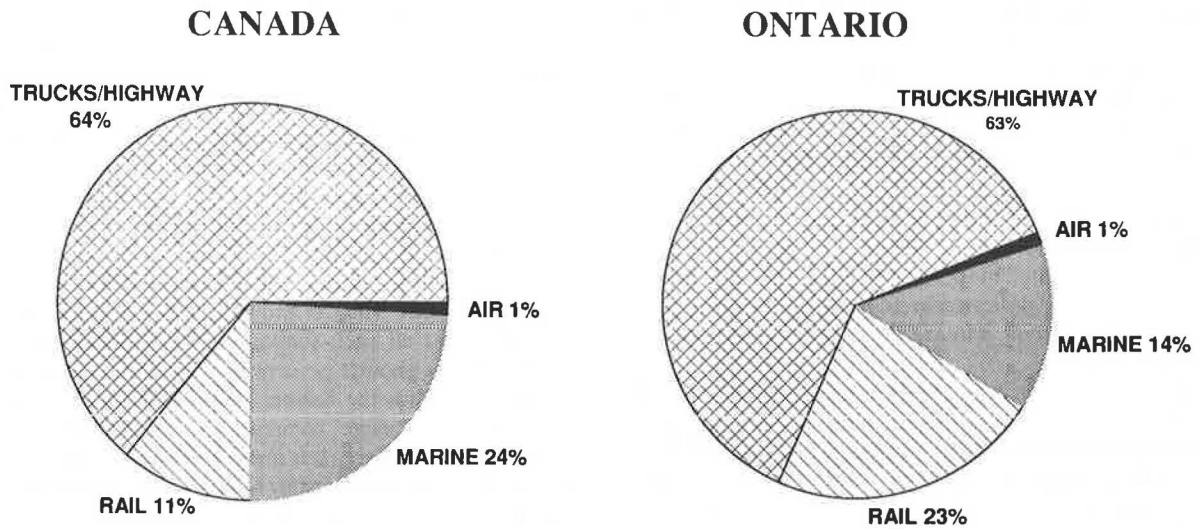
Import and export data presented here are derived from Statistics Canada's International Trade Division's computer files (informal communication) in Ottawa. In 1977, the truck/highway mode handled 37 percent of the transported export value of dangerous goods moved from the province of Ontario. By 1985, it increased its share to 46 percent, at the expense of the rail mode. In 1977, the truck/highway mode handled 56 percent of the transported import value of dangerous goods moved to the province of Ontario. By 1985, it had also increased its share, to 59 percent (Figure 3). For the nation, Transport Canada estimates that the tonnage share held by trucks increased from 55 percent in 1981 to about 63 percent in 1989.

Although trends suggest a shift in modal share, there is probably an upper limit to how much dangerous goods cargo



SOURCE: Statistics Canada

FIGURE 1 Increases in dangerous goods quantities for Ontario.



SOURCE: Ontario Ministry of Transportation, Transport Canada

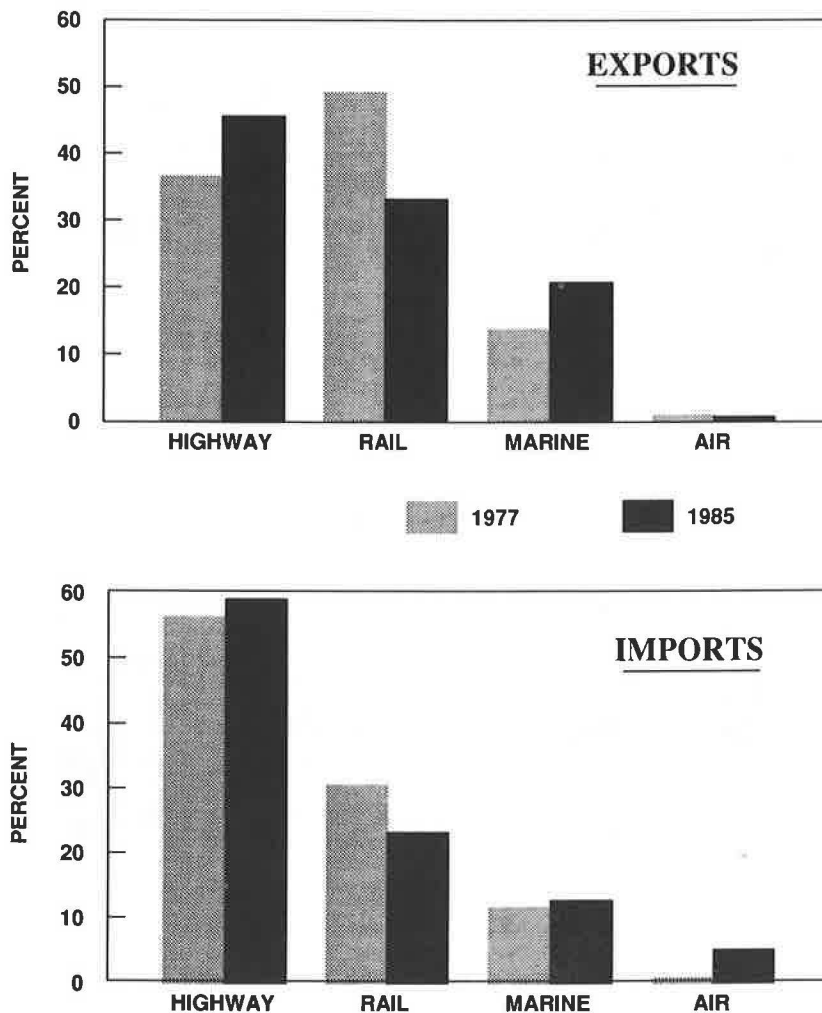
FIGURE 2 Dangerous goods tonnage estimated modal shares, 1989.

can be hauled by truck. For example, compressed bulk gases are now predominately, and more safely, transported great distances by rail. This assertion was partially supported by the findings of a recent (1988) analysis of U.S. DOT data, which concluded that, at least for rail tank cars and for-hire tank trucks (which tend to travel greater distances than their private truck counterparts), the release accident rate for rail was lower than that of its principal long-distance competitor (1). However, preliminary information from the Canadian Ministry of Transportation's 1988 Commercial Vehicle Survey

suggests that even for commodities such as compressed gases, there is increasing use of trucks to haul it.

The present modal share relationship should not change appreciably in the near future. As such, the rate of change in modal share in dangerous goods transport between rail and truck has been less, and in the short term is anticipated to continue to be less than for all other commodities.

For example, in the movement of all of Ontario's imports and exports to the United States, the rate of modal shift in favor of the truck/highway mode recently has been quite pro-



SOURCE: Statistics Canada

FIGURE 3 Modal shares in 1977 and 1985.

found. Between 1977 and 1987, the proportion of the value of Ontario's imports transported by truck/highway mode increased from 71 to 86 percent, while the export value handled by the truck/highway mode increased from 59 to 70 percent (Figure 4).

Dangerous goods are estimated as constituting approximately 18 percent of all truck tonnage in Ontario. This amount is equivalent to just over 1 million truckloads a year or some 4,100 truckloads a day in the province. But, in many instances, dangerous goods form but a small part of a larger general cargo movement—for example, a box of butane lighters as part of a large shipment of goods being delivered to a convenience or department store. Thus, the number of trucks that are actually hauling dangerous goods is much larger.

The principal commodity hauled by each mode varies. In terms of shipments, medicine is by far the most frequently transported dangerous good shipment by truck, followed by corrosive liquids, flammable liquids, paints and varnishes, and ethanol, in that order. In terms of tonnage, about 63 percent of the dangerous goods transported by truck is flammable liquids, such as gasoline, fuel oil, or ethanol; the largest components of the remainder are fertilizers and corrosive liquids.

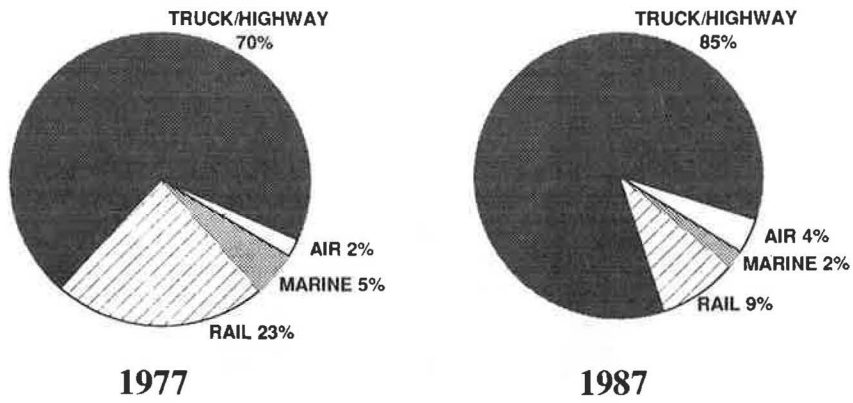
In contrast, three quarters (74 percent) of what is hauled by rail are compressed gases (Figure 5). Flammable liquids are also the most prominent (84 percent) dangerous good hauled by the marine mode (2,3, and Transport Canada's Dangerous Goods Directorate, Evaluation Analysis Division, informal communication).

The majority of dangerous goods truck movements in Ontario (63 percent) are intraprovincial in nature (Figure 6), and close to 40 percent of all trips involve a location in the greater Toronto area itself.

In 1988, a major goods movement study was completed for metropolitan Toronto. In its cursory analysis of dangerous goods movements, the Metropolitan Toronto Goods Movement Study found that the characteristics of dangerous goods transport was not altogether different, in terms of trip pattern and frequency, than all other forms of truck movement (4).

During the course of that study, firms were surveyed as to the nature of the commodities they shipped. It was determined that although close to one-quarter of firms surveyed shipped dangerous goods, less than 5 percent of their loads were dangerous goods. In addition, although the total quantities of dangerous goods being transported could not be measured

## IMPORTS



## EXPORTS

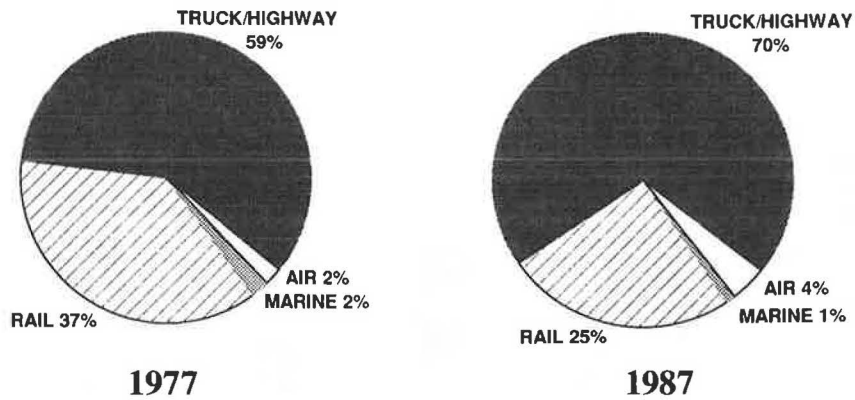


FIGURE 4 Ontario-United States trade relationship—modes used to cross customs for 1977 and 1987.

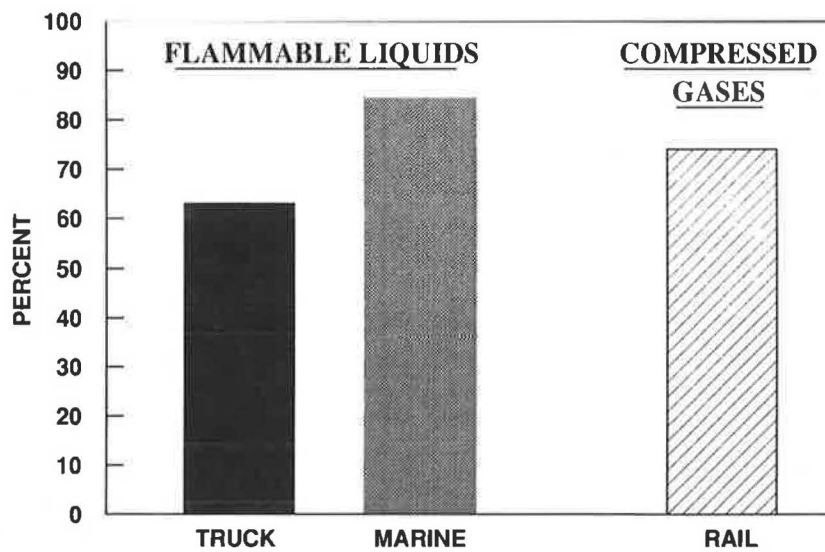


FIGURE 5 Principal quantities hauled by major transport modes, 1986.

with certainty, commodity and trip information revealed that at a minimum, there were 18,000 movements per day of chemicals in the Toronto area alone.

In the Canadian Ministry of Transportation's periodic commercial vehicle surveys was found a greater amount of international movements of dangerous goods compared to such trips for all other commodities. Some 20 percent of dangerous goods truck movements in 1983 were to the United States; consequently a higher proportion of truck traffic near border areas was related to dangerous goods. The value of trade in dangerous goods between Ontario and the United States was on the order of \$5.6 billion in 1985.

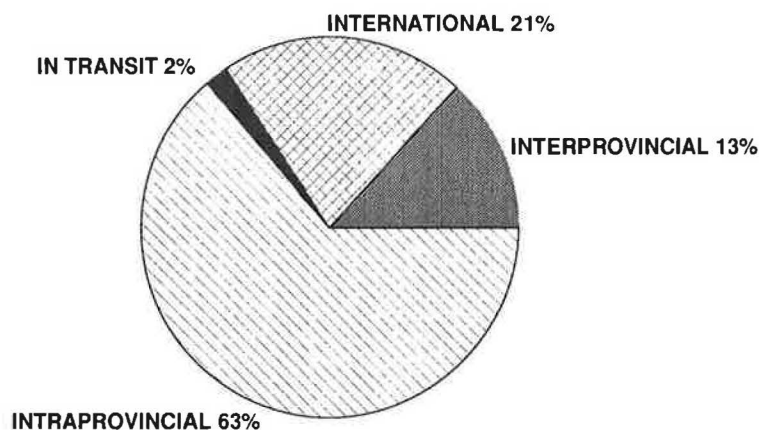
In terms of how dangerous goods were hauled by truck, the ministry's 1983 Commercial Vehicle Survey established that generally larger vehicles were used (Table 1), and there

were greater private fleet involvement and use of vehicles not registered in Ontario (2, Chapter 4). Those findings were confirmed by preliminary information supplied by the ministry's 1988 Commercial Vehicle Survey.

Because of concerns about dangerous goods rail transport incidents, a federal government task force was established in 1986 to inquire about

- The feasibility of rerouting or relocating rail traffic carrying dangerous goods in the Toronto area, and
- Any additional requirements governing the safe transportation of dangerous goods by rail.

The Gilbert Task Force included Provincial Transport Ministry representation; final reports were published in 1988.



**FIGURE 6** Origins and destinations of dangerous goods movements, 1983 (2).

**TABLE 1** DANGEROUS GOODS TRUCK TRIP CHARACTERISTICS, 1983 (2)

	<u>GENERAL TRUCK POPULATION</u>	<u>DANGEROUS GOODS CARRIERS</u>
<b>USE OF NON-ONTARIO REGISTERED VEHICLES</b>	16%	22%
<b>INTRAPROVINCIAL MOVEMENTS</b>	62%	60%
<b>AVERAGE TRIP LENGTH (kms)</b>	345	335
<b>PRIVATE TRUCK HAULAGE</b>	55%	64%
<b>REGISTERED GROSS VEHICLE WEIGHT (kilogram average)</b>	37,200	44,100

From information submitted to the task force, it was found that for long distance moves, generally more than 400 km in length, rail was the predominate means of transport for dangerous goods. For example, in contrast to the truck mode, 42 percent of dangerous goods movements by rail in Ontario was interprovincial (Figure 7), whereas only one-third was intraprovincial.

Given the nature of the existing rail infrastructure, a lot of rail traffic in urban areas is through movement (Figure 8). Information supplied to the task force by Canada's national railways noted that 53 percent of the 67,000 rail carloads in the Toronto area containing dangerous goods were merely passing through Toronto to another destination (3).

## ISSUES AND CONCERNS

There are four principal issues or concerns related to dangerous goods:

- The safety levels of each transport mode;
- Risk minimization;
- Incident management adequacy; and
- Cost effectiveness of enforcement, regulations, and movement restrictions.

The objective of federal and provincial legislation is to protect the public. The regulations require safety marks and documentation, enabling incidents to be dealt with safely and quickly. In addition, diligent enforcement ensures greater compliance with the regulations. Enforcement for on-highway activity is carried out by ministry enforcement officers, municipal police departments, and the Ontario Provincial Police (OPP).

The key areas of compliance are

- Proper and complete documentation,
- Appropriate safety marks (labels and placards), and
- Certificate of training for the driver.

Much more work is still necessary in this area. For example, a major U.S. truck carrier manually audited every hazardous

material freight bill for a week and found that 62 percent of its shipping customers was providing improper information or was in some way violating regulations (5).

On-highway enforcement is still the predominant means of ensuring compliance. Since 1985 in Ontario, the ministry and the OPP have laid over 2,000 charges, and the courts have levied fines ranging from \$100 to \$2,000. In addition, occasional checks are made of the containers hauling dangerous goods by enforcement personnel. The experience of enforcement staff and the trucking industry is that the greatest risk of spills and the cited violations for the general freight carrier were in damage to or failure of drums and pails containing liquids.

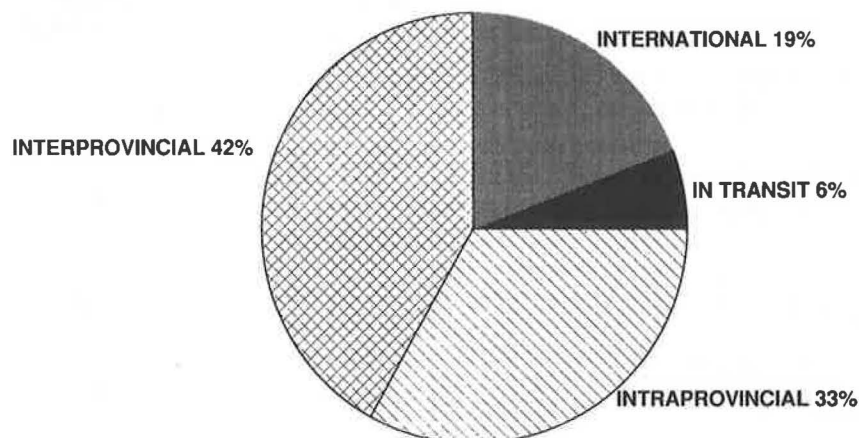
## INCIDENT EXPERIENCE

Although dangerous goods movements are frequent and accidents do occur from time to time, few accidents are significant enough to result in the release of dangerous goods, and fewer result in injuries or fatalities. The destruction of the James Snow overpass on Highway 401 near Milton in 1986 was the result of a dangerous goods incident that was initiated by a drunk driver. It was contained with the loss of only one life that occurred from the accident itself, not the dangerous good. The 1979 Mississauga derailment of toxic and chemical cargo, despite the temporary evacuation of 240,000 persons, did not involve a single fatality.

For the most part, in the event of an incident, the type and amount of commodity transported would impact system operating personnel rather than the general public. Any harm would largely be contained within the immediate right-of-way. However, exposure may be relatively high in certain instances, and there may be sufficient justification to rationalize the transportation network, in order to spread the risk.

In the United States, over 900 million tons of dangerous goods is moved over the nation's highway system annually. Since 1981, the country has averaged about 5,400 incidents, 12 deaths, and 200 injuries per year (5).

In Ontario, only one-third of the reported dangerous goods spills occur while the commodity is being transported. Thirty



SOURCE: Statistics Canada

FIGURE 7 Origins and destinations of rail tonnage for Ontario, 1986.

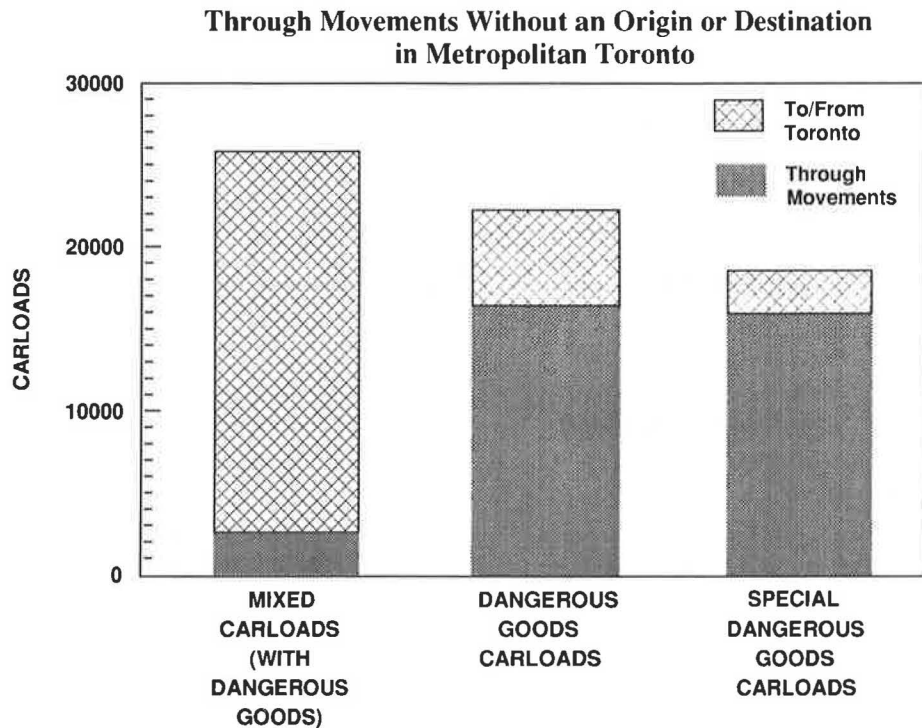


FIGURE 8 In-transit dangerous goods transport by rail, 1988 (I).

percent of spills were attributed to processing mishaps whereas a further 25 percent were related to storage (Transport Canada, Dangerous Goods Directorate, unpublished data) (Figure 9). The number of incidents that occur on the road network annually has averaged about 130 over the past few years, about one-half being related to tank trucks (Figure 10).

Driver error was the most predominant reason for such a road transport related incident (26 percent), twice that for equipment failure (13 percent); inclement weather was a more infrequent reason for the occurrence of an incident (4 percent).

A review of Ministry of Environment dangerous goods spills summaries from 1981 to 1984 found that the highest proportion of spills occurred in northeastern Ontario (29 percent), while the highest percentage of tank truck incidents occurred in central Ontario (29 percent). There was no discernible explanation for this spatial distribution (6).

The number of accidents involving dangerous goods has declined nationwide from 1986 to 1988 (Transport Canada, Dangerous Goods Directorate, informal communication). The highest proportion of dangerous goods accidents—just over one-third—occur each year in Ontario (Figure 11). Alberta and Quebec are the next most frequent locations for dangerous goods accidents. Ontario levels are higher because of the larger volume of dangerous goods movement and the larger number of vehicle-miles traveled in the province. Also, the accident rate of major transportation modes during this time frame decreased considerably (Figure 12).

Between 1986 and 1988, however, an average of 15 persons were killed and 165 persons injured annually in dangerous goods accidents in Canada. Although one-half of the injuries could be directly attributed to the dangerous good, on average only two of the deaths each year were the result of the dangerous good (Figure 13).

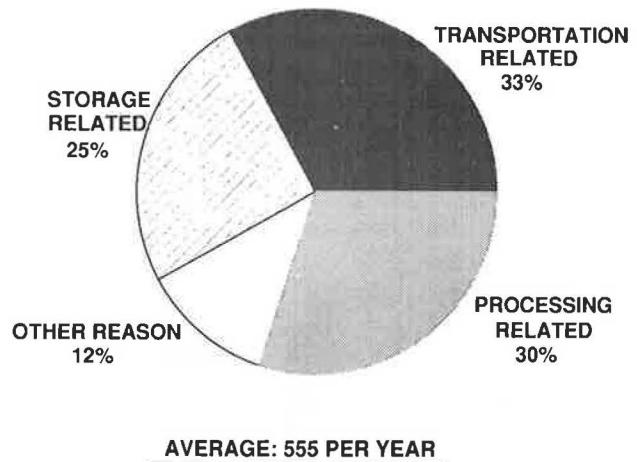


FIGURE 9 Dangerous goods incidents by type for Ontario, 1977-1985 (7).

Evidence conflicts as to what constitutes the safest mode for dangerous goods transport between cities. Theoretically, because the rail mode has its own right-of-way and can carry a larger quantity of such goods, the potential for an incident could be assumed to be less for this mode than for more frequent truck travel required to carry the same volume of a commodity.

The potential for an incident to affect a larger area or population would be greater for the rail mode, given the larger volumes of goods involved. The 1988 U.S. analysis also suggests that the estimated accident release rate for rail was in excess of that found for all trucks.

A cursory review of Transport Canada data would seem to support that conclusion simply on the basis of the number of accidents per tonne transported. Between 1986 and 1988, the

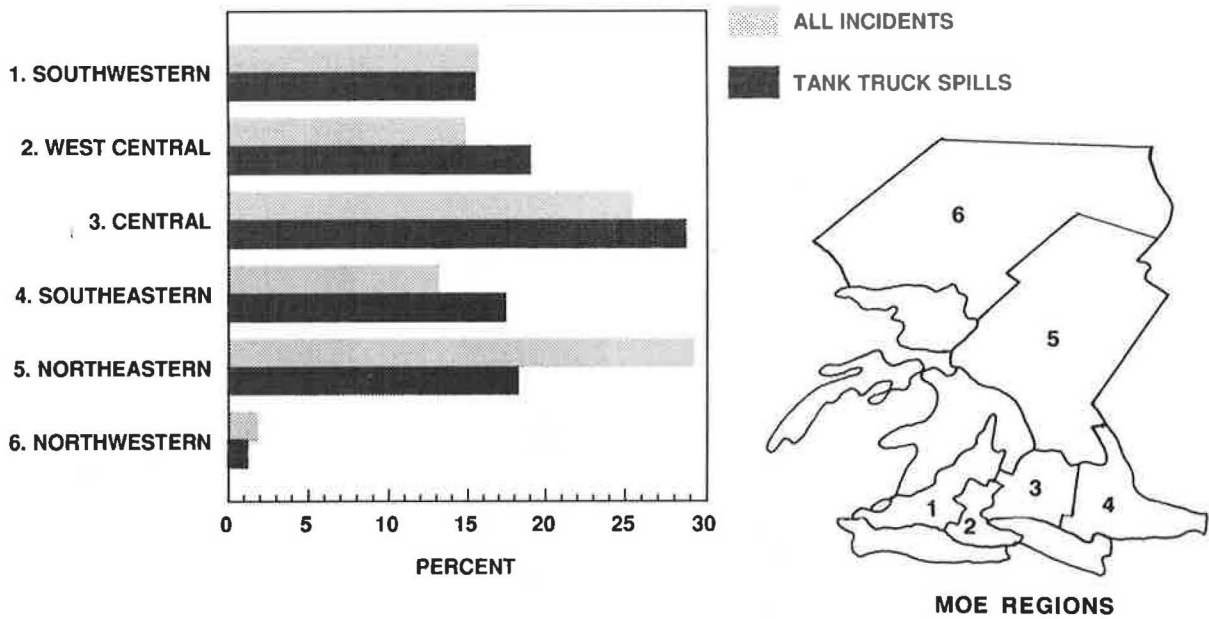


FIGURE 10 Dangerous goods incidents and tank truck spills by MOE region, 1981-1984.

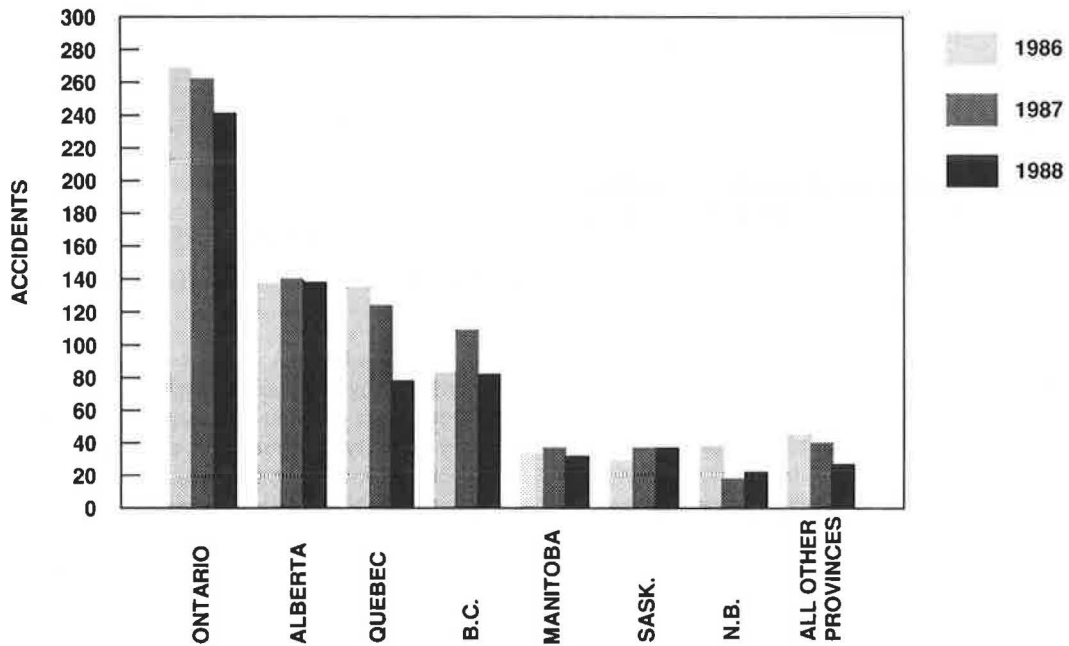


FIGURE 11 Dangerous goods accidents by province of Canada, 1986-1988.



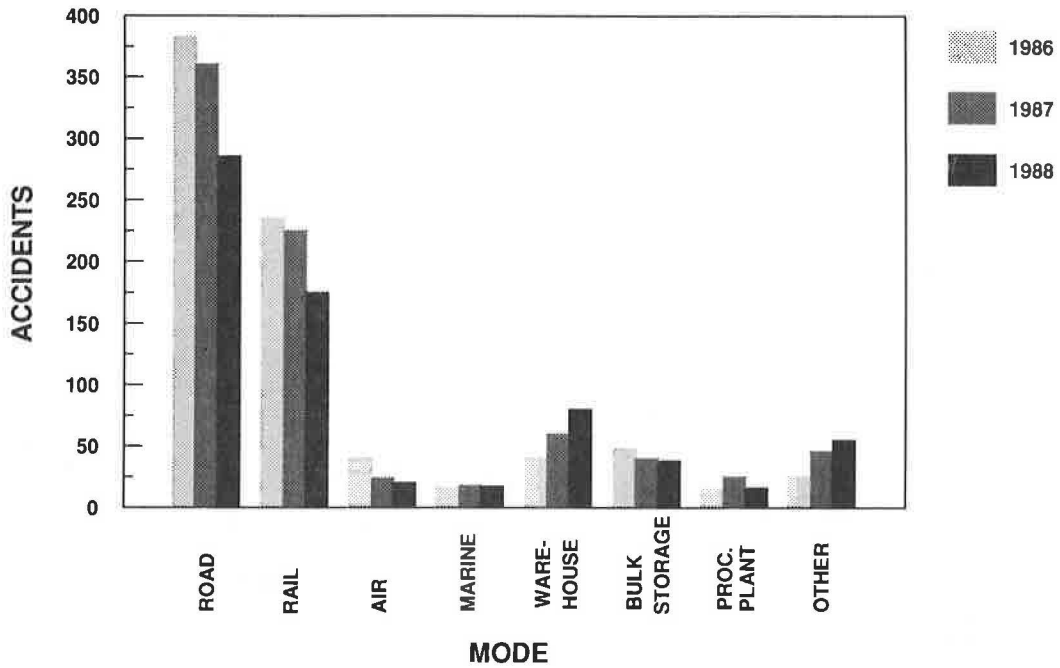
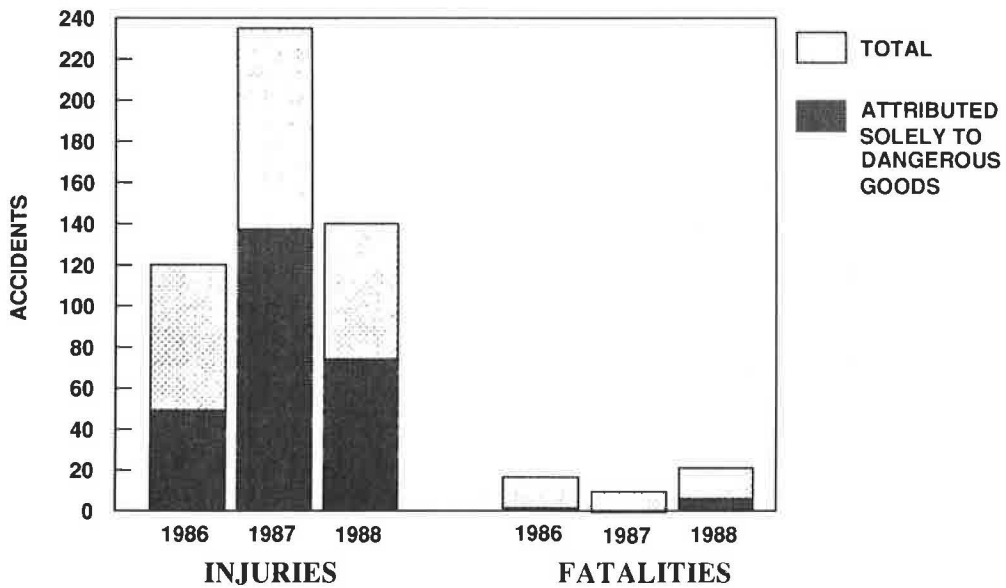


FIGURE 12 Dangerous goods accidents by mode for Canada, 1986-1988.



SOURCE: Transport Canada

FIGURE 13 Dangerous goods accidents for Canada, 1986-1988.

rail mode accounted for about 11 percent of the dangerous goods tonnage moved (Figure 2), but more than one-third of the accidents related to dangerous goods (Figure 12) among the various transport modes, while the truck/highway mode accounted for 63 percent of the tonnage moved and 57 percent of the accidents.

However, considering the differences in volume and capacity between rail and truck cargo tanks, and the distance traveled for that cargo, inverse conclusions may well be drawn using other measurement units.

### SOCIETAL RISK ASSESSMENT

In spite of a seemingly large number of dangerous goods incidents, the likelihood of an incident's causing death at a given location is remote. The probability of an annual occurrence of an accident involving death is on the order of 1 in 100 million. Information presented at the Gilbert Task Force indicated that the societal risk involved from the rail transport of dangerous goods is quite low—roughly equivalent to that from earthquakes and lightning (Table 2).

Although the level of public risk with the existing system under current operating conditions has been estimated as being 4 to 5 per year on average, the rail mode has experienced no deaths because of dangerous goods accidents across the entire country of Canada over the past 10 years.

The likelihood of 10 fatalities resulting from a dangerous good rail mishap was estimated at being 1 in 100 years (Figure

14). Thus, much of the risk associated with an incident at a particular location is more perceived than real. However, clearly events have and will continue to occur, and possible outcomes must be addressed.

Public concern, as well as constructive actions by government, shippers, and carriers, has resulted in

- Mandatory placarding of dangerous goods vehicles in excess of a certain weight (1985 in Ontario);
- Institution of dangerous goods truck routes in certain communities (Edmonton, Alberta);
- Lower train speeds for trains handling such products through major populated areas (Toronto, Ontario);
- Rerouting of rail traffic away from some residential areas (Vancouver, British Columbia);
- Provision of specialized training by and for shippers and carriers and emergency response personnel; and
- Development of programs such as the Transportation Emergency Assistance Plan.

### POLICY IMPLICATIONS AND OPPORTUNITIES

The transportation of dangerous goods raises many issues, among them: At what price is such transport truly safe? What level of enforcement is enough? and What degree of compliance is acceptable? For example, the pattern of land use and community development in Ontario and the cost of additional infrastructure make it impractical to construct dangerous goods bypass routes throughout the province.

TABLE 2 SOCIETAL RISK CAUSED BY VARIOUS HAZARDOUS EVENTS (3)

	<b>Societal Risk (fatalities per year)</b>
<b>Motor vehicle accidents</b>	<b>4,238</b>
<b>Falls</b>	<b>1,829</b>
<b>Poisoning +</b>	<b>665</b>
<b>Dwelling Fires</b>	<b>487</b>
<b>Excessive cold</b>	<b>121</b>
<b>Cataclysmic storms</b>	<b>13</b>
<b>Earth movements</b>	<b>5</b>
<b>Lightning</b>	<b>3</b>
<b>Rail Transport of Dangerous Goods (TDG) in the Greater Toronto Area (baseline risk based on existing system)</b>	<b>4.1*</b>

\* This is the estimated societal risk in "statistical" fatalities per year as determined by risk assessment. All of the other societal risk numbers are "actual" fatalities recorded Canada-wide. (Source: Statistics Canada, 1985, "Causes of Death," Publication #84203)

+ Includes accidental poisoning due to poisonous and other substances, surgical complications and misadventures to patients.

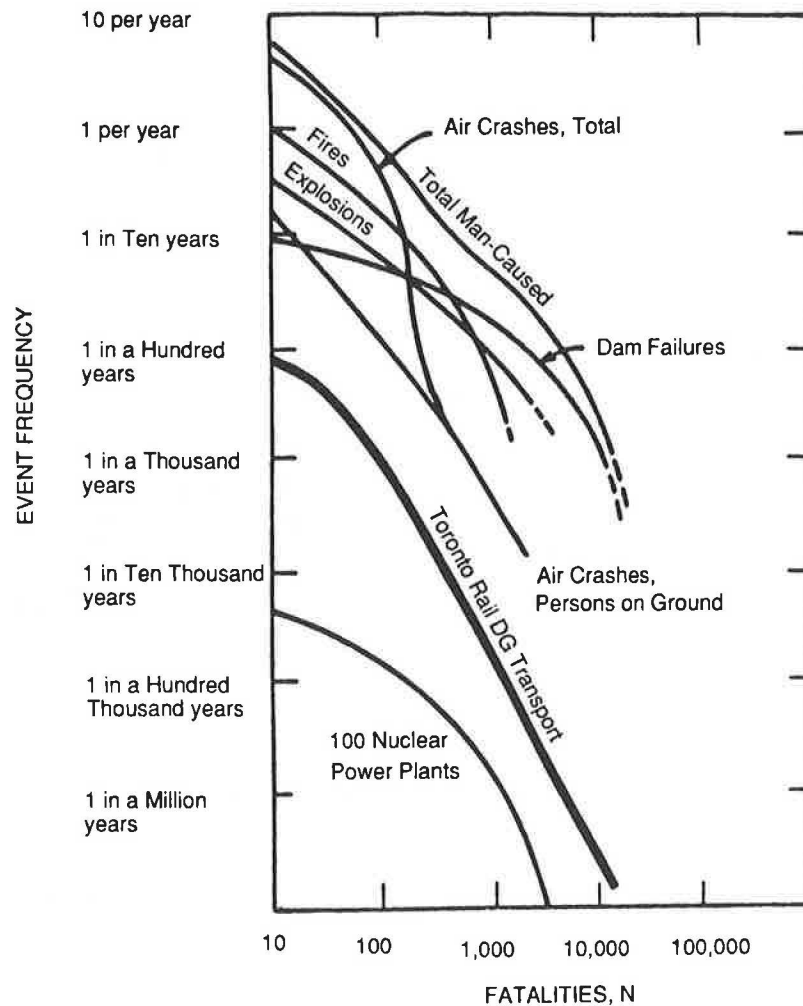


FIGURE 14 Risk assessment (3).

For the most part, routing restrictions, such as the superimposing of dangerous goods truck routes in an existing community, merely transfer risk and enhance the potential for a more severe incident by increasing the number of vehicle-kilometers that have to be driven. Also, the effect of concentrating, in a restricted area, the movement of commodities that are even more dangerous when mixed in an incident must be considered.

The practicality of such restrictions is questionable when the multitude of destinations for dangerous goods products—hospitals, retail paint and convenience stores, corner gasoline stations, etc.—is considered.

Time-of-day restrictions affect delivery schedules, and may result in the clustering of placarded vehicles parked along the side of a road or highway during banned hours.

The position of the Ontario Ministry of Transportation is that the movement of dangerous goods should not be unnecessarily hindered between shippers and receivers. Additional fees or restrictions can place a considerable economic burden on goods movement, whether assumed by the public or private sector.

For example, reducing risk to public safety from movement of dangerous goods at a regional level either by rerouting

dangerous goods rail traffic through operational changes or by relocating dangerous goods rail traffic by developing new rail lines north of Metropolitan Toronto was evaluated by the Gilbert Task Force. The estimated costs of such an undertaking ranged from a low of \$60 million (capital and operating cost) to a high of \$1.7 billion, depending on the alternative chosen (Figure 15).

## CONCLUSION

The subject of dangerous goods movement in the province of Ontario is quite complex. Minimizing the risk to the public from occasional incidents has been achieved with regulations, voluntary compliance, and enforcement. Many groups have contributed to safety—shippers, carriers, and all levels of government. As such, the level of public risk is quite low, but further improvement is possible.

If decision makers are of the opinion that the existing risk level is still too high, alternative actions can be contemplated. These actions would have to be evaluated in terms of societal risk, community impacts, effects on the natural environment, and economic ramifications.

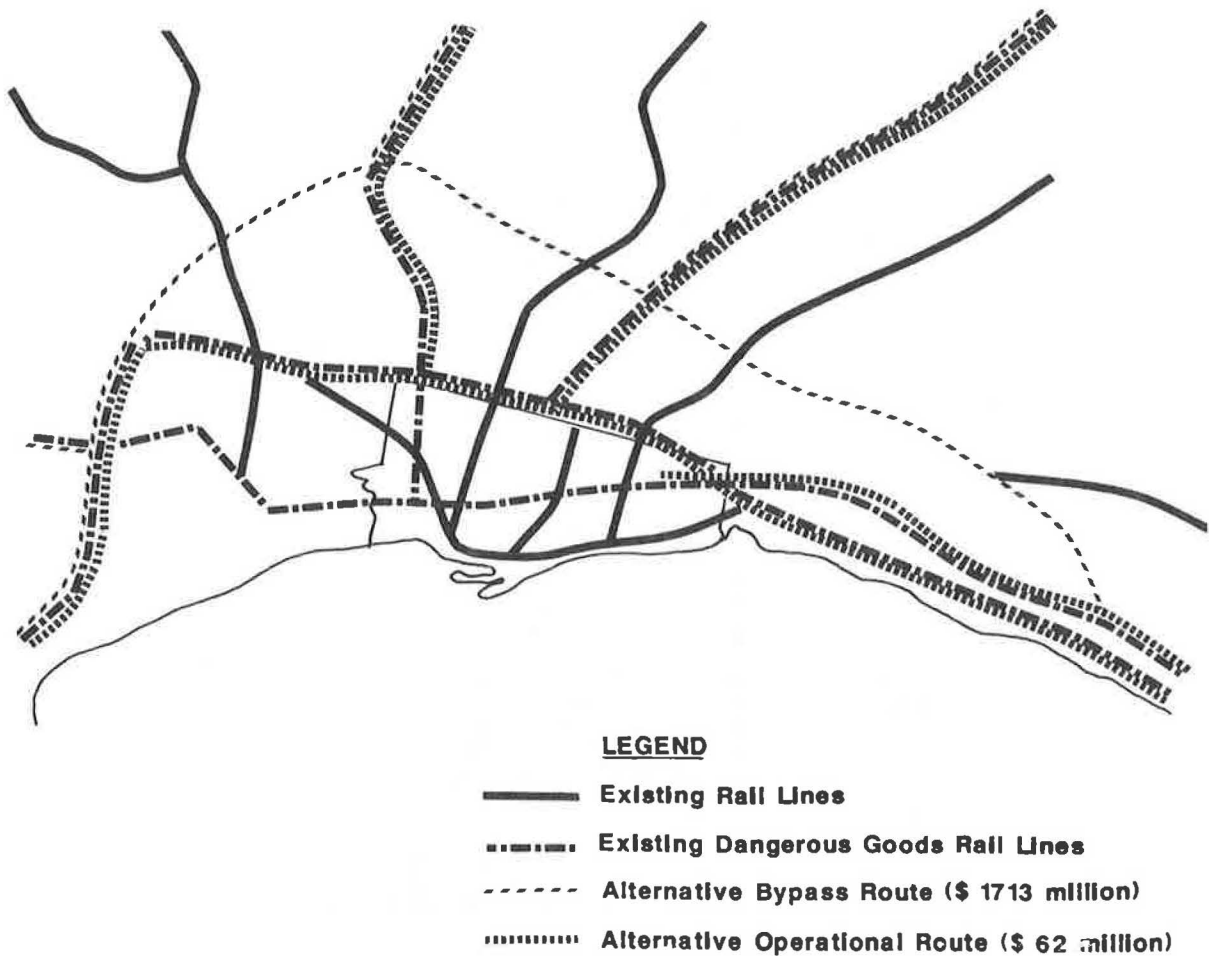


FIGURE 15 Alternative bypass route concept (3).

Whatever action is taken has to be achievable, effective, and enforceable. As always, value judgment on the appropriateness of each alternative can only be made by the broader political process.

#### ACKNOWLEDGMENTS

The author is greatly indebted to the following individuals: R. Puccini and D. Burton, Ontario Ministry of Transportation; R. Valentine, Ministry of the Environment; and N. Bernier, Transport Canada, for their assistance. This work was sponsored by the Municipal Transportation Policy Planning Branch, Ontario Ministry of Transportation.

#### REFERENCES

1. T. S. Glickman. Benchmark Estimates of Release Accident Rates in Hazardous Materials Transportation By Rail and Truck. In

*Transportation Research Record 1193*, TRB, National Research Council, Washington, D.C., 1988.

2. M. Perera and E. Corupe. *Ontario Commercial Vehicle Survey—1983*. TDF-84-05. Policy Planning Branch, Ontario Ministry of Transportation, Toronto, Ontario, 1984.
3. The Toronto Area Rail Transportation of Dangerous Goods (Gilbert) Task Force. Final Report, T44-3/14-1. Ministry of Supply and Services, Toronto, Ontario, 1988.
4. Cole, Sherman and Associates. *The Metropolitan Toronto Goods Movement Study*. Metropolitan Toronto Roads and Traffic Department, Toronto, Ontario, 1988, Chapter 5.
5. J. V. Murphy. Focus: Hazardous Materials Transportation. *Traffic World*, Feb. 6, 1989.
6. *Spill Report Summaries: 1981–1984*. Ministry of the Environment, Pollution Control Branch, Toronto, Ontario (unpublished data).

*The opinions expressed in this paper are solely those of the author, and in no way reflect the position of the Ontario Ministry of Transportation.*