A METHODOLOGY FOR THE SPATIAL EVALUATION OF THE TRANSPORTATION OF DANGEROUS GOODS AND THE IMPACT OF RISK IN THE PROVINCE OF MANITOBA.

By

Andrea J. Downey

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ABSTRACT

Two simple models have been designed and tested in this study in an attempt to both extract data and spatially evaluate the transportation of dangerous goods in the province of Manitoba.

The first model (Part I) accrues to the transportation network and employs data obtained from a sample industry survey to produce a spatial assessment of route utilization for one chemical type or group. Although this exercise considers the 'in transit' (dynamic) parameters of approximate frequency of shipments and approximate volume (L.) per shipment, the model has the capacity to evaluate alternate parameters in subsequent studies.

The second model (Part II) accrues to the impact of risk along the transportation routes estimated in Part I given the occurance of mishap or unintentional release of a dangerous good (s). Human population, the selected impact of risk criteria, is evaluated according to the static parameters of rural population density and urban population, and the dynamic parameter, average annual daily volume of traffic. All data for the test parameters in Part II are extracted from secondary sources.

Notwithstanding delimitations, assumptions and controlled variables, each model provides a reasonable methodology to spatially evaluate the transportation system in terms of 'in transit' commodity flows and the estimated impact of risk.

DEDICATION

This practicum is dedicated to my precious family and to the loving memory of Edna Lydeard Montgomery (1897-1985), who have provided the incentive to achieve and the strength to persevere through wisdom, support and love.

ACKNOWLEDGEMENTS

It is one year since pen was first put to paper to design a research proposal which pertained to the transportation of dangerous goods in Manitoba. In the ensuing months of what became a most challenging research effort, I had the fortune to meet and work with a special group of dedicated individuals whose time, guidance and patience exceeded all reasonable limits.

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Last but by no means least, I commend five individuals who produced superior work despite the 'afterthoughts' and 'I forgots'. Thanks are due Ms. Marg Boyle and Mr. David Webb for laboriously typing the tables, Mr. Weldon Hiebert for the skilled cartography, Mr. Don Barnicki for the camera-ready layouts, and my fiance Don Franchuk who made a fine 'production assistant' but, most of all, believed in me.

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Chapter I

PRACTICUM PROPOSAL

1.1 BACKGROUND AND PROBLEM STATEMENT

This practicum is designed to examine the transportation of dangerous goods[1] in the province of Manitoba. In Part I a model which is capable of evaluating transportation route utilization for dangerous goods has been designed. Part II consists of a model which can assess the impact of risk along the routes designated in Part I, given an accident involving dangerous goods.

Since the fall of 1984, both federal and provincial legislation has governed the transportation of dangerous goods in the province of Manitoba. Paradoxically, a unified and complete data base consisting of nature of goods transport-

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[1] In section 1 of The Dangerous Goods Handling and Transportation Act (S.M. 1984, c. 7 - D12), 'dangerous goods' are defined as [...] any product, substance or organism designated in the regulations, or conforming with the criteria set out in the regulations, or in any regulation adopted in accordance with this Act, and includes hazardous wastes [...]. The classification of dangerous goods are as follows: Class 1 - explosives; Class 2 - gases; Class 3 - flammable and combustible liquids; Class 4 - flammable solids, spontaneously combustible, dangerous when wet; Class 5 - oxidizing substances, organic peroxides; Class 6 - poisonous and infectious substances; Class 7 - radioactive materials and prescribed substances; Class 8 - corrosives; and, Class 9 - miscellaneous dangerous substances or articles.

ed, the routes utilized, the frequency or the volume of shipments, is virtually non-existant. Whatever data are available is negligible, incomplete or scattered. These deficiencies preclude rigorous spatial evaluations of dangerous goods transportation routes and likewise, knowledge of the magnitude of impact under circumstances of unintentional release or spill. In terms of procedure for research, there are no apparent precedents.

Identification of administrative jurisdiction, land use, population density and/or environmental sensitivity along routes, is paramount. Route identification, and estimated risk impacts, are required to evaluate the transport of dangerous goods both within the transportation system, and, in terms of the geographically diverse regions thereof. As Hewitt and Burton (1971) remark:

> [i]n hazard studies, the 'weakest link' will vary with the type of hazard, with the type of community and with space and time, but it is especially important to try to isolate these various levels of vulnerability.

The means of creating a useful data base, a spatial evaluation tool and an impact of risk model, are essential to maintain effective and efficient administration of dangerous goods in transit.

This practicum has been designed as a planning tool. The research herewith is not an exhaustive analysis of the transportation of dangerous goods, but rather, a methodology intended to extract information regarding the transportation of dangerous goods.

It is intended that this approach will benefit federal and provincial administrators, municipalities, and local government districts in Manitoba.

1.2 OBJECTIVES

The purpose of this research project was:

1. to design a model (Part I) which will enable a spatial assessment of road utilization and flows of dangerous goods in the province of Manitoba,
2. to design a model (Part II) which will enable the identification of the impact of risk given mishap or accidental release of a dangerous good (s), which is based on the roads identified in Part I,
3. to test the effectiveness of each model with actual data,
4. to provide recommendations based on the practical application of each model, and,
5. to provide recommendations based on the test results of each model.

1.3 DELIMITATIONS

Delimitations pertaining to the methodologies employed in the transportation route utilization model and the impact of risk model are outlined specifically in Chapter 3.

1.4 PRACTICUM FORMAT

The practicum research document consists of five chapters. Chapter 1 is the practicum proposal with general information about the study. Chapter 2 is a literature review which contains background information, and in particular, risk analysis, a brief discussion of federal and provincial legislation and the economic effects of implementing dangerous goods safety regulations. Chapter 3 outlines the methodologies employed to conduct Part I and Part II of the study. Chapter 4 presents the results of the study and discussion. Chapter 5 provides recommendations and summarizes the practicum.

LITERATURE CITED -- CHAPTER 1

Hewitt, Kenneth and Burton, Ian. 1971. The Hazardousness of a Place. A Regional Ecology of Damaging Events. University of Toronto Department of Geography; Research Publications; Toronto. pp. 11 -30; 124 - 147.

Chapter II

LITERATURE REVIEW -- RISK ANALYSIS, LEGISLATION AND ECONOMICS

2.1 INTRODUCTION

This chapter is designed to provide background information on the transportation of dangerous goods. The sections will address risk analysis, present a brief discusssion of federal and provincial legislation and assess the economic effect of implementing dangerous goods safety regulations.

2.2 RISK ANALYSIS

2.2.1 Introduction

To a degree, virtually all activity involves the element of risk. By some, risk has been termed 'the occurance or potential of a particular accident, which consists of an event or sequence of events' (McCormick, 1981). Others define risk as 'the chance of harm or, the potential realization of the unwarranted consequences of an event' (Rowe, 1980). Frequently, formal definitions fail to state that risks need not be negative. It is noteworthy that particular risks may be unavoidable.

Risks are evident in most personal decisions, and undoubtedly risks play an important role in decisions which affect many lives. Of pertinence to this chapter is the latter category, when decisions or activities involving a substantial degree of risk and human life are made outside or beyond the control of the individual, such as for the transportation of dangerous goods.

The process to measure risk is termed <u>risk analysis</u>, which considers the probability of an accident occuring and its subsequent consequences (McCormick, 1981). The impact of risk may be assessed in a similar fashion; however, the parameters of interest concern those persons or places which may be affected should mishap occur. Collectively, risk analyses identify relationships among factors in a particular system, enable the evaluation of these relationships and provide a basis for planning the reduction of the probability of occurance(s) or the mitigation of the consequence(s). Risk analyses may also be comparative where two or more projects or systems are evaluated simultaneously.

In pursuit of implementing policy or regulation, administrative agencies and private industry must understand the nature of risks and translate this knowledge effectively; this is the essence of <u>risk management</u>. However, risk analyses are not easily conducted.

In this part of Chapter 2, objective and subjective risk estimation techniques and deficiencies are critically evaluated. By no means should this presentation be considered exhaustive. Through application of slightly different terminology, the components and relationships of risk estimation have been organized by Rowe (1980), as illustrated in Figure 2.1.

2.2.2 Objective Risk Estimation

Objective risk estimation is closely related to the statistical field of probability where the probability of risk is assessed in terms of theory, theorem and proof.[2] This section has been restricted to an overview of principles.

2.2.2.1 Estimating Risk as an Event

An event may occur as a result of natural circumstances (commonly phrased 'act of God') or an event may be attributed to a deliberate (i.e. man-made, man-induced) circumstance (McCormick, 1981). One format used to express risk is a sequence, chain or series of events resulting from a particular risk (e.g. hazard --> outcome --> exposure --> consequence), which in turn produces a multiplicity of interconnected outcomes (Ess, 1981a).

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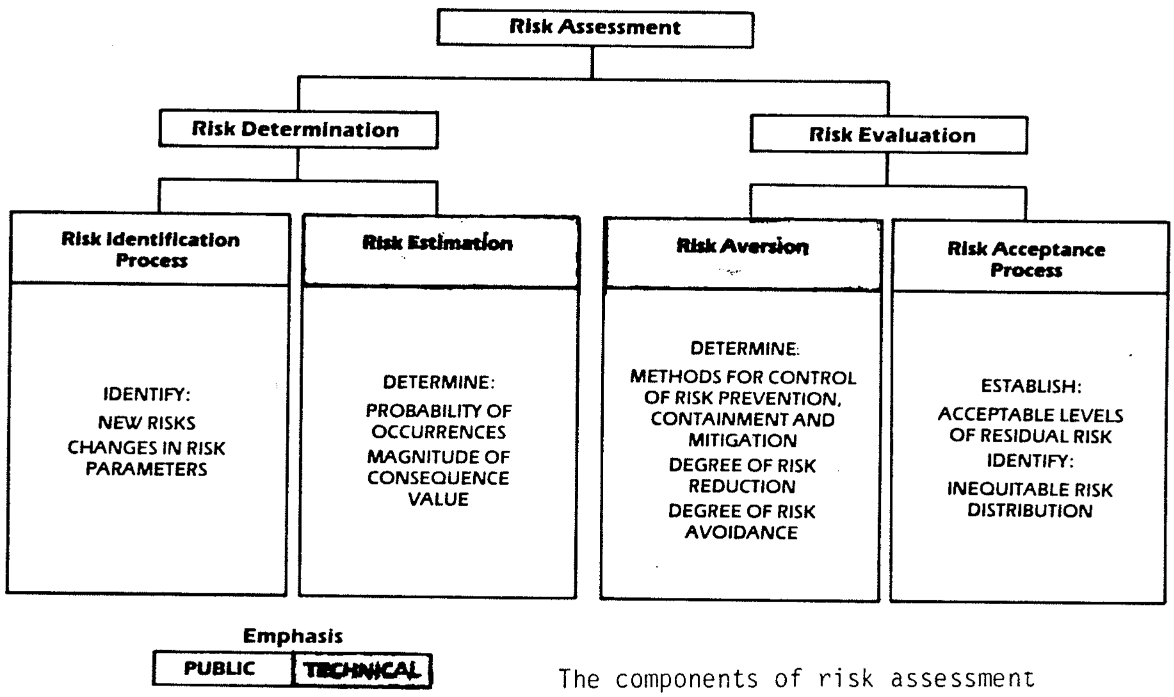
[2] Refer to Ess, 1981a; McCormick, 1981, and/or Rowe, 1980 for reference. (See 'Literature Cited', pages 38-39.)



The components of risk assessment

Figure 2.1

Source: Rowe, 1980

For practical purposes, simplification is essential, especially if a numerical value is to be computed for the event. One formula designed to achieve both objectives, is a mathematical description of risk: risk is the function of its probability multiplied by the value of its consequence (Rowe, 1980). Thus,

$$\text{Risk } (R) = f(\ p,\ C(v)\ ).$$

Ess (1981a) purports that the evaluation of risk is the product of the consequence occuring and the value of the consequence, multiplied by the probability of the event occuring:

$$\text{Risk } (R) = P(\text{consequence occuring X value of consequence}).$$

There are limitations, however, to basic statistical presentations of risk estimation. In particular, Rowe (1980) identifies serious problems in accurately estimating the probability of occurance for <u>rare events</u>. The probability of occurance is largely based upon historical data of the previous frequency of an event or related events occuring. For rare events, the statistical base may be insufficient for adequate analysis. This is perhaps the greatest practical problem of risk analyses which seek to evaluate the transportation of dangerous goods. Events of mishap generally occur infrequently but with potentially great magnitude or consequence.

Similarly, when risk analyses are conducted for new technologies, there are usually limited, or non-existent data bases available for comparison or there may be lack of knowledge or appreciation of critical elements in the risk pathway. Rare events, and other factors influencing objective risk estimations will be discussed in section 2.2.4.

2.2.2.2 Dependent/ Independent Event Estimation

The difference between dependent and independent events is significant in risk analysis. Two or more events are independent, if the occurance, or non-occurance, of one of the events does not change the occurance of the other event(s) (Mendenhall, 1983). If this does not hold true, the events are dependent. The following computations are based on the sequence: Hazard (H) --> Outcome (O) --> Exposure (E) --> Consequence (C).

The dependent consequence occurance formula resembles basic conditional probability, where:

$$P(\text{consequence occuring}) = P\,(H \times O \times E \times C) =$$
$$P\,(H) \times P\,(O/H) \times P\,(E/O \times H) \times P\,(C/E \times O \times H).$$

Here, the risk is dependent upon one or more events occuring.

Independence of the occurance of each event is expressed by the formula:

$$P(\text{occurance, each event}) = P(H \times O \times E \times C) =$$
$$P(H) \times (O) \times (E) \times (C).$$

In this case, the risk occurs independently of the occurance of one or more separate events.

Once again, the reliability of data computed in this exercise is dependent upon the availability of information regarding previous events in the sequence (Ess, 1981a). If there exists limited or incomplete data, which is usually the case for the transportation of dangerous goods, the results will be inaccurate or unfounded.

2.2.2.3 Expected Value Estimation

A mathematical expectation is the average of a random variable calculated for the theoretical population defined by its probability distribution (Mendenhall, 1983). Expected value estimations can be conducted in risk analyses, if the probability of the consequence(s) is known (Ess, 1981a). Computation of the expected value is a multiplicative function of the relationship between the probability of the consequence and the value of the consequence where, for simple events:

$$E[X] = P(\text{consequence}) \times \text{value}(\text{consequence}),$$

and for multiple events,

E [X] = the Σ of P(consequence) X value (consequence)

of each event.

Ess (1981a) criticizes this approach by indicating, in particular, that societal perceptions (characteristically influenced by the magnitude of the probability of the consequence) have been ignored. Thus, for analyses which attempt to include a degree of human perception, calculation of the expected value of risk is not suitable. Suffice to say at this time, societal risk perception has played an important part in directing administrative attention toward the transportation of dangerous goods. The implications of this observation, however, exceed the scope of the present study.

2.2.2.4 Absolute vs Relative Risk Estimation

Rowe (1980) classifies risk into absolute risk and relative risk. Absolute risk is an estimation of the likelihood of an event with a specific consequence. Relative risk considers the likelihood of other events of similar magnitude.

The value of absolute risk estimations will depend upon risk estimation and the range of uncertainty (Rowe, 1980). Compared to an indifferent condition, absolute risk can be measured in terms of 'greater than' or 'less than'. This terminology is useful to decision makers who may seek to identify a risk-taking/ risk-aversion margin.

On the otherhand, relative risk estimation will produce groups of alternatives which can be useful for priority-setting or ranking. In this case, the conditions of indifference for the probability of occurance are estimated (Rowe, 1980). Data would then be compared and a choice made.

The work of Rowe (1980) aids in grouping formative statistical estimations which, by themselves, are complex and useless to the decision maker. However, some may argue that grouping data foregoes objectiveness.

2.2.2.5 Upper and Lower Limits to Risk Estimations

The Poisson probability distribution provides a good approximation of the dispersion of many variables and in particular, rare events (Mendenhall, 1983). Rowe (1980) asserts that the upper and lower limits of the probability of an event(s) can be determined by this process. If the probability of risk is less than one in one million (10^6), by convention it is removed from the analysis, provided suitable explanation is submitted (Rowe, 1980). However, if circumstances preclude explanation, all low probability risks must be included. From a technical viewpoint, this methodology is suitable for risk analyses which seek to determine the probability of occurance of transportation accidents involving dangerous goods.

2.2.2.6 Fault Tree Risk Estimation

In recent years, fault tree analyses have evolved and have increased in popularity (Slovic et al, 1980). Fault trees are highly sophisticated mechanisms designed to estimate risk from virtually undocumented intuition (Ess, 1981a). In the judgement of Ess (1981a) fault trees meet all of the objectives of a suitable analytical method by:

1. providing an estimation of risk probability,
2. enabling multiple input of various individuals and disciplines, and,
3. producing an easily reviewed evaluation of risk.

In essence, the components of a risk-related problem can be illustrated until the level of probability required to calculate event occurance, is either known or easily determined. The top 'event' represents a key situation or group of situations, in the risk pathway. Actual, estimated or anticipated causes for the top event follow in 'branches' (Ess, 1981a). Symbols in the fault tree have a specific meaning which pertain to the relationships among events.

There is potential for complex numerical calculations in fault tree analysis. For simplification, therefore, Ess (1981a) suggests that Boolean algebra, and Shannon's method for expanding Boolean functions, will reduce equations to the smallest combination of component failures. Essentially, if these failures occur, the top event occurs.

The fault tree analysis has been subject to scrutiny. Slovic et al (1980) observe in particular that fault trees entertain a potentially high amount of human judgement and thus, there is no guarantee of objectivity or discretion. Ess (1981a) supports this and indicates that in some cases there are no feasible objective methods for estimating event probabilities. In this case, judgemental probabilities must be utilized.

The fault tree analysis should be considered as a tool which expresses the relationships among events and estimates all corresponding probabilities of occurance. It would appear that this methodology is theoretically suitable for evaluating transportation mishaps involving dangerous goods.

2.2.3 Risk/Benefit Analyses

From an alternate perspective, risk can be estimated through a risk/benefit analysis. Risk/benefit analyses are subsequently less objective than fault trees, with numerical values equating losses and gains attributed to a particular risk.

2.2.3.1 Risk/Benefit Analyses and Equity

Rowe (1980) observes that throughout life an individual is faced with many gambles which incur trade-offs between the quality of life and the quantity or longevity of life.

More often than not, attention is directed at inequitable gambles which do not promote Pareto Optimality. However, almost every major technological or social undertaking is a particular gamble involving a degree of inequity. According to Rowe (1980), and supported by McCormick (1981), there is no phenomenon of 'zero risk'. Risk analyses which entertain a goal of zero risk, fail to realize both the trade-offs between risk and benefit and the relative impossibility of reaching this goal.

Trade-offs make risk/benefit analyses possible. For administrative agencies or private industry, the risk/benefit analysis is appealing because it will illustrate the economic, or dollar value, of risk in a manner which can be understood and utilized efficiently. Attempts can be made through this methodology to minimize loss (risk) and maximize gains (benefits).

Two examples of risk/benefit analyses have been submitted: 1. the cost/value analysis, and, 2. the value/impact analysis.

2.2.3.2 Risk/Benefit - Cost/Value Analyses

Risk/benefit - cost/value analysis requires a dollar value for benefit(s) and a dollar value for risk(s); these values are then weighed against each other (McCormick, 1981). In simple terms, risk includes the dollar value of disability and death, and benefit includes the value of resources. The total social cost (disability and death) can be computed by the number of individuals multiplied by the cost of one disability day; in turn, these are multiplied by a discount rate for a specific time period (McCormick, 1981). The formula for total social cost is:

$$TSC = N\ C\ (1 + i)t \quad T \geq 6000$$

where the variable N represents the number of individuals; the variable C represents the dollar value of one disability day; (1 + i) represents the discount rate; the variable (t) represents time in consecutive days of disability; and, the figure (6000) represents the number of days equivalent to a fatality (McCormick, 1981).

There are several ways to acquire dollar values for cost/value analyses. The value of human life can be estimated from insurance premiums or the discounted value of a person's future earnings can be used (McCormick, 1981). Alternatively, records of what has been spent to avoid accidents in the past (e.g. safety equipment; guardrails; etc.) can be examined to compute similar values (McCormick, 1981). However, past decisions are not always optimal.

In the cost/value analysis, safety expenditures should be made until the marginal or last dollar exchange between social costs and risk control costs equal (McCormick, 1981). At this point, the expenditure of one dollar for safety would reduce the social cost by one dollar. At some point, however, the cost effectiveness (e.g. value received/unit expenditure), falls below a level of acceptability or practicality (McCormick, 1981).

One major criticism of the cost/value analysis arises in regard to the appropriate 'value' of human life. McCormick (1981) suggests that a social consensus be acquired prior to the endorsement of any specific dollar value.

2.2.3.3 Value/Impact Analyses of Risk

A value/impact analysis is defined as the cost of saving lives (McCormick, 1981). Alternatively stated, a value/impact analysis considers the cost of preventing or avoiding an extra death before the age of 65 years from any cause (e.g. cost of saving an extra statistical life) (McCormick, 1981). Understandably, this approach would receive public support, but industry might perceive the method as less practical or too costly.

Potentially, risk/benefit analyses can satisfy the objectives of certain interested parties or users better than others. One must be wary of reports which quote risk/benefit statistics without specifying the parameters, delimitations and assumptions employed. It is important to determine what a particular risk/benefit analysis represents. For example, a risk analysis may be a special case of cost/

benefit analysis, or it may be the optimal use of insurance which protects human life (McCormick, 1981). Once a critical evaluation of the risk/benefit analysis is conducted, decision-makers can set regulations in the best interest of society, which reflect both the protection from risk and the necessity for the activity in question (McCormick, 1981).

2.2.4 The Limitations of Risk Analysis

Thus far in the evaluation, some limitations of risk analysis have been outlined but because of the high frequency and significance of these limitations, further discussion is required. As will be apparent in subsequent sections, this information is particularly important in any analysis designed to evaluate the transportation of dangerous goods.

2.2.4.1 Rare Events and the Relevance of Historical Data

One of the key problems encountered in risk analysis is the estimation of the probability of occurance for rare events (Rowe, 1980). Rowe (1980) identifies two classes of rare events: events of low probability and high consequence termed 'zero - infinity' events, and, all freak occurances such as, for example, rare events masked by numerous competing events which cannot be identified 'a priori' (Rowe, 1980). Rare events typically obey a Bernoulli probability function and are independent; these events either occur with a probability (P) or they do not occur (1 - P) (Rowe, 1980).

Rare events commonly lack substantive historical data bases used to estimate the probability of occurance value. Documentation of the occurance of events is usually employed to estimate risk. Thus, historical data provide insight into the relative causes of past occurances and, theoretically, present a basis for comparison. If data are lacking, objective and reliable calculations are prevented. For example, when the number of trials of an event are large, by convention the estimation of risk is objective (Rowe, 1980). However, when the number of events is small or conjectured, the estimation of risk is subjective (Rowe, 1980). By their nature, rare events fall into the latter category and accordingly, so do the consequence values. Limited data bases can be attributed to the infrequent nature of rare events, where direct observation is not always possible (Rowe, 1980).

Despite uncertainty, risk analyses commonly involving rare events and values of risk computed under these circumstances, should be viewed in light of potential inaccuracies or understatement. However, rare event calculations provide a useful range of outcomes for decision-makers who are obliged to act before, not after, the fact.

2.2.5 Methodologies of Risk Analysis -- Discussion and Summary

This section has provided information about the complex discipline of risk analysis, in terms of the competing and sometimes conflicting techniques, the factors which should be incorporated and frequent gaps in knowledge (Covello, 1980). There are no apparent precedents, definitions or branches of risk analysis specifically pertaining to the transportation of dangerous goods. A table of strengths and weaknesses of the various methodologies is submitted as Figure 2.2 and a comparison of these techniques is submitted as Figure 2.3. Present risk analysis methodologies, or combinations thereof, should be carefully considered and then employed according to the nature of a specific study and the desired use of the results. As a final point, it is important to consider that the results of risk analyses can compete with the beneficial aspects of risk-taking (Covello, 1980).

2.3 THE RISKS OF DANGEROUS GOODS IN TRANSIT

2.3.1 Public Perception

Dangerous goods are conveyed on public transportation systems in ever increasing amounts (Silverstone, 1982). Whether the goods are in transit for industrial or for domestic consumption, an accident or mishap may produce effects ranging from inconvenience to disaster (Silverstone, 1982). In an illustration of the scope of the matter, Hall (1982), observes that the consumption of gasoline for private and commercial use places the vast majority of society in contact with the inherent risks of a highly flammable substance; public exposure to these risks may be greater during transportation to the service station than at the service station.

A large proportion of the gasoline for public consumption is transported by road (Hall, 1982; Krewski et al, 1982). Tank trucks travelling between bulk storage facilities and service stations pass through a variety of environments ranging from sparsely populated or rural regions to densely populated or urban centres (Krewski et al, 1982). Hall (1982) asserts that although accidents may occur at any point in production, transportation or end-use, the greatest risk exists during transportation. Perhaps this is due in part to the multidimensional risk inherent to any transport system and the lives of unprotected parties who may be victimized by mishap. This principle can be applied to dangerous goods other than gasoline and various transportation modes.

When a dangerous good(s) accident occurs, a range of hazards may arise, depending upon the precise location of the mishap, the degree of spillage and the properties of the material involved (Krewski et al, 1982). It is according to this information that the rate at which the material is

TECHNIQUE	STRENGTH	WEAKNESSES
FORMAL ANALYSIS		
Benefit/Cost Analysis	* Systematic * Ease of review * Handles all decision dimensions	* Discounts attributes which can not be readily conver- to economic terms * Large data requirements * Can't handle subjective value judgements
Decision Analysis	* Systematic * Ease of review * Flexible * Handles all decision dimensions * Incorporates decision makers judgement * Handles uncertainty well	* Large data requirements * Can't handle public perceptions of risk
COMPARATIVE ANALYSIS		
Revealed Preference	* Establishes absolute limits * Incorporates historical experience	* Past decisions often were not always optimal * Circumstances changing ra idly * Disaggregated historical baseline hard to establish * Does not address whole decision * Subject to inherent limitations of society and its citizens
Expressed Preference	* Establishes absolute limits * Allows for widespred public involvement	* Dependent on ability to get unbiased survey * Public does not always understand or have a preference * Does not address whole decision * Subject to inherent limitations of society and its citizens
Natural Standard	* Establishes absolute limits * Not subject to limitations of society	* Many of todays pollutants did not exist before * Does not address whole decision * Geological time baseline hard to establish * Does not allow for tradeoffs
PROFESSIONAL JUDGEMENT	* Handles all decision dimensions * Flexible * Easy to implement * Well established	* Hard to impossible to review * Bias due to employer * Stretched intuitive & cognitive skills can lead to erroneous judgements * Professional appear to be losing public support

Figure 2.2 Technique Strengths and Weaknesses

Source: Ess, 1981a

TECHNIQUE	DECISION MAKING CRITERIA	LOCUS OF WISDOM	PRINCIPAL ASSUMPTIONS	DECISION ATTRIBUTES POSSIBLE	DATA REQUIREMENTS
FORMAL ANALYSIS					
* Benefit/ Cost Analysis	Economic optimization	Formalized intellectual processes	* Man is or should be a rational economic maximizer * Decisions should be purely objective	Anything which can be converted to money	* All significant economic events & consequences * Accurate probabilities & magnatudes for each
* Decision Analysis	Utility optimization	Formalized intellectual processes	* Man is or should be a rational utility maximizer * Decisions should use decision makers value judgements	Anything; any number	* All significant events & consequence * Accurate probabilities & magnatudes for each
COMPARATIVE ANALYSIS					
* Revealed Preference	Preservation of historical balance	Societal decisions during recent past	* Past decisions were essentially optimal * Little or no change in circumstances	Risk only	* Current risk * Historical risk
* Expressed Preference	Current preference	Societal decisions now	* Public understands & have well articulated preferences	Risk only	* Current risk * Current preferences
* Natural Standards	Biological wisdom	Long term species survival	* The optimal level of exposure to pollutants is characteristic of conditions during species evolution	Risk only	* Current risk * Risk magnitudes during geologic time
PROFESSIONAL JUDGEMENT	Professional judgement	Intuitive intellectual processes	* Professionals understand & have well articulated preferences	Anything but limited number	Almost anything

Figure 2.3 Comparison of Techniques

Source: Ess, 1981a

disseminated throughout the environment, the number of injuries and/or deaths (employee, third party)[3] and property damages (company, third party), can be assessed (Hall, 1982). Transport Canada (1981) suggests that

> [l]ittle or nothing can be done to change an individual's behavior or to make the interaction between individual's less dangerous.

Although risks are greatest during the transportation of dangerous goods, it is asserted that the relative frequency of spectacular events (e.g. the Mississauga-type railway incident of 1979) have been relatively low (Slovic et al, 1981). Transport Canada (1981) supports this by stating that

> [most] accidents are minor although the potential for catastrophe is great where large quantities are involved.

Paradoxically, however, public perception of risk has a tendency to overestimate the spectacular events and underestimate the relatively higher frequency of unspectacular events (Slovic et al, 1980). Rowe (1977 cited by Ess, 1981b), suggests that public risk perception is influenced by factors such as involuntary, uncontrolled, undesirable and catastrophic events involving a group with which one can identify.

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[3] Third parties include the transport worker, handler, firefighter, police and the public (Transport Canada, 1981).

There is an apparent correlation between the public perception of a risky industrial practice (e.g. the transportation of dangerous goods) and vociferous public pressure via the media, on politicians and governments for corrective legislation and regulation (Hall, 1982). In the opinion of McCullough and Burton (1982) administrative (i.e. governmental) risk-related decisions tend to be as dependent on public pressure as they are based on science (e.g. probability of an event occuring). As the federal administrative agency, Transport Canada (1981) states that

> [d]emands arising from the general public indicate an increasing awareness that the transportation system is moving ever larger quantities of chemicals and products having a danger to life, property and the environment [and thus] a concerted approach to the regulation of these substances is essential.

As illustrated in section 2, evaluating risks is a difficult task. Hovever, uncertainty is not restricted to the aspect of risk analysis methodology; uncertainty is largely reflected in human risk perceptions. Usually lay people evaluate risks without reference to, or reliance on, statistical data (Slovic et al, 1980). Society tends to rely on inference or information remembered (e.g. hearsay; observations) (Slovic et al, 1980) which relates to the phenomenon: 'fear of the unknown' (Gavin, pers. comm.). Attributed to the multiplicity and intangibility of risk pathways, the normal individual is characteristically perplexed or confused and subsequently this is reflected in erroneous judgements of risk (Ess, 1981b; Dalkey, 1972). When expanded, this concept gives rise to the assertion that people seldom view reality realistically and rarely do people share similar perceptions (Ess, 1981b).

To reiterate, Slovic et al (1980) have identified a tendency for overestimation by laymen in their perceptions of spectacular events and a corresponding underestimation of unspectacular events. Surprisingly, the relative frequencies of unspectacular events are significantly greater than those which are spectacular; in theory, individuals should be more concerned about high probability events than low probability events (Slovic et al, 1980). It has also been observed that people are typically adamant and overconfident about their judgements (Slovic et al, 1980). Furthermore, Slovic et al (1980) cite Ross (1977) as observing that the beliefs of people change slowly and are extremely persistent in the face of contrary evidence; new evidence will be considered reliable, only if it supports a former judgement. This is related to the phenomenon of 'self-fulfilling prophecy' (Gavin, pers. comm.). For example, convincing people that the occurance of a catastrophe is unlikely, is difficult even under ideal conditions. Hall (1982) asserts that at some point within this network of factors, the trade-offs between risks and benefits become obscured. Thus, herein lies the rationale for public information and education by government and industry alike (Gavin, pers. comm.).

2.3.2 Legislation

The Transportation of Dangerous Goods Act (S.C. 1980, c. 36) is founded on Criminal Law with respect to safety and stems from the residual powers of the federal government under the Peace, Order and Good Government provision of the British North America Act of 1867 (Transport Canada, 1981). In a paper addressing jurisdiction and liability with respect to the transportation of dangerous goods, Silverstone (1982) remarks:

> [...] it is clear that the primary role of the legislative and regulatory systems with respect to the carriage of dangerous goods is the anticipation and alleviation of circumstances and procedures that may increase the likelihood of an accident and to provide for control and minimization of damage should one happen.

The regulations pursuant to the federal Act are designed to promote safety through the communication of information in terms of the nature of the products being transported, and to ensure that reasonable safety standards are established for packaging, handling and transportation (Transport Canada, 1981). The Act and regulations encompass all modes of transportation (e.g. road, rail, air, water) into one "complete package", thereby eliminating the previously complicated, confused and uncoordinated regulatory system (Transport Canada, 1981).

In accordance with the Transportation of Dangerous Goods Act (S.C. 1980 c. 36), the classes of dangerous goods are as follows (Transport Canada, 1983):

1. Class 1 -- explosives,
2. Class 2 -- gases,
3. Class 3 -- flammable and combustible liquids,
4. Class 4 -- flammable solids, spontaneously combustible, dangerous when wet,
5. Class 5 -- oxidizing substances, organic peroxides,
6. Class 6 -- poisonous and infectious substances,
7. Class 7 -- radioactive materials and prescribed substances,
8. Class 8 -- corrosives, and,
9. Class 9 -- miscellaneous dangerous substances or articles.

Manitoba has enacted The Dangerous Goods Handling and Transportation Act (Cap. D12, S.M. 1984, c. 7) which complements the federal legislation. The provincial statute encompasses both the transport and disposal of hazardous wastes (S.M. 1984, c. 7, s. 8, 9, 10) and includes a provision for municipal by-laws governing the transportation of dangerous goods (S.M. 1984, c. 7, s. 43).

2.3.3 Economic Consideration of Safety Regulations

The economic ramifications which result from new legislation and regulations, are seldom considered by lay people. Public attention and involvement is usually stimulated by controversial events or issues and diminishes when statutes are enacted and regulations enforced. Even when concern is directed towards public well-being, the inevitable costs incurred to secure the benefits are frequently overlooked by society.

This presentation is not to be regarded as an exhaustive list of economic effects (i.e. costs, benefits, spin-offs), but rather, constitutes an overview of economic impacts resulting from the regulation of the transportation of dangerous goods.

2.3.3.1 The Economics of Risk Management

To justify the new legislation and regulation, Transport Canada (1981) supports the economic rationale that:

> externalities arise in a market transaction if costs or benefits are imposed on third parties not included in the contract ... [sic.] Regulation is required to 'internalize' the externality - make the market more efficient by incorporating the costs of health, safety and environmental damage into the price of goods which generate such costs (Green and Waitzman, 1979 as cited by Transport Canada, 1981).

Gavin (pers. comm.) reports that this important principle is also endorsed by Environment Canada. It is this rationale, however, which has generated the greatest concern and criticism from industry. As illustrated by Dooley and Byer (1982), in most environmental decisions there is often a risk regardless of what is done: a risk if action is taken and a risk if no action is taken. Hall (1982) reports that there is increasing evidence that regulations are causing a significant economic burden on industry and hence, on society. Thus a trade-off has to be made between the risks and benefits and between the level of risk and cost (Dooley and Byer, 1982), otherwise the economic penalties may be such that regulatory action is counter-productive (Hall, 1982). Although not discussed in this report, these assertions reflect a classic divergence between micro and macro economic theory (Gavin, pers. comm.).

Hall (1982) suggests that if decision-making were based only on competitive market forces, enterprises would accept higher levels of risk to society than society itself would accept. In industry, risks to the well-being of the business accrue to competitive pressures on prices, loss of markets, rising labour costs, increased taxes, government regulations and accidents during job-related activities among others (Hall, 1982). Invariably, these components of risk can be expressed in monetary terms and are considered costs. In a competitive economy, efficiency is attained through cost- minimization. Thus there is some incentive, irrespective of regulations, for companies to direct funds toward accident and risk reduction (Hall, 1982) and thus, minimize the costs which they might bear.

However, history shows that industry cannot regulate itself, or that it is unwilling to do so (Gavin, pers. comm.). Again, the 'role of government' in setting standards or 'ground rules' is important. The relationship between the level of risk, the cost of accidents and accident reduction for any company is illustrated in Figure 2.4. Expenditures for accident reduction are justifiable only to the point that the incremental (private) cost of accident reduction is less than the incremental reduction in (private) cost of the accident avoided (i.e. the point where the slope of total cost is zero and the slopes of the cost of accident reduction and the costs of accidents are equal and opposite) (Figure 2.4) (Hall, 1982). Levels of risk due to accidents either above or below this point of financial acceptability, increases the company's cost and moves away from the optimum overall risk/benefit balance assumed by the owner (Hall, 1982).

The effect is that safety regulations increase the cost of accident reduction and thus increase the total cost of production (i.e. the curve shifts upwards and/or changes slope). The consumer will undoubtedly absorb these increased costs to some extent (Hall, 1982).

The risk-cost relationship for society can be expressed using similar reasoning as that considered for the firm (Figure 2.5). McCormick (1981) suggests that the law of diminishing returns applies to risk reduction.

Safety expenditures should be made until the marginal (or 'last dollar') exchange between social cost and risk control cost is equal; at this point the expenditure of one dollar for safety would reduce the social cost by one dollar. Illustrated by the total cost curve, costs diminish up to this point and increase past this point (Figure 2.5).

It is a considerably difficult task to determine the cost of accidents and the cost of accident reduction (Hall, 1982). As presented, Figures 2.4 and 2.5 are highly conceptual, illustrating the relationship between cost and effectiveness, a financially acceptable range of alternatives and the optimum safety level. It would be a formidable task to determine the precise location or range of alternatives and the optimum safety level.

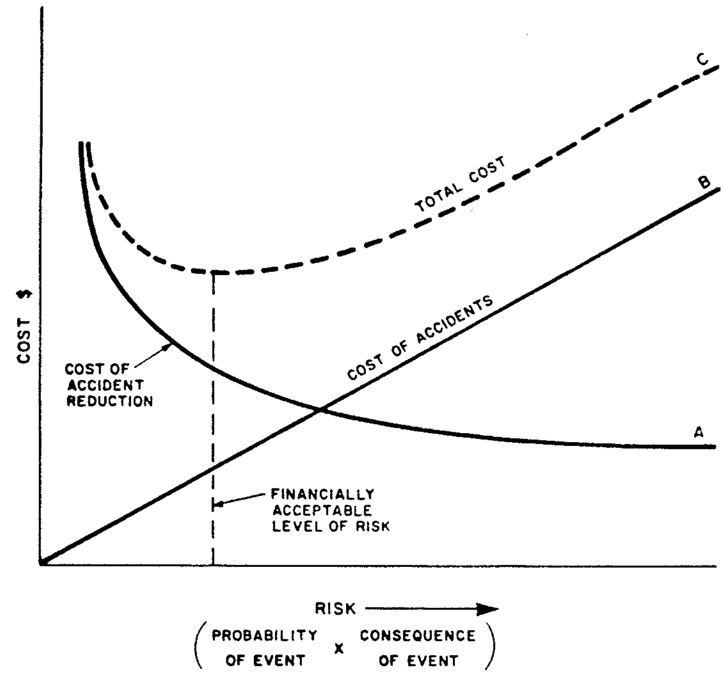
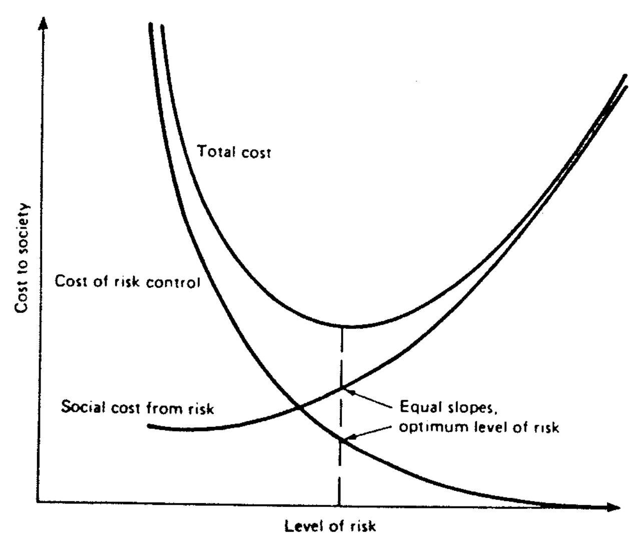


Figure 2.4 Risk-Cost Relationship for Industry

Source: Hall, 1982



Social costs and control costs versus level of risk. (Reproduced with permission from the Annual Review of Energy, *1, 629. Copyright © 1976 by Annual Reviews Inc.)*

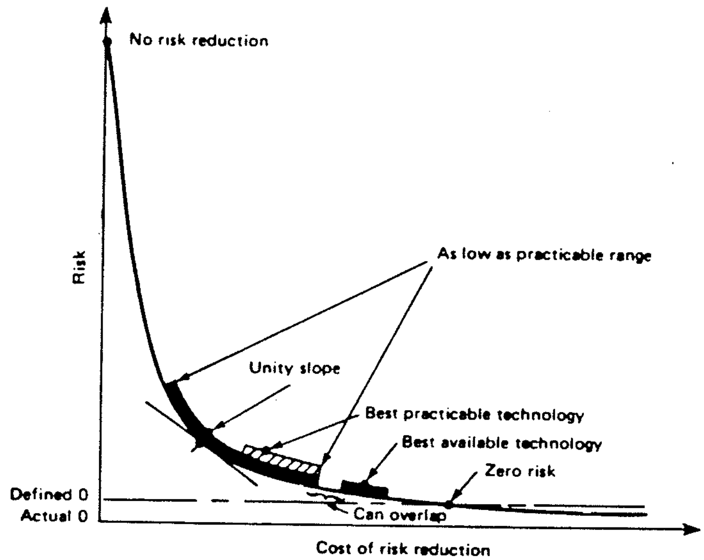
Figure 2.5 Risk-Cost Relationship for Society

Source: McCormick, 1981

It is worthy to note the great cost to a firm and to society to attain the level of 'zero-risk'. Figure 2.6 illustrates a cost-effectiveness relationship where risk, the costs of risk reduction and technology to achieve risk minimization are compared. It is on the basis of cost-effectiveness reasoning that industry has expressed concern about the regulations governing dangerous goods, insofar as this 'practicable range' is exceeded (Figure 2.6). Alternatively stated, industry fears over-regulation but as previously discussed, government intervention is required to some degree (Gavin, pers. comm.).

In contrast to costs, benefits are usually more difficult to quantify in monetary terms. The benefits accruing to safety regulations include lives saved, injury avoided, reduced clean-up costs and avoided accidents (Transport Canada, 1981). Public assurance may be the greatest intangible benefit of all.

Considering that both federal and provincial legislation is in force, the economic spin-offs which may result are virtually unavoidable. However, the potential for <u>further</u> legislation exists in section 43 of <u>The Dangerous Goods Handling and Transportation Act</u> (Cap D12, S.M. 1984, c.7) of Manitoba. In consideration of the information contained in this section, an additional group of regulations for the transportation of dangerous goods may be an unreasonable economic alternative.



Some criteria for acceptance levels of cost effectiveness of risk reduction. (From W. D. Rowe, "An Anatomy of Risk," Wiley, 1977.)

Figure 2.6

Some Criteria for Acceptance Levels

of Cost Effectiveness Risk Reduction

Source: Rowe, 1977 as illustrated by McCormick, 1981

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Chapter III

THE TRANSPORTATION ROUTE MODEL AND IMPACT OF RISK MODEL METHODOLOGY

3.1 PART I -- THE TRANSPORTATION ROUTE MODEL

3.1.1 Introduction

In fulfillment of the primary objective which, to reiterate, is the development of a mechanism or framework to assess route utilization and flows of dangerous goods in Manitoba, the following methodology has been designed. The initial goal is to construct a simple model; the second goal is to test the model with actual data from Manitoba and observe the results. In order to achieve this, effort has been directed towards the control of specific parameters. It is anticipated that simplicity will be more effective at this stage. Thus if the model proves to be successful, subsequent studies may relax the simplifications and vary parameters as desired.

3.1.2 The Population

The transportation model requires the identification of a population of industries which are reasonably uniform in terms of the following parameters:

1. equal or comparable technologies,
2. equal or comparable inputs (e.g. dangerous goods),
3. equal or comparable scale (e.g.expressed in number of employees),
4. equal or comparable scope (e.g. expressed in terms of output),
5. regionality (e.g. exists within a specific region or regions), and,
6. spatial diversity within the specified region(s).

An attempt should be made such that all six (6) criteria receive equal weight. In practice, the application of this procedure will furnish the researcher with a specific block or group of industries.

To test the model group 27 of the standard industrial code[4] (S.I.C.) classification was chosen. This group accrues to printing, publishing and allied industries, of which there are nine sub-categories. For the purposes of this study, the diversity of this group requires further deduction. In terms of best satisfying the population parameter criteria, a reasonable choice is newspaper publishers of group 2710.[5] Thus, a case study population to test the model has been determined.

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[4] Information source: Dunn and Bradstreet. 1979. Guide to Canadian Manufacturers. Howard and Smith publishers, Toronto.

[5] Refer to footnote 4.

3.1.3 The Population Sample

The criteria used to evaluate the population sample, follows similarly to that applied to the population itself. Considering the test group of newspaper publishers (S.I.C. 2710) the sample size is determined according to the following criteria.

1. Regionality: expressed in terms of five (5) of the six (6) Hazardous and Special Waste Management Environmental Control Regions of Manitoba (1985) as indicated on Figure 4.1:

   E: Eastern Region (mapping symbol 2)

   S: Southern Region (mapping symbol 3)

   W: Western Region (mapping symbol 4)

   P: Parklands Region (mapping symbol 5)

   N: Northern Region (mapping symbol 6)

2. Sample Number: will not exceed four (4) companies per region, therefore a maximum of twenty (20) companies will be sampled.

   $N = \leq 4$ companies per region.

3. Size of Community: expressed in terms of population.

   population = $\leq$ 5000

4. Geographical Location of Samples: a subjectively predetermined decision criteria with the intent to achieve spatial diversity within each region.[6]

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[6] Information source: 1985. 138th Year of Publication, Canadian Almanac and Directory 1985. sr. ed. Susan Bracken. Copp Clark Pitman Ltd.; Toronto. pp. 118 - 119.

5. Scale of Industry: expressed in terms of employment,[7]

A: < 11 employees

B: 11 - 25 employees

6. Scope of Industry: expressed in terms of output,[8]

One (1) issue per week.

3.1.3.1 Exceptions to the Population Sample

To achieve spatial diversity the following exceptions were made for the population sample criteria.

1. Three samples in the Northern Region[9] and one sample in the Parklands Region do not meet the 'size of community' parameter of the population sample criteria.
2. Two samples in the Northern Region do not meet the 'scope of industry' parameter of the population sample criteria.
3. Two samples in the Northern Region and one sample in the Eastern Region do not meet the 'scope of industry' parameter of the population sample criteria.

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[7] Information source: March, 1983. Manitoba Trade Directory. Winnipeg, Manitoba. pp. 103 - 105.

[8] Refer to footnote 6.

[9] Hazardous and Special Waste Management Environmental Control Regions of Manitoba, 1985.

3.1.4 <u>The Population Sample Survey Criteria</u>

Telephone interviews will be conducted with each of the newspaper publishers in the population sample in accordance with the following criteria.

1. The assurance of confidentiality, in terms of the following coding scheme:

   a) Digits 1 and 2: random sequence number

   b) Digit 3: region identification

   c) Digit 4: scale of firm in employees

   d) Digit 5: scope of firm in output
2. The affirmation of use of a particular chemical group employed in the operations of each firm.
3. The distributor of the chemical group.
4. The location of the distributor for the chemical group.
5. The means of transportation for shipment by the distributor of the firm for the chemical group (Road = RD; Rail = RL).
6. An approximation of the volume of the chemical group per shipment.
7. An approximation of the frequency of shipments.

3.1.4.1 A Chemical Group Identification Procedure

The following step will be employed to increase the efficiency of the survey with respect to the general chemical types and groups employed in the newspaper publishing process. Criteria:

1. A large metropolitan newspaper of E scale (e.g. 101-200 employees)[10] will be approached.
2. This company will be considered 'representative' of the newspaper industry, insofar as employing processes similar to those in smaller scale operations.
3. This company will be solicited for the express purpose of determining a range of principle chemical groups or types which may be employed by the population sample.

3.1.5 The Distributors Survey Criteria

Determined in the population sample survey, distributors of the chemical group identified will be contacted to add dimension and scope to the spatial analysis of transportation routes. Therefore, these companies are not determined via the same deductive parameters as those for the population sample.

This exercise will provide a linkage between the provincial consumers (e.g. the sample population) and the suppliers (e.g. in the province of Manitoba, in Canada, etc.) and identify routes which would not be apparent otherwise. As a follow-up to the principal sample survey, telephone inter-

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[10] Refer to footnote 7 for source.

views with chemical distributors in the province of Manitoba will be conducted according to the following criteria.

1. The assurance of confidentiality in terms of the following criteria.

   a) Digit 1 and 2: random sequence number

   b) Digit 3 (4): region identification[11]

2. The geographic location of the supplier for the chemical group identified in the population sample survey.

3. The means of transport for shipment by the supplier for the chemical group in question (Road = RD; Rail = RL).

4. An approximation of the frequency of shipments for the chemical group in question.

5. An approximation of the volume of the chemical group in question per shipment.

3.1.6 Post Survey Follow-Up

Companies solicited in the two surveys will be sent a letter of appreciation for participation in the study.

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[11] Distributor region identification includes the sixth (6) Hazardous and Special Waste Management Environmental Control region WP: Winnipeg (mapping symbol 1) and any region outside of Manitoba.

3.1.7 Table and Map Format

3.1.7.1 The Data Tables

Data obtained in the telephone surveys will be organized in a series of tables according to:

1. the results of the population sample and distributor surveys,
2. the estimated transportation routes by least distance[12] (kilometers),
3. cumulative frequency of shipments per segment of estimated transportation route, and,
4. cumulative volume per year, per segment of estimated transportation route.

3.1.7.2 The Mapping Procedure

The population sample survey data and distributor survey data will be plotted simultaneously on base maps to illustrate the spatial distribution of transportation route utilization in the province. The chemical group or type will be mapped in terms of the estimated least-distance (kilometers) transportation route utilization for road and rail for each of the following:

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[12] Least-distance (kilometers) between the origin of the shipment and recipient of the shipment, is determined in terms of major highways (either provincial trunk highways or provincial roads) and does not consider multiple-destination truck routings (e.g. considers direct, non-stop transit).

1. estimated transportation routes utilized (general; both surveys),
2. estimated population sample and distributor survey number of users (grouped; both surveys) along the estimated transportation routes,
3. the number of shipments per year (grouped; both surveys), and,
4. the volume of the commodity per shipment (grouped; both surveys).

3.1.8 The Delimitations of Part I

Since the primary objective of Part I is the derivation of a model to evaluate transportation route utilization for dangerous goods, and, the second objective is to test the suitability of the model with actual data, the following delimitations apply.

1. The test of the model will not examine transportation routes within urban centres (e.g. cities).
2. The static aspects of the transportation system (e.g. holding facilities, warehousing, transfer facilities, etc.) are not considered.
3. The model does not account for non-stop, interprovincial shipments or transportation flows of the chemical group or type of interest.
4. The City of Winnipeg is excluded from the population survey sample because it does not meet the population sample criteria in this study.

5. Product Identification Numbers (P.I.N.) are not used in reference to the chemical group because of variations in chemical composition and manufacturer brand names.

3.2 PART II -- THE IMPACT OF RISK MODEL

3.2.1 Introduction

In fulfillment of the second research objective, Part II seeks to design and test a methodology which is capable of assessing the impact of risk along the road routes identified in Part I. Similar to the model of Part I, it is essential that the complexity of the analysis be controlled.

The second model will be tested by one variable (not multiple variables) under the condition of mishap or accidental release of a dangerous good (s). The information will be mapped according to the relative impact of risk along the transportation routes determined in Part I. It is anticipated that this procedure will provide additional dimension in the evaluation of the transportation of dangerous goods, which is of particular importance to policy makers.

In the future, impact of risk analyses can be conducted to evaluate alternate impact of risk criteria which are not considered at this time.

3.2.2 Definition of Terms

The following definitions apply to the evaluation in Part II.

1. The impact of risk refers to the anticipated repercussions and/or magnitude of a mishap or accidental release of a dangerous good (s) in transit (transit being dynamic) according to the 'environment' in which the event occurs.
2. 'Environment' refers to land use.
3. The estimated impact of risk refers to the reasonable estimation of a parameter given the conditions outlined in point one listed above.

3.2.3 The Impact of Risk Model

In this study the impact of risk model utilizes the transportation routes identified in Part I; therefore, the criterion for population and sample selection in Part I applies to Part II. All exceptions, assumptions and delimitation outlined in Part I apply to the transportation routes further evaluated in Part II.

If the Transportation Route Model and the Impact of Risk Model of this document are not simultaneously employed, an equal or comparable methodology, which enables the identification of dangerous goods transportation routes, must be utilized.

3.2.4 <u>The Impact of Risk Model Test Criteria</u>

As outlined in the introduction to Part II, a <u>single</u> test <u>criterion</u> (variable) must be selected from the <u>entire range</u> of impact of risk criteria (variables). For purposes of this study, the 'impact of risk' has been defined as the anticipated repercussions and/or magnitude of impact, of a mishap or accidental release of a dangerous good (s) in transit according to the 'environment' in which the event occurs. Similarly, 'environment' has been defined as land use. Of the numerous classifications of land use, <u>human population</u> has been subjectively chosen as the appropriate criterion to test the impact of risk model.

3.2.4.1 Test Criteria Parameters

Land use, as a function of human population, has been subjectively subdivided into three (3) categories of interest for purposes of this analysis:

1. urban population[13] (static variable),
2. rural population density[14] (static variable), and,

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[13] Urban population as illustrated in the <u>Atlas of Manitoba</u> (1983) according to Statistics Canada, <u>Place Name Reference List, Western Provinces</u> (1978) data.

[14] Rural population density as illustrated in the <u>Atlas of Manitoba</u> (1983) according to the 1976 Census of Canada, <u>Population, Geographic Distributions, Census Divisions and Subdivisions in Western Canada and Territories</u>, and <u>Population Counts for Unincorporated Places, 1976</u>, from D. Bright, Chief, Customer Services Section, Data Dissemination Division (1977) data.

3. provincial trunk highway and provincial road traffic volume[15] (dynamic variable).

Data for each of the three (3) impact-of-risk-model-test-parameters have been obtained from secondary data bases. Each parameter will be evaluated seperately in the analysis.

3.2.4.2 Exceptions to the Test Criteria Parameters

Data used to assess the test criteria parameters do not include:

1. Indian Reserves and Hutterite colonies,
2. urban centres with a population less than 50 people, and,
3. rural population densities north of the 53rd parallel.

3.2.5 Table and Map Format

3.2.5.1 The Data Tables

Each parameter of the human population test criteria will be organized in a series of three (3) tables according to:

1. rural population density per segment of estimated transportation route (Part I),

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[15] Annual average daily volumes of traffic from Manitoba Highways and Transportation 1983 Traffic Flow Map for Provincial Trunk Highways and Provincial Roads Map M-703.

2. urban population of cities and towns of 50 people and over per segment of estimated transportation route (Part I), and,
3. annual average daily volumes of traffic by subsegment per segment of estimated transportation route (Part I).

3.2.5.2 The Mapping Procedure

Data for each parameter of the human population test criteria will be plotted <u>separately</u> on base maps to illustrate the estimated impact of risk, which arises from the spatial distribution of transportation route utilization in the province of Manitoba for one group or type of dangerous goods.

The mapping sequence for the estimated impact of risk zones will be according to each of the following:

1. rural population per segment of transportation route (Part I),
2. urban population per segment of transportation route (Part I), and,
3. annual average daily volumes of traffic by subsegment per segment of estimated transportation route (Part I).

It must be stressed that the impact of risk mapping sequence pertains to the transportation routes identified in

Part I, and to the one specific chemical type or group identified thereof.

3.2.6 The Delimitations of Part II

The test criteria of human population does not include:

1. seasonal population fluctuations (e.g. parks, cottages, campsites, etc.), and,
2. seasonal traffic fluctutations (e.g. summer, weather conditions, etc.).

The Impact of Risk Model does not take into consideration

1. the issue of jurisdiction or liablility in the event of mishap or accidental release of the dangerous good type or group.

3.3 THE MAPPING DESIGN (PART I, PART II)

If rigorous spatial analysis is to be achieved, much information must be presented in map form for each analysis (Part I, Part II). To prevent overcrowding of maps and to maximize information, all mapping is through a system of overlays where general information is presented in hard copy form (i.e. paper copies) and all mapped data are presented in overlay (i.e. acetate) form. It is anticipated that the interchangable capacity of this mapping design will permit maximum user utility.

3.4 THE DOCUMENT SUMMARY

Upon completion of both Part I and Part II, each spatial analysis will be judged by merit (s) and the applicability of the model (s) to alternate industries, commodities, impact of risk criteria and regions through consideration of all controlled variables and exceptions and delimitaitons thereof.

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Chapter IV

THE ANALYSIS

4.1 THE TRANSPORTATION ROUTE MODEL (PART I) ANALYSIS

4.1.1 The Survey Results

4.1.1.1 Chemical Group Identification

A newspaper publishing company (S.I.C. 2710) which employs approximately 200 persons and publishes 6 days per week in Winnipeg, was contacted (study identification 01WPE6) on March 25, 1985. The purpose of the telephone interview was to increase the efficiency of the population sample survey by determining a group of chemicals which would be consumed by members of the newspaper publishing industry, despite the size and production capacity (e.g. scale) of the sample.

As a result of the conversation with the production manager of 01WPE6, it was suggested that a range of 'developing chemicals employed in the typesetting process' would be an appropriate chemical group to survey. Not all small centre newspapers print issues or operate presses but most have typesetting facilities.

For illustrative purposes the following list provides several examples of the types of products which are included in the broad classification of 'developing chemicals employed in the typesetting process'.

1. Ultra No. 2 Developer Replenisher.[16] This is a photographic developer for photo-mechanical films, which comprises an aqueous neutral solution of primarily mild reducing agents and a formaldehyde bisulfite addition compound.
2. Ultra No. 2 Developer Replenisher Part E.[17] This is a photographic developer for photomechanical films which consists of an aqueous alkaline solution.
3. Starfix Fixer.[18] This is a photographic rapid fixer for film and papers which consists of a mild aqueous solution.
4. Graphomatic Fixer.[19] This is a reproduction film fixer which consists of a proprietary aqueous solution of predominantly inorganic salts.

Consideration that other firms manufacture similar or comparable products, would confirm that this list is not exhaustive. Hazard classification information regarding chemicals of this nature is reserved for discussion in section 4.2.1 of this chapter.

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[16] Manufactured by the Philip A. Hunt Chemial Corporation, Palisades Park, New Jersey.

[17] See footnote 15.

[18] See footnote 15.

[19] See footnote 15.

4.1.1.2 The Population Sample Survey

Twenty (20) population sampling units were determined according to the methodology outlined in Chapter 3 (3.1.2, 3.1.3 and 3.1.3.1) and a telephone survey was designed. The survey commenced March 26, 1985 and each sample population member was solicited for the following information with respect to 'developing chemicals for typesetting':

1. confirmation of use of this chemical group,
2. the geographical location of the distributor of this chemical group,
3. the mode of transportation by which the shipments are received,
4. an approximation of the frequency of shipments for this chemical group, and,
5. an approximation of the volume of this chemical group per shipment.

Respondents were confidentially classified according to the criteria discussed in Chapter 3 (3.1.4, point 1). Table 1 in Appendix A contains the raw data collected in the survey.

Of the twenty (20) calls, two (2) samples (e.g. 13NA1 and 16EA.5) did not utilize 'developing chemicals for typesetting' because this service was performed by the printer.

Variation in the reported frequency and volume of the samples is not evaluated, because the data cannot be compared. However, to achieve consistency of units and measures for the forthcoming analyses, all frequency units are converted to approximate frequency per year and all volume units are converted to litres (L.) (3.8 X U.S. gal. = Litres; 4.55 X Cdn. gal. = Litres). To observe this conversion step, Table 3 in Appendix A has been prepared.

The route estimation criterion is based on the assumption that transportation carriers use paved routes which are the least distance in kilometers (km.) between the origin (distributor) of the shipment and the recipient of the shipment. Not all of the sample locations are served by one least-distance route, therefore, both the estimated routing sequences and single estimated least-distance transportation routes have been included in Table 3 of Appendix A.

All newspaper publishers in the population sample received shipments via truck transport, with evidence suggesting a dependency between the frequency of shipments and the volume of chemical shipped. For example, sample member 05PA1 makes significant single purchases of developing chemicals from time to time, whereas other samples purchase smaller volumes more frequently.

4.1.1.3 The Distributors Survey

Most respondents of the population survey sample volunteered the name of the distributor who supplied the 'developing chemicals for typesetting'. Because of repetition, only six (6) different distributors were identified. Each distributor was surveyed for the following information:

1. the geographical location of the supplier of 'developing chemicals for typesetting',
2. the mode of transportation by which the shipments were received,
3. an approximation of the frequency of shipments of this chemical group, and,
4. an approximation of the volume of this chemical group per shipment.

Each distributor solicited was confidentially classified according to the criteria discussed in Chapter 3 (3.1.5, point 1).

The results of the distributor survey are shown in Table 2 in Appendix A. One distributor in Ontario (e.g. 010) did not respond. Each distributor response related to frequency of shipments and volume per shipment was converted for consistency of units (Table 4, Appendix A).

All distributors received shipments of 'developing chemicals for typesetting' by truck transport. Volume appears to be related to the frequency of shipments as previously infered for the population sample survey. It must be stressed, however, that the distributors of the chemical group, service others not included in the population sample. Distributors inevitably supply newspaper publishers of varying scale not considered in this study, as well as industries other than those included in the standard industrial code 2710.

4.1.2 Base Maps

Figure 4.1 and Figure 4.2 are base maps to be used with the overlay maps of subsequent sections. Figure 4.1 is a general information base map which illustrates the six (6) Hazardous and Special Waste Management Environmental Control Regions (1985), all railway lines, provincial trunk highways and a selection of urban centres (for geographical location). Figure 4.2 illustrates by name, each rural municipality and local government district in south-central Manitoba.

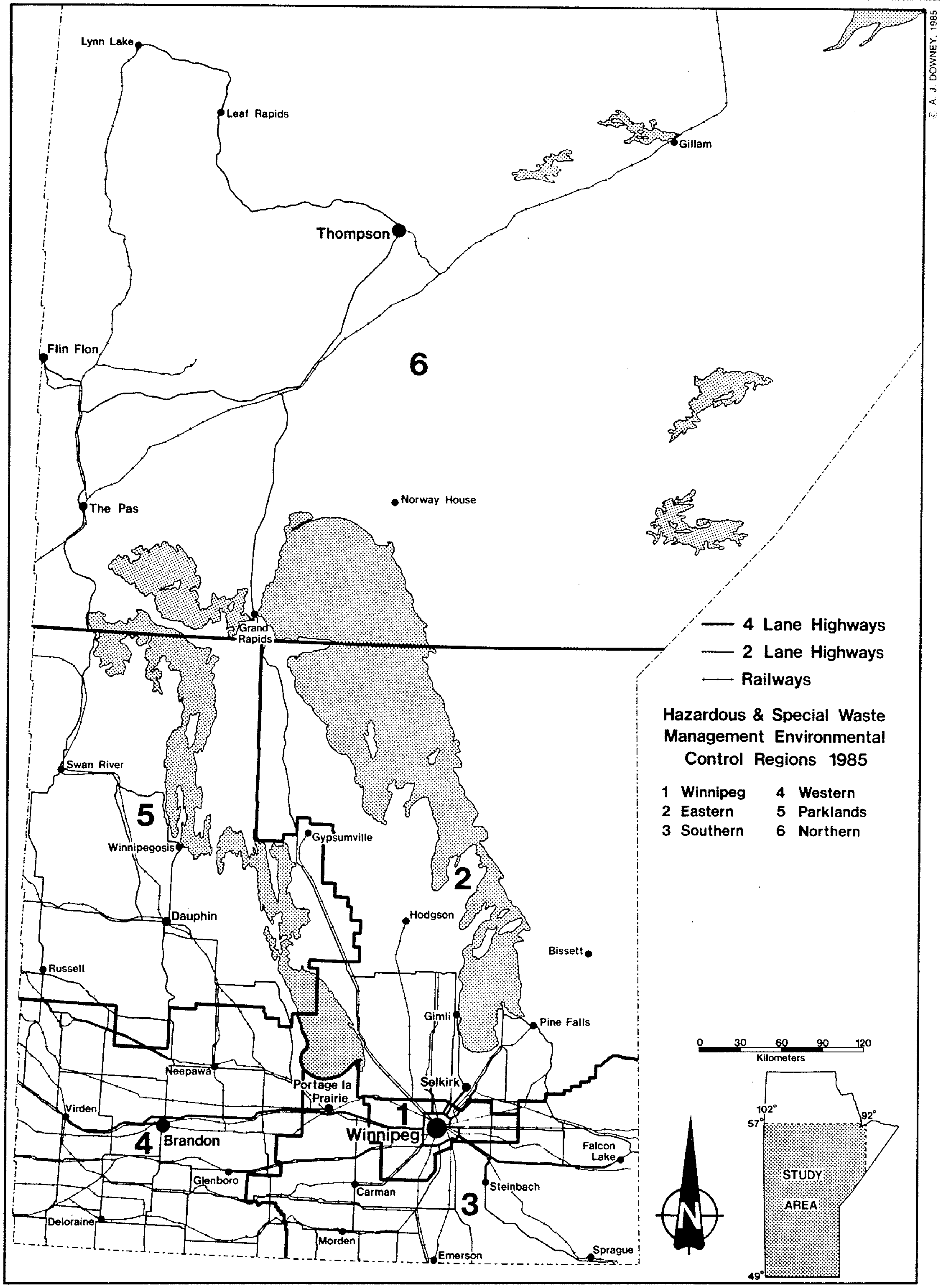

FIGURE 4.1: General information base map for Figures 4.3 to 4.6, and Figure 4.8.

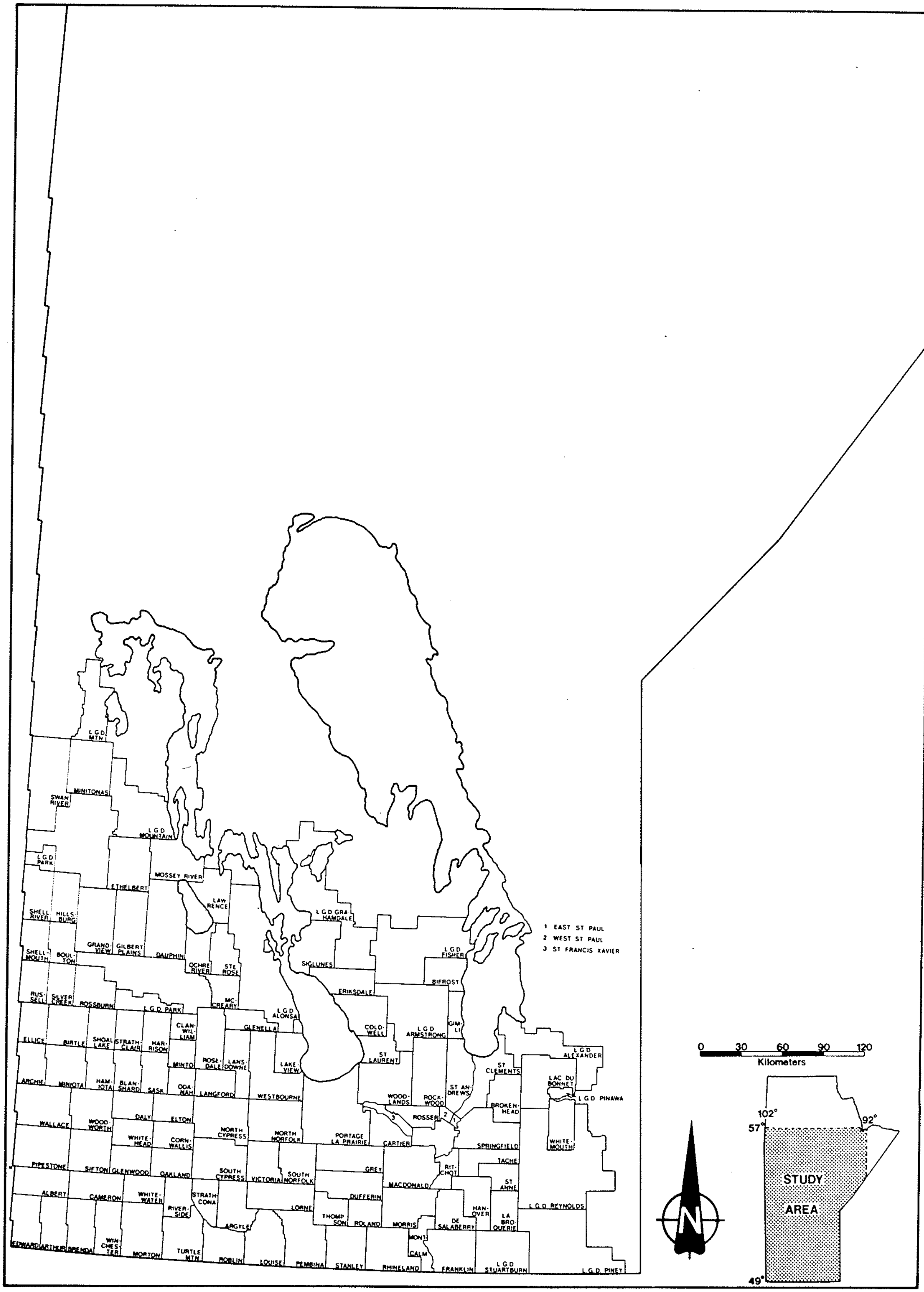

FIGURE 4.2:
Municipality and Local Government District jurisdictions. Base map for Figures 4.3 to 4.6, Figure 4.8 and Figure 4.9

4.1.3 Route Utilization (population and distributor samples)

To generate a spatial analysis of the estimated routes utilized by the population and distributor samples, the estimated routing sequences of Table 1A and 1B are examined. To reiterate, this methodology employs the least paved road distance in kilometers (km) between distributor and consumer, supplier and distributor. Figure 4.3 indicates the direction of flow of each routing sequence determined (no repetitions). This simple illustration of the estimated routes, facilitated by each survey sample, provides the baseline data for future analysis in Part I and Part II.

Figure 4.3 in the map pocket (back cover) illustrates that all estimated routing sequences for the population sample radiate from Winnipeg. This is the desired outcome of the transportation route model analysis of Part I (Chapter 3, 3.1.3, point 4). It appears that the population sample criteria has enabled a spatially diverse test of the Transportation Route Model.

Table 1A. Population sample survey data--estimated transportation routes, developing chemicals for typesetting.

I.D. #	Transportation Mode (Rd=Road)	Distribution Location	Estimated Routing Sequence	Frequency of Shipments Per Year	Volume Per Shipment (l.)
02PB1	Rd	Wpg	1W/16/5	12	45.5
03PA1	Rd	Wpg	1W/16/83	2	273
04PA1	Rd	Wpg	1W/16/5/10	12	11.38
05PA1	Rd	Wpg	1W/16	1	234
06SB1	Rd	Wpg	3	4	5
07SA1	Rd	Wpg	75/14/30	10	50.05 (Av. 45.5-54.6)
08SA1	Rd	Wpg	2	8	19
09SA1	Rd	Wpg	3	6	22.75
10NB2	Rd	Wpg	1W/16/5/10	2	22.75
11NA6	Rd	Wpg	6/391W	12	10
12NB1	Rd	Wpg	6/391N	12	10
13NA1	n/a	n/a	n/a	n/a	n/a
14EA1	Rd	Wpg	7	24	22.75
15EA1	Rd	Wpg	59/44	4	70.25
16EA.5	n/a	n/a	n/a	n/a	n/a
17EB1	Rd	Wpg	59/44/11	4	76
18WA1	Rd	Wpg	2/83	3.5 (Av. 3-4)	18
19WA1	Rd	Wpg	1	7	54.6
20WA1	Rd	Wpg	2	2.5 (Av. 2-3)	38
21WA1	Rd	Wpg	1W/16	4	30

Table 1B. Distributor survey data--estimated transportation routes, developing chemicals for typesetting.

I.D. #	Transportation Mode (Rd=Road)	Supplier Location	Estimated Routing Sequence	Frequency of Shipments Per Year	Volume Per Shipment (1.)
010	n/a	n/a	n/a	n/a	n/a
02WP	Rd	Toronto	1E	24	200
03WP	Rd	Toronto	1E	54 (Av. 48-60)	125 (Av. 113.5-136.5)
04WP	Rd	Toronto	1E	24	571.38
05WP	Rd	Toronto	1E	48	100
06WP	Rd	Toronto	1E	12	2,000

The distributor survey revealed that 'developing chemicals for typesetting' are not manufactured in Manitoba and that all Manitoba distributors sampled, received shipments from suppliers in southern Ontario. Therefore, <u>for this particular test</u> of the Transportation Route Model, the only flow of 'developing chemicals for typesetting' <u>into</u> Manitoba is along the Trans Canada Highway, from the Ontario border to Winnipeg.

4.1.4 <u>Estimated Number of Users per Route/ Cumulative Frequency</u>

Table 2A and Table 2B are designed to extract further information from the population sample and distributor surveys. In accordance with the estimated routes utilized (Table 1A and Table 1B), each route has been segmented. A segment refers to a portion of a specific route between two major highway intersections. The number of users per segment of an estimated transportation route has been determined by computing the cumulative frequency of shipments per year, for each survey, per segment of highway.

Table 2A. Distributor survey data--cumulative frequency of shipments per year and number of users per segment of estimated transportation route, developing chemicals for typesetting.

No. of Users (n)	I.D. #	Transportation Mode (Rd=Road)	Estimated Highway	Highway Segment From	Highway Segment To	Frequency of Shipment/Year	Cumulative Frequency of Shipments/ Year/Segment of Highway
1	02PB1	Rd	1	Wpg	16	12	12
2	03PA1	Rd	1	Wpg	16	2	14
3	04PA1	Rd	1	Wpg	16	12	26
4	05PA1	Rd	1	Wpg	16	1	27
5	10NB2	Rd	1	Wpg	16	2	29
6	19WA1	Rd	1	Wpg	16	7	36
7	21WA1	Rd	1	Wpg	16	4	40
1	19WA1	Rd	1	16	83	7	7
1	02PB1	Rd	16	1	5	12	12
2	03PA1	Rd	16	1	5	2	14
3	04PA1	Rd	16	1	5	12	26
4	05PA1	Rd	16	1	5	1	27
5	10NB2	Rd	16	1	5	2	29
6	21WA1	Rd	16	1	5	4	33
1	02PB1	Rd	5	16	20	12	12
2	04PA1	Rd	5	16	20	12	26
3	10NB2	Rd	5	16	20	2	14
1	02PB1	Rd	20	5	5/10	12	12
2	04PA1	Rd	20	5	5/10	12	24
3	10NB2	Rd	20	5	5/10	2	26

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Table 2A. (cont.)

No. of Users (n.)	I.D. #	Transportation Mode (Rd=Road)	Estimated Highway	Highway Segment From	Highway Segment To	Frequency of Shipment/Year	Cumulative Frequency of Shipments/Year/Segment of Highway
1	04PA1	Rd	5/10	20	83	12	12
2	10NB2	Rd	5/10	20	83	2	14
1	10NB2	Rd	10	83	10 North	2	2
1	03PA1	Rd	16	5	83	2	2
2	05PA1	Rd	16	5	83	1	3
1	03PA1	Rd	83	16	5	2	2
2	05PA1	Rd	83	16	5	1	3
1	08SA1	Rd	2	Wpg	18	8	8
2	18WA1	Rd	2	Wpg	18	3.5	11.5
3	20WA1	Rd	2	Wpg	18	2.5	14
1	18WA1	Rd	2	18	83	3.5	3.5
1	18WA1	Rd	83	2	83 South	3.5	3.5
1	06B1	Rd	3	Wpg	13	4	4
2	09SA1	Rd	3	Wpg	13	6	10
1	09SA1	Rd	3	13	34	6	6

... 3

Table 2A. (cont.)

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No. of Users (n)	I.D. #	Transportation Mode (Rd=Road)	Estimated Highway	Highway Segment From	To	Frequency of Shipment/Year	Cumulative Frequency of Shipments/ Year/Segment of Highway
1	11NA6	Rd	6	Wpg	391	12	12
2	12NB1	Rd	6	Wpg	391	12	24
1	11NA6	Rd	391	6	391 West	12	12
1	12NB1	Rd	391	6	391 North	12	12
1	14EA1	Rd	7	Wpg	67	24	24
1	15EA1	Rd	59	Wpg	44	4	4
2	17EB1	Rd	59	Wpg	44	4	8
1	15EA1	Rd	44	59	11	4	4
2	17EB1	Rd	44	59	11	4	8
1	17EB1	Rd	11	44	14	4	4
1	07SA1	Rd	75	Wpg	14	10	10
1	07SA1	Rd	14	75	30	10	10
1	07SA1	Rd	30	14	30 South	10	10

Table 2B. Distributor survey data--cumulative frequency of shipments per year and number of users per segment of estimated transportation route, developing chemicals for typesetting.

No. of Users (n)	I.D. #	Transportation Mode (Rd=Road)	Estimated Highway	Highway Segment From	To	Frequency of Shipment/Year	Cumulative Frequency of Shipments/ Year/Segment of Highway
1	010	n/a	n/a	n/a	n/a	n/a	n/a
2	02WP	Rd	1E	Ont	Wpg	24	24
3	03WP	Rd	1E	Ont	Wpg	54 (Av. 48-60)	78
4	04WP	Rd	1E	Ont	Wpg	24	102
5	05WP	Rd	1E	Ont	Wpg	48	150
6	06WP	Rd	1E	Ont	Wpg	12	162

The number of users per route provides an opportunity to estimate the use of designated routes by the population and distributor samples for a specific chemical group as illustrated in Figure 4.4 (map pocket, back cover). According to the estimated transportation route criteria and by virtue of the geographic location of population samples, the Trans Canada Highway between Winnipeg and the intersection of highway #16 and the Trans Canada Highway from the Ontario border to Winnipeg are both dominant segments. Once again, there appears to be a radii of diminishing estimated route use originating at Winnipeg.

The cumulative frequency data provide an estimate of shipments per year of 'developing chemicals for typesetting' for the population and distributor surveys. Attributed to the distributor survey data, the Trans Canada Highway between the Ontario border and Winnipeg (Figure 4.5, back cover pocket) is dominant. The Trans Canada highway to the junction of highway #16 also indicates a high frequency of shipments; however, this pattern is attributable to the population sample data. As in Figure 4.3 and Figure 4.4, the cumulative frequency of route utilization diminishes as routes progress from Winnipeg. This is attributed to the diminishing number of users per route, the function of sample location and the estimation of routes procedure.

4.1.5 Cumulative Volume

An estimation of cumulative volume has been computed in Table 3A and 3B. For each estimated highway segment the frequency of shipments per year per sample, was multiplied by the volume (litres) per shipment. This calculation produces the cumulative volume (litres) per year, per highway segement. These calculations estimate the amount of 'developing chemicals for typesetting' which may be transported along a specified route during a calendar year.

Table 3A. Population survey sample data--cumulative volume (1) per year, per segment of estimated transportation route, developing chemicals for typesetting.

I.D. #	Estimated Highway	Highway Segment From	Highway Segment To	Frequency of Shipment/Year	x Volume (1)/ Shipment	= Volume(1)/ Year	Cumulative Volume(1)/ Year/Segment of Highway
02PB1	1	Wpg	16	12	45.5	546	546
03PA1	1	Wpg	16	2	273	546	1092
04PA1	1	Wpg	16	12	11.38	136.56	1228.56
05PA1	1	Wpg	16	1	234	234	1462.56
10NB2	1	Wpg	16	2	22.75	45.5	1508.06
19WA1	1	Wpg	16	7	54.6	328.2	1836.26
21WA1	1	Wpg	16	4	30	120	1956.26
19WA1	1	16	83	7	54.6	382.2	382.2
02PB1	16	1	5	12	45.5	546	546
03PA1	16	1	5	2	273	546	1092
04PA1	16	1	5	12	11.38	136.56	1228.56
05PA1	16	1	5	1	234	234	1462.56
10NB2	16	1	5	2	22.75	45.5	1508.06
21WA1	16	1	5	4	30	120	1628.06
02PB1	5	16	20	12	45.5	546	546
04PA1	5	16	20	12	11.38	136.56	682.56
10NB2	5	16	20	2	22.75	45.5	728.06
02PB1	20	5	5/10	12	45.5	546	546
04PA1	20	5	5/10	12	11.38	136.56	682.56
10NB2	20	5	5/10	2	22.75	45.5	728.06

... 2

Table 3A. (cont.)

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I.D. #	Estimated Highway	Highway Segment From	Highway Segment To	Frequency of Shipment/Year x	Volume(1)/ Shipment =	Volume(1)/ Year	Cumulative Volume(1)/ Year/Segment of Highway
04PA1	5/10	20	83	12	11.38	136.56	136.56
10NB2	5/10	20	83	2	22.75	45.5	182.06
10NB2	10	83	10 North	2	22.75	45.5	45.5
03PA1	16	5	83	2	273	546	546
05PA1	16	5	83	1	234	234	780
03PA1	83	16	5	2	273	546	546
05PA1	83	16	5	1	234	234	780
08SA1	2	Wpg	18	8	19	152	152
18WA1	2	Wpg	18	3.5	18	63	215
20WA1	2	Wpg	18	2.5	38	95	310
18WA1	2	18	83	3.5	18	63	63
18WA1	83	2	83 South	3.5	18	63	63
06SB1	3	Wpg	13	5	4	20	20
09SA1	3	Wpg	13	6	22.75	136.5	156.5
09SA1	3	13	34	6	22.75	136.5	136.5

... 3

Table 3A. (cont.)

... 3

I.D. #	Estimated Highway	Highway Segment From	To	Frequency of Shipment/Year x	Volume(1)/ Shipment =	Volume(1)/ Year	Cumulative Volume(1)/ Year/Segment of Highway
11NA6	6	Wpg	391	12	10	120	120
12NB1	6	Wpg	391	12	10	120	240
11NA6	391	6	391 West	12	10	120	120
12NB1	391	6	391 North	12	10	120	120
14EA1	7	Wpg	67	24	22.75	546	546
15EA1	59	Wpg	44	4	70.25	281	281
17EB1	59	Wpg	44	4	76	304	585
15EA1	44	59	11	4	70.25	281	281
17EB1	44	59	11	4	76	304	585
17EB1	11	44	11 North	4	76	304	304
07SA1	75	Wpg	14	10	50.05	500.5	500.5
07SA1	14	75	30	10	50.05	500.5	500.5
07SA1	30	14	30 South	10	50.05	500.5	500.5

Table 3B. Distributor survey data--cumulative volume (1) per year, per segment of estimated transportation route, developing chemicals for typesetting.

I.D. #	Estimated Highway	Highway Segment From	To	Frequency of Shipment/Year x	Volume(1)/ Shipment =	Volume(1)/ Year	Cumulative Volume(1)/ Year/Segment of Highway
010	n/a	n/a	n/a	n/a	n/a	n/a	n/a
02WP	1E	Ont	Wpg	24	200	4800	4800
03WP	1E	Ont	Wpg	54	125	6750	11550
04WP	1E	Ont	Wpg	24	571.38	13713.12	25263.12
05WP	1E	Ont	Wpg	48	100	4800	30063.12
06WP	1E	Ont	Wpg	12	2000	24000	54063.12

Figure 4.6 (map pocket, back cover) presents the cumulative volume (litres) per year per segment, of estimated transportation route for the population and distributor samples. Several high volume flows are apparent in this spatial illustration. These would include, for example, the Trans Canada highway between the Ontario border and Winnipeg (exceptional volume), the Trans Canada highway to highway #16, highway #16 to highway #83, highway #7, highway #59 to highway #44 and highway #75 to highway #14, among others. This mapping exercise illustrates how the consumption (by volume) of a specific chemical by small scale consumers can be very significant.

4.1.6 Discussion

The principal objective of Part I was to provide a spatial analysis of route utilization for the express purpose of transporting dangerous goods. The population sample and distributor surveys related to 'developing chemicals for typesetting', combined with the assumption that carriers utilize routes of least-distance (kilometers) between the origin and recipient, have been successful criteria to spatially evaluate dangerous good (s) transportation routes.

Policy makers should not overestimate the results of the model, however. Other industries and other dangerous goods should be evaluated and compared to the routes indentified in this study. Indeed, with more information, trends may arise and on that basis, more effective decisions can be made.

4.2 THE IMPACT OF RISK MODEL (PART II) ANALYSIS

4.2.1 Route Assessment by Human Population

To reiterate, the 'impact of risk' is defined as the anticipated repercussions and/or magnitude of a mishap or accidental release of a dangerous good in transit (Chapter 3, 3.2.2). The Impact of Risk Model (Part II) utilizes the routes determined in Part I.

Human population has been selected as the Impact of Risk Model test criterion (Chapter 3, 3.2.4). This criterion is based on the assertion, or value judgement, that the element of human exposure to any mishap or accidental release of a dangerous good (s), is of utmost concern. As indicated in Chapter 2, value judgements of this sort are inevitable in most risk analyses.

In section 4.1.1.1 of this chapter, four (4) brand name 'developing chemicals for typesetting' were cited. D. Wilson, Environmental Officer, Environmental Management Services, Manitoba Department of the Environment and Workplace Safety and Health (telephone interview, April, 1985), suggests that' developing chemicals for typesetting' belong to Class 6 (poisonous and infectious substances) of the federal dangerous goods classification scheme, if the chemicals are transported in useable form (i.e. water based). On the other hand, if the chemicals are transported in concentrated form, the classification may be expanded to include Class 3 (flammable and combustible liquids). Since the population and distributor surveys perused general information regarding this chemical group, it is only possible to estimate the federal classification for this dangerous goods group.

Notwithstanding these limitations this information is of importance to administrators and emergency personnel in the event of mishap or accidental release of a shipment (s) of 'developing chemicals for typesetting'. The extent of emergency procedure and clean-up, however, will be dependent upon the magnitude of the event in terms of all transportation and impact of risk criteria.

4.2.2 The Rural Population Base Map

For illustrative purposes, Figure 4.7 has been submitted as a base map for use with overlay Figures 4.8, 4.9 and 4.10. The information contained on this map shows rural population density which can be used to compare the urban population impact of risk map (Figure 4.8) and/or to cross-reference the rural population impact of risk map (Figure 4.9).

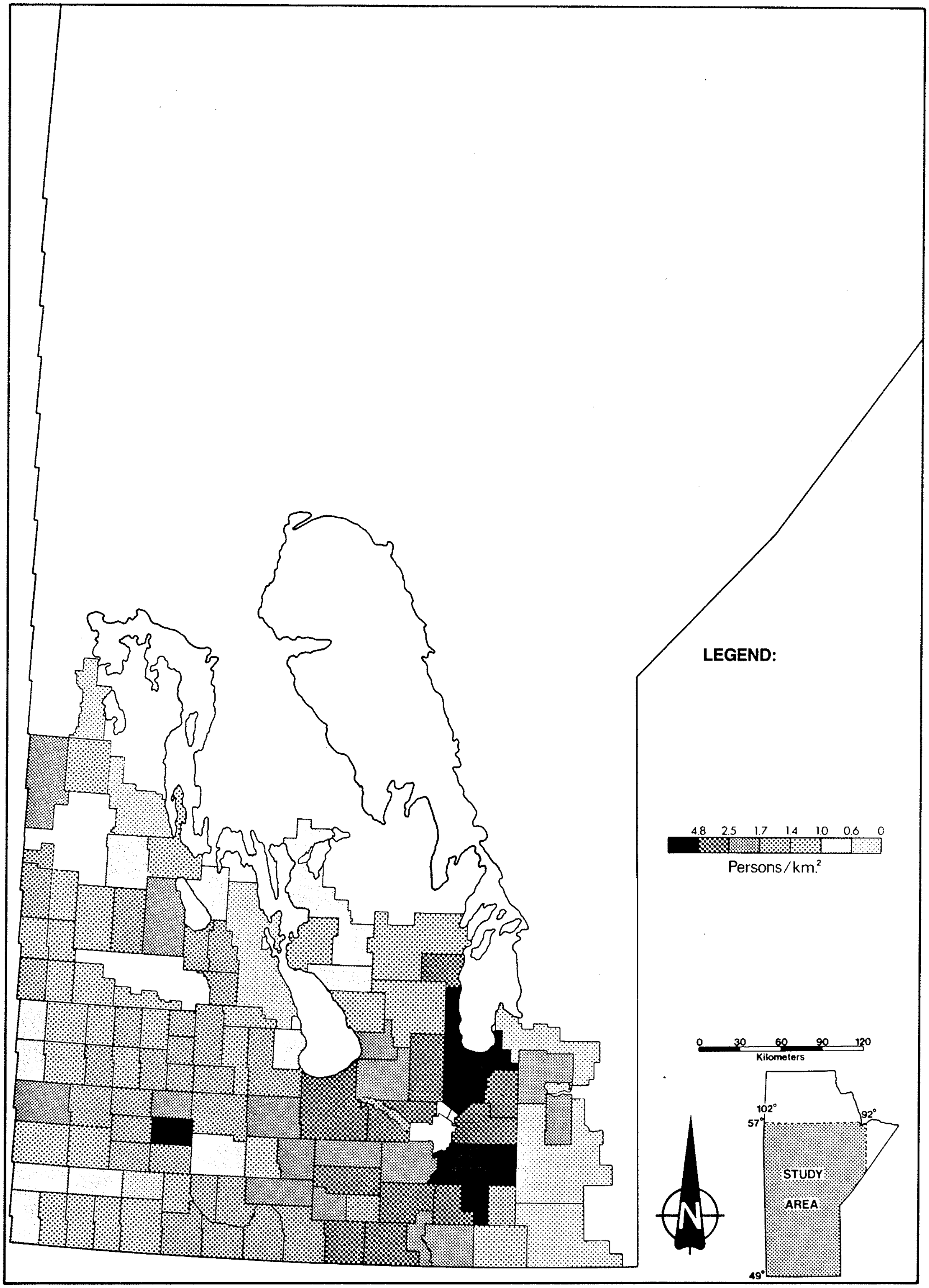

FIGURE 4.7:
Rural population density (persons per square kilometer).
Base map for Figure 4.8 and Figure 4.9.
(Source: Atlas of Manitoba, 1983.)

4.2.2.1 The Rural Population Density Parameter

Rural population density, in this study, is considered to be the first of two relatively static measurements of the concentration of human population along the estimated transportation routes of Part I. This criterion is significant considering that a potential mishap or accidental release of a dangerous good will not necessarily occur in a densely populated zone or one of few inhabitants. A guide to the rural population along each segment of the estimated transportation route is necessary when planning evacuation routes, estimating the magnitude of human exposure to any dangerous good (s) mishap or assessing the emergency response potential of a particular region.

Rural population along each segment of the estimated routes of Part I, is submitted in Table 4. Data for this exercise were obtained from the Atlas of Manitoba (1983). Statistics for the local government districts north of the 53rd parallel were not included in this source. However, because most of the northern local government districts in Manitoba are dominated by urban centres, it is anticipated that this information will be furnished through the urban population parameter exercise in the following section.

For purposes of the present study, the legend provided with Figure 4.7 has been divided into three (3) categories of risk (Source: Atlas of Manitoba, 1983):

High 1.7 - ≥ 4.8 persons/km^2

Moderate 1.0 - 1.7 persons/km^2

Low 0.0 - 1.0 persons/km^2

The boundaries of each interval can be set or regulated by the researcher. The maps of Part II illustrate how information may be grouped and/or organized into distinct categories, and mapped in an efficient manner.

Table 4. Population Sample and Distributor Survey Data -- Rural Population Density by Municipality or Local Government District,[1] per Segment of Estimated Transportation Route (Part I).

Estimated Highway (Part I)	Highway Segment (Part I) From	To	Municipality or Local Government District	Rural Population Density[1]
1	Wpg	16	Cartier	2.5 - 4.8
			Portage la Prairie	2.5 - 4.8
1	16	83	North Norfolk	1.7 - 2.5
			North Cypress	1.4 - 1.7
			Cornwallis	> 4.8
			Elton	2.5 - 4.8
			Whitehead	1.4 - 1.7
			Sifton	1.0 - 1.4
			Wallace	1.7 - 2.5
16	1	5	Portage la Prairie	2.5 - 4.8
			Westborne	1.4 - 1.7
			Lansdowne	1.0 - 1.4
			Rosedale	1.4 - 1.7
5	16	20	Rosedale	1.4 - 1.7
			McCreary	1.4 - 1.7
			Ste. Rose	1.4 - 1.7
			Ochre River	1.4 - 1.7
20	5	5/10	Ochre River	1.4 - 1.7
			Dauphin	1.7 - 2.5
10	5	83	Dauphin	1.7 - 2.5
			Gilbert Plains	1.4 - 1.7
			Ethelbert	0.6 - 1.0
			L.G.D. Mountain	0.0 - 0.6
			Minitonas	1.0 - 1.4
			Swan River	1.7 - 2.5
10	83	10 north	Swan River	1.7 - 2.5
			L.G.D. Mountain	0.0 - 0.6

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Table 4. (cont.)

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Estimated Highway (Part I)	Highway Segment (Part I) From	To	Municipality or Local Government District	Rural Population Density[1]
16	5	83	Rosedale	1.4 - 1.7
			Minto	1.4 - 1.7
			Saskatchewan	1.4 - 1.7
			Harrison	1.0 - 1.4
			Strathclair	1.4 - 1.7
			Shoal Lake	1.0 - 1.4
			Birtle	1.0 - 1.4
			Russell	1.4 - 1.7
83	16	5	Russell	1.4 - 1.7
			Shellmouth	1.0 - 1.4
			Shell River	1.4 - 1.7
2	Wpg	18	MacDonald	1.7 - 2.5
			Grey	1.7 - 2.5
			South Norfolk	1.7 - 2.5
			Victoria	1.0 - 1.4
			South Cypress	0.6 - 1.0
2	18	83	Oakland	1.4 - 1.7
			Glenwood	1.4 - 1.7
			Sifton	1.0 - 1.4
			Pipestone	1.0 - 1.4
83	2	83 south	Pipestone	1.0 - 1.4
			Albert	0.6 - 1.0
3	Wpg	13	MacDonald	1.7 - 2.5
			Dufferin	2.5 - 4.8

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Table 4. (cont.)

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Estimated Highway (Part I)	Highway Segment (Part I) From	To	Municipality or Local Government District	Rural Population Density[1]
3	13	34	Dufferin Roland Stanley Pembina Louise	2.5 - 4.8 1.4 - 1.7 2.5 - 4.8 1.4 - 1.7 1.4 - 1.7
6	Wpg	391	Rosser Woodlands St. Laurent Coldwell Eriksdale L.G.D. Grahamdale Siglunes L.G.D. Grahamdale	2.5 - 4.8 1.7 - 2.5 1.7 - 2.5 1.0 - 1.4 0.6 - 1.0 0.6 - 1.0 1.0 - 1.4 0.6 - 1.0
7	Wpg	67	Rosser Rockwood	2.5 - 4.8 2.5 - 4.8
59	Wpg	44	St. Clements	> 4.8
44	59	11	Brokenhead Lac du Bonnet	2.5 - 4.8 1.7 - 2.5
11	44	11 north	Lac du Bonnet L.G.D. Alexander	1.7 - 2.7 0.0 - 0.6
75	Wpg	14	Ritchot Morris Montcalm	> 4.8 2.5 - 4.8 1.7 - 2.5
14	75	30	Montcalm Rhineland	1.7 - 2.5 2.5 - 4.8

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Table 4. (cont.)

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Estimated Highway (Part I)	Highway Segment (Part I) From	To	Municipality or Local Government District	Rural Population Density[1]
30	14	30 south	Rhineland	2.5 - 4.8
1	Ont	Wpg	L.G.D. Reynolds St. Anne Tache Springfield	0.0 - 0.6 > 4.8 > 4.8 2.5 - 4.8

[1]Rural population density as illustrated in the Atlas of Manitoba (1983) according to the 1976 Census of Canada, Population, Geographic Distributions, Census Divisions and Subsdivisions in Western Canada and Territories, and, Population Counts for Unincorporated Places, 1976, from D. Bright, Chief, Customer Services Section, Data Dissemination Division (1977) data.

The mapping symbols of Figure 4.8 (map pocket, back cover) are arbitrarily assigned. For example, all density intervals between 1.7 persons per kilometer^2 and greater than, or equal to, 4.8 persons per kilometer^2 are assigned a 'high' rating. For maximum user utility, mapping symbols are not specifically defined. Thus, one user may interpret the hexagon symbol for example, as 'high population density', whereas another user might interpret this symbol as 'high <u>risk</u> according to population density'.

As illustrated by Figure 4.8, the diminishing "rings" of rural population which originate at Winnipeg, are apparent. In some instances, it is anticipated that urban centres within the boundaries of each unit may be contributing to the skewness of the reported density.

4.2.2.2 The Urban Population Parameter

Urban population, in this study, is considered to be the second of two static measurements of human population along the estimated transportation routes of Part I. This criterion is most significant in terms of the magnitude of the impact of risk due to the concentration of population in a defined space. Magnitude, however, is dependent on the size of the urban centre. In terms of administrative priority, urban population is perhaps of greatest concern.

All urban centres along the segments of the estimated routes of Part I are shown in Table 5. According to the source for this information (Atlas of Manitoba, 1983) 'urban centre' refers to "any cluster of residences together with related buildings having a population of 50 or more in 1976." This analysis, however, does not include Indian Reserves or Hutterite colonies. As in section 4.2.2.1. centres of urban population have been categorized into three groups of risk according to the following scale, for Figure 4.9 (Source: Atlas of Manitoba, 1983):

High 2,001 - 25,000 persons/centre

Moderate 501 - 2,000 persons/centre

Low 50 - 500 persons/centre

Table 5. Population Sample and Distribution Survey Data -- Urban[1] Population of Cities and Towns of 50 people and over[2] (excluding Indian Reserves, Hutterite Colonies, or other ethnic communities) per segment of estimated transportation route (Part I).

Estimated Highway (Part I)	Highway Segment (Part I) From	To	Urban Centre[1]	Population[2] Group
1	Wpg	16	Elie	201 - 500
			Portage La Prairie	10,001 - 25,000
1	16	83	MacGregor	501 - 1,000
			Austin	201 - 500
			Sidney	50 - 200
			Douglas	50 - 200
			Brandon	> 25,000
			Alexander	201 - 500
			Griswold	50 - 200
			Oak Lake	201 - 500
			Virden	2,001 - 5,000
16	1	5	MacDonald	50 - 200
			Westbourne	50 - 200
			Gladstone	501 - 2,001
			Neepawa	2,001 - 5,000
5	16	20	Eden	50 - 200
			Riding Mountain	50 - 200
			Kelwood	201 - 500
			McCreary	501 - 1,000
			Ste. Rose du Lac	1,001 - 2,000
			Ochre River	201 - 500
20	5	5/10	Dauphin	5,001 - 10,000
10	5	83	Ethelbert	201 - 500
			Garland	50 - 200
			Pine River	201 - 500
			Cowan	50 - 200
			Minitonas	501 - 1,000
			Swan River	2,001 - 5,000

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Table 5. (cont.)

Estimated Highway (Part I)	Highway Segment (Part I) From	To	Urban Centre[1]	Population Group[2]
10	83	10 North	Bowsman	201 - 500
			Birch River	501 - 1,000
			Mafeking	201 - 500
			The Pas	5,001 - 10,000
			Wanless	201 - 500
16	5	83	Minnedosa	2,001 - 5,000
			Basswood	50 - 200
			Newdale	201 - 500
			Strathclair	201 - 500
			Shoal Lake	501 - 1,000
			Foxwarren	50 - 200
83	16	5	Binscarth	201 - 500
			Russell	1,001 - 2,000
			Roblin	1,001 - 2,000
2	Wpg	18	Springstein	50 - 200
			Starbuck	201 - 500
			Fannystelle	50 - 200
			Elm Creek	201 - 500
			Haywood	50 - 200
			St. Claude	501 - 1,000
			Rathwell	50 - 200
			Treherne	501 - 1,000
			Holland	201 - 500
			Cypress River	201 - 500
			Glenboro	501 - 1,000
2	18	83	Wawanesa	201 - 500
			Souris	1,001 - 2,000
			Pipestone	50 - 200
83	2	83 South	Melita	1,001 - 2,000

Table 5. (cont.)

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Estimated Highway (Part I)	Highway Segment (Part I) From	To	Urban Centre[1]	Population[2] Group
3	Wpg	13	Sanford	201 - 500
			Brunkild	50 - 200
			Sparling	50 - 200
			Carman	2,001 - 5,000
3	13	34	Morden	2,001 - 5,000
			Darlingford	50 - 200
			Manitou	50 - 200
			La Riviere	201 - 500
			Pilot Mound	501 - 1.000
			Crystal City	501 - 1,000
6	Wpg	391	Grosse Isle	50 - 200
			Warren	201 - 500
			Woodlands	50 - 200
			St. Laurent	50 - 200
			Oak Point	201 - 500
			Lundar	501 - 1,000
			Eriksdale	201 - 500
			Ashern	501 - 1,000
			Moosehorn	50 - 200
			Grand Rapids	501 - 1,000
391	6	391 West	Cranberry Portage	501 - 1,000
			Flin Flon	5,001 - 10,000
391	6	391 North	Wabowden	501 - 1,000
			Thompson	10,001 - 25,000
7	Wpg	67	Stony Mountain	1,001 - 2,000
			Stonewall	1,001 - 2,000
59	Wpg	44	Birds Hill	501 - 1,000
44	59	11	Garson	201 - 500
			Tyndall	201 - 500
			Beausejour	2,001 - 5,000

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Table 5. (cont.)

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Estimated Highway (Part I)	Highway Segment (Part I) From	To	Urban Centre[1]	Population[2] Group
11	44	11 North	Seven Sisters Falls	50 - 200
			Lac du Bonnet	501 - 1,000
			Great Falls	201 - 500
75	Wpg	14	Glenlea	50 - 200
			Ste. Agathe	201 - 500
			Morris	1,001 - 2,000
			St. Jean Baptiste	501 - 1,000
14	75	30	Rosenfeld	201 - 500
30	14	30 South	Altona	2,001 - 5,000
1	Ontario	Wpg	West Hawk Lake	50 - 200
			Falcon Lake	50 - 200
			Richer	201 - 500
			Ste. Anne	1,001 - 2,000

[1] According to the Atlas of Manitoba (1983) the term "urban" refers to "any cluster of residences together with related buildings having a population of 50 or more in 1976."

[2] Urban population as indicated in the Atlas of Manitoba (1983) according to Statistics Canada, Place Name Reference List, Western Provinces (1978) data.

In Figure 4.9 (map pocket, back cover) the mapping symbols relate to arbitrary intervals of urban population. In anticipation of any mishap or accidental release of a dangerous good (s), urban centres of greater than 2,000 persons received a 'high' rating. The versatility of the mapping symbol presentation and user interpretation for Figure 4.9 is outlined in section 4.2.2.1.

In this exercise (Figure 4.9), the spatial array of mapping symbols along the estimated routes of Part I is considerably different from that of the previous maps. The arbitrary radii of diminishing use, frequency of shipments, volume of shipments and rural population density are not discernable. Instead, urban population is highly variable and unpredictable, a condition which adds dimension to the spatial analysis in the impact of risk evaluation. However, it may also present undue complications in the interpretation and use of information by administrators.

4.2.2.3 Annual Average Daily Volume of Traffic Parameter

The annual average daily volume of traffic[20] refers to the average amount of traffic on a particular stretch of highway for a 365 day period, based on either permanent or short-term counting station observations. The importance of

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[20] The definition of annual average daily volume of traffic as reported by M. Lai, a Traffic Analysis Engineer of the Manitoba Department of Highways and Transportation (telephone interview; April 23, 1985).

this dynamic measurement of human population relates to the number of vehicles which might come into contact with a mishap and/or accidental release of a dangerous good (s) by virtue of route utilization. Consideration of the annual average daily volume (A.A.D.V.) of traffic adds interesting and useful scope to the impact of risk analysis.

The following scale has been developed in order to categorize and hence map the Annual Average Daily Volume of Traffic in terms of the impact of risk along the routes of interest to this study:

Exceptional	> 10,000 A.A.D.V.
High	5,000 - 10,000 A.A.D.V.
Moderate	1,000 - 5,000 A.A.D.V.
Low	< 1,000 A.A.D.V.

Table 6. Population Sample and Distributor Survey Data -- Annual Average Daily Volume of Traffic per Segment of Estimated Transportation Route (Part I).

Estimated Highway (Part I)	Highway Segment (Part I) From	To	Highway Count Recording Station Location[1] by highway subsegment (prov. road intersection)[2]	Annual Average Daily Volume[3] by highway subsegment (prov. road intersection)	Mapping Category ! : Exceptional A.A.D.V. H : High A.A.D.V. M : Moderate A.A.D.V. L : Low A.A.D.V.
1	Wpg	16	100 - 334	12,130	!
			334 - 248	7,333	H
			248 - 430	6,858	H
			430 - East of Portage	7,760	H
			East of Portage bypass - West of Portage bypass	7,604	H
1	16	83	West of Portage bypass - 350	4,800	M
			350 - 34	3,948	M
			34 - 352	4,094	M
			352 - 5	3,768	M
			5 - 464	3,868	M
			464 - 10	4,744	M
			10 - West of Brandon	3,692	M
			West of Brandon - 21	2,890	M
			21 - 254	2,725	M
			254 - 83	2,784	M
16	1	5	1 - 50	2,435	M
			50 - 460	2,280	M
			460 - 352	2,880	M
			352 - 5	3,315	M

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Table 6. (cont.)

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Estimated Highway (Part I)	Highway Segment (Part I) From	To	Highway Count Recording Station Location[1] by highway subsegment (prov. road intersection)[2]	Annual Average Daily Volume[3] by highway subsegment (prov. road intersection)	Mapping Category ! : Exceptional A.A.D.V. H : High A.A.D.V. M : Moderate A.A.D.V. L : Low A.A.D.V.
5	16	20	5 - 265	1,969	M
			265 - 357	1,420	M
			357 - 261	1,240	M
			261 - 19	1,070	M
			19 - 462	1,030	M
			462 - 50	1,231	M
			50 - 480	1,035	M
			480 - 235	1,414	M
			235 - 20	1,322	M
20	5	5/10	20 - 5	1,900	M
			5 - 10	2,251	M
10	5	83	5 - 267	955	L
			267 - 274	842	L
			274 - 271	715	L
			271 - 20	562	L
			20 - 366	914	L
			366 - 83	1,763	M
10	83	10 north	83 - 279	1,722	M
			279 - 268	1,005	M

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Table 6. (cont.)

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Estimated Highway (Part I)	Highway Segment (Part I) From	To	Highway Count Recording Station Location[1] by highway subsegment (prov. road intersection)[2]	Annual Average Daily Volume[3] by highway subsegment (prov. road intersection)	Mapping Category ! : Exceptional A.A.D.V. H : High A.A.D.V. M : Moderate A.A.D.V. L : Low A.A.D.V.
10 (contd.)	83	10 North	268 - 365	832	L
			365 - 277	863	L
			277 - 327	758	L
			327 - 282	577	L
			282 - 283	1,650	M
			283 - 287	1,498	M
16	5	83	5 - 466	2,915	M
			466 - 262	2,480	M
			262 - 270	1,715	M
			270 - 250	1,700	M
			250 - 354	1,344	M
			354 - 21	1,490	M
			21 - 472	1,320	M
			472 - 83	1,006	M
83	16	5	16 - 478	1,292	M
			478 - 45	1,635	M
			45 - 254	935	L
			254 - 366	789	L
			366 - 5	952	L

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Table 6. (cont.) ... 4

Estimated Highway (Part I)	Highway Segment (Part I) From	To	Highway Count Recording Station Location[1] by highway subsegment (prov. road intersection)[2]	Annual Average Daily Volume[3] by highway subsegment (prov. road intersection)	Mapping Category ! : Exceptional A.A.D.V. H : High A.A.D.V. M : Moderate A.A.D.V. L : Low A.A.D.V.
2	Wpg	15	100 - 332	1,868	M
			332 - 248	1,457	M
			248 - 13	1,370	M
			13 - 240	1,430	M
			240 - 244	1,274	M
			244 - 34	1,259	M
			34 - 342	1,061	M
			342 - 5	1,045	M
			5 - 18	838	L
2	18	83	18 - 344	1,033	M
			344 - 10	1,159	M
			10 - 348	1,162	M
			348 - 22	1,492	M
			22 - 21	962	L
			21 - 254	800	L
			254 - 83	661	L
83	2	83 South	2 - 345	550	L
			345 - 3	710	L
3	Wpg	13	100 - 247	2,625	M
			247 - 305	1,850	M
			305 - 336	1,835	M

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Table 6. (cont.)

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Estimated Highway (Part I)	Highway Segment (Part I) From	To	Highway Count Recording Station Location[1] by highway subsegment (prov. road intersection)[2]	Annual Average Daily Volume[3] by highway subsegment (prov. road intersection)	Mapping Category ! : Exceptional A.A.D.V. H : High A.A.D.V. M : Moderate A.A.D.V. L : Low A.A.D.V.
3 (contd.)	Wpg	13	336 - 13	2,245	M
3	13	34	13 - 23	2,258	M
			23 - 14	2,058	M
			14 - 432	4,173	M
			432 - 528	1,150	M
			528 - 244	1,165	M
			244 - 242	1,031	M
			242 - 253	940	L
			253 - 423	790	L
			423 - 34	620	L
6	Wpg	391	101 - 321	2,714	M
			321 - 67	1,900	M
			67 - 323	1,920	M
			323 - 414	1,560	M
			414 - 415	1,330	M
			415 - 419	1,140	M
			419 - 68	970	L
			68 - 235	1,110	M
			235 - 325	930	L
			325 - 239	830	L
			239 - 328	650	L

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Table 6. (cont.)

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Estimated Highway (Part I)	Highway Segment (Part I) From	To	Highway Count Recording Station Location[1] by highway subsegment (prov. road intersection)[2]	Annual Average Daily Volume[3] by highway subsegment (prov. road intersection)	Mapping Category ! : Exceptional A.A.D.V. H : High A.A.D.V. M : Moderate A.A.D.V. L : Low A.A.D.V.
6 (contd.)	Wpg	391	328 - 327	270	L
			327 -	275	L
			Along	330	L
			Route	336	L
			- 391	379	L
391	6	391 West	6 - 392	233	L
			392 - 10	300	L
			10 -	792	L
			Along Route	636	L
			- Sask. Border	1,200	L
391	6	391 North	6 - 373	427	L
			373 -	491	L
			Along	452	L
			the	462	L
			Route	475	L
			- 375	710	L
			375 - Thompson	855	L
7	Wpg	67	101 - 321	4,620	M
			321 - 67	3,720	M

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Table 6. (cont.)

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Estimated Highway (Part I)	Highway Segment (Part I) From	Highway Segment (Part I) To	Highway Count Recording Station Location[1] by highway subsegment (prov. road intersection)[2]	Annual Average Daily Volume[3] by highway subsegment (prov. road intersection)	Mapping Category ! : Exceptional A.A.D.V. H : High A.A.D.V. M : Moderate A.A.D.V. L : Low A.A.D.V.
59	Wpg	44	101 - 213	12,496	!
			213 - Birds Hill	6,657	H
			Birds Hill - 44	5,208	H
44	59	11	59 - Tyndall	2,986	M
			Tyndall - Beausejour turnoff	2,604	M
			Beausejour turnoff - 12	1,192	M
			12 - 316	2,541	M
			316 - 11	1,230	M
11	44	11 North	44 - 211	950	L
			211 - 214	850	L
			214 - 317	740	L
			317 - Great Falls	745	L
75	Wpg	14	100 - 200 Turnoff	12,964	!
			200 Turnoff - 247	4,577	M
			247 - 305	2,912	M
			304 - 205	2,840	M
			205 - 23	3,000	M
			23 - 523	2,965	M
			523 - 246	2,980	M
			246 - 14	2,180	M

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Table 6. (cont.) ... 8

Estimated Highway (Part I)	Highway Segment (Part I) From	To	Highway Count Recording Station Location[1] by highway subsegment (prov. road intersection)[2]	Annual Average Daily Volume[3] by highway subsegment (prov. road intersection)	Mapping Category ! : Exceptional A.A.D.V. H : High A.A.D.V. M : Moderate A.A.D.V. L : Low A.A.D.V.
14	75	30	75 - 30	1,060	M
30	14	30 South	14 - 21	2,016	M
1	Ont. Border	Wpg	Ont. Border - 44	2,724	M
			44 - 301	2,840	M
			301 - 308	2,969	M
			308 - 11	3,216	M
			11 - 302	3,084	M
			302 - 207	3,750	M
			207 - 12	3,900	M
			12 - 290	6,094	H
			290 - 100	8,090	H

[1]The highway count recording station location illustrated by the 1983 Traffic Flow Map for Provincial Trunk Highways and Provincial Roads (M-703) (issued by the Manitoba Department of Highways and Transportation) has been approximated between major intersections of provincial roads, provincial trunk highways or any combination thereof.

[2]Provincial road intersections and corresponding traffic counts of interest include all statistics within the highway segments designated in Part I.

[3]As reported by M. Lai, a Traffic Analysis Engineer of the Manitoba Department of Highways and Transportation (telephone interview, April 23, 1985), "Annual Average Daily Volume of Traffic" refers to the average amount of traffic on a particular stretch of highway for a 365 day period, based on either permanent or short term counting station observations.

Table 6 contains the relative A.A.D.V. of traffic with respect to each segment of the estimated routes of Part I. Data were obtained from the Manitoba Department of Highways and Transportation Traffic Flow Map for Provincial Trunk Highways and Provincial Roads (Map M-703) (1983). For purposes of this study, traffic count stations were estimated by subsegment (e.g. provincial road intersection), within each highway segment of the estimated routes from Part I.

Mapping symbols represent arbitrary intervals of traffic counts. For Figure 4.10 (back cover map pocket), it was necessary to include a category of exceptional frequency. This unusually high category may be attributed to the use of the perimeter highway (e.g. highway #100, highway #101) by residents of Winnipeg.

At first glance, Figure 4.10 appears to have a concentric-circle pattern of traffic flow radiating from Winnipeg. However, when examined more closely, there are some exceptions to this assertion. The average annual volume of traffic in some cases tends to increase in close proximity to urban centres. Intuitively, this is a reasonable explanation.

4.2.3 Discussion

The Impact of Risk Model in this study is based on the routes which were estimated in Part I according to a population sample and distributor survey for one chemical group. Of significance to this analysis is the reliance on relative rather than absolute impact of risk. The absolute impact of risk is an unreasonable goal, for similar reasons to those outlined for zero-risk in Chapter 2.

The final comment pertaining to this section relates to the implicit need to implement value judgements in the impact of risk analysis. In the selection of the impact of risk critera and the parameters for mapping, choices must be made and subjective decision criteria must be employed.

Chapter V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

(Part I/Part II)

5.1 DISCUSSION AND APPLICATIONS PART I

Transportation Route Model

The Transportation Route Model is a methodology which enables the identification of estimated transportation routes for the transport of dangerous good (s) shipments. Potentially, any route may be utlized for the transportation of dangerous goods; however, the importance of this information lies in the confidence of estimations for policy makers.

The accuracy of the results of the Transportation Route Model may be impeded by errors in either decision criteria or the actual execution of analysis. For example, the information obtained in each of the two sample surveys is subject to error in terms of respondent misinterpretation of survey questions and/or the element of over or under estimation in the responses. This point reaffirms the necessity of keeping research objectives in focus when interpreting results. In this exercise, the responses were used to confirm route utilization.

The versatility of application is perhaps the greatest advantage of the Transportation Route Model. While the industry tested in this exercise resulted in a road route application, the principles for rail routing are essentially the same. The model can be used to evaluate existing and prospective transportation corridors for any transportation mode (e.g. railroad, pipeline, water course, air) in <u>any</u> geographical region.

The ease with which this model can be computerized to provide management, fire, police, municipal and industrial agencies with urgent information, is fundamental. This information can be compiled with accident statistics, route and environmental hazards, and many other criteria. The Transportation Route Model was intentionally designed to control all potential factors influencing the transportation network because it is not possible to address all variables or criteria at one time. Any delimitations which apply to this particular test of the Transportation Route Model can be relaxed in future analyses. The potential for variation is infinite.

It is anticipated that the model would be best employed as a planning tool. In terms of the principal objective of this research study, the resulting test of the Transportation Route Model has been most successful in providing a spatial assessment of route utilization.

5.2 DISCUSSION AND APPLICATIONS PART II

The Impact of Risk Model

The Impact of Risk Model is a useful tool which can identify variables of importance in situations of mishap or accidental release of a dangerous good. The principal advantage of 'impact of risk' data relates to the immediate estimation of the magnitude of a dangerous good(s) mishap or accidental release. With the aide of compiled data pertaining to different impact of risk criteria, administrative agencies can swiftly determine the potential effects and ramifications of a dangerous good(s) incident. Time, effort and cost will be minimized, and efficiency greatly enhanced.

Any emergency response initiated at the time of an accident or mishap is inevitably subject to scrutiny by the media and by the public (as discussed in Chapter 2, section 2.3.1). The regional P.C.B. spill in northwestern Ontario serves as a prime example of the 'panic syndrome' which often accompanies dangerous good mishaps. If a comprehensive data base of product information, routes, impact of risk and emergency response were in existence, at the very least, it would indicate that administrators are reasonably aware of and in control of the situation. The information would place an incident in perspective.

Thus, in the near future, efforts must be made to expand the concepts introduced in this document. Additional product and route 'impact of risk' criteria should be evaluated. If this were to take place in time, a coordinated data base would result and, if the data were computerized (as suggested in section 5.1), information could be available instantaneously.

The only condition of the Impact of Risk model applies to users. Although 'impact of risk' has been defined for purposes of this study as 'the anticipated repercussions and/or magnitude of a mishap of a dangerous good(s) in transit according to the 'environment' in which the event occurs', the user must realize that all data are estimated, and that if any changes to the model are desired, that they be documented and defined.

5.3 RECOMMENDATIONS AND SYNOPSIS

The models designed in this study, the data and spatial analyses, can be employed to identify alternatives for policy or procedure by any agency. Indeed, it would have been appropriate to employ the methodology and resulting data of this document, in the design phase of regulation development. However, formulation of the regulations of the *Transportation of Dangerous Goods Act* (S.C. 1980 c. 36) and the *Dangerous Goods Handling and Transportation Act* (Cap. D12 S.M. 1984 c.7) preceded this research.

Existing regulations should not be amended on the basis of information contained in this document. This applies to the provision in the Manitoba statute for municipal jurisdiction also; effort must be made to avoid the over-regulation of specific industries (e.g. transport carriers, shippers, handlers, etc.) as discussed in Chapter 2 (section 2.3.3.1). The new regulations must be enforced for a sufficiently long period to enable effective and objective judgement. It is recommended that this study be used to evaluate transportation systems in pursuit of more efficient and effective emergency response in the event of a dangerous good(s) mishap or accidental release.

This study has designed and employed two models which may be used acquire information relating to the transportation of dangerous goods in Manitoba. The methodology which has been introduced, provides a systems approach to the evaluation of dangerous goods in transit; if adopted, there should be decreased administrative and social costs and a notable increase in administrative efficiency, in the long run.

Notwithstanding the delimitations and assumptions, the approach introduced in this practicum has maximized user-utility. Seven different parameters relating to the transportation of of dangerous goods, and the environment in which the transportation system exists, were successfully evaluated and spatially translated. The use of overlay maps has provided a versatile media to present information in a clear, uncomplicated manner. Thus, the study has effectively met all research objectives.

Appendix A

SURVEY DATA

Table 1. Population sample survey data--common chemical group data.

I.D. #	Chemical Group	Distributor Location	Mode of Shipments (Rd=Road)	Approximate Frequency of Shipments	Approximate Volume Per Shipment
01WPE6	Typesetting Developing Chemicals	-	-	-	-
02PB1	"	Wpg	Rd	1/mo	10 gal
03PA1	"	Wpg	Rd	1/6mos	60 gal
04PA1	"	Wpg	Rd	1/mo	2.5 gal
05PA1	"	Wpg	Rd	1/year	234 l
06SB1	"	Wpg	Rd	1/3mos	5 l
07SA1	"	Wpg	Rd	10/year	10-12 gal
08SA1	"	Wpg	Rd	1/1.5mos	19 l
09SA1	"	Wpg	Rd	1/2mos	5 gal
10NB2	"	Wpg	Rd	2/year	5 gal
11NA6	"	Wpg	Rd	1/mo	10 l
12NB1	"	Wpg	Rd	1/mo	10 l
13NA1	n/a	n/a	n/a	n/a	n/a
14EA1	"	Wpg	Rd	2/mo	5 gal
15EA1	"	Wpg	Rd	4/year	15 gal
16EA.5	n/a	n/a	n/a	n/a	n/a
17EB1	"	Wpg	Rd	4/year	20 U.S. gal
18WA1	"	Wpg	Rd	3-4/year	18 l
19WA1	"	Wpg	Rd	7/year	12 gal
20WA1	"	Wpg	Rd	2-3/year	10 U.S. gal
21WA1	"	Wpg	Rd	4/year	30 l

Table 2. Distributor survey data--developing chemicals for typesetting.

I.D. #	Chemical Group	Mode of Supplier Location	Transportation Shipments (Rd=Road)	Approximate Frequency of Shipments	Approximate Volume Per Shipment
010	Typesetting Developing Chemicals	n/a	n/a	n/a	n/a
02WP	"	Toronto	Rd	2/mo	200 l
03WP	"	Toronto	Rd	4-5/mo	25-30 gal
04WP	"	Toronto	Rd	2/mo	378 l + 17 (2.5) gal
05WP	"	Toronto	Rd	4/mo	100 l
06WP	"	Toronto	Rd	1/mo	2,000 l

Table 3. Population sample survey data (converted) and estimated routing sequence.

I.D. #	Origin of Estimated Route	Transportation Mode of Shipments (Rd=Road)	Estimated Routing Sequence	Approximate Frequency of Shipments/Year (Converted)	Approximate Volume/Shipment (l.) (Converted)
02PB1	Wpg	Rd	1W/16/5	12	44.5
03PA1	Wpg	Rd	1W/16/83	2	273
04PA1	Wpg	Rd	1W/16/5/10	12	11.38
05PA1	Wpg	Rd	1W/16	1	234
06SA1	Wpg	Rd	3	4	5
07SA1	Wpg	Rd	75/14/30	10	45.5-54.6
08SA1	Wpg	Rd	2	8	19
09SA1	Wpg	Rd	3	6	22.75
10NB2	Wpg	Rd	1W/16/5/10	2	22.75
11NA6	Wpg	Rd	6/391	12	10
12NB1	Wpg	Rd	6/391	12	10
13NA1	n/a	n/a	n/a	n/a	n/a
14EA1	Wpg	Rd	7	24	22.75
15EA1	Wpg	Rd	59/44	4	70.25
16EA.5	n/a	n/a	n/a	n/a	n/a
17EB1	Wpg	Rd	59/44/11	4	76
18WA1	Wpg	Rd	2/83	3-4	18
19WA1	Wpg	Rd	1	7	54.6
20WA1	Wpg	Rd	2	2-3	38
21WA1	Wpg	Rd	1W/6	4	30

Table 4. Distributor survey data (converted) and estimated routing sequence.

I.D. #	Origin of Estimated Route	Transportation Mode of Shipments (Rd=Road)	Estimated Routing Sequence	Approximate Frequency of Shipments/Year (Converted)	Approximate Volume/Shipment (1.) (Converted)
010	n/a	n/a	n/a	n/a	n/a
02WP	Toronto	Rd	1E	24	200
03WP	Toronto	Rd	1E	48-60	113.75 -136.5
04WP	Toronto	Rd	1E	24	571.38
05WP	Toronto	Rd	1E	48	100
06WP	Toronto	Rd	1E	12	2,000

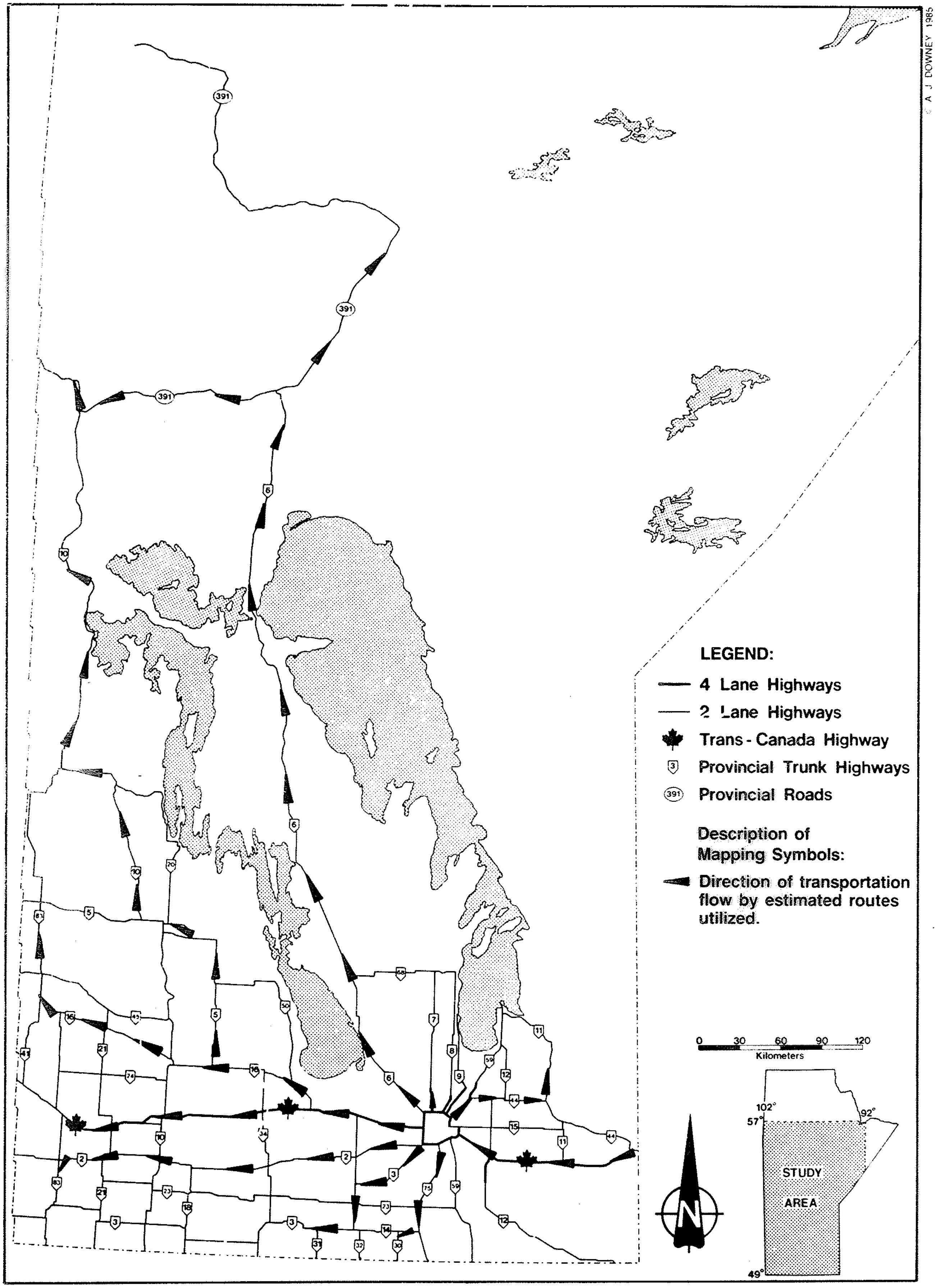

FIGURE 4.3: Overlay map for Figure 4.1 and Figure 4.2. Direction of transportation flows by estimated routes utilized, developing chemicals for typesetting, newspaper industry (S.I.C. 2710) sample and distributor sample.

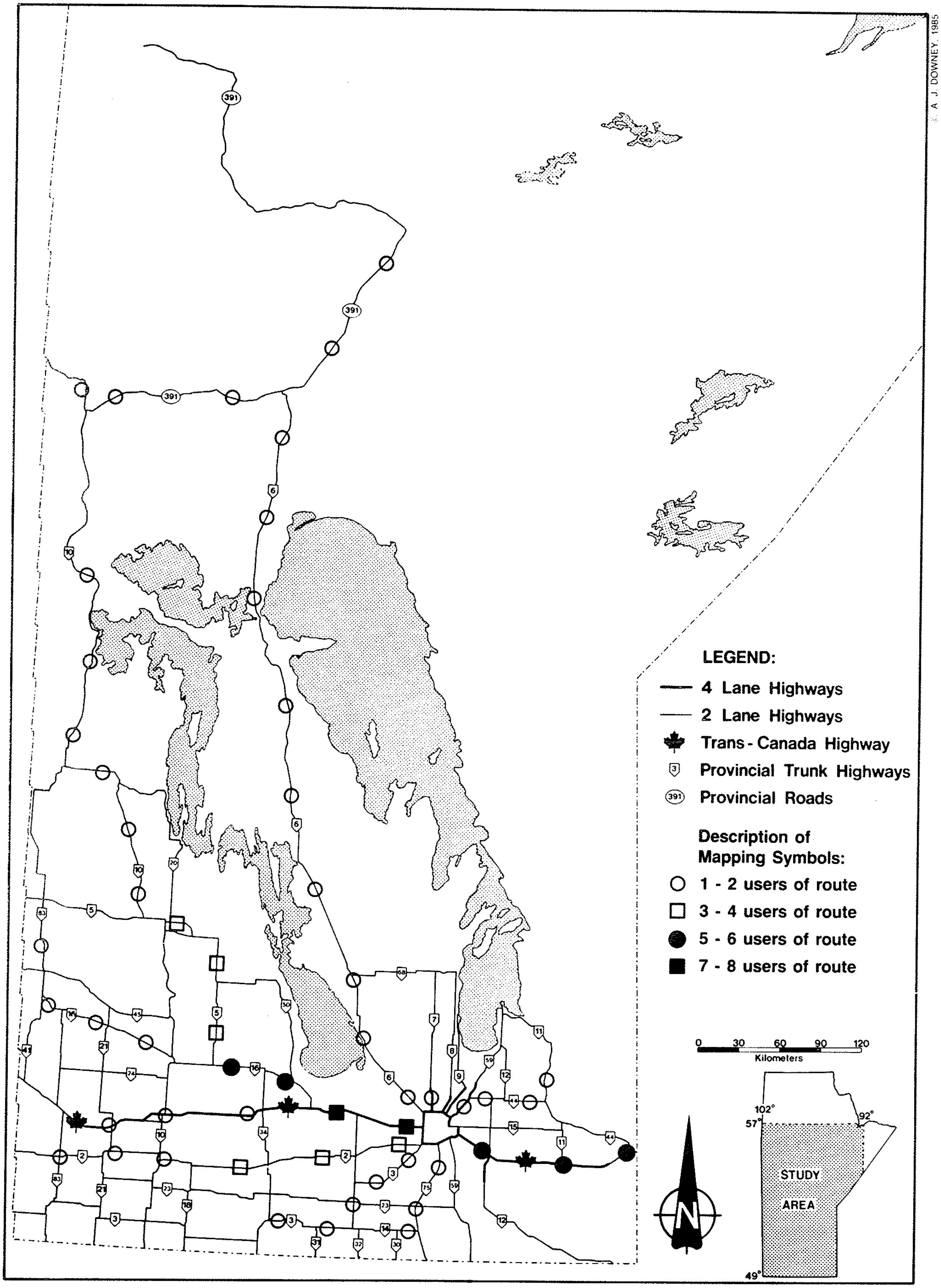

FIGURE 4.4: Overlay map for Figure 4.1 and Figure 4.2. Number of users of estimated transportation routes, developing chemicals for typesetting, newspaper industry (S.I.C. 2710) sample and distributor sample.

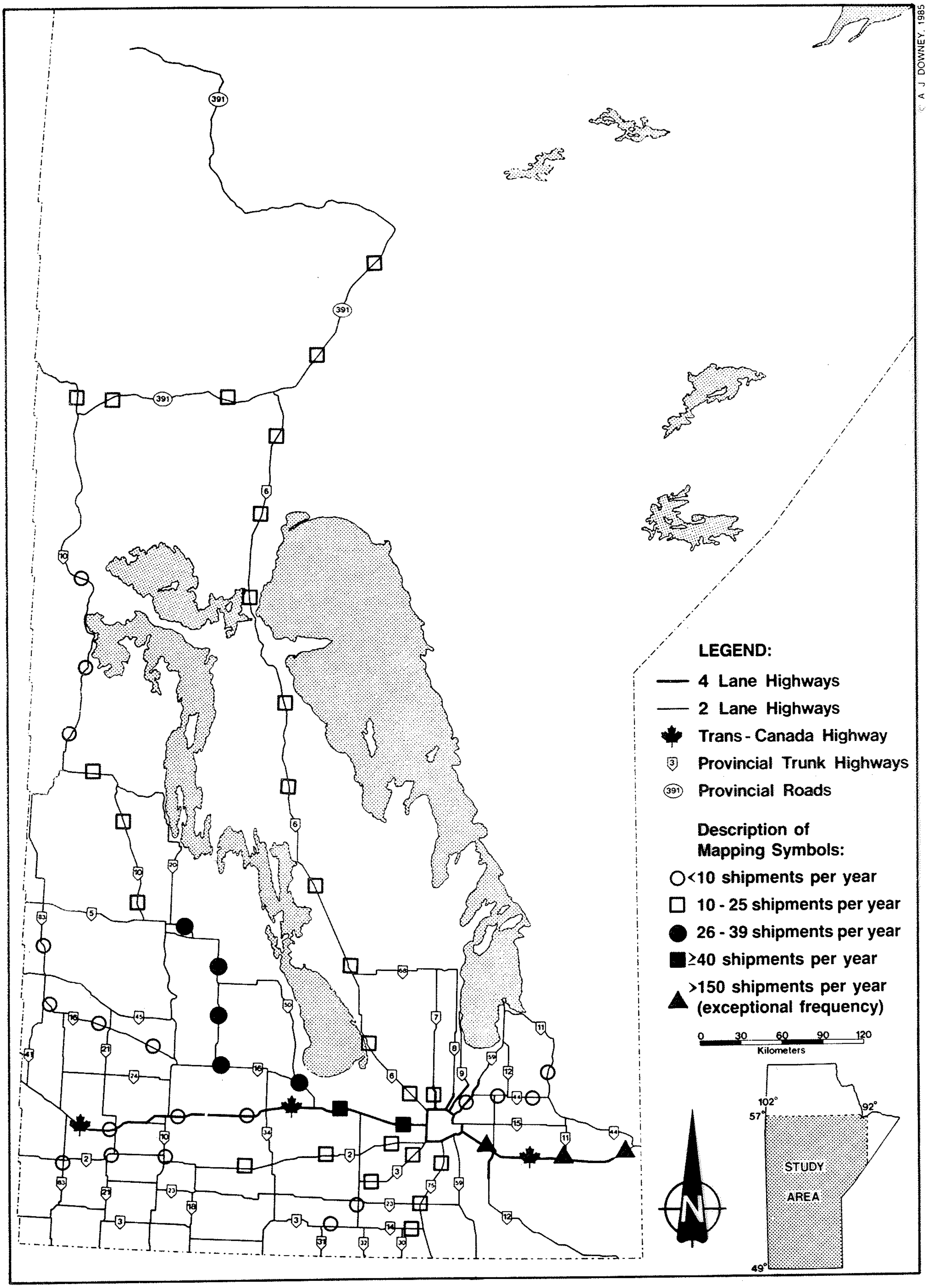

FIGURE 4.5: Overlay map for Figure 4.1 and Figure 4.2. Cumulative frequency of shipments per year, per segment of estimated transportation route; developing chemicals for typesetting, newspaper industry (S.I.C. 2710) sample and distributor sample.

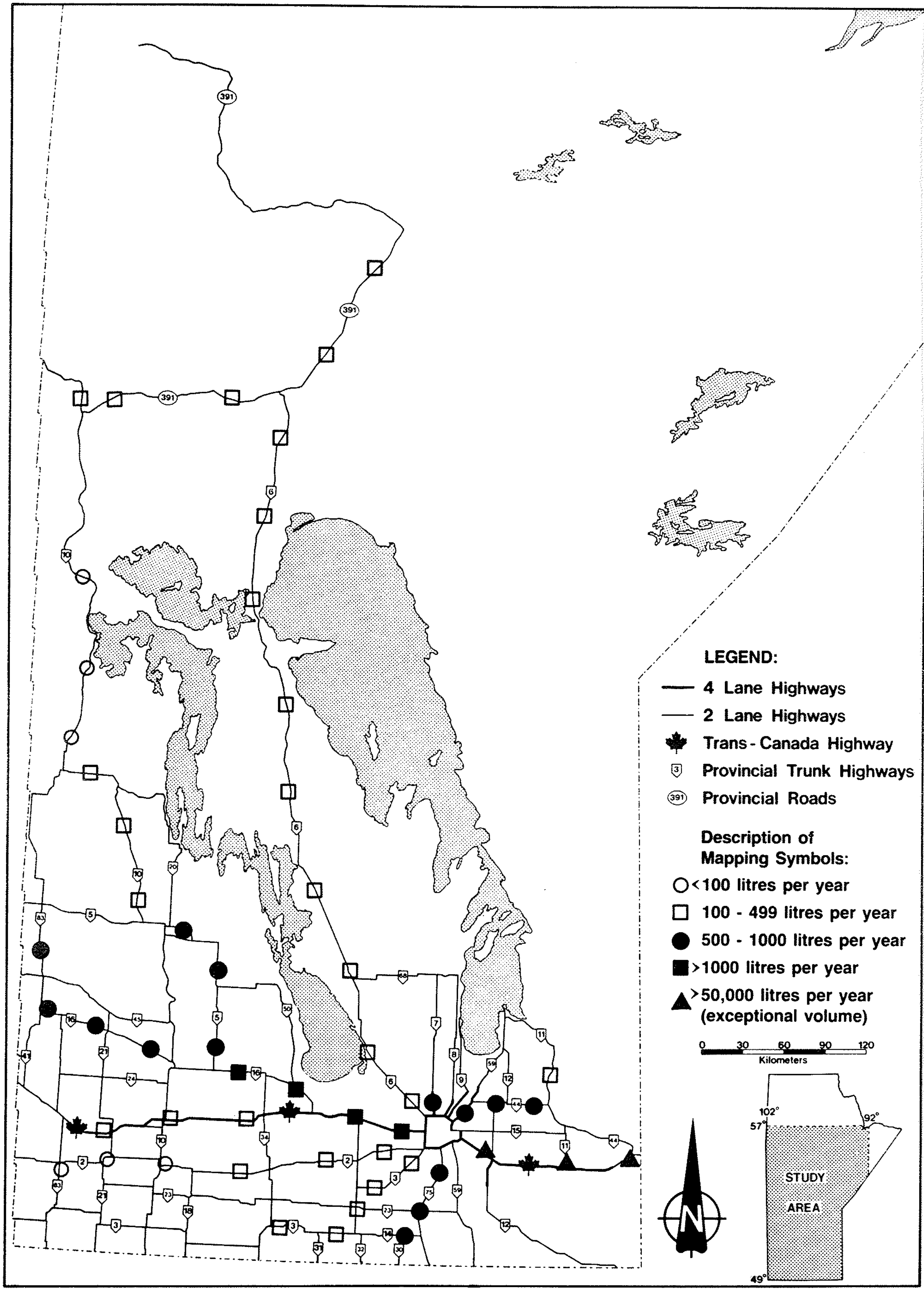

FIGURE 4.6: Overlay map for Figure 4.1 and Figure 4.2. Cumulative volume (litres) per year, per segment of estimated transportation route; developing chemicals for typesetting, newspaper industry (S.I.C. 2710) sample and distributor sample.

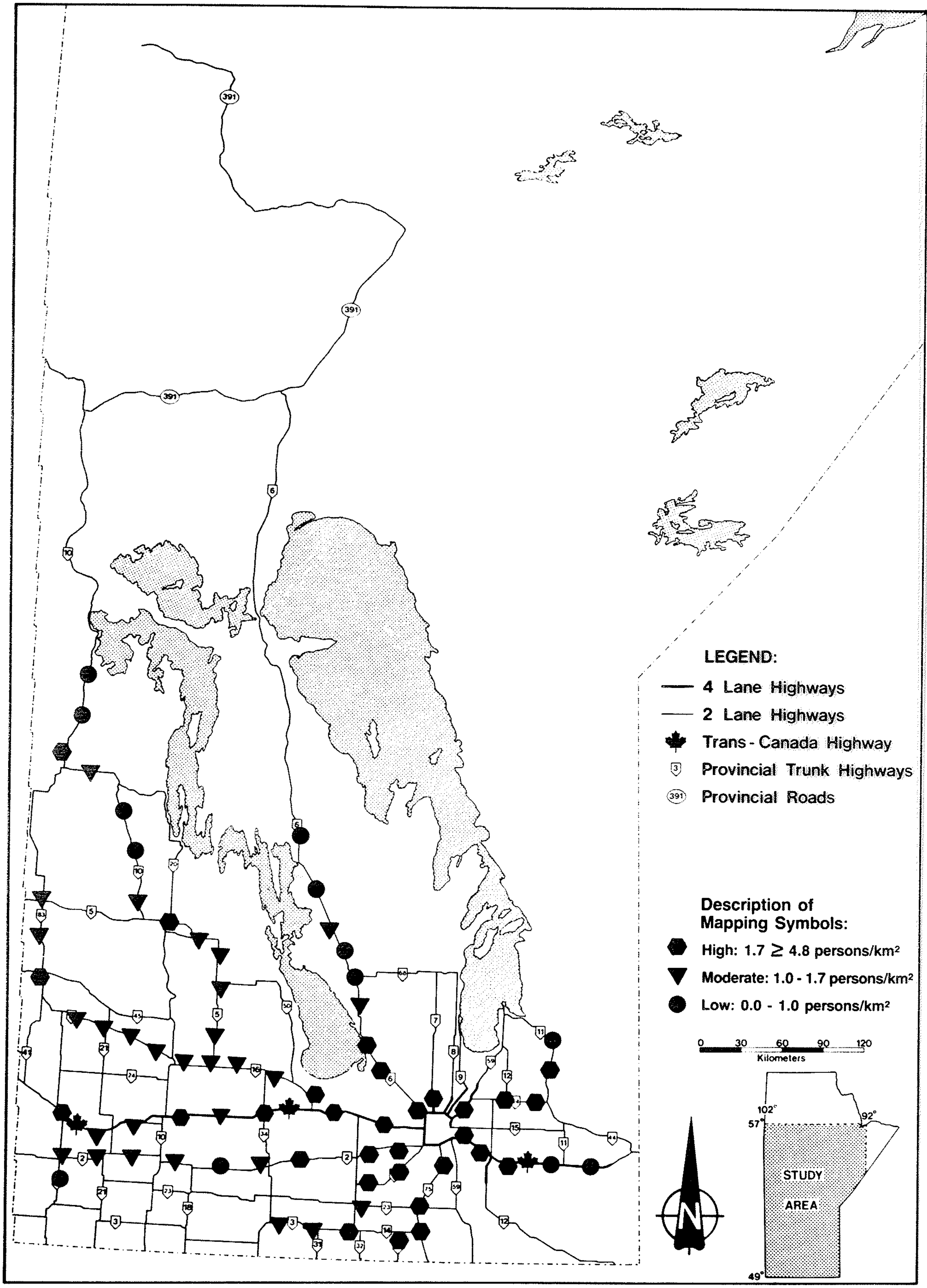

FIGURE 4.8: Overlay map for Figures 4.1, 4.2 and Figure 4.7. Estimated impact of risk zones per segment of transportation route (Part I) by Municipality or Local Government District population density. (Source: Atlas of Manitoba, 1983.)

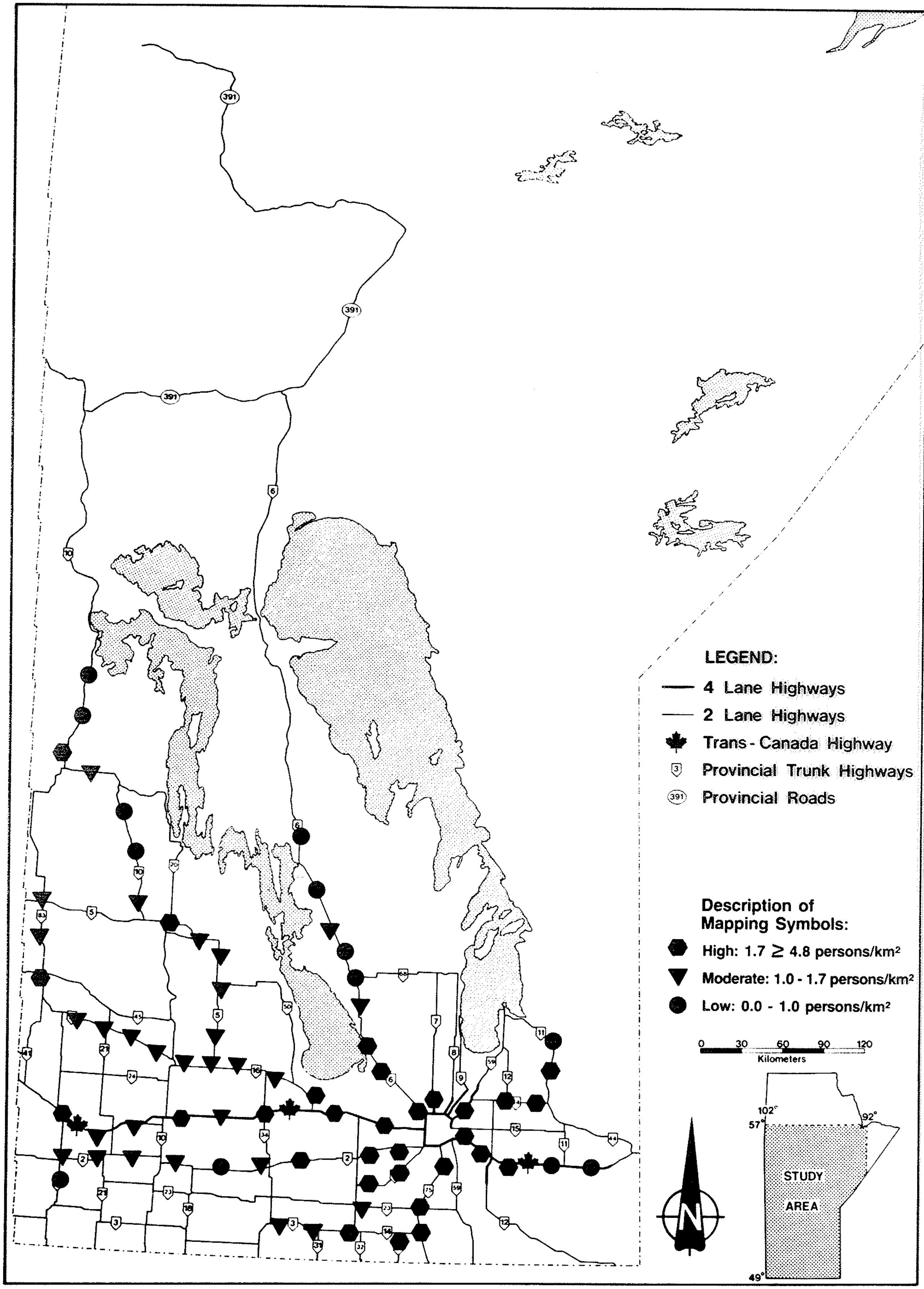

FIGURE 4.8: Overlay map for Figures 4.1, 4.2 and Figure 4.7. Estimated impact of risk zones per segment of transportation route (Part I) by Municipality or Local Government District population density. (Source: Atlas of Manitoba, 1983.)

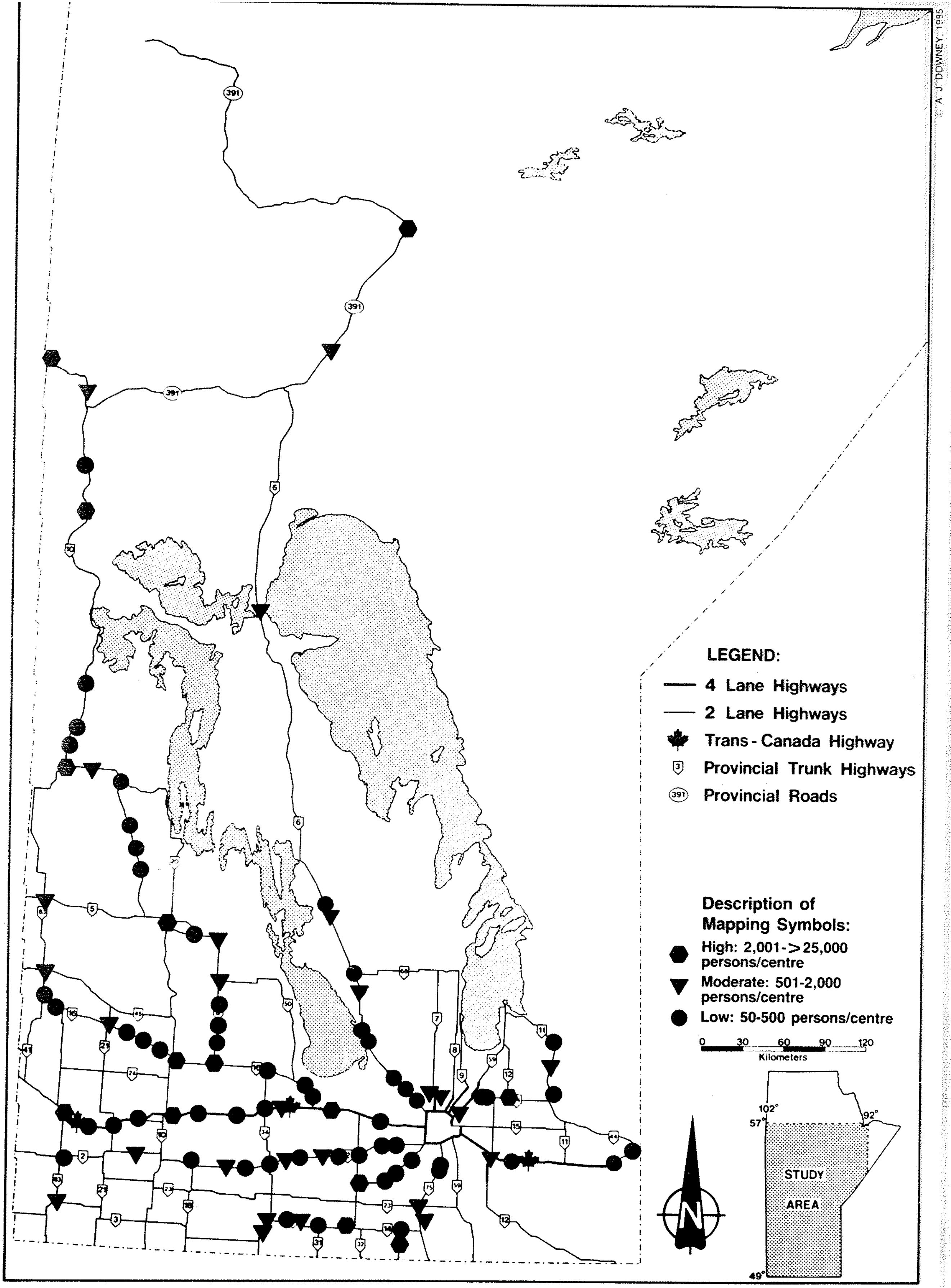

FIGURE 4.9: Overlay map for Figures 4.1, 4.2 and Figure 4.7. Estimated impact of risk zones per segment of transportation route (Part I) by urban population (excluding Indian Reserves). (Source: Atlas of Manitoba, 1983.)

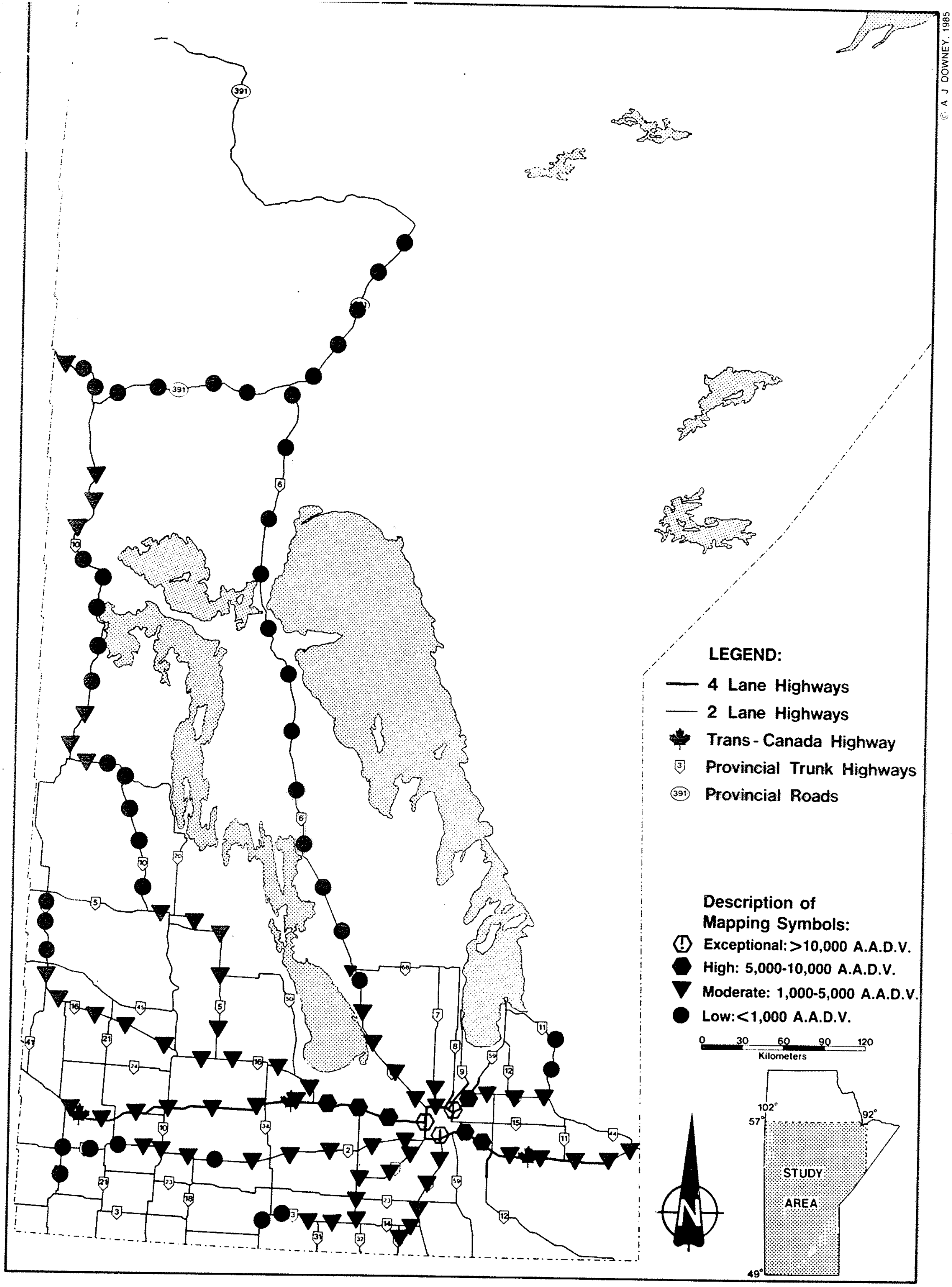

FIGURE 4.10: Overlay map for Figures 4.1, 4.2 and Figure 4.7. Estimated impact of risk zones per segment of transportation route (Part I) by annual average daily volumes (A.A.D.V.) of traffic. (Source: Manitoba Highways and Transportation, 1983.)