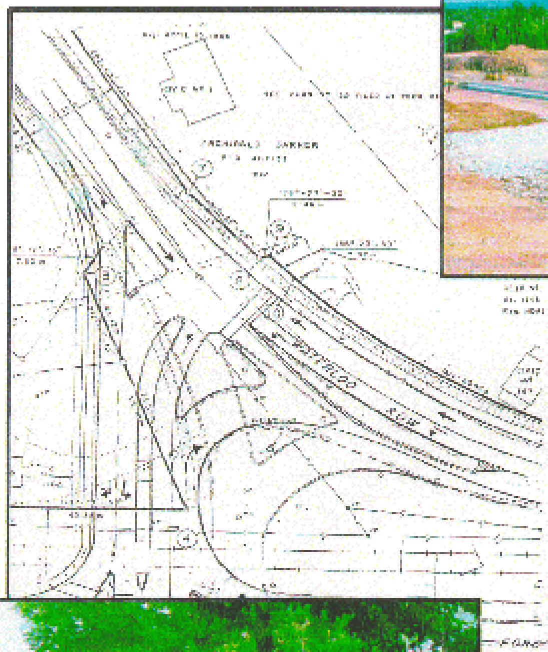
Road Safety Audit Guidelines

- Existing Practices
- Principles
- Audit Process
- Economics
- Legal Issues
- Case Studies
- Checklists



University of New Brunswick
Transportation Group

Road Safety Audit Guidelines

developed by

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FOREWORD

Although practiced elsewhere for nearly two decades, the concept of Road Safety Audits has only recently gained acceptance in North America. Originally developed in the United Kingdom in the 1980s as part of Accident Investigation and Prevention techniques, they have evolved to the point where they are now an integral component of the road safety process.

The road safety audit process is best characterized as a proactive approach to road safety by addressing issues before accidents occur. This is a radically different approach to traditional *blackspot* analyses used to identify problem areas based on frequency of accident occurrence. A fundamental trait of road safety audits is that they are most effective when undertaken during the early stages of project development and design. Despite this, much of the promotion of road safety audits within North America seems to focus on existing or in-service facilities where the potential influence is usually less than if applied during a design stage.

This document was developed to provide a reference containing a local perspective of the road safety audit process. It provides a synthesis of existing documentation and is tempered to suit Canadian conditions, standards, and practices. The guide provides an overview of practices and suggests issues to be considered for audits undertaken at different stages. Experience, discretion and good judgement must complement the use of a manual. Although road safety audit procedures will continue to evolve, the main spirit of the approach is captured by this document.

Diverse opinions and views currently exist regarding the scope, role, and application of safety audits. It is hoped that a common document will help focus the development and harmonize the application of road safety audits among Canadian authorities. Expected users of the manual include federal, provincial, and municipal authorities involved in road design/operation. Consultants and road safety experts should find the manual a useful reference when contracted to undertake an audit.

ACKNOWLEDGMENTS

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Finally, the authors wish to thank MRDC and the National Research Council's Industrial Research Assistance Program (IRAP) for their financial assistance throughout this project. Their support has enabled this project to develop from concept to reality.

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1.0 INTRODUCTION

1.1 PURPOSE

These guidelines were developed to provide transportation agencies and independent auditors with a sequence of effective techniques and instructions for the undertaking of a road safety audit. The document presents a composite of current practices from various jurisdictions and tailors them to Canadian roads, design practices, and operating conditions. The guidelines explicitly addresses: (1) different road classes; (2) new construction versus upgrading of existing facilities; and (3) urban versus rural facilities.

1.2 BACKGROUND

1.2.1 Road Safety Audit Concept

The original objective of the road safety audit (RSA) process was geared toward the reduction of road casualties through the incorporation of a more *proactive approach*. Traditional *blackspot* analysis is a reactive measure of addressing safety problems and can be considered "the end result of a failure on the part of the designers to recognize the full safety implications of their work" (Jordan and Barton, 1992). Despite adherence to prevailing design standards, roads are still being built with problematic locations resulting in disproportionate rates of road collisions. Introducing road safety audits early in the design of a highway is a cost-effective way of eliminating potential safety problems before roads are built.

1.2.2 What is a Road Safety Audit?

AUSTROADS, the national association of road transport and traffic authorities in Australia, defines a road safety audit as

> "....a formal examination of an existing or future road or traffic project, or any project which interacts with road users, in which an independent, qualified examiner looks at the project's accident potential and safety performance" (1994).

Although many other definitions exist, most include the concept that a RSA is a *formal examination* which applies *safety principles* from a multi-disciplinary perspective. In all cases, RSAs are concerned with the safety of all road users.

The main objective of a RSA is to ensure a high level of safety from the onset of the project development by removing or mitigating preventable accident-producing elements.

1.2.3 Why Road Safety Audits?

Over the years, road safety has become a principal concern of many transportation agencies. The rapid growth of the highway network, changing vehicle population, mixes of vehicles on the roads (smaller vehicles sharing the road with larger trucks), number and age of drivers, economic constraints in road construction, and technological advances, have contributed to an environment of increased accident potential. Furthermore, the three principal elements which contribute to highway accidents –driver, vehicle, and road– are also affected by the social and political environment under which they interact.

In an effort to increase highway safety, some transportation agencies have introduced safety programs specifically designed to address some of the more prevalent elements contributing to highway accidents. At the same time, engineering design has greatly improved in terms of incorporating safety into road building. In earlier years, engineers designed and built "stay-between-the-lines" highways, which provided little means of protection to vehicles colliding with infrastructure or roadside elements outside travel lanes. In the 1960s and 1970s, engineers started building "forgiving highways" which incorporated critical design elements that mitigated the consequence of colliding with elements beyond the travel lanes. More recently, engineers have begun to develop "caring highways" by emphasizing the need to prevent (rather than mitigate) collisions. Nevertheless, there is still an entrenched practice of designing infrastructures to minimum standards using a *cookbook* approach. This practice is largely driven by the desire or need to keep initial construction costs to a minimum. At issue is the consequence that a roadway designed to a series of minimum standards does not necessarily ensure a facility that is safe overall.

While attempting to reduce costs, engineers must also consider a number of factors during the design process including capacity requirements, right-of-way availability, geotechnical conditions, archaeological considerations, environmental constraints, socio-economical impacts and budget constraints (Hamilton Associates, 1998). Designers therefore have a substantial responsibility to balance the opposing pressures that are relevant to any modern road design project. This may often lead to compromises to reach as many project objectives as possible, sometimes at the expense of safety.

Road safety audits help to ensure that issues associated with road safety are specifically addressed and are given equal importance as the other factors in a design project. In cases where the facility is already in service, a RSA can identify problems that, if properly addressed by the owner, would improve the safety of that facility. It should be emphasized that this is perhaps the weakest application of the RSA procedure. Mitigative measures to compensate for poor design and potential safety problems are often disruptive and expensive for in-service roads and are consequently less cost effective. However, a keystone to the RSA process is that prevention of a safety problem is more effective than a cure. Traffic accidents can be reduced by proactively addressing road safety issues at the time the road is conceptualized, designed, constructed, or in service.

1.2.4 Why Canadian Guidelines ?

Road safety audit manuals have been prepared by transportation agencies in Australia, New Zealand and the United Kingdom. However, these manuals often reflect local road systems, characteristics, design standards, and practices of the country in which the audit process is implemented.

Road safety audits are relatively new to the Canadian transportation sector. As discussed in Chapter 2, several provinces have introduced the concept of road safety audits; though varying in design and scope. No generic document exists that formally presents a recommended sequence of the most effective techniques and practices which accommodate Canadian roads, design practices, and operating conditions. The need for a Canadian manual results from the fact that Canadian roads are unique in many ways such as:

- *Local climatic conditions*: Road users in Canada experience arduous driving conditions resulting from snow, freezing rain and sleet during the winter months. Road maintenance issues such as snow plowing and storage are also important factors to include within a Canadian manual.

- *Size of the country*: Due to its size, most of Canada has large areas of sparsely populated land and long highway segments connecting population centers. Road users traveling from one population center to the next drive for long periods of time without encountering high levels of activity on the highway.

- *Fleet mixes*: There are a wide variety of special vehicles that use the roads, and their mix is constantly changing. There are now more, longer, and heavier trucks sharing the road with smaller vehicles. There is also an increased use of snow mobiles, sport utility vehicles, and all-terrain vehicles that interact within the road environment.

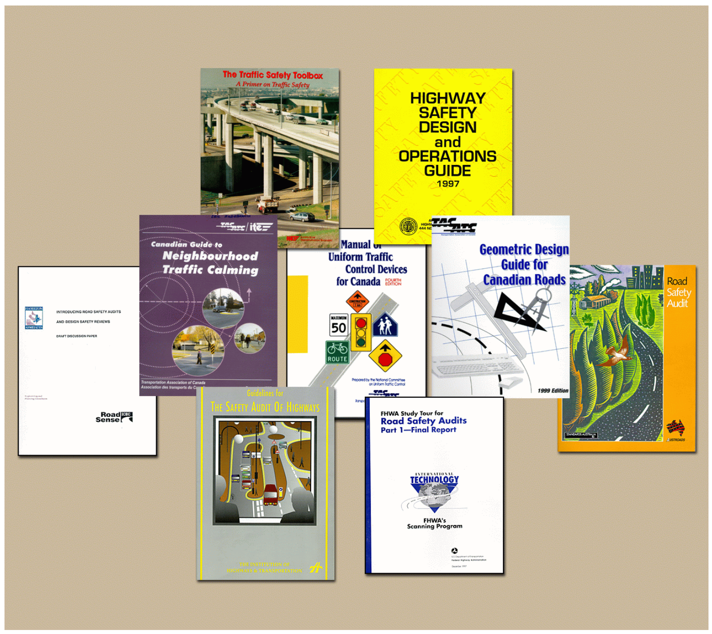
- *Traffic volumes*: Most Canadian highways experience low traffic volumes. In some provinces, a small percentage of the highway mileage accounts for approximately 90 percent of all traffic volume. This requires careful consideration when incorporating safety principles in the design of highways.

- *Types and characteristics of animals*: In most of Canada, the migration of animals such as deer and moose across highways poses a significant threat to motorists.

The development of a Canadian manual is of benefit to transportation agencies, road safety professionals, and other parties interested in conducting road safety audits to improve highway safety in Canada.

Perhaps the most significant contribution of this manual is the development of checklists reflective of Canadian issues and practices. However, the manual also attempts to draw together the best and most recent materials related to RSA procedures. The synthesis provided by this document draws on the following key documents:

> AUSTROADS, *Road Safety Audit*; United Kingdom, *Guidelines for the Safety Audit of Highways*; TAC, *Geometric Design Guidelines for Canadian Roads*; G.D. Hamilton Associates Consulting Ltd., *Introducing Road Safety Audits and Design Safety Reviews Draft Discussion Paper*; *FHWA Study Tour for Road Safety Audits Part 1 and 2 Final Report*; ITE, *The Traffic Safety Toolbox*; TAC, *Manual of Uniform Traffic Control Devices for Canada Fourth Edition*; *Canadian Guide to Neighbourhood Traffic Calming*; and, AASHTO, *Highway Safety Design and Operations Guide 1997*.



1.3 STRUCTURE OF MANUAL

This manual is divided into seven chapters as follows:

Chapter 2 presents a review of existing practices regarding road safety audits in the United Kingdom, Australia, New Zealand, and the United States. A discussion about existing practices in Canada is also presented. The Canadian provinces that have introduced the concept of road safety audits are British Columbia, Alberta, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

Chapter 3 discusses the principles of road safety audits. The chapter begins by providing an overview of the stages involved in an audit: feasibility, draft design, detailed design, pre-opening, and post-opening/existing. The chapter continues by discussing the types of projects which can be audited, the composition and characteristics of the audit team, the roles and responsibilities of those involved in the audit process, the organization of road safety audits, and the training of auditors. The chapter concludes with a description regarding the monitoring and evaluation of the audit process.

Chapter 4 presents a discussion of the safety audit process. This discussion describes the complete process followed from the selection of the audit team to the completion meeting and follow-up. The chapter also discusses the methodology used when conducting audits at different project stages. Finally, there is a detailed discussion addressing municipal audits.

Chapter 5 presents an overview of checklists for road safety audits. The chapter discusses the structure of the checklists, as well as their use. The master checklist and detailed checklists are also presented in this chapter.

Chapter 6 is a cursory evaluation of the economic implications of road safety audits. The chapter, which is divided into three sections, discusses: (1) costs of conducting road safety audits; (2) benefits; and (3) benefit-to-cost ratios associated with road safety audits.

Chapter 7 provides a discussion of legal issues associated with road safety audits.

Appendix A contains the checklists used for the conduct of safety audits of new facilities and/or upgrades. Appendix B contains the checklists used for the conduct of safety audits of municipal networks. Appendix C presents illustrative examples of road safety audits conducted in New Brunswick including highway audits and a municipal audit of a portion of Fredericton. Appendix D contains a glossary of key terms.

2.0 REVIEW OF EXISTING ROAD SAFETY AUDIT PRACTICES

This chapter presents a review of existing practices regarding road safety audits in the United Kingdom, Australia, New Zealand, and the United States. A discussion of existing practices in Canada is also presented. The Canadian provinces that have initiated road safety audit studies include British Columbia, Alberta, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

2.1 UNITED KINGDOM

The concept of road safety audits originated in the United Kingdom during the 1980s. In 1987, the United Kingdom (UK) Department of Transport formulated strategies directed toward achieving a one-third reduction in the number of annual highway casualties by the year 2000. In 1988, the UK passed legislation requiring all road authorities in mainland Britain to take necessary steps to reduce crashes on new roads. This requirement led to the development of two key publications: *A Road Safety Code of Good Practice* (Local Authorities Association, 1989) and *Guidelines for the Safety Audit of Highways* (Institution of Highways and Transportation, 1990, revised 1996).

In 1991, the UK Department of Transport made road safety audits mandatory for all national trunk roads and freeways. It currently remains the responsibility of the individual highway organizations to determine what to audit and when as a function of their highway programs, design procedures, and type of project.

2.2 AUSTRALIA

In Australia, the national association of road transport and traffic authorities is known as AUSTROADS. In 1994, AUSTROADS released a publication entitled, *Road Safety Audit*. This publication establishes a broad set of guidelines for a national road safety audit program. It includes widely adopted checklists, developed through close interaction with Transit New Zealand, which are used to ensure all areas of safety are considered when conducting a road safety audit.

Individual states are incorporating road safety audits at different rates throughout Australia. The state of Victoria's road agency, Victoria Roads Corporation (VicRoads), considers the road safety audit to be an integral component of the quality management process. Road safety audits are carried out from project conception to construction completion on all projects costing in excess of A$5 million (CDN $4.8 million). Furthermore, VicRoads randomly audits 20 percent of other construction projects at one or more stages and 10 percent of maintenance work.

The Roads and Traffic Authority (RTA) is responsible for road safety in New South Wales. RTA published a road safety audit manual as part of the New South Wales quality management approach in 1991. Twenty percent of existing roadways within all regions are to be audited to "identify deficiencies in existing roads and identify priorities for action" (Roads and Traffic Authority, 1991). Furthermore, twenty construction projects, varying in project size and stages, are to be audited every year within each region.

2.3 NEW ZEALAND

Transit New Zealand (TNZ) is the national road agency responsible for the maintenance and improvements to the New Zealand highway network. In 1989, TNZ created an Authority whose main objective is the provision of an integrated and safe highway network. After reviewing the practices and procedures of road safety audits developed by the UK and Australia, TNZ published a document entitled, *Safety Audit Policy and Procedures* (Transit New Zealand, 1993). This publication states that all projects costing more than NZ$5 million (CDN$4.2 million) would be audited from project conception to construction completion. TNZ mandated that road safety audits would be conducted on a 20 percent sample of state highway projects, however, there are no guidelines for the identification of projects to be included in the sample.

2.4 UNITED STATES

In 1996, the Federal Highway Administration (FHWA) dispatched a scanning team to evaluate the road safety audit process in Australia and New Zealand. The group consisted of a multi-disciplinary delegation of highway engineers, safety specialists, and educators. In a 1997 report entitled, *FHWA Study Tour for Road Safety Audits - Parts 1 and 2* (Trentacoste *et al*.,1997), the scanning team concluded that road safety audits could maximize safety of roadways design and operation. The program participants recommended that a United States pilot study be conducted. The team provided the FHWA with a nine-goal implementation strategy. These goals include (Trentacoste *et al*.,1997):

- Goal 1: "Get the word out"
- Goal 2: Gain support and enlist pilot agencies
- Goal 3: Pilot the RSA Process
- Goal 4: Revise the RSA Process
- Goal 5: Develop "best practices" guide
- Goal 6: Train support group
- Goal 7: Develop training course
- Goal 8: Monitor implementation
- Goal 9: Adopt guidelines

Subsequently, the FHWA started a Road Safety Audit Pilot Project in 1998 to determine the feasibility of national implementation of road safety audits into the process of roadway project development, construction and operation. Fourteen states are currently involved in the pilot project. Pennsylvania and Kansas had already been conducting road safety audits prior to the FHWA pilot project. Kansas is not participating in the FHWA pilot project.

The FHWA has sponsored road safety audit workshops for all parties engaged in the pilot project. The Pennsylvania Department of Transportation, which initiated road safety audits in 1997, presented their most recent work at the May 1998 workshop. A contractor was employed to evaluate the pilot process and a written report is expected in 1999.

2.5 CANADA

There is a growing recognition among Canadian provincial jurisdictions that a more pro-active approach to road safety is needed. Although Ontario is currently establishing a structured framework to enhance safety, other efforts have focussed on isolated reviews of specific projects. An overview of recent road safety initiatives undertaken by different Canadian Provinces is provided below.

2.5.1 British Columbia

The Insurance Corporation of British Columbia (ICBC), in association with the British Columbia Ministry of Transportation, and various municipalities, has actively identified and funded improvements to high accident locations throughout the province. ICBC has recently acted to promote more pro-active strategies, including the implementation of road safety audits. A key document entitled, *"Introducing Road Safety Audit and design reviews -Draft Discussion Paper"*, was recently funded by ICBC and produced by Hamilton Associates in 1998. Efforts continue toward the development of a more formal framework for the implementation of audits.

2.5.2 Alberta

Within the Province of Alberta, a few applications of the safety audit process have been recently undertaken. The City of Calgary used a road safety audit approach as part of a more comprehensive safety/needs review for on Highway 22X (Bowron and Morrall, 1998). There has been some local activity through the University of Calgary toward the promotion of the road safety audit process. Smaller audits have recently been conducted at different locations within the province including the City of Red Deer.

2.5.3 Ontario

Based on the needs identified by internal staff of the Ministry of Transportation of Ontario (MTO) and in the wake of the Highway 407 Safety review, it was decided that a comprehensive, cohesive approach is required to amalgamate data, procedures, techniques and expertise to address road safety (Porietti and Anders, 1998). This has lead to the development of a wholistic, system-wide approach to safety through the "Road Operational

Performance Framework". The framework was delivered in the spring of 1999 and the MTO is currently implementing the program.

This framework combines operational performance with the decision-making processes associated with the development and management of road infrastructure. Furthermore, Ontario's approach systematically incorporates road safety improvement opportunities. The framework consists of three broad processes which encompass seven main activities. These include (Proietti and Anders, 1998):

Network Evaluation: An annual *screening* of road networks is conducted on the basis of actual verses expected safety performance. Where unforeseen operational performance characteristics are identified, *diagnosis* and analysis can be conducted to understand further the nature of the operation. *Cost-beneficial countermeasures* are identified for locations where collision severity and numbers may be reduced. Ultimately, the evaluation yields a prioritized list of projects organized according to their operational performance and potential for improvement. To facilitate the network evaluation process, a computer model has been developed to automate the screening and diagnosis activities.

Design and Construction Procedures: Operational performance awareness and knowledge will be incorporated into the *engineering* development process. This inclusion involves training and the provision of appropriate tools necessary for estimating the decision performance implications throughout the feasibility planning, preliminary design, detailed design, construction, and post-opening stages of the project. These procedures will be applied to all project types, including expansion and rehabilitation projects. Performance issues should be considered early in the project and properly documented.

An *independent assessment* may be conducted on certain projects by a multi-disciplinary team. The assessment is formal in nature and identifies key safety-related problems associated with the project. Essentially the equivalent of a road safety audit; it is conducted early in the project life cycle and is well documented.

Improvements to Standards, Policies, and Procedures: This process involves the development of a 'knowledge engine' through performance analyses, the latest research findings and the experience of other jurisdictions. This tool can be used for the ongoing refinement of the framework components.

A *development/ review* activity will provide an understanding of the performance effect of the several components of a road network and how they relate to standards, engineering processes and operational procedures. Modifications to standards, policies, and procedures should be implemented where advisable. This stage essentially provides a feedback loop which allows any necessary changes to be made.

An overall *performance evaluation* activity is conducted on the techniques and procedures used. It will assist in incorporating changes toward an improved knowledge-based management of road operational performance.

2.5.4 Quebec

In 1995, the Quebec Ministry of Transportation developed an Action Plan that recommended Road Safety Audits be incorporated as part of their safety regime (Vaillancourt, 1999). Since then, an RSA framework has not been adopted in favour of higher priority issues. Nevertheless, only a few audits have been undertaken within the province on selected road projects. The staff within the Ministry is currently working toward promoting the integration of RSAs for inclusion in the 2000-2004 Action Plan.

During January 1998, *winter maintenance audits* were undertaken for two major arterial roads near Quebec City. These “audits” scrutinized winter road maintenance practices and corresponding safety issues attributed to accumulated snow and poor snow removal/plowing.

2.5.5 New Brunswick

In early 1998, the Maritime Road Development Corporation (MRDC) was awarded a contract by the Province of New Brunswick to design/build/operate the 195-kilometre toll highway from Fredericton to Moncton. MRDC is the first organization in North America to incorporate fully a road safety audit procedure in the development of a highway from the preliminary design stage through to the post-opening of the facility. This project (value of approximately $600 million) represents a textbook application of a classical road safety audit. MRDC retained a three-member team to conduct the audit process.

2.5.6 Nova Scotia

The Nova Scotia Department of Transportation and Public Works has recently contracted for an RSA of a proposed realignment/upgrading of Highway 104 in Antigonish. The audit process supplemented a safety review of three proposed alignments with the objective of identifying the scheme with the “greatest safety”.

2.5.7 Prince Edward Island

The Prince Edward Island Department of Transportation and Public Works recently had an RSA conducted for a 67 km section of the Trans-Canada Highway. The audit was undertaken as part of the assessment and strategic planning for longer term improvements to the corridor.

3.0 PRINCIPLES OF ROAD SAFETY AUDITS

This chapter discusses the broader principles of road safety audits. An overview is presented of the development stages at which audits can be conducted: feasibility, draft design, detailed design, pre-opening, and post-opening/existing. The chapter then continues by discussing the types of projects that can be audited, the composition and characteristics of the audit team, the roles and responsibilities of those involved in the audit process, the organization of road safety audits, and the training of auditors. Finally, a description of the monitoring and evaluation process of audits is presented.

3.1 DEFINING ROAD SAFETY AUDIT

A road safety audit has been defined as. . .

> *". . . a formal examination of an existing or future road or traffic project, or any project that interacts with road users, in which an independent, qualified examiner reports on the project's accident potential and safety performance"* (AUSTROADS, 1994).

The Road and Traffic Authority in New South Wales, describes a road safety audit as

> *". . . a means of checking the design, implementation and operation of road projects against a set of safety principles as a means of accident prevention and treatment."* (RTA, 1991).

A key concept associated with road safety audits is that they are conducted independently by an individual or team, with pertinent training and experience in road safety engineering, who have no prior affiliation with the project. The primary objective is to identify potential safety deficiencies for <u>all</u> road users and to consider the measures required to eliminate or reduce their impacts. Explicit consideration is given to all road users rather than motorists only. Users include pedestrians (young and old), cyclists, motorcyclists, automobiles, trucks, buses, and public transit riders.

A road safety audit is normally a formalized process whereby a written report is submitted to the design team and/or client listing safety deficiencies. The audit report should not contain recommended remedial measures although exemplary solutions may be identified. The design team, who remains responsible for all design decisions, must give the audit team a documented response addressing all safety recommendations.

To avoid misconceptions, it is necessary to identify tasks that are beyond the scope of a traditional road safety audit. The following items have often been a source of confusion.

- ***Road safety audits are not a project redesign***.
  Deficiencies should only be identified by the audit team. It is not within an audit's mandate for a redesign or recommendation to be made to mitigate a deficiency. This responsibility will rest with the project owners or their design staff. Auditors may suggest exemplary measures, but it is not their responsibility to make specific recommendations nor to promote a particular solution. The primary task should be for auditors to 'describe the problem'.

- ***Road safety audits are not intended for high cost projects only***.
  In fact, experience has shown that RSAs can be particularly effective for smaller projects where design teams have limited labor and resources. Larger projects often have enough individuals involved with the required expertise so that internal checks become either inherent or a structured part of the design process.

- ***Road safety audits are not informal checks or inspections***.
  Informal reviews should be a part of the normal design process separate from the service an RSA provides.

- ***Road safety audits are not a means to select among alternative projects***.
  It is inappropriate to rely on the products of an audit to choose among alternative projects/alignments or to solve public opinion conflicts concerning route location.

- ***Road safety audits should not be viewed as a check of standards compliance***.
  Highway safety goes well beyond adherence to a set of minimum design standards. An audit is meant to be a wholistic and multi-disciplinary review of the safety level provided by a facility.

AUSTROADS and the United Kingdom identified the following benefits of conducting a road safety audit. (AUSTROADS, 1994 and IT, 1996). An RSA can:

(1) reduce the risk (including probability and severity)of accidents on new projects and at interfaces with existing roads;

(2) increase the prominence of road safety in the minds of all involved in the planning, design, construction, and maintenance of the project;

(3) reduce the whole life cost of the project by reducing the number of post-opening modifications; and

(4) ensure inclusion of all road users rather than the traditional focus on the automobile.

Belcher and Proctor (1990) suggest that road safety audits can provide increased safety in two ways:

(1) by removing preventable accident-producing elements, such as inappropriate intersection layouts, at the planning and design stages; or

(2) by mitigating the effects of remaining or existing problems by the inclusion of suitable crash-reducing features, such as anti-skid surfacing, guard fencing, traffic control devices, and delineation.

It should be stressed that audits are most effective when conducted during the earlier stages of planning and design. Economics are greatly diminished at the final design, construction, and post-opening stages of project development since mitigation is typically much more expensive.

3.2 AUDIT STAGES

Road safety audits can be effective for most projects, regardless of size, and at any or all key milestones in the development of a highway project. Traditionally, audits have been undertaken at the following key stages:

(1) feasibility (planning);
(2) draft (preliminary/layout) design;
(3) detailed design;
(4) pre-opening; and
(5) post-opening (including existing or in-service facilities).

The complexity and level of effort of the audit process changes with each stage. An overview of what each of the audit stages entails is provided below.

3.2.1 Feasibility (Planning) Stage

An audit at the feasibility stage assesses the potential safety performance of the conceptual design proposal with respect to the route location, road design standards, and the scope of the project. Auditors should focus on how the facility will affect the continuity of the adjacent road network and identify the safety needs of all road users (*i.e.*, pedestrians, cyclists, motorists, and others). Audits can be very effective at this stage; changes or improvements to the project are often highly cost effective due to inexpensive implementation costs.

3.2.2 Draft (Preliminary/Layout) Design Stage

An audit may be conducted upon completion of the draft design plans. Primary objectives are to evaluate the relative safety of intersection or interchange layout, horizontal and vertical alignment, cross section, sight distance, and other design standards. Audits conducted at this stage should be completed before the finalization of land acquisition to avoid complications if significant alignment changes are required.

3.2.3 Detailed Design Stage

An audit should be undertaken upon completion of the detailed design plans and typically prior to the preparation of the contract documents. The geometric design, lighting, traffic signing, and landscaping plans are made available to the audit team and evaluated in relation to the operation of the facility.

3.2.4 Pre-Opening Stage

Immediately before opening a facility, the audit team should conduct a site inspection to ensure the safety needs of all road users (*i.e.*, pedestrians, cyclists, motorists, and others) are adequate. The audit team should conduct day and night drive through inspections and, if possible, perform the inspection in adverse weather conditions. This type of audit attempts to determine if hazardous conditions exist which were not evident in the previous audits.

3.2.5 Post-Opening (and Existing) Stage

Road safety audits can be undertaken soon after opening a new facility to the public. Insight into operational behaviour and subsequent problem areas can be gained through observation which may not have been readily apparent before opening the facility. Corrective measures, although much more expensive to carry out at this stage, may still be cost effective.

RSAs can also be conducted on any section of an existing road network to identify safety-related deficiencies. The information collected from accident reports is an important component for these audits; however, as an extension of traditional *blackspot* analyses they should be supplemented by informed judgements surrounding the potential for other accidents.

Hamilton Associates have developed a table which summarizes a range of project types and the corresponding recommended stages for audits. This table is intended to help road agencies decide which projects to audit and at what stage. As they indicate, Table 3-1 represents a recommended practice, and should only be used as a guide.

Table 3-1: Recommended Stages for Various Projects

PROJECT	AUDIT STAGE				
	Feasibility	Preliminary Design	Detailed Design	Pre-Opening	Post-Opening
Major new highway	T	T	T	T	T
Minor new highway		T	T	T	T
Major rehab./retrofit		T	T	T	
Minor rehab./retrofit		T	T		
Major Development	T	T	T	T	T
Minor Development		T	T		
Traffic calming			T	T	T

Note: **T** denotes recommended

Source: G. D. Hamilton Associates Consulting Ltd., *Introducing Road Safety Audits and Design Safety Reviews Draft Discussion Paper,* Vancouver, British Columbia, Canada, 1998.

3.3 TYPES OF PROJECTS TO AUDIT

Road safety audits have been conducted on a wide range of projects varying in size, location, type, and classification. The types of projects that can be audited are categorized under the following headings:

- Major Highway Projects
- Existing Facilities
- Minor Improvement Projects
- Traffic Management Schemes (construction)
- Development Schemes
- Maintenance Works
- Municipal Streets

Conducting road safety audits on all projects would be ideal, however, resource allocation is a major factor in determining which projects to audit. It is often necessary for road authorities to develop methods for ranking projects which should be audited and at which stage. In Australia and the United Kingdom, the road authorities are currently evaluating which projects should be audited and at what stage audits are most effective. It is important to note that certain road authorities require all major road projects to be audited while others are only able to audit a sample of projects due to financial constraints.

Road authorities must be aware that audits of large projects do not always produce the greatest benefits. Often larger projects have sufficient labor to provide internal checks on design. Smaller projects may lack team members with the expertise to identify safety-related design flaws. Conducting an audit on such projects may make them a more effective use of the audit process as it encourages a more careful review of safety issues.

3.4 THE AUDIT TEAM

3.4.1 Independence

Most practitioners agree that road safety auditors should be independent of the project design team to ensure that those who are unbiassed and those who may have a different perspective are reviewing the project. Audit teams can be established within large organizations or by using consultant firms or consortia. It is essential that an environment exists which fosters good communication between the audit team and the client/design team to ensure the audit is effective.

3.4.2 Qualifications

Road safety audits should be conducted by an individual or team with adequate experience in road safety engineering principles and practices, accident investigation and prevention, traffic engineering and road design. Additionally, members with experience in enforcement, maintenance, and human factors can be added to the team on a project by project basis and at different audit stages. Human factor expertise may, in selected areas, contribute to a road safety audit by providing an understanding of the interactive nature of user behaviour with the road environment.

3.4.3 Experience

It is imperative that the audit team has substantial collective experience in the key areas noted in the pervious section. While audit checklists serve to identify critical items/areas to be considered, they should only be considered memory aides for individuals with a wealth of experience and not an exhaustive listing of issues.

Australia has implemented a national accreditation for those conducting audits. Accredited auditors must have undertaken a two-day course in road safety audits and have participated in at least five audits with an experienced auditor, including at least three at the design stages. This process should be carefully reviewed and considered with caution before Canadian adoption is contemplated. Placing the audit process in the hands of a few selected persons could deprive the process of a wide range of specialists and experience.

3.4.4 Audit Team Size

The associated benefits of conducting an audit with a multi-disciplinary team are the diverse knowledge and approaches of each individual, cross fertilization of ideas that can be the result of discussions, and more than one pair of eyes reviewing the project (AUSTROADS, 1994). Using a multi-disciplinary team also provides the opportunity to expand the number of persons in an organization that are experienced in the audit process

The size of the audit team will vary depending upon the size and type of project. It is recommended that the team consist of two to five multi-disciplinary individuals. The use of at least two individuals provides cross fertilisation. When the team becomes too large, it becomes difficult to reach a consensus and develop a focussed/concise audit. Additional expertise may be added to the project team as required at different stages of the audit process (*i.e.*, police officers, maintenance personnel, human factors, and others).

There may be projects that –due to their size– only require the review of a single plan, a field visit, and a one page report. In this situation, an audit by two or more individuals may not be justified. A carefully-selected individual may be sufficient to conduct the audit and raise issues that could result in significant safety-related savings.

3.4.5 Composition by Audit Stage

The selection of an audit team depends on the size and type of project, the stage of the audit and available resources. An assortment of young and older individuals may constitute the audit team. This ensures that safety issues are analyzed from a variety of perspectives. This information is a composite of current practices in other jurisdictions, including Australia, New Zealand, the United Kingdom, the United States, and Canadian provinces. The following are some suggestions for selecting an audit team (Hamilton Associates, 1998; Institution of Highways and Transportation, revised 1996).

3.4.5.1 Feasibility and Preliminary Design (Stages 1 and 2)

Audits undertaken at both the feasibility and preliminary design stages should only be conducted by an experienced audit team which includes:

- A road safety specialist experienced in:

(1) accident reconstruction and collision investigation;
(2) safety management;
(3) safety engineering;
(4) road safety audits; and
(5) knowledge of the latest safety research and standards.

C A highway design engineer who has knowledge of the current road design standards and practices. Furthermore, the engineer must be able to visualise the three-dimensional layout of the project from two-dimensional plans.

C An individual experienced in conducting road safety audits who can prompt discussions, assist in the audit procedure, and preferably has expertise with at least one prospective aspect of the audit.

Individuals involved in this type of audit can cover more than one of the above areas. A road safety specialist may also be a highway design engineer, or traffic engineer, who is familiar with the current road design standards and practices, and traffic operating conditions.

3.4.5.2 Detailed Design (Stage 3)

An audit at the detailed design stage requires the expertise identified in the previous section and may include additional individuals with expertise and skills, depending on the nature of the project, in such areas as traffic signal control, intelligent transportation systems, cyclists and pedestrians, transit systems and facilities, street lighting and traffic calming.

3.4.5.3 Pre-Opening (Stage 4)

Pre-opening audits require the expertise identified for Stage 1 and 2 audits. However, additional expertise may be added to the team where required. This may include one or more of the following: (1) a police officer with traffic and safety experience; (2) an engineer or supervisor who is familiar with all aspects of facility maintenance including signage, lighting, traffic controls, vegetation, snow removal, and others; and (3) an individual with knowledge of human behavioural aspects of road safety.

3.4.5.4 Post-Opening (Stage 5)

Post-opening audits require the same team composition and expertise as identified in the pre-opening audit stage.

3.4.5.5 Existing (In-Service) Roads

To evaluate the safety issues associated with existing roads, an audit team requires members with similar qualifications and experience to those individuals outlined in the pre-opening stage.

3.4.5.6 Municipal Audits

A municipal audit can be conducted by a single person or a team of experts. The selection of an auditor or audit team depends on the nature of the project and the city in which the audit is to be performed. Ideally, a municipal audit should be conducted by two or three auditors knowledgeable in traffic management and safety, road design, driver behaviour, and crash investigation and prevention, (Haiar and Wilson, 1999). Members of a municipal audit team should also have experience at street safety audits and must be able to assess and identify safety concerns of urban streets in an independent and objective manner.

In municipalities where funding is limited, hiring qualified consultants may not be feasible. Depending on the size of the audit, a reasonable alternative may involve utilizing local personnel from a nearby town or city. It is important that the auditor(s) possess adequate knowledge and skill in traffic safety engineering and that the auditor is not associated with the municipality requesting the audit.

3.5 ROLES AND RESPONSIBILITIES OF PARTICIPANTS

Terms of reference should be developed at the beginning of a project. This document should contain the scope of the audit and the roles and responsibilities of all parties (*i.e.*, client, design and audit team) involved in the audit. The terms of reference may be a standard agency document or one developed for a specific project. It should incorporate any special requirements of the audit (*i.e.*, a night site inspection during winter conditions) and describe the process for the presentation of the audit results.

From one agency to another, the roles and responsibilities of the parties involved in an audit will vary depending upon the resources available and the operating procedures for highway design and implementation. It is the responsibility of all parties to maintain good communication throughout the audit. This is to ensure the audit is conducted efficiently and to provide a means for resolving conflicts. The typical roles and responsibilities of all parties involved in the safety audit process are outlined in the following sections (Hamilton Associates, 1998; Institution of Highways and Transportation, revised 1996).

3.5.1 Client (Highway Authority)

Road safety audits should be considered an integral component of highway conception, feasibility and design processes. It is therefore essential that highway authorities allocate sufficient funding and resources to support the road safety audit process.

Highway authorities should: (1) consent to road safety audits as a quality management requirement; (2) commission audits at the proper project stages; and (3) review the formal audit report and act upon recommendations whenever appropriate and feasible. Without the client's full commitment to the process, particularly by giving genuine consideration to recommendations, the audit process becomes ineffective.

The highway authority should provide training at all levels within the organization to ensure that safety is an integral component of all phases of a highway project (*i.e.*, planning, design, construction, and maintenance). Correct training of personnel increases the potential of safety issues being identified by the audit team.

It is the responsibility of the highway authority to: (1) select an audit team with the appropriate training and experience; (2) provide project documentation; (3) ensure the auditors have satisfied the requirements described in the terms of reference; (4) attend the initial and completion meetings; and (5) refer all design changes to the audit team.

3.5.2 Design Team/Project Manager

It is the responsibility of the design team/project manager to provide the audit group with project background information (including previous audit reports), design drawings, traffic composition and characteristics, accident reports where available, and any other documentation affecting the design. The design team/project manager initiates audits when required; attends the initial and completion meetings; and reviews the issues raised by the audit report.

The audit report, in turn, provides the design team/project manager with a list of safety-related deficiencies; however, it should not provide specific design solutions or recommendations. As noted previously, the audit may list "possible" mitigative measures, but specific recommendations are not given. The responsibility of developing and adopting corrective solutions lies with the design team/project manager.

The design team/project manager in turn provides the audit team with a written response addressing all safety issues. This includes either: (1) accepting the possible mitigative measures and providing a design solution for the hazard; or (2) rejecting the measures and stating the reasons for this action.

It is the responsibility of the design team/project manager to assess financial and budget constraints to determine whether, how, or when to adopt an audit's suggested solutions. The design team/project manager is responsible for all design decisions; however, decisions may sometimes require the involvement of the highway authority (if design is being undertaken externally). Any design changes must be submitted to the audit team who decides whether to audit the revised design further or to incorporate it into the next audit stage.

3.5.3 Audit Team

The primary role of the audit team is to identify potential safety problems of a highway project by reviewing project documentation and drawings, and conducting site inspections. They typically do not redesign the project or implement changes. The audit team may use a developed set of checklists to assist them while conducting the audit. Checklists identify issues and problems that can arise at the relevant stages of an audit. These checklists are merely guides and should not be used as a substitute for experience. They also provide a measure of continuity from audit to audit.

The audit team is required to submit a report to the design team/project manager, identifying critical issues based on safety engineering experience. A completion meeting is held between the audit team, the design team/project manager, and the client to discuss the audit findings. The audit team is required to review the design team/project manager's response to the audit report. It is not the role of the audit team to approve of or agree with the obtained response.

3.6 ORGANIZATION OF ROAD SAFETY AUDITS

There are several methods of organizing a road safety audit while ensuring the audit team has the appropriate training, expertise and independence of the design team. AUSTROADS (1994) has developed a list of recommendations outlining how a road safety audit should be organized (similar information is not discussed in any of the other available published material). As indicated by AUSTROADS, there are three preferred ways of organizing a road safety audit: (1) audit by a specialist auditor or team; (2) audit by other road designers; and (3) audit within the original design team. Beyond the AUSTROADS model, there is a growing trend toward using a team which consists of numerous specialists. The team concept has the advantage of allowing the cross-fertilization of ideas and issues due to different perspectives.

3.6.1 Audits Conducted by a Specialist Auditor or Team

Specialist audit teams can be established within a highway organization or by consulting firms or consortia. Road safety audits should be conducted by an individual or team with adequate experience and training, and independent of the design team. This maximizes the effectiveness of the processes and ensures that unforseen safety problems are identified.

In cases where an audit is conducted by a specialist team, the audit findings can be reported in one of the following ways: (1) the specialist can report the findings to the client or an independent third party on behalf of the client; or (2) the specialist can report the findings directly to the original designer.

3.6.1.1 Specialist Audit Team, reporting to an Independent Third Party

The road safety audit team may submit a formal report to a third party who is responsible for deciding what actions are to be taken regarding the safety issues raised by the audit team. This method can be adopted by highway authorities when major highway projects are designed by a consulting firm. The design is submitted by the consulting firm to the audit team who submits a report to the independent third party. The independent third party provides the audit team and the Highway Authority with a documented response addressing all safety issues.

The third party may be a senior manager within a highway organization with no direct line of management to the project being audited. The possibility of conflicts between the audit team and the design team can be reduced when an independent third party is involved.

3.6.1.2 Specialist Audit Team, reporting to the Designer/Project Manager

This is similar to the previous method but the audit team report is submitted to the original designer or design team who provides the audit team and client with a documented response addressing all safety mitigative measures.

3.6.2 Audits Conducted by Other Road Designers

Audits conducted by another design team are an alternative means of conducting a road safety audit. This approach may be used by large highway organizations that have more than one design team. However, in cases where the highway organization only has one design team, it may be feasible to approach another road agency for assistance.

A weakness of this approach (*i.e.*, having road designers conduct audits) is the lack of multi-disciplinary knowledge that designers bring to the process. For example, they may have little or no experience in safety engineering, maintenance, operations, and accident investigation and prevention. The design team can assess the project for compliance to road design standards; however, these aspects are a minimal component of a road safety audit.

In cases where a safety audit is conducted by other road designers, the findings from the audit can be either submitted to the client, or an independent third party on behalf of the client; or to the designer/project manager for their comments.

3.6.2.1 Second Design Team, reporting to an Independent Third Party

The project is audited by another design team, within or outside an organization, and a written report is submitted to an independent third party on behalf of the client for review. The individual who provides the response to the audit report should have no direct line of management to the original or auditing designers. This is to make certain that independent appraisals can be made where disagreements arise. Note that a second design team can also lack the broader multi-disciplinary approach.

3.6.2.2 Second Design Team Audit, reporting to Designer/Project Manager

This approach is similar to the previous method (3.6.2.1); however, the audit report is submitted to the original design team or project manager. The disadvantages of this method are that the original designer may reject criticism of the design either for genuine reasons or time constraints. The original design team provides the auditing designers with a documented response addressing all safety issues raised.

3.6.3 Design Team Self-Audit

This type of road safety audit, which is the least desirable due to the lack of independence, is conducted by a member of the original design team. While all designers and design teams are typically concerned with safety, they are too familiar with the design process; therefore, they are prone to offer biassed opinions about the design. It is preferable that individuals who are not involved in the project conduct the audit.

3.7 TRAINING OF AUDITORS

There are currently no national guidelines for the training of road safety auditors. In Canada and abroad, short courses have been offered as an introduction to the road safety audit process which included some comments on training. Audit teams should be composed of individuals with a variety of backgrounds related to the design, maintenance, operations and safety evaluation of highway infrastructure. The benefits from safety audits will to a degree depend on the expertise, experience and common sense of the members of the team. It will be incumbent for the client to ensure that the personnel assembled for undertaking an audit provide a blend of appropriate expertise and experience.

There are varying philosophies concerning the designation of auditors. One such philosophy sets out very specific guidelines governing education and experience. Typically, a specific number of audits are required to be completed each year in order to maintain auditor status. For example, a *lead* auditor should have a particular number of years experience, have completed a training course and participated in a prescribed number of audits. Of these completed audits, a predetermined number must address specific design stages.

An alternate school of thought believes that highway safety is not "rocket science", but requires practical experience and training in the field. Audit participants should have completed a sound training program and have practical experience in one or more of the following areas: road design, human behaviour, traffic safety, reconstruction techniques, etc. A *lead* auditor should have previous audit experience, but need not have completed any specific number of audits and need not be active at a specified level each year. In many Canadian jurisdictions, it would not be possible to obtain exposure to say five audits each and every year.

UNB follows the second of the above mentioned philosophies. A less rigid scheme produces more benefits and allows a greater number of people to be involved in the audit process. To increase the awareness level of highway safety and expand the safety audit process, a provincial department of transportation/highways for example should develop a process that involves a number of their professionals in the audit process. A structured and restrictive system for the selection of auditors would be exclusionary and discourage that objective. A mandatory completion of a certain number of audits in a year is not crucial. The goal of training as many people in an organization as possible to understand the audit process, and therefore be able to participate in audit activity, is a better use of resources. It is not in the best interest of the road users, or of expanding the RSA concept, to establish a select number of auditors with stringent criteria.

The training course need not be extensive. A two day course would be sufficient to provide experienced personnel with enough knowledge for meaningful participation in an audit. Day 1 would provide an overview of audits. Topics to be covered include a history of audits, how and when to audit, and an explanation of the checklists and audit report preparation. Day 2 would consist of practical work, either laboratory or field exercises concerning both municipal and rural situations.

3.8 MONITORING AND EVALUATION

All highway organizations involved with safety audits should monitor and evaluate their road safety audit procedures. This may be accomplished by maintaining a complete record of the safety audit projects conducted by the organization. The record would contain a list of common deficiencies identified during all stages of road safety audits. This, in turn, provides feedback for designers and auditors performing future projects. The intent is to prevent recurring deficiencies from being designed into road projects. Otherwise, designers will continue to "build blackspots" into the road system.

4.0 ROAD SAFETY AUDIT PROCESS

This chapter presents an overview of the safety audit process. This refers to the complete process, from the selection of the audit team to the completion meeting and follow-up. A schematic of this is presented in Figure 4-1 and is consistent with the broad schemes presented by others (AUSTROADS, 1994). The chapter also discusses the methodology used when conducting audits at different project stages. Finally, the undertaking of municipal audits is addressed.

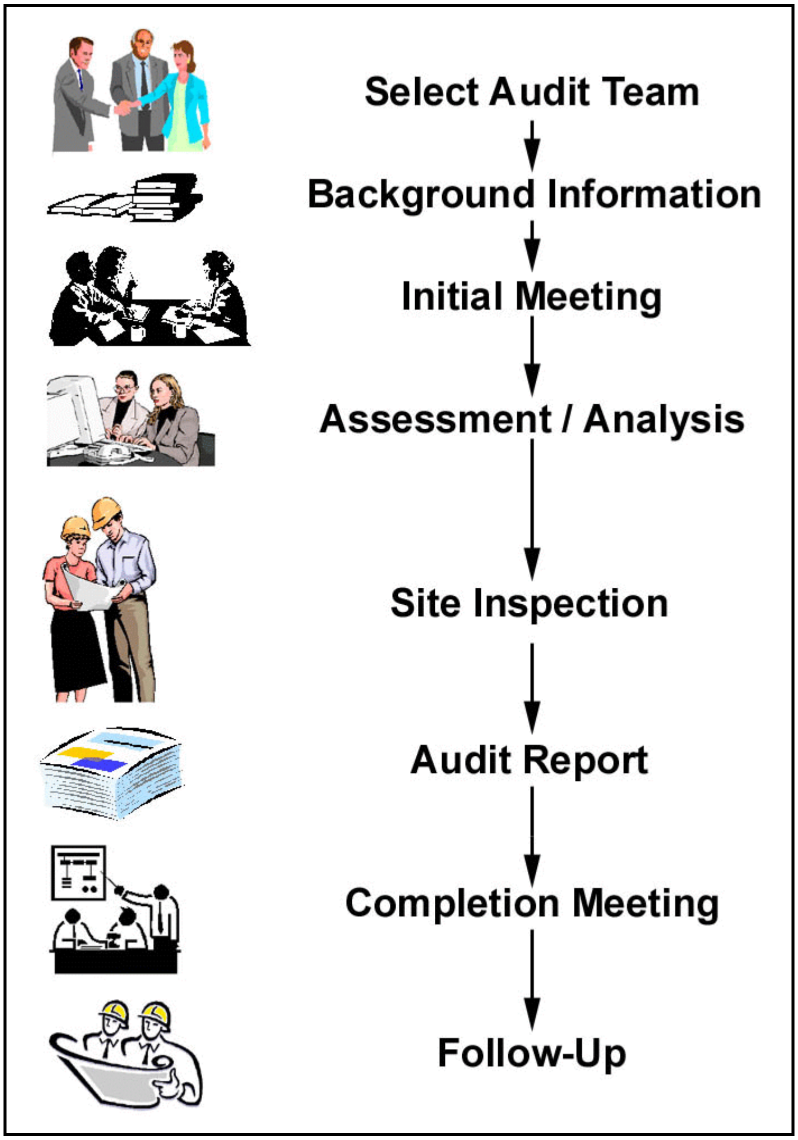


Figure 4-1: Process for Conducting Road Safety Audits

4.1 SELECTING THE AUDIT TEAM

It is the responsibility of the client to select the audit team. As previously noted, the audit team should be independent of the design team and have appropriate experience and training in road safety engineering. A list of potential auditors, including qualifications, would be beneficial to the client when selecting the audit team. An audit team leader should be selected who has experience in road safety engineering and has participated in previous audits. The client should exercise caution when selecting the audit team. The team with the lowest bid is not always the most experienced. In road safety audits, experience is paramount, and cost is secondary.

4.2 COLLECTION OF BACKGROUND INFORMATION

The client is responsible for providing all relevant project documentation; including reports, data, drawings, contract documents and where required traffic volumes. This information will be used by the audit team to assess the project from a safety perspective. Further details about this are discussed in Section 4.4.1.1.

4.3 INITIAL MEETING

An initial meeting is normally held between the audit team, client and designer. The objective of this meeting is to familiarize the audit team with the project scope and safety-related information, exchange data, delegate responsibilities, and to set up communication lines (Hamilton Associates, 1998).

The audit team can familiarize the designer and client with the audit process and familiarize the design team with the checklists to be used. The client/designer should inform the audit team of any problems encountered during the planning, design, and construction stages. The terms of reference identifying the project scope, and roles/responsibilities during the audit should be completed. Project schedules and special requirements should be identified and discussed at this stage.

4.4 THE PROCESS

After the initial meeting, it is the responsibility of the audit team to assess the project documentation and to conduct site inspections (if appropriate) to determine the safety-related issues of the project. The following sections present the process used when conducting road safety audits for highways, isolated facilities, and in municipalities. This information is a composite of current practices in other jurisdictions, including Australia, New Zealand, the United Kingdom, the United States, and Canadian provinces.

4.4.1 Highway Audits

Figure 4-1 shows the general steps to follow when conducting road safety audits (this also applies to audits of isolated facilities, and municipalities). While all the steps apply to all audit stages, there are specific items to consider in each of the different steps, depending on the audit stage.

4.4.1.1 Background Information

The client must provide the audit team with all necessary background information prior to the start of the audit. This information will assist the team in developing an adequate assessment of the facility prior to the audit.

For audits at the feasibility stage, the required background information may include:

(1) project scope, goals, and objectives;
(2) general project constraints;
(3) route choice and layout options;
(4) continuity with adjacent road networks and land uses; and
(5) environmental and geotechnical constraints.

For audits at the preliminary and detailed design stage, the required background information may include:

(1) standards and design criteria used;
(2) land acquisition;
(3) information about previous consultation with the community;
(4) design drawings;
(5) details of plans;
(6) plans showing adjacent roads which may be affected by the project;
(7) traffic forecasts;
(8) right-of-way; and
(9) potential/expected road users.

For audits at the pre-opening stage, it is necessary to provide the audit team with previous audit reports (if available) and other relevant information, such as road users expected to travel on that road. Audits that are conducted at the post-opening stage or on existing facilities require background information regarding:

(1) traffic volumes for all road users;
(2) collision information;
(3) previous audit reports–if available; and
(4) as-built drawings.

4.4.1.2 Assessment/Analysis of Background Information

Once all the background information is collected, the audit team needs to assess/evaluate and analyze all the available information. For audits at the feasibility, preliminary design, or detailed design stage, the audit team should examine the details about the proposed project, details of plans and background information on a section by section basis. This provides an opportunity to consider the impact of the design on all road users.

If the audit is being conducted at the pre-opening or post-opening stage, or if this is an audit of an existing facility, the team should analyze all pertinent information such as accident reports (this does not apply to pre-opening stage), and all other relevant information. The analysis of accident reports is not intended to be used as a blackspot analysis, but as an aid for the auditors in determining potential areas with safety problems. This would make the audit pro-active rather than reactive.

The use of a multi-disciplinary team provides the opportunity for 'brainstorming' sessions. This results in a more constructive and comprehensive assessment of safety issues.

4.4.1.3 Site Inspections

Field inspections are required at all stages because they provide the team with a feel for the existing conditions.

Prior to going to the field, the team should become familiar with checklists to ensure the inspection is productive and relevant concerns are raised. The use of checklists, in addition to background information, will assist the auditors to ensure that relevant safety aspects are addressed. Checklists should not be used as a substitute for experience, nor considered exhaustive.

For audits at the feasibility, preliminary design, and detailed design stages, the team conducts a site inspection, including 'green field' sites, upon completion of the preliminary assessment. The audit team should examine the transition between any new and existing roads to ensure consistency from a multi-modal perspective. This includes cyclists, elderly drivers, elderly pedestrians, truck and bus drivers, pedestrians, children, disabled, all terrain vehicles, and snowmobiles. Additionally, the team should focus on prevailing climate and geographic conditions.

Audits at the pre-opening and post-opening stage, as well as audits of existing facilities, review the physical characteristics of the project by conducting a site inspection. These inspections involve assessing the furniture, signs, lighting, markings, delineation, and geometric features from a multi-modal perspective. The team should identify issues that may affect the road users' perception of the road or restrict sight lines. In the case of pre-opening audits, the inspection should be conducted as close as possible to the opening date but still allow time for the design team to implement any changes. For larger projects, pre-opening audits may be conducted in phases as the sections of the project become complete.

The audit team should conduct the inspection by driving and walking (if feasible) through the project in opposite directions. In addition, site inspections should be conducted at night and in adverse weather conditions if possible. The team should consider going beyond project limits to assess the adjacent road network, paying particular attention to the interface if it is a new project. Photographs and videotapes can be used to capture roadway features for later discussions.

After conducting the site inspection, document assessments and site inspection material are analyzed, with the use of checklists, to determine if all relevant safety issues were addressed. The team should not address non-safety related issues such as aesthetics, amenities, etc. An audit should not be used to simply evaluate highway capacity issues.

4.4.1.4 Audit Findings

Once the site inspections are completed, the audit report is prepared. The report should clearly and concisely describe the project, the audit stage, the audit team members, the process of the audit, any safety issues identified, and mitigative countermeasures. These countermeasures are conceptual in nature and should not provide the design team with design solutions. If time constraints are identified in pre-opening audits, a preliminary report may be developed immediately and submitted to the project manager before the final report is prepared.

4.4.2 Audits of Isolated Facilities

Road safety audits can also be used to evaluate isolated safety concerns of a highway facility. An audit of a localized facility can be conducted where a change in design of a section or all of an existing facility has been proposed. For example, the audit team may be required to conduct a safety audit on a short section of highway that requires realignment. Similarly, the proposed widening of an auxiliary lane at an existing intersection may be audited. In either case, the audit of an isolated facility investigates the safety issues at various stages of design and construction. Since the safety issues will vary depending on the facility, no single checklist can be recommended for this style of audit. Furthermore, depending on the project, it may not be necessary to conduct a full-scale audit of each stage of the design process. Audits of isolated facilities can also be conducted following the steps illustrated in Figure 4-1. The type of project to be audited determines the initial stage at which the audit will be conducted. Table 4-1 illustrates the various isolated projects that an audit team may encounter, as well as recommended design stages that may apply to the audit process.

Table 4-1: Isolated Facility Projects and Recommended Design Stage Audits

Facility	AUDIT STAGE				
	Feasibility	Preliminary Design	Detailed Design	Pre-Opening	Post- Opening and Existing
Curves		T	T		
Interchanges	T	T	T	T	T
Intersections	T	T	T	T	T
Lane Width		T	T		
Lane Alignment		T	T	T	
Lane Cross Section		T	T	T	

Note: **T** denotes recommended

4.4.3 Municipal Audits

The literature available to date has focused primarily on safety concerns associated with individual highways. However, a safety audit can be applied to a network of local streets and intersections within an urban or municipal setting. Identifying the safety issues associated with municipal roads is a relatively new concept in the field of safety audits. In fact, most road safety manuals currently available do not address this topic. A possible explanation for this lack of attention is that the municipal audit focus can be quite broad. Specifically, a municipal audit can be conducted on a section of road or a network of streets. Furthermore, municipal audits can also be performed on existing streets or roads developed for new housing subdivisions. Despite its broad definition, the audit of urban roads should not be overlooked. The safety issues identified in a municipal audit are important for minimizing the potential for future accidents within an urban setting.

A set of checklists for a municipal audit have been developed for this manual. These checklists can be used as a stand-alone document on-site regardless of the municipal audit focus. When performing an audit of a road designed for a new subdivision, however, auditors are encouraged to supplement the municipal checklists with the checklists developed for new highways. It is important to note that the numbering system presented in this document for linking together the *Master* and *Detailed* checklists for a municipal audit is different from the system prepared for new/existing highways. The list of safety items investigated in a municipal audit is more extensive than a highway audit and for those items common to municipal and highway checklists, the detailed descriptions can differ.

4.5 DOCUMENTATION AND AUDIT REPORT

The audit report should clearly and concisely identify aspects of a project which could impact negatively on the level of safety for users. It is not the responsibility of the audit team to provide specific recommendations to modify the safety deficiencies. During the audit, there may arise safety issues for which there are no specific short term remediations. In this case, the safety issues should not be ignored but identified for further investigation.

A number of methods are used to list safety issues within an audit report. One method is to rank the issues from the most to the least important (AUSTROADS, 1994). All safety hazards which warrant immediate remediation should be identified with words such as "FOR IMMEDIATE ATTENTION". Any safety problems which the audit team considers to be significantly hazardous should be identified as "IMPORTANT". The use of these terms does not imply that the other safety issues resulting from the audit are unimportant.

The approach described above can inadvertently result in the audit's client, after considering the ranking, deciding that those not highlighted or "flagged" as important receive less consideration than warranted or not receive any consideration within a reasonable time frame. The Audit Team should consider other categories for listing or prioritizing the audit issues in a manner that clearly conveys the priority ratings intended by the Team. The underlying concern is whether any issue should be listed in an audit which the Audit Team does not believe requires attention by the client within a reasonable time frame. If an issue is not of sufficient importance to receive timely consideration and action then Audit Teams should not list those items. The Audit Team should guard against the inclusion of individual Team members personal viewpoints on highway safety.

The audit team should maintain communication with the designer/project manager to discuss any misunderstandings or uncertainties before making final comments. These may be avoided if the audit team is provided with all background information.

A road safety audit report should contain, as a minimum, the following sections:

1. Report title page
    a. Audit stage (*e.g.*, Stage 3: 50% Detailed Design Road Safety Audit)
    b. Project name
    c. Project location
    d. Date
    e. Audit team members and qualifications
    f. Clients name and address

2. Introduction
    a. Auditors and Audit Process
        i. Stage of Audit
        ii. Location (Map)

        iii. Audit Process
            1. Meetings (including with whom, date and reason for meeting)
            2. Inspections (date and whether day or night)
            3. Discuss documentation not provided and reasons
            4. Discuss information that was not provided on plans
            5. Description of the procedure used to conduct the audit
            6. Statement regarding the disclaimer for liability of the audit team

    b. Description of Project

        This section provides a brief description of the project.

    c. Deficiencies and ranking of safety issues

        Description of the ranking system used for identifying: safety hazards which warrant immediate attention or removal; those that are considered to present a serious safety hazard; and, those requiring attention and are in the category of general safety concerns.

d. Responding to the Audit Report

Identify that the client and designer are under no obligation to accept all safety issues raised by the audit team but must respond stating their acceptance/rejection of suggestions and reasons. Describe the format the design team may use to document their response to the audit findings. Example of a concise format:

AUDIT FINDINGS	AUDIT RECOMMENDATIONS	CLIENT RESPONSE	
		ACCEPT: YES/NO	REASONS/ COMMENTS

3. Safety Issues from Previous Audit Stages

Identify and list safety issues from any previous audits which still require attention.

4. Findings from Current Audit

Provide a brief statement of deficiencies identified during site inspections and review of documentation. Photographs may be used to illustrate deficiencies.

5. Next Audit Stage

The audit team may recommend when the next audit will be conducted if information was not provided to assess a portion of the project.

6. Concluding Statement

7. Names and Signatures of Auditors

4.6 COMPLETION MEETING

Once the audit report has reached the stage where all findings are clearly documented, a completion meeting should be held to allow all interested parties a chance to interact and discuss the results. This meeting should precede the development of client responses to the audit team's findings. The completion meeting should involve the audit team, the client, the design team, and any other employees who might be involved in formulating responses to the audit findings.

The objective of the completion meeting is to foster a constructive dialogue centred on the audit report findings. The meeting provides an opportunity to:

1. formally present the audit findings and clarify or elaborate their meaning,
2. suggest improvements to the report structure,
3. discuss possible remedial measures for problems identified, and
4. set a timetable for completion of client responses.

It is crucial that a positive, constructive, and cooperative tone pervade the meeting. The meeting should be prefaced with a reminder that the intent of an audit is simply to enhance safety of the final project and that it is not a critique of individual or design team performances. It is essential for those involved to believe that the audit is a beneficial part of project development. Special effort therefore should be made to ensure that those involved have been educated in the audit process and the positive experiences associated with it. Meeting facilitators should be careful to maintain an atmosphere for positive exchange and not to permit animosity or unfounded disagreement. Discretion and insight are required attributes that all parties should bring to the meeting.

4.7 FOLLOW-UP

The follow up process is lead by the designer/project manager. The designer/project manager reviews the audit report and prepares a written response to each concern cited. Each remedial measure suggested in the audit report can be accepted or rejected. For each accepted suggestion, logical remedial measures should be identified and adopted by the designer/project manager. The redesign should then advance to diminish the safety hazard. All project redesigns should be submitted to the audit team for consideration or re-auditing. The designer/project manager must make sure that modifications are made to the project which result from agreed improvements described in the audit report.

For each audit suggestion rejected, justification (physical, economic, or social) should be documented in the report by the client. The designer/project manager should confirm the decided action for every suggestion in the audit report. Both the audit report and the designer/project manager's response become part of the final audit record. A formal signed acceptance of the final report may be a requirement within the organization.

5.0 OVERVIEW OF CHECKLISTS FOR ROAD SAFETY AUDITS

This chapter presents an overview of checklists for road safety audits. The chapter discusses the structure of the checklists, as well as their use. The master checklist and detailed checklists are also discussed in this chapter. The checklists developed for this manual are based on Australian, New Zealand, United Kingdom, United States, and Canadian experiences.

5.1 STRUCTURE OF CHECKLISTS

The four series of checklists developed for this manual are contained in Appendices A and B. Two of the checklists apply to highway audits (Appendix A), and two apply to municipal audits (Appendix B). For each case, there is a *master* checklist and a *detailed* checklist. The *master* checklist provides the auditor with a general listing of the topics to be considered depending on the stage of design at the time of audit. The *detailed* checklists elaborate on the topics contained in the *master* checklist. These lists provide exemplary issues/items to be considered - grouped by area of concern (*e.g.*, alignment, intersections, road surface, visual aids, physical object, and others). The detailed checklists contain two columns: one that displays the audit item, and another that provides key points to consider for each item when conducting the audit. Appendix C contains case studies of a highway and a municipal audit where these checklists were applied.

It is important to note that the checklists should serve only as a guide or memory-aid for the individual or team conducting the safety audit. They are not all inclusive, nor are they intended to be used as a substitute for knowledge or experience.

5.2 USE OF CHECKLISTS

The first step involved in using the system of checklists presented in this manual is to refer to the appropriate column in the *master* checklist depending on the design stage being audited. The *master* checklist can then be used to scan the key topics to be considered for that audit. The *master* checklist should encourage the auditor to begin thinking about the safety audit and help identify any additional topics that are not included in the manual. The *detailed* checklist should be consulted if a *master* checklist item is vague or misunderstood. The *detailed* list should be consulted before, during, and after the field portion of the safety audit.

During the field visit, team members may wish to carry a copy of both the *master* and *detailed* checklists. It must be reemphasized that the checklists provided in this manual should only be used as a guide or memory aid. The topics listed are intended to remind the auditor or audit team of common elements involved in a safety audit. A comprehensive safety audit can only be achieved through the collaboration and participation of each auditor during the audit process based on individual experience and knowledge.

6.0 ECONOMIC IMPLICATIONS OF ROAD SAFETY AUDITS

This chapter provides an overview of the economic implications of road safety audits. The chapter is divided into three sections that include: (1) costs of conducting road safety audits; (2) benefits; and (3) benefit-to-cost ratios associated with road safety audits.

6.1 COSTS OF CONDUCTING ROAD SAFETY AUDITS

In the safety audit manual published by TNZ (1993), the cost of audits was divided into three categories: consultant fees, the client's time to manage the audit, and costs associated with implementing recommendations that are adopted. The client's time on a project averaged about 1 day per audit. It is important to note that additional costs may result from changes to a project's scope and schedule. RTA indicated that a safety audit of a new facility cost approximately the same as a geotechnical survey (FHWA Study Tour, 1997).

Recent experience places the average cost of a conventional audit for small to mid-sized projects between $1,000 and $5,000 (Sabey, 1993, Jordan, 1994, Pieples, 1999). TNZ found that fees range from NZ$1000 to $8000 (US$700 to $6000) with most falling in the NZ$3000 to $5000 (US$2000 to $3600) range (1993). The actual cost depends greatly on the size and complexity of the project and composition of the required audit team. Hamilton Associates estimate that audits add approximately 5 to 10 percent to design costs, or less than one-half of 1 percent to construction expenses (1998). These estimates are slightly higher than costs experienced to date for the MRDC project. AUSTROADS approximates that audits will add 4 to 10 percent to the road design costs (1994). As design costs are roughly 5 to 6 percent of the project sum, the increase in total cost is usually quite small. On smaller projects (traffic calming or retrofits), the costs may be a higher percentage of the overall capital cost. Costs of redesign/rectification should be considered which will vary on a project-to-project basis. The cost of rectifying deficiencies depends on how early in the design process the problem is identified as well as the amount of time required to redesign the area.

6.2 BENEFITS OF CONDUCTING ROAD SAFETY AUDITS

Benefits of road safety audits extend from economics of reduced accidents to improvements in policy and design. Some of these benefits include:

- Safer highways through accident prevention and accident severity reduction. Research in the United Kingdom indicated that up to 1/3 of collisions may be prevented on a road that has been audited. Other research indicated a 1 to 3 percent reduction in injury collisions.
- Safer road networks.

- Enhancement of road safety engineering.
- Reduced whole life costs of road schemes.
- Reduced need to modify new schemes after construction.
- A better understanding and documentation of road safety engineering.
- Safety improvements to standards and procedures in the future.
- More explicit consideration of the safety needs of vulnerable road users.
- Encouragement of other personnel in road safety.
- Foster a principle of safety conscious design among owners and designers.
- By providing a high quality product, the potential for future remedial work may be reduced, thus reducing the overall risk taken by the agency.
- Claims cost savings, lower health care and societal costs due to reduced collisions.
- Design improvement.
- Enhancement of the corporate safety culture .
- Cross-fertilization between specialists within a highway department (eg. Design, Maintenance, Traffic, etc.).

(AUSTROADS, 1994; Hamilton Associates, 1998).

6.3 BENEFIT-TO-COST RATIOS ASSOCIATED WITH ROAD SAFETY AUDITS

Although cost effectiveness of road safety audits is difficult to estimate, Scotland has estimated a benefit:cost ratio of 15:1 based on experience, while New Zealand has estimated the ratio to be closer to 20:1 (TNZ, 1993). A 1994 study of minor works projects in Surrey compared 2 groups matched by project type; one group having been audited, the other not. It was determined that the economic benefits would be well in excess of the audit cost for these small projects. For larger projects, the potential saving in casualties is likely to be greater, justifying the greater resources incorporated within their audits.

7.0 SAFETY AUDIT LEGAL ISSUES - AN OVERVIEW

Safety audits are a vehicle to identify deficiencies or problems which have the capacity to impact on the safety of highway infrastructure. They also identify remedial actions that could reduce or eliminate the potential safety problems. These audits raise legal issues which the auditor should consider. The time frame during which safety audits have been used is short relative to that required for building case histories on which legal precedence can be based and/or influenced.

The experience to date in the United Kingdom and Australia indicate that claims related to the use of safety audits have not been a problem. The experience in Canada is the same. In the United States, where the level of road accident litigation is considered to be high, the use of road safety audits is not yet extensive and the litigation climate has not commenced.

Notwithstanding this positive record, road safety audits will play an increasing role in road accident litigation. This situation should not influence the adoption of the safety audit process. The associated legal issues should be recognized and legal counsel obtained by particular parties to the process on an as required basis.

A statement in the AUSTROADS (1994) report on Road Safety Audits is worth noting by those individuals/agencies concerned with the legal issues related road safety audits. That statement is: “Will the undertaking of road safety audits expose those authorities that adopt them to greater liability than at present? The answer is no.”

The authors of the UNB manual are of the opinion that consideration should be given to the possibility that the non-use of road safety audits in an environment where they are being extensively applied elsewhere could raise in the legal environment the question: “Will the absence of the use of a road safety audit which could have identified the safety problem under consideration be considered in a negative context by the courts?” We believe that the answer to this question will eventually be *“yes”*.

The history of legal discussions relative to highway safety in England, Australia, New Zealand, etc. is different than Canada. This fact further complicates the comparison of the climate around the safety audit legal issues between those jurisdictions and Canada. The bottom line is that any highway authority owes a duty of care to the users of the facilities to provide a safe roadway operating environment and not to omit strategies that are known to improve highway safety. Road safety audits provide a means to check that all reasonable safety initiatives have been taken in the planning, design, construction and operation of roadways.

A useful reference on the issue of legal aspects of road safety audits is an introductory assessment of the potential legal impact upon the participants in the audits and review process. That paper was prepared in British Columbia and is included as Appendix A in the discussion paper prepared by Hamilton Associates (1998). Since there does not exist any body of legal references on the topic, examples used in the document relate to hypothetical cases or situations.

In Canada, there is a Supreme Court decision that "true policy decisions should be exempt from tort claims so that governments are not restricted in making decisions based upon social, political or economic factors. However, the implementation of those decisions may well be subject to claims in tort" (Justice vs. British Columbia (1994)). This position should be considered when owners/clients are responding to a safety audit. To use this position to reject safety audit findings of specific safety issues based simply on social, political or economic factors would no doubt require solid justification beyond just a general policy statement.

The owner/client's response to the audit report should provide reasons for not accepting any finding/recommendation. The reason for the detailed response is that in most jurisdictions in Canada the safety audit report can, through the right to information Acts, find its way to the public forum and hence to any lawyers who may commence action on any real or perceived safety issue. This fact should not deter the use of audits but instead ensure that responses are detailed and defendable.

Chapter 3 contains a discussion of the stages at which road safety audits can be effective and the types of projects where audits can be applied. There is concern in some circles that safety audits applied to **existing** facilities could increase an agency/owner's exposure to liability if safety issues identified on existing facilities are not addressed or not addressed within a reasonable time frame. The authors believe that it is a short sighted position to avoid auditing existing facilities in fear of litigation. In fact, as safety audits become more widely accepted and applied such a position may even attract litigation. One of the benefits of safety audits is to increase for the user the level of safety of the facility. Should not the users of existing facilities receive the same benefits as users of new facilities?

Safety audits of existing facilities can identify safety deficiencies and provide suggested remedies. In turn this data can be used to establish priorities and a time frame to implement improvements. (This is not far removed from some black spot programs that have been in place in jurisdictions for decades).

It is unlikely that some employees of an agency/owner would not have been aware of some of the safety issues identified in a safety audit report of an existing facility. To argue that avoiding a safety audit will enable the agency/owner to plead "ignorance" of safety deficiencies on an existing facility appears to be ill founded. Safety audits of existing facilities will only strengthen an agency/owner's ability to defend against litigation arising from safety issues on existing facilities.

Members of a safety audit team can incur exposure to liability unless they are very specific as to their role in conducting audits. Auditors must be clear that they are not performing any design role. Further, it must be explicitly stated that they are not approving any designs or operational procedures. The auditors are simply identifying safety issues or concerns that have the potential to lower the safety level of the facility under review. They must be specific that no guarantee is being made that every safety issue will be identified in an audit - rather that a reasonable effort will be made to identify issues and/or deficiencies.

The authors believe that upon completing an audit the sole auditor (or team) should clearly identify their position with a statement in the report similar to the one stated below.

> *"This audit (identify it as a design, pre-opening, night time audit, etc.) covers physical features which may affect road user safety and it has sought to identify potential safety hazards. However, the auditors point out that no guarantee is made that every deficiency has been identified. Further, if all recommendations in this report were to be followed, this would not confirm that the highway is "safe" rather, adoption of the recommendations should improve the level of safety of the facility"* (Wilson, 1999).

Some highway safety audits could become a factor at some time in litigation. The benefits of safety audits far outweigh legal issue disbenefits and the legal environment should not deter agencies/owners from adopting audits.

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Appendix A

Master Checklist

MASTER CHECKLIST

NEW FACILITIES / UPGRADES ³ DEVELOPMENT STAGES þ					EXISTING ROADS
FEASIBILITY (PLANNING) STAGE	**PRELIMINARY (DRAFT) DESIGN**	**DETAILED DESIGN**	**PRE-OPENING**	**POST-OPENING**	
GENERAL	**GENERAL**	**GENERAL**	**GENERAL**	**GENERAL**	**GENERAL**
G1. Scope G2. Staging of Construction G12. Consistency of Design Parameters	G2. Staging of Construction G5. Changes since Previous Audit G12. Consistency of Design Parameters G13. Rest areas/Picnic sites	G2. Staging of Construction G3. New/Old Facility Interaction * G4. Impact on Adjacent Networks * G5. Changes since Previous Audit G6. Traffic Barrier Warrants G7. Landscaping G12. Consistency of Design Parameters G13. Rest areas/Picnic sites	G3. New/Old Facility Interaction * G5. Changes since Previous Audit G6. Traffic Barrier Warrants G7. Landscaping G8. Construction Clean-up G12. Consistency of Design Parameters G13. Rest areas/Picnic sites	G3. New/Old Facility Interaction * G6. Traffic Barrier Warrants G7. Landscaping G9. Temporary Works G10. Headlight Glare G12. Consistency of Design Parameters G13. Rest areas/Picnic sites	G6. Traffic Barrier Warrants G7. Landscaping G9. Temporary Works G10. Headlight Glare G11. Accident Reports G12. Consistency of Design Parameters G13. Rest areas/Picnic sites

** denotes items unique to upgraded facilities*

Master Checklist (continued)

NEW FACILITIES / UPGRADES ³ DEVELOPMENT STAGES þ					EXISTING ROADS
FEASIBILITY (PLANNING) STAGE	**PRELIMINARY (DRAFT) DESIGN**	**DETAILED DESIGN**	**PRE-OPENING**	**POST-OPENING**	
ALIGNMENT AND CROSS SECTIONS	**ALIGNMENT AND CROSS SECTIONS**	**ALIGNMENT AND CROSS SECTIONS**	**ALIGNMENT AND CROSS SECTIONS**	**ALIGNMENT AND CROSS SECTIONS**	**ALIGNMENT AND CROSS SECTION**
A1. Classification A2. Design Speed / Posted Speed * A3. Route Selection/ Alignment A4. Cross Sectional Elements	A1. Classification A2. Design Speed/Posted Speed * A3. Route Selection/ Alignment A4. Cross Sectional Elements A4.1 Drainage A4.2 Lane Width A4.3 Shoulders A4.4 Cross Slopes/ Superelevation A4.5 Pavement Widening A5. Alignment A5.1 Horizontal A5.2 Vertical A5.3 Combined Vertical and Horizontal A6. Sight Distance A8. Bridge Structures	A2. Design Speed/Posted Speed * A4. Cross Sectional Elements A4.1 Drainage A4.2 Lane Width A4.3 Shoulders A4.4 Cross Slopes/ Superelevation A4.5 Pavement Widening A5. Alignment A5.1 Horizontal A5.2 Vertical A5.3 Combined Vertical and Horizontal A6. Sight Distance A8. Bridge Structures	A2. Design Speed/Posted Speed * A4. Cross Sectional Elements A4.1 Drainage A4.2 Lane Width A4.3 Shoulders A4.4 Cross Slopes/ Superelevation A4.5 Pavement Widening A5. Alignment A5.1 Horizontal A5.2 Vertical A5.3 Combined Vertical and Horizontal A6. Sight Distance A8. Bridge Structure	A2. Design Speed/Posted Speed * A4. Cross Sectional Elements A4.1 Drainage A4.2. Lane Widths A4.3. Shoulders A4.4. Cross Slopes/ Superelevation A4.5. Pavement Widening A5. Alignment A5.1 Horizontal A5.2 Vertical A5.3 Combined Vertical and Horizontal A6. Sight distance A7. Readability by Drivers A8. Bridge Structure	A1. Classification A2. Design Speed/Posted Speed * A4. Cross Sectional Elements A4.1. Drainage A4.2. Lane Widths A4.3. Shoulders A4.4. Cross Slopes/ Superelevation A4.5. Pavement Widening A5. Alignment A5.1. Horizontal A5.2. Vertical A5.3. Combined Vertical and Horizontal A6. Sight Distances A7. Readability by Drivers A8. Bridge Structures

** denotes items unique to upgraded facilities*

Master Checklist (continued)

NEW FACILITIES / UPGRADES ³ DEVELOPMENT STAGES þ					EXISTING ROADS
FEASIBILITY (PLANNING) STAGE	**PRELIMINARY (DRAFT) DESIGN**	**DETAILED DESIGN**	**PRE-OPENING**	**POST-OPENING**	
INTERSECTIONS	**INTERSECTIONS**	**INTERSECTIONS**	**INTERSECTIONS**	**INTERSECTIONS**	**INTERSECTIONS**
S1. Quantity S2. Type S3. Location / Spacing	S3. Location/Spacing S4. Visibility/Conspicuity S5. Layout S6. Sight Distances	S3. Location/Spacing S4. Visibility/Conspicuity S5. Layout S5.1 Manoeuvres S5.2 Auxiliary/Turning Lanes S6. Sight Distance S7. Controls S7.1 Markings S7.2 Signs S7.3 Signals S7.4 Signal Phasing S8. Warnings	S3. Location/Spacing S4. Visibility/Conspicuity S5. Layout S5.1 Manoeuvres S5.2 Auxiliary/Turning Lanes S6. Sight Distances S7. Controls S7.1 Markings S7.2 Signs S7.3 Signals S7.4 Signal Phasing S8. Warnings	S3. Location/Spacing S4. Visibility/Conspicuity S5. Layout S5.1 Manoeuvres S5.2 Auxiliary/Turning Lanes S6. Sight Distances S7. Controls S7.1 Markings S7.2 Signs S7.3 Signals S7.4 Signal Phasing S8. Warnings	S3. Location/Spacing S4. Visibility/Conspicuity S5. Layout S5.1 Manoeuvres S5.2 Auxiliary/Turning Lanes S6. Sight Distances S7. Controls S7.1 Markings S7.2 Signs S7.3 Signals S7.4 Signal Phasing S8. Warnings

Master Checklist (continued)

NEW FACILITIES / UPGRADES ³ DEVELOPMENT STAGES þ					EXISTING ROADS
FEASIBILITY (PLANNING) STAGE	**PRELIMINARY (DRAFT) DESIGN**	**DETAILED DESIGN**	**PRE-OPENING**	**POST-OPENING**	
INTERCHANGES	**INTERCHANGES**	**INTERCHANGES**	**INTERCHANGES**	**INTERCHANGES**	**INTERCHANGES**
C1. Considerations C2. Location/Spacing C6. Lane Balance/Basic Lanes/Lane Continuity	C2. Location/Spacing C3. Weaving Lanes C4. Ramps C4.1. Exit Terminals C4.2. Entrance Terminals C6. Lane Balance/Basic Lanes/Lane Continuity	C2. Location/Spacing C3. Weaving Lanes C4. Ramps C4.1 Exit Terminals C4.2 Entrance Terminals C5. Service Road Systems C6. Lane Balance/Basic Lanes/Lane Continuity C7. Auxiliary/Turning Lanes	C2. Location/Spacing C3. Weaving Lanes C4. Ramps C4.1 Exit Terminals C4.2 Entrance Terminals C5. Service Road Systems C6. Lane Balance/Basic Lanes/Lane Continuity C7. Auxiliary/Turning Lanes	C2. Location/Spacing C3. Weaving Lanes C4. Ramps C4.1 Exit Terminals C4.2 Entrance Terminals C5. Service Road Systems C6. Lane Balance/Basic Lanes/Lane Continuity C7. Auxiliary/Turning Lanes	C2. Location/Spacing C3. Weaving Lanes C4. Ramps C4.1 Exit Terminals C4.2 Entrance Terminals C5. Service Road Systems C6. Lane Balance/Basic Lanes/Lane Continuity C7. Auxiliary/Turning Lanes
			ROAD SURFACE	**ROAD SURFACE**	**ROAD SURFACE**
			R1. Skid Resistance	R1. Skid Resistance	R1. Skid Resistance R2. Pavement Defects R3. Surface Texture R4. Ponding

Master Checklist (continued)

NEW FACILITIES / UPGRADES ³ DEVELOPMENT STAGES þ					EXISTING ROADS
FEASIBILITY (PLANNING) STAGE	**PRELIMINARY (DRAFT) DESIGN**	**DETAILED DESIGN**	**PRE-OPENING**	**POST-OPENING**	
		VISUAL AIDS	**VISUAL AIDS**	**VISUAL AIDS**	**VISUAL AIDS**
		D1. Pavement Markings D2. Delineations D3. Lighting D4. Signs	D1. Pavement Markings D2. Delineation D3. Lighting D4. Signs	D1. Pavement Markings D2. Delineation D3. Lighting D4. Signs	D1. Pavement Markings D2. Delineation D3. Lighting D4. Signs
PHYSICAL OBJECTS	**PHYSICAL OBJECTS**	**PHYSICAL OBJECTS**	**PHYSICAL OBJECTS**	**PHYSICAL OBJECTS**	**PHYSICAL OBJECTS**
P1. Poles and Other Obstructions P2. Medians	P1. Poles and Other Obstructions P2. Medians	P1. Poles and Other Obstructions P2. Medians P3. Hazardous Object Protection P4. Clear Zone P5. Culverts P6. Railroad Crossings	P1. Poles and Other Obstructions P2. Medians P3. Hazardous Object Protection P4. Clear zone P5. Culverts P6. Railroad Crossings	P1. Poles and Other Obstructions P2. Medians P3. Hazardous Object Protection P4. Clear Zone P5. Culverts P6. Railroad Crossings	P1. Poles and Other Obstructions P2. Medians P3. Hazardous Object Protection P4. Clear Zone P5. Culverts P6. Railroad Crossings
ENVIRONMENTAL CONSIDERATIONS	**ENVIRONMENTAL CONSIDERATIONS**	**ENVIRONMENTAL CONSIDERATIONS**	**ENVIRONMENTAL CONSIDERATIONS**	**ENVIRONMENTAL CONSIDERATIONS**	**ENVIRONMENTAL CONSIDERATIONS**
E1. Weather E2. Animals	E1. Weather E2. Animals	E1. Weather E2. Animals	E1. Weather E2. Animals	E1. Weather E2. Animals	E1. Weather E2. Animals

Master Checklist (continued)

NEW FACILITIES / UPGRADES ³ DEVELOPMENT STAGES þ					EXISTING ROADS
FEASIBILITY (PLANNING) STAGE	PRELIMINARY (DRAFT) DESIGN	DETAILED DESIGN	PRE-OPENING	POST-OPENING	
ROAD USERS	**ROAD USERS**	**ROAD USERS**	**ROAD USERS**	**ROAD USERS**	**ROAD USERS**
U1. Motorised Traffic U1.1 Heavy Vehicles U1.2 Public Transport U1.3 Road Maintenance U1.4 Emergency Vehicles U1.5 Slow-moving Vehicles U1.6 Snowmobiles and ATVs U2. Non-motorised Traffic U2.1 Cyclists U2.2 Pedestrians	U1. Motorised Traffic U1.1 Heavy Vehicles U1.2 Public Transport U1.3 Road Maintenance U1.4 Emergency Vehicles U1.5 Slow-moving Vehicles U1.6 Snowmobiles and ATVs U2. Non-motorised Traffic U2.1 Cyclists U2.2 Pedestrians	U1. Motorised Traffic U1.1 Heavy Vehicles U1.2 Public Transport U1.3 Road Maintenance U1.4 Emergency Vehicles U1.5 Slow-moving Vehicles U1.6 Snowmobiles and ATVs U2. Non-motorised Traffic U2.1 Cyclists U2.2 Pedestrians	U1. Motorised Traffic U1.1 Heavy Vehicles U1.2 Public Transport U1.3 Road Maintenance U1.4 Emergency Vehicles U1.5 Slow-moving Vehicles U1.6 Snowmobiles and ATVs U2. Non-motorised Traffic U2.1 Cyclists U2.2 Pedestrians	U1. Motorised Traffic U1.1 Heavy Vehicles U1.2 Public Transport U1.3 Road Maintenance U1.4 Emergency Vehicles U1.5 Slow-moving Vehicles U1.6 Snowmobiles and ATVs U2. Non-Motorised Traffic U2.1 Cyclists U2.2 Pedestrians	U1. Motorised Traffic U1.1 Heavy vehicles U1.2 Public transport U1.3. Road Maintenance U1.4 Emergency Vehicles U1.5 Slow-moving Vehicles U1.6 Snowmobiles and ATVs U2. Non-Motorised Traffic U2.1 Cyclists U2.2 Pedestrians

Master Checklist (continued)

NEW FACILITIES / UPGRADES ³ DEVELOPMENT STAGES þ					EXISTING ROADS
FEASIBILITY (PLANNING) STAGE	**PRELIMINARY (DRAFT) DESIGN**	**DETAILED DESIGN**	**PRE-OPENING**	**POST-OPENING**	
ACCESS AND ADJACENT DEVELOPMENT	**ACCESS AND ADJACENT DEVELOPMENT**	**ACCESS AND ADJACENT DEVELOPMENT**	**ACCESS AND ADJACENT DEVELOPMENT**	**ACCESS AND ADJACENT DEVELOPMENT**	**ACCESS AND ADJACENT DEVELOPMENT**
AA1. Right-of Way	AA1. Right-of-Way	AA1. Right-of-Way	AA2. Proposed Development AA3. Driveways	AA2. Proposed Development AA3. Driveways	AA1. Right-of-Way AA2. Proposed Development AA3. Driveways AA4. Roadside Development AA5. Building Setbacks

MASTER TEMPLATE

NEW FACILITIES / UPGRADES ³ DEVELOPMENT STAGES þ					EXISTING ROADS
Feasibility (Planning) Stage	**Preliminary (Draft) Design**	**Detailed Design**	**Pre-Opening**	**Post-Opening**	
General G1, G2, G12	**General** G2, G3, G4, G5, G6, G7, G12, G13	**General** G3, G5, G6, G7, G8, G12, G13	**General** G3, G6, G7, G9, G10, G12, G13	**General** G6, G7, G9, G10, G11, G12, G13	**General** G6, G7, G9, G10, G11, G12, G13
Alignment A1, A2, A3, A4	**Alignment** A2, A4, A5, A6, A8	**Alignment** A2, A4, A5, A6, A8	**Alignment** A2, A4, A5, A6, A7, A8	**Alignment** A2, A4, A5, A6, A7, A8	**Alignment** A2, A4, A5, A6, A7, A8
Intersections S1, S2, S3	**Intersections** S3, S4, S5, S6	**Intersections** S3, S4, S5, S6, S7, S8	**Intersections** S3, S4, S5, S6, S7, S8	**Intersections** S3, S4, S5, S6, S7, S8	**Intersections** S3, S4, S5, S6, S7, S8
Interchanges C1, C2, C6	**Interchanges** C2, C3, C4, C6	**Interchanges** C2, C3, C4, C5, C6, C7	**Interchanges** C2, C3, C4, C5, C6, C7	**Interchanges** C2, C3, C4, C5, C6, C7	**Interchanges** C2, C3, C4, C5, C6, C7
			Road Surface R1	**Road Surface** R1	**Road Surface** R1, R2, R3,R4
		Visual Aids D1, D2, D3, D4	**Visual Aids** D1, D2, D3, D4	**Visual Aids** D1, D2, D3, D4	**Visual Aids** D1, D2, D3, D4
Physical Obj. P1, P2	**Physical Obj** P1, P2	**Physical Obj**. P1, P2, P3, P4, P5, P6	**Physical Obj**. P1, P2, P3, P4, P5, P6	**Physical Obj**. P1, P2, P3, P4, P5, P6	**Physical Obj**. P1, P2, P3, P4, P5, P6
Environment E1, E2	**Environment** E1, E2	**Environment** E1, E2	**Environment** E1, E2	**Environment** E1, E2	**Environment** E1, E2
Road Users U1, U2	**Road Users** U1, U2	**Road Users** U1, U2	**Road Users** U1, U2	**Road Users** U1, U2	**Road Users** U1, U2
Access AA1	**Access** AA1	**Access** AA1	**Access** AA2, AA3	**Access** AA2, AA3	**Access** AA1, AA2, AA3, AA4, AA5

*** Stages:** 1 = Feasibility, 2 = Preliminary, 3 = Detailed Design, 4 = Pre-Opening, 5 = Post-Opening, E = Existing

Appendix A

Detailed Checklist

NEW FACILITIES/UPGRADES/EXISTING

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
GENERAL		
G1. Scope	1	Review all pertinent documentation to gain an understanding of the scope of the project; including project objectives, user characteristics, design vehicles, access, adjacent development, existing network information, and future network expansion.
G2. Staging of Construction	1,2,3	What are the effects of staging the construction of the project or dividing it into several contracts?
G3. New / Old Facility Interaction	3,4,5	Check that the horizontal and vertical alignments of the proposed facility co-ordinate effectively with those of existing facilities.
		Are road transition environments safe? Is advance warning required?
		Is there a sudden change in speed regime, access or side friction characteristics?
		Does the interface occur near hazards (i.e.,. crest, bend, etc.)?
G4. Impact on Adjacent Networks	3	Will traffic volume on nearby roads change as a result of this project?
		If traffic volume and flow have altered along adjacent roads, has a change in ROW been considered?
G5. Changes Since Previous Audit	2,3,4	Check for changes in the scope of the project.
		Check for changes in the conditions for which the project was designed.
G6. Traffic Barrier Warrants	3,4,5,E	Presence of non-traversable or fixed object hazards within clear zone.
		Does a potential risk exist for vehicles crossing over the median into the path of an opposing vehicle?
		Accident history of area.

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Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
GENERAL (continued)		
G7. Landscaping	3,4,5,E	Landscaping along road in accordance with guidelines?
		Required clearances and sight distances restricted due to future plant growth?
G8. Construction Clean-up	4	Interaction between construction clean-up area and traffic flow.
		Signage of clean-up area.
		Visibility of clean-up area from approaching traffic.
G9. Temporary Work	5,E	Interaction between temporary work and traffic flow.
		Is temporary work adequately signed?
		Does temporary work signage remain even though construction is complete?
		Visibility of temporary work area from approaching traffic.
G10. Headlight Glare	5,E	Severity of head light glare during night time operations.
G11. Accident Reports	E	Accident reports available for specific facility?
		Frequency of accidents at facility.
		Common accident characteristics discussed in reports.
G12. Consistency of Design Parameters	1,2,3,4,5, E	Ensure design parameters are consistent in alignment, cross section, interchanges, and intersections.
G13. Rest areas/ Picnic sites	2,3,4,5,E	Are rest areas/picnic sites desirable?
		Is the number of rest areas/picnic sites within the project adequate?
		Do rest areas/picnic sites have safe access?
		Are rest areas/picnic sites placed at appropriate locations?
		Have appropriate signs been chosen and placed correctly to notify drivers of an upcoming rest area/picnic site?

*** Stages:** 1 = Feasibility, 2 = Preliminary, 3 = Detailed Design, 4 = Pre-Opening, 5 = Post-Opening, E = Existing

Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
ALIGNMENT AND CROSS SECTIONS		
A1. Classification	1,2,E	Check the appropriateness of the classification and design for the proposed project's design volume and traffic composition.
		Is the design of the proposed project flexible enough to accommodate unforseen increases in volume or changes in traffic characteristics?
A2. Design Speed / Posted Speed	1,2,3,4,5, E	Check the appropriateness of the design speed for horizontal and vertical alignment, visibility, etc.
		Check the continuity of the design speed and the posted speed.
		Is the posted speed on each curve adequate?
		Is the traffic following the posted speed?
A3. Route Selection / Alignment	1,2	Are horizontal and vertical curves minimized?
		Do excessive grades affect heavy vehicle operations and service levels?
		Check for poor combinations of features (eg. small radius horizontal curve at end of long tangent)?
A4. Cross Sectional Elements	1,2,3,4,5, E	Determine if the proposed project has a suitable cross section for the ultimate requirements of the road including: - classification - design speed - level of service/peak service volumes
		Determine if adjustments in dimensions can be made for future expansion possibilities.
A4.1 Drainage	2,3,4,5,E	Is the drainage channel appropriate for topography, maintenance and snow drifting?
		Is there possibility of surface flooding or overflow from surrounding or intersecting drains and water courses?
		Does the proposed roadway have sufficient drainage?
A4.2 Lane Width	2,3,4,5,E	Is the lane width sufficient for road design / classification?

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Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
ALIGNMENT AND CROSS SECTIONS (continued)		
A4.3 Shoulders	2,3,4,5,E	Are shoulder widths adequate for all vehicles and road users?
		Is crossfall of shoulder adequate for drainage?
		Is treatment of embankments sufficient?
		Are there drop-offs?
		Is shoulder surfacing appropriate for road classification?
		Are rumble strips properly installed where warranted?
A4.4 Cross Slopes / Superelevation	2,3,4,5,E	Do crown and cross slope designs provide sufficient storm water drainage and facilitate de-icing treatments?
		Do different rates of cross slope exist along adjacent traffic lanes?
A4.5 Pavement Widening	2,3,4,5,E	Is sufficient pavement width provided along curves where offtracking characteristics of vehicles are expected?
A5. Alignment	2,3,4,5,E	Are there excessive curves that cause sliding in adverse weather conditions?
A5.1 Horizontal	2,3,4,5,E	Check that a transition curve is required between a tangent and a circular curve.
		Is the superelevation with transition curves suitable in relation to affects of drainage?
A5.2 Vertical	2,3,4,5,E	Are there excessive grades which could be unsafe in adverse weather conditions?
		Is a climbing lane provided where overtaking and passing manoeuvres are limited due to terrain?
		Is a climbing lane provided in areas where the design gradient exceeds the critical length of the grade?
		Verify that escape lanes are provided where necessary on steep down grades. If not, are escape lanes feasible?
		Is there adequate provision of passing opportunities?

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Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
ALIGNMENT AND CROSS SECTIONS (continued)		
A5.2 Vertical (continued)	2,3,4,5,E	Is there sufficient spacing between passing zones?
A5.3 Combined Vertical and Horizontal	2,3,4,5,E	Check the interaction of horizontal and vertical alignments in the road (ie., *roller coaster* alignments, sequencing of horizontal/vertical curves, etc.)
A6. Sight Distance (Stopping, Decision, Passing)	2,3,4,5,E	Ensure that adequate passing opportunities are provided.
		Determine if adequate stopping sight distance is provided throughout the length of the project.
		Check that there is decision sight distance provided for interchange and intersection signing throughout the project.
A7. Readability by Drivers	5,E	Check for sections of roadway having potential for confusion -alignment problems -old pavement markings not properly removed -streetlight/tree lines don't follow road alignment
A8. Bridge Structures	2,3,4,5,E	Check that the horizontal and vertical alignment conforms with the approach roadways.
		Check for sufficient vertical clearance and proper signage of height restrictions.
		Is the horizontal clearance adequate from the roadway to the bridge rails/parapets?
		Is stopping and passing sight distances obstructed by bridge abutments and parapets?
		Is signing required for delineation, weight restriction, or warning of deck freezing? Is it properly installed?
		Are there drainage grates that interfere with cyclists?
		Are shoulder widths reduced across structure? Are warning signs required?
		Is the proper clearance window provided at underpasses? Is the window providing the minimum clearances for height and width?

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Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
ALIGNMENT AND CROSS SECTIONS (continued)		
A8. Bridge Structures (continued)	2,3,4,5,E	Are the proper curb heights used for sidewalks, parapets and safety curbs on bridge structures?
		Are the proper drainage features incorporated into the design of underpasses, overpasses and bridge structures to prevent ponding?
		Will there be a visual perception of narrowing or funneling at underpasses and overpasses due to the location and type of abutment walls in relation to the traveled roadway passing under the structure?
		Are the toes of slope at abutments clear of the clear recovery zone for the classification of highway?
		Do all the appropriate side clearances, median clearances and hazard clearances for bridges meet classification standards?

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Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
INTERSECTIONS		
S1. Quantity	1	Is the number of intersections appropriate given the surrounding network?
S2. Type	1	Are types of intersections selected appropriate for traffic and safety aspects of the project?
		Can intersection designs accommodate all design vehicle classifications?
S3. Location / Spacing	1,2,3,4,5, E	Is there sufficient spacing between intersections?
		Does horizontal/vertical alignment affect the location/spacing of the intersections?
		Junctions and access adequate for all permitted vehicle movements?
S4. Visibility / Conspicuity	2,3,4,5,E	Does the horizontal and vertical alignment provide adequate visibility of the intersection?
		Are sight lines to the intersection obstructed?
S5. Layout	2,3,4,5,E	Are the lane widths adequate for all vehicle classes?
		Are there any upstream and downstream features which may affect safety? (i.e., "visual clutter", angle parking, high volume driveways)
		Are separate through lanes needed but not provided?
S5.1 Maneuvers	3,4,5,E	Are vehicle maneuvers obvious to all users?
		Identify any potential conflicts in movements.
S5.2 Auxiliary / Turning Lanes	3,4,5,E	Are they of appropriate length?
		Is there advance warning of approaching auxiliary lanes?
		Is sight distance for entering/leaving vehicles adequate?
		Are tapers installed where needed? Are they correctly aligned?

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Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
INTERSECTIONS (continued)		
S6. Sight Distance (Stopping, Crossing, Turning, Sight Triangle)	2,3,4,5,E	Are all sight distances adequate for all movements and road users?
		Are sight lines obstructed by signs, bridge abutments, buildings, landscaping, etc.?
		Could sight lines be temporarily obstructed by parked vehicles, snow storage, seasonal foliage, etc.?
		Do grades at intersecting roadways allow desirable sight distance?
S7. Controls		
S7.1 Markings	3,4,5,E	Are pavement markings clearly visible in day and night time conditions?
		Check retroreflectivity of markings.
S7.2 Signs	3,4,5,E	Check visibility and readability of signs to approaching users.
		Check location and number of signs
		Check for any missing/redundant/broken signs.
		Are stop/yield signs used where appropriate?
S7.3 Signals	3,4,5,E	Have high intensity signals/target boards/shields been provided where sunset and sunrise may be a problem?
		Check location and number of signals. Are signals visible?
		Ensure that traffic signals adjacent to roads do not affect driver perception of the road.
		Are primary and secondary signal heads properly positioned?
		Are auxiliary heads necessary?
S7.4 Signal Phasing	3,4,5,E	Are minimal green and clearance phases provided?
		Is the signal phasing plan consistent with adjacent intersections?

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Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
INTERSECTIONS (continued)		
S8. Warnings	3,4,5,E	Is adequate warning provided for signals not visible from an appropriate sight distance? (i.e., signs, flashing light, etc.)
		Are lateral rumble strips required and properly positioned?
		Are pavement markings appropriate for the intersection?

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Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
INTERCHANGES		
C1. Considerations	1	Check the appropriateness of the interchange design with respect to topographical, environmental and operational considerations.
		Is interchange layout consistent with other designs throughout the corridor or network?
C2. Location / Spacing	1,2,3,4,5, E	Does the location of the interchange service the needs of the surrounding community?
		Determine if spacing between interchanges in the network is sufficient.
C3. Weaving Lanes	2,3,4,5,E	Ensure appropriate length and number of weaving lanes.
C4. Ramps	2,3,4,5,E	Is the design speed appropriate for site limitations, ramp configurations, and vehicle mix?
		Adequate distance between successive entrance and exit noses?
		Is design of main lane adequate at exit/entrance terminals?
C4.1 Exit Terminals	2,3,4,5,E	Is the length adequate for deceleration?
		Is adequate sight and decision sight distance provided?
		Are spiral curves warranted? If so, do spirals begin and end at appropriate locations?
C4.2 Entrance Terminals	2,3,4,5,E	Is the length appropriate for acceleration and safe and convenient merging with through traffic?
		Are spiral curves warranted? If so, do spirals begin and end at appropriate locations?
		Is the length of acceleration adequate for traffic composition (i.e. truck, buses, etc.)
		Is there an adequate view of the speed change lane at the nose?
		Is visibility obscured by traffic barriers and other obstructions?

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Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
INTERCHANGES (continued)		
C5. Service Road Systems	3,4,5,E	Is there adequate distance between the highway and the service road to allow for future development?
		Does service road traffic adversely affect traffic flow along the highway?
		Is there sufficient access to/from the service road?
C6. Lane Balance / Basic Lanes / Lane Continuity	1,2,3,4,5, E	Is the number of lanes appropriate for safe operations and to accommodate variations in traffic patterns?
		Is there coordination of lane balance and basic lanes?
		Is lane continuity maintained?
C7. Auxiliary / Turning Lanes	3,4,5,E	Are they of appropriate length?
		Is there advance warning of approaching auxiliary lanes?
		Is sight distance for entering/leaving vehicles appropriate?
		Are tapers installed where needed? Are they correctly aligned?
		Is the service road being used for its original intent?

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Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
ROAD SURFACE		
R1. Skid Resistance	4,5,E	Does adequate skid resistance exist especially at curves, intersection approaches and steep grades?
		Has skid resistance testing been carried out?
R2. Pavement Defects	E	Check that pavement is free of defects. (i.e., potholes, rutting, etc.)
		Check for segregation of mix. (i.e., pooling of bitumen, segregation of aggregates)
R3. Surface Texture	E	Visibility in wet conditions.
		Check headlight glare/reflection during night time operations.
R4. Ponding	E	Ensure that pavement is free of depression areas where ponding can occur.

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Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
VISUAL AIDS		
D1. Pavement Markings	3,4,5,E	Are centre lines and edge lines clearly visible in day and night time conditions?
		Have old pavement markings been removed?
		Check retroreflectivity of existing markings.
		Estimate obliteration.
		Are raised profile markings necessary?
D2. Delineation	3,4,5,E	Is delineation adequate? Effective in all conditions?
		Are chevron markers placed correctly? Has retroreflectivity been measured?
D3. Lighting	3,4,5,E	Have frangible or slip-base poles been used?
		Will luminares create glare for road users on adjacent roads?
		Check appropriate location of luminares at interchanges, intersections, etc.
		Affect of adjacent road lighting on driver perception of road?
		Do locations exist where lighting may interfere with traffic signals or signs?
		Has lighting for signs been provided where necessary?
		Have bases been installed at the proper height?
D4. Signs	3,4,5,E	Are all necessary regulatory, warning and guide signs in place and visible?
		Check correct location of signs. (i.e., proper height, offset, distance in advance of hazard.)
		Check for signs which restrict sight distances.

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Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
VISUAL AIDS (continued)		
D4. Signs (continued)	3,4,5,E	Check effectiveness of signs in all operating conditions (day, night, rain, fog, snow, etc.) if possible.
		Are frangible bases provided where its impossible to locate extruded aluminum sign standards outside clear zone?
		Are any signs redundant/missing/broken?
		Are proper grades of retroreflective sheetings used?
		Have bases been installed at the proper height? Are they frangible?
		Is signage of horizontal alignment adequate where required?
		Check operation of variable message signs.
		Check consistency of variable message signs with respect to standard fonts and phrases.

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Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
PHYSICAL OBJECTS		
P1. Poles and Other Obstructions	1,2,3,4,5, E	Unprotected median widths appropriate for lighting poles?
		Appropriate positioning of traffic signal and other service poles?
		Consider the location of services and utilities with respect to the project (i.e. buried and overhead) Clearance for overhead wires?
P2. Medians	1,2,3,4,5, E	Is type of median chosen appropriate for width available?
		Do barriers possess the proper geometrical configuration?
		Are slopes of grass median adequate?
		Are median barriers sufficiently offset from roadway?
		Are median barrier offsets in the correct range of values?
		Do roadside barriers and bridge barriers meet the appropriate crash test performance level that is consistent with the roadway classification?
		Is there sufficient width for overpass/underpass piers and light standards?
		Check appropriate spacing between median crossovers.
P3. Hazardous Object Protection	3,4,5,E	Is adequate protection provided where required? (i.e., barriers, energy attenuators)
		Is protection visible in all operating conditions?
		Are end treatments of guiderail properly treated?
		Are dimensions (i.e. length) of protection appropriate?
		Are barrier treatments consistent throughout?
		Is there appropriate transition from one barrier to another?
		Are reflectorized tabs used to delineate guiderail?
P4. Clear Zone	3,4,5,E	Ensure no unprotected objects (temporary or permanent) are within the required clear zone.
		Check that clear zone is of adequate dimensions.

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Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
PHYSICAL OBJECTS (continued)		
P5. Culverts	3,4,5,E	Check adequate protection of culverts at abutting driveways and intersecting roads.
P6. Railroad Crossings	3,4,5,E	Ensure proper active/passive signing and pavement markings.
		Check sight distances for signing and also approaching trains.

*** Stages:** 1 = Feasibility, 2 = Preliminary, 3 = Detailed Design, 4 = Pre-Opening, 5 = Post-Opening, E = Existing

Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
ENVIRONMENTAL CONSIDERATIONS		
E1. Weather	1,2,3,4,5, E	Check the effects of rain, fog, snow, ice, wind on design features of the project.
		Has snow fall accumulation been considered in the design? *(i.e.,. storage, sight distance around snowbanks, etc.)*
		Check the mitigating measures for effects of snow with respect to: - prevailing winds - snow drifting - open terrain
E2. Animals	1,2,3,4,5, E	Are there any known animal travel/migration routes in surrounding areas which could affect design?
		Are fencing and underpasses installed where required?
		Ensure appropriate signing (i.e cattle crossing, deer warning, etc) where required.

*** Stages:** 1 = Feasibility, 2 = Preliminary, 3 = Detailed Design, 4 = Pre-Opening, 5 = Post-Opening, E = Existing

Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
ROAD USERS		
U1. Motorized Traffic		
U1.1 Heavy Vehicles U1.2 Public Transport	1,2,3,4,5, E	Can facility accommodate movements of heavy/public transport vehicles where required? (clearances, turning radii, shoulder widths, operational capacity?)
		Is there adequate signage of heavy vehicle/public transport activity?
U1.3 Road Maintenance U1.4 Emergency Vehicles	1,2,3,4,5, E	Can facility accommodate movements of road maintenance and emergency vehicles (clearances, turning radii, shoulder widths)
		Are medians and cross overs visible and in adequate locations for these vehicles?
U1.5 Slow Moving Vehicles	1,2,3,4,5, E	Can shoulders accommodate slow-moving vehicles where required? -width -structural capacity -continuity
		Is there appropriate signing of slow-moving vehicles as necessary?
U1.6 Snow-mobiles and ATVs	1,2,3,4,5, E	Check visibility of adjacent trail signage. Could it cause confusion to road users?
		Check signage and visibility of points where trails cross the highway.
		Has adequate stopping sight distance been considered where trails cross the highway?
		Could headlight of oncoming snowmobile/ATV confuse motorist?
U2. Non-Motorized Traffic U2.1 Cyclists U2.2 Pedestrians	1,2,3,4,5, E	Are shoulders wide enough to accommodate cyclists/pedestrians where required?
		Are shoulders/sidewalks provided on bridges?
		Will snow storage disrupt pedestrian access or visibility?

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Detailed Checklist (continued)

Item	Stages*	Potential Safety Issues (Note: Not all Issues Pertain to Each Audit Stage)
ACCESS AND ADJACENT DEVELOPMENT		
AA1. Right-of-way (ROW)	1,2,3,E	Check width of ROW as affected by access requirements.
		Are there any upstream or downstream factors which may effect access?
		Will there be "visual clutter" (excessive commercial signing or lighting) beyond ROW?
AA2. Proposed Development	4,5,E	Check effects on traffic patterns.
AA3. Driveways	4,5,E	Check interaction between driveway and road. Is driveway adequately designed for land use?
		Check for adequate space between driveways on same side of street.
		Check effects on traffic patterns.
AA4. Roadside Development	E	Check effects on traffic patterns.
AA5. Building Setbacks	E	Ensure adequate distance from edge of ROW.

*** Stages:** 1 = Feasibility, 2 = Preliminary, 3 = Detailed Design, 4 = Pre-Opening, 5 = Post-Opening, E = Existing

Appendix B

Municipal Checklists

MUNICIPAL MASTER CHECKLIST

MUNICIPAL ROAD NETWORKS
General
1. Scope 2. Traffic Barrier Warrants 3. Landscaping 4. Construction Clean-up 5. Temporary Work 6. Headlight Glare 7. Accident Reports 8. Traffic Calming 9. Congestion Areas 10. Street Network 11. School and Recreational Areas 12. Pavement Buildup
Alignment and Cross Sections
1. Classification 2. Design Speed/Posted Speed 3. Cross Sectional Elements 3.1 Drainage 3.2 Lane Width 3.3 Cross Slopes/Superelevation 3.4 Pavement Widening 3.5 Curbs and Gutters 3.6 Boulevards and Borders 3.7 Sidewalks 4. Alignment 4.1 Horizontal 4.2 Vertical 4.3 Combined Vertical and Horizontal 5. Sight Distance 6. Readability by Drivers 7. Bridge Structures

MUNICIPAL ROAD NETWORKS
Intersections
1. Type 2. Visibility/Conspicuousness 3. Layout 3.1 Manoeuvers 3.2 Channelization 3.3 Auxiliary/Turning Lanes 3.4 Islands 4. Sight Distance 5. Controls 5.1 Markings 5.2 Signs 5.3 Signals 5.4 Signal Phasing 6. Landscaping
Road Surface
1. Skid Resistance 2. Pavement Defects 3. Surface Texture 4. Ponding 5. Pavement Edge Rounding
Visual Aids
1. Pavement Markings 2. Delineation 3. Lighting 4. Signs
Physical Objects
1. Services and Utilities 2. Medians 3. Hazardous Object Protection 4. Clear Zone 5. Culverts 6. Poles and Other Obstructions 7. Railroad Crossings

MUNICIPAL MASTER CHECKLIST (continued)

MUNICIPAL ROAD NETWORKS
Road Users
1. Motorised Traffic 1.1 Heavy Vehicles 1.2 Public Transport 1.3 Road Maintenance 1.4 Emergency Vehicles 1.5 Tramways 2. Non-Motorised Traffic 2.1 Cyclists 2.2 Pedestrians 2.2.1 Elderly and Disabled 2.2.2 Paths and Crosswalks 2.2.3 Barriers and Fencing
Access and Adjacent Development
1. Right-of-Way 2. Proposed Development 3. Driveways 4. Roadside Development 5. Building Setbacks 6. Loading/Unloading Areas
Parking
1. Parking Lots 2. Street Parking

MUNICIPAL DETAILED CHECKLIST

Item	Description
General	
1. Scope	Review all pertinent documentation to gain an understanding of the scope of the project; including project objectives, user characteristics, design vehicles, access, adjacent development, existing network information, and future network expansion.
2. Traffic Barrier Warrants	Presence of non-traversable or fixed object hazards within clear zone.
	Does a potential risk exist for vehicles crossing over the median into the path of an opposing vehicle?
	Accident history of area.
3. Landscaping	Landscaping along road in accordance with guidelines?
	Required clearances and sight distances restricted due to future plant growth?
4. Temporary Work Area (Maintenance/Construction)	Interaction between work area and traffic flow.
	Is temporary work site adequately signed for approaching traffic?
	Does temporary work signage remain even though construction is complete?
	Visibility of temporary work area from approaching traffic.
6. Glare	Severity of head light glare during night time operations.
	Do areas exist along a road or at an intersection where sunlight reduces visibility?
7. Traffic Calming	Are traffic calming measures effective at reducing vehicle speeds?
	Is traffic calming required?
8. Congestion Areas	Have areas of congestion been identified?
	Are areas of regular congestion visible by approaching road users?
9. Street Network	Have changes in traffic flow altered hierarchy of streets.

MUNICIPAL DETAILED CHECKLIST (continued)

Item	Description
General (continued)	
10. School and Recreation Areas	Is posted speed limit appropriate for neighbourhood activities?
	Is speed limit effective at controlling traffic speed?
	Is existing signage sufficient at notifying motorists of upcoming activities, or is some other traffic control device necessary?
	Visibility of signage from approaching traffic adequate?
	Visibility of school and recreational areas by approaching traffic.
	Does on-street parking exist near school? If so, will visibility of children be obstructed by parked vehicles?
	Do crosswalks exist in area? If so, what is their condition?
	Does approaching traffic adhere to pedestrian rules at crosswalks or are further traffic control measures necessary? (Crossing guard, pedestrian corridors, etc.)
11. Environmental Considerations	Check the effects of adverse weather conditions on the facility.

MUNICIPAL DETAILED CHECKLIST (continued)

Item	Description
Alignment and Cross Sections	
1. Classification	Is road classification appropriate for current traffic distribution and volume.
	Are one-way streets clearly marked at intersections and along the street?
2. Design Speed / Posted Speed	Check the appropriateness of the design speed for horizontal alignment, vertical alignment and visibility.
	Is the traffic following the posted speed?
3. Cross Sectional Elements	
3.1 Drainage	Is there possibility of surface flooding or overflow from surrounding or intersecting drains and water courses?
	Does the roadway have sufficient drainage?
	Are the slits of a storm grate oriented perpendicular or parallel to traffic flow? (i.e., cyclist safety)
3.2 Lane Width	Is the lane width adequate for the road classification and/or traffic volume?
3.3 Cross Slopes / Superelevation	Do crown and cross slopes provide sufficient storm water drainage and facilitate de-icing treatments?
	Do different rates of cross slope exist along adjacent traffic lanes?
3.4 Pavement Widening	Is sufficient pavement width provided along curves where off-tracking characteristics of vehicles are expected?
3.5 Curbs and Gutters	Are curbs and gutters installed where necessary.
	Are curbs and gutters constructed according to guidelines.
	Physical condition of curbs and gutters.
3.6 Boulevards and Borders	Are boulevards and borders constructed according to guidelines.
	Does street furniture in these areas pose safety concerns to road users?

MUNICIPAL DETAILED CHECKLIST **(continued)**

Item	Description
Alignment and Cross Sections (continued)	
3.7 Sidewalks	Physical condition of sidewalk.
	Is sidewalk width adequate for pedestrian volumes?
	Do objects exist on or near sidewalk that cause pedestrians to use street (i.e. canopies, patios, advertisement signs, etc.)
4. Alignment	
4.1 Horizontal	Are there excessive horizontal curves that cause sliding in adverse weather conditions?
	Signage of excessive horizontal alignment adequate?
4.2 Vertical	Are there excessive grades which could be unsafe in adverse weather conditions?
4.3 Combined Vertical and Horizontal	Check the interaction of horizontal and vertical alignments in the road.
5. Sight Distance	Any obstructions that could interfere with sight distance along route.
	Determine if adequate stopping sight distance is provided.
6. Readability by Drivers	Check for sections of roadway having potential for confusion -alignment problems -old pavement markings not properly removed -streetlight/tree lines don't follow road alignment
7. Bridge Structures	Check that the horizontal and vertical alignment conforms with the approach roadways.
	Check for sufficient vertical clearance and proper signage of height restrictions.
	Is the horizontal clearance adequate from the roadway to the bridge rails/parapets?
	Is horizontal sight distance obstructed by bridge abutments and parapets?
	Is signing required for delineation, weight restriction, or warning of freezing deck? Is it properly installed?

MUNICIPAL DETAILED CHECKLIST **(continued)**

Item	Description
Alignment and Cross Sections (continued)	
7. Bridge Structures (continued)	Are there drainage grates that interfere with cyclists?
	Adequate provisions for pedestrians and cyclists crossing bridge.
	Are shoulder widths reduced across structure? Are warning signs required?

MUNICIPAL DETAILED CHECKLIST (continued)

Item	Description
Intersections	
1. Type	Are types of intersections selected appropriate for current and future traffic volumes as it relates to safety?
	Can intersection designs accommodate all design vehicle classifications?
2. Visibility / Conspicuity on Approach	Does the horizontal and vertical alignment provide adequate visibility of the intersection?
	Are sight lines to the intersection obstructed by buildings, trees, etc.?
3. Layout	Is layout of the intersection appropriate for the road function?
	Are the lane widths adequate for all vehicle classes?
	Are there any upstream and downstream features which may affect safety? (i.e., “visual clutter”, angle parking, high volume driveways)
	Junctions and access adequate for all vehicle movements?
3.1 Maneuvers	Are vehicle maneuvers obvious to all users?
	Are there any potential conflicts in movements?
	Do certain traffic movements need to be prohibited/discouraged by using one-way streets, cul-de-sacs, chokers or medians?
3.2 Channelization	Are channelization features effective?
	Any areas of uncontrolled pavement that may require channelization features?
3.3 Auxiliary Lanes	Are they of appropriate length?
	Is decision sight distance for entering/leaving vehicles adequate?
	Are tapers installed where needed? Are they correctly aligned?

MUNICIPAL DETAILED CHECKLIST (continued)

Item	Description
Intersections (continued)	
3.4. Islands	Presence of visual clutter on island affecting sight distance?
	Is an island required to channel vehicle traffic at the current location?
	Are the dimensions of the island adequate for the intersection (width, length, turning radius)?
	Is the existing island clearly visible to drivers?
4. Sight Distance at Intersections	Are all sight distances adequate for all movements and road users?
	Are sight lines obstructed by signs, bridge abutments, buildings, or landscaping?
	Could sight lines be temporarily obstructed by parked vehicles, snow storage, seasonal foliage, etc.?
5. Controls	
5.1 Markings	Are pavement markings clearly visible in day and night time conditions?
	Check retro-reflectivity of markings.
	Are all necessary pavement markings present?
5.2 Signs	Check visibility and readability of signs to approaching users.
	Check location and noise induced by signs.
	Check for any missing/redundant/broken signs.
	Is adequate warning provided for signals not visible from an appropriate sight distance?
5.3 Signals	Have high intensity signals/target boards/shields been provided where sunset and sunrise may be a problem?
	Check location and number of signals. Are signals visible?
	Are primary and secondary signal heads properly positioned?

MUNICIPAL DETAILED CHECKLIST (continued)

Item	Description
	Are auxiliary heads necessary?
Intersections (continued)	
5.4 Signal Phasing	Are minimal green and clearance phases provided?
	Is a dedicated left turn signal required?
	Is the signal phasing plan consistent with adjacent intersections?
6. Landscaping	Will current or future plant growth interfere with required clearances, traffic flow devices, or sight distances?

MUNICIPAL DETAILED CHECKLIST (continued)

Item	Description
Road Surface	
1. Skid resistance	Does adequate skid resistance exist along curves, intersection approaches and steep grades?
	Has skid resistance testing been carried out?
2. Pavement Distresses	Check that pavement is free of distresses. (i.e., potholes, rutting, etc.)
3. Surface Texture	Visibility in wet conditions.
	Can visibility be reduced due to sunlight conditions?
	Headlight response during night time operations.
4. Ponding	Ensure that pavement is free of depression areas where ponding can occur.
5. Pavement Edge Rounding	Is pavement edge rounding adequate?

MUNICIPAL DETAILED CHECKLIST (continued)

Item	Description
Visual Aids	
1. Pavement Markings	Are centre lines clearly visible at all times?
	Have old pavement markings been removed?
	Check retro-reflectivity of existing markings.
	Could obliteration problems cause confusion?
2. Delineation	Is delineation adequate? Effective in all conditions?
	Are retro-reflective devices intended for heavy vehicle operators at their eye height?
	Are chevron markers placed correctly? Has retro-reflectivity been measured?
3. Lighting	Will luminares create glare for road users on adjacent roads?
	Check appropriate location of luminares at interchanges, intersections, along route, etc.
	Do locations exist where lighting may interfere with traffic signals or signs?
	Has lighting for signs been provided where necessary?
4. Signs	Are all current signs visible?
	Do conditions exist which require additional signs?
	Check correct location of signs. (i.e., proper height, offset, distance in advance of hazard.)
	Do any signs restrict the sight distances of road users?
	Check effectiveness of signs in all operating conditions (day, night, rain, fog, snow, etc.)
	Are any signs redundant/missing/broken?
	Do any signs contradict one another?
	Check condition of sign and supporting structure.
	Are any existing signs no longer applicable?
	Are proper grades of retro-reflective sheetings used?

MUNICIPAL DETAILED CHECKLIST (continued)

Item	Description
Physical Objects	
1. Medians	Is type of median chosen appropriate for width available?
	Are slopes of grass median adequate?
	Are median barriers sufficiently offset from roadway?
	Is there sufficient width for overpass/underpass piers and light standards?
	Check appropriate spacing between median crossovers.
2. Hazardous Object Protection	Is adequate protection provided where required? (i.e., barriers, energy attenuators)
	Check for guy wires which may interfere with protection.
	Are end treatments sufficiently anchored?
	Is pavement buildup reducing the effectiveness of roadside guardrails/barriers?
	Are dimensions (i.e. length) of protection appropriate?
	Is there appropriate transition from one barrier to another?
	Are reflectorized tabs used where necessary?
3. Clear Zone	Ensure no objects (temporary or permanent) are within the required clear zone.
	Check that clear zone is of adequate dimensions.
4. Culverts	Check adequate protection of culverts at abutting driveways and intersecting roads.
5. Poles and Other Obstructions	Are poles and other obstructions adequately protected?
	Unprotected median widths appropriate for lighting poles.
	Check clearance for overhead wires/
	Have frangible or slip-base poles been used?
	Appropriate positioning of traffic signal and other service poles

MUNICIPAL DETAILED CHECKLIST (continued)

Item	Description
Physical Objects (continued)	
6. Railroad Crossings	Ensure proper active/passive signing and pavement markings.
	Check sight distances for signing and also approaching trains.
	Are gates of adequate width?
	Are at-grade crossings approximately level with traveled roadway?
7. Manholes	Are manholes too high or too low?

MUNICIPAL DETAILED CHECKLIST (continued)

Item	Description
Road Users	
1. Motorized Traffic	
1.1 Heavy Vehicles 1.2 Public Transport	Can facility accommodate movements of heavy/public transport vehicles? (clearances, turning radii, shoulder widths, operational capacity)
	Is there adequate signage of heavy vehicle/public transport activity?
	Check location of bus stops and clearance from the traffic lane.
	Check visibility of bus stops by approaching traffic.
	Are bus bays/lanes required?
1.3 Road Maintenance 1.4 Emergency Vehicles	Can facility accommodate movements of road maintenance and emergency vehicles (clearances, turning radii, shoulder widths)
	Check provisions for snow-plowing in cul-de-sacs.
	Are medians and cross overs visible and in adequate locations for these vehicles? Are they properly signed?
1.5 Tramways	Interaction between tramway lines, pedestrians and traffic flow.
	Do certain vehicular movements require restriction to minimize conflict between traffic and tramway system?
	Location of tramway stops with respect to road user visibility.
2. Non-Motorized Traffic	
2.1 Cyclists	Is there adequate width along the shoulder for cyclists sharing the street with motorists?
	Are shoulders properly maintained for cyclist traffic?
	Are alignment and cross section for bicycle facilities appropriate?

MUNICIPAL DETAILED CHECKLIST **(continued)**

Item	Description
Road Users (continued)	
2.1 Cyclists (continued)	If bike route exists, are adequate markings and signage provided?
	Are bike lanes required?
2.2 Pedestrians	Will snow storage disrupt pedestrian access or visibility?
	Are hand rails provided (on bridges, ramps)?
	Check signal timing (cycle length, pedestrian clearance time).
	Is there adequate signage for pedestrian paths?
	Are sight lines for pedestrians clear? (i.e., around parked cars)
	Are pedestrian bridges necessary?
2.2.1 Elderly and Disabled	Are there adequate provisions for the elderly, the disabled, children, wheelchairs and baby carriages (curb and median crossings, ramps, raised crosswalks, curb cuts, etc.)?
	Does tactile paving exist? Is it properly used?
2.2.2 Paths and Crosswalks	Check location of crosswalks along the road (signage, sight distance, spacing).
	Check the visibility of traffic from the crosswalk and the visibility of pedestrians from the traffic flow.
	Verify condition of crosswalk markings.
2.2.3 Barriers and Fencing	Is there adequate fencing to guide pedestrians and cyclists to crossings/overpasses?
	Check visibility at night.
	Are solid horizontal rails present in the fence?

MUNICIPAL DETAILED CHECKLIST (continued)

Item	Description
Access and Adjacent Development	
1. Right-of-way	Check width of ROW as affected by access requirements.
	Are there any upstream or downstream factors which may affect access?
	Ensure that traffic signals and lighting on adjacent roads do not affect driver perception of the road.
	Will there be "visual clutter" (excessive commercial signing or lighting) beyond ROW?
2. Driveways / Approaches	Check interaction between driveway and road. (i.e., sight distance)
	Check for adequate space between driveways/approaches on same side of street.
	Ensure that driveways across the road from one another are staggered.
	Check effects on traffic patterns.
3. Roadside Development	Check effects on vehicle distribution.
4. Building Setbacks	Ensure adequate distance from edge of traveled roadway.
5. Loading/Unloading Areas	Interaction between loading areas and traffic flow.
	Visibility of loading areas.
	Check if heavy vehicles block visibility to signs and signals while in loading/unloading areas.
	Is loading area adequately signed?

MUNICIPAL DETAILED CHECKLIST (continued)

Item	Description
Parking	
1. Parking Lots	Visibility of entrance/exit by approaching vehicles
	Visibility of vehicles entering and exiting parking facilities.
	Signage of parking lot facilities.
	Visibility of pedestrians on sidewalks near parking lot entrance/exits
2. Street Parking	Is parking orientation (parallel, angled) along route appropriate?
	Are parked vehicles obstructing sight distances?
	Parking restrictions during peak hours.
	Are excessive manoeuvers required to park a vehicle within the dimensions of the parking space?
	Are the parking facilities along a route appropriate for the classification of the route? If not, should off street parking be provided?
	Are parking restrictions near intersections sufficient?
	Visibility and circulation of pedestrians around parked vehicles.

Appendix C

Exemplary Audits

ROUTE 1000

BETWEEN ROUTE 666 AND ROUTE 999

Audit Dates: June 25 and 29, 1999

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EXISTING HIGHWAY SAFETY AUDIT
ROUTE 1000 (FROM ROUTE 666 TO ROUTE 999)

Introduction

Although the concept of Road Safety Audits is relatively new in Canada, there is a strong interest in their application to develop safer road facilities. Numerous audits have already been undertaken on both existing road facilities and those in the design stage.

A basic objective of road safety audits is the reduction of road casualties through the adoption of a more *proactive* approach, contrary to traditional blackspot analysis which is a *reactive* method of identifying high accident locations. The intent is to identify and mitigate problem areas before accidents have a chance to occur.

A road safety audit was conducted on a section of Route 1000 on June 25 and 28, 1999. The 41.3 kilometre section extends from Route 1000's intersection with Route 666 (Ashton) to Route 999 (Medford). The collector provides a secondary east-west connection between the communities of Ashton and Medford.

The audit covers physical features of the study area which may affect road user safety and it has sought to identify potential safety hazards. However, the auditors point out that no guarantee is made that every deficiency has been identified. Further, if all the recommendations in this report were to be followed, this would not confirm that the highway is ‘safe’; rather, adoption of the recommendations should improve the level of safety of the highway.

Study Area

Site surveys were conducted on June 25 (all day) and the late evening of June 28 (it was foggy and raining during the night time audit). The audit consisted of a careful and detailed examination of each of the control sections within the study area. The following areas were considered during this review: (1) background information (2) alignment and cross section; (3) intersections and access; (4) road surface; (5) visual aids; (6) the roadside; and (7) road users. The following sections summarize the relevant information and observations recorded during the site visits.

The audited area is illustrated in Figure 1. Three control sections make up this road segment:

Control section 005 – from Route 666 to bridge S11 - 17.53 km.
Control section 006 – from bridge S11 to Route 555 - 19.00 km.
Control section 007 – from Route 555 to Route 999 - 4.77 km.

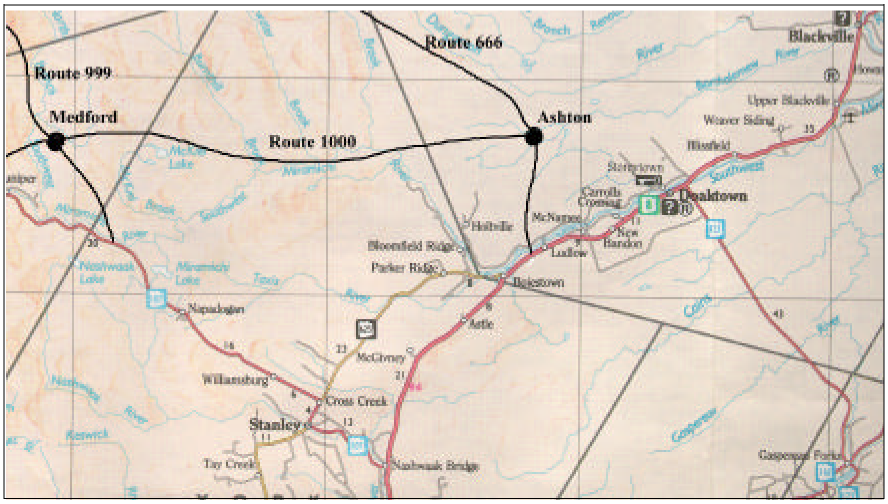

Figure 1. Study Section

The road section is a two-lane undivided collector with a posted speed limit of 80 km/h with some areas reduced to 50 km/h. Near Medford, the posted speed limit changes to 70 km/h. One general observation about this road segment is that most vehicles operate above the posted speed limit.

Trucks are permitted on this road at a maximum gross vehicle weight (GVW) of 43,500 kilograms. The AADT for this road section varies from 1,090 near the east end to 440 at the western end. Typical road users include a broad mix of passenger cars, commercial trucks, farm machinery, RV's, pedestrians, and cyclists.

A cursory review of previous accidents within the study area showed annual totals that varied from 5 to 24 per year between 1993 and 1997. The most frequent accident configurations involved vehicles striking a tree/pole (40%), running off the road (33%), or rear-end collisions (10%).

To facilitate easy exchange of information between auditors and client, the audit report has been prepared in tabular format. There are three columns; the first describing the audit team's observations, the second suggesting possible remediation initiatives and the third providing a space for the client response. Once the client had addressed each issue on paper, a copy of the document with responses was returned to the auditors.

OBSERVATIONS	POSSIBLECOUNTERMEASURES	CLIENT/OWNER RESPONSE
2. Alignment and Cross Section		
2.1 Much of the study section shows a series of vertical curves with long straight horizontal tangent sections (resulting in a roller coaster effect).		
2.2 There are many cases in which horizontal curves start just beyond a crest curve. This creates a potentially hazardous situation, especially at night, since it is difficult for drivers to delineate the road alignment.	Install curve warning signs or post mounted delineations where warrants are met.	Agree. Sign installation will be scheduled for next construction year.
2.3 In general, this road segment has poor sight distance due to the alignment. This problem is greatly intensified at night.		
2.4 The road has little or no shoulder area throughout its length. This is particularly important since the lanes are 3- 3.5 metres in width and there is need to accommodate pedestrians, and bicyclists.	Consider upgrading and/or surfacing of shoulders; widening of lanes.	The route will be included in the priority list for future budget consideration.
2.5 There is a potentially hazardous situation, particularly for traffic traveling eastbound, at the intersection with Madison Road. Because Madison Road intersects Route 1000 at the apex of one of its horizontal curves, it results in optical confusion for drivers. It appears as if Route 1000 continues straight ahead (with no curve) but in fact, it is Madison Road which intersects the highway at this location (photo 1). This would confuse drivers, especially at night, if there is a vehicle traveling towards the intersection on Madison Road. A similar situation exists at Route 1000's intersection with Royal Park (photo 2)	Use of chevrons, edge lines, and/or improved signing to heighten driver awareness of the curve.	Agree. Chevrons and edgeline markings will be scheduled for next construction year.
2.6 There are many areas where the side slopes are less than desirable – approximately 2:1. AASHTO considers side slopes of 4:1 to be the steepest slopes that permit vehicle control. TAC indicates that slopes between 3:1 and 4:1are non-recoverable (i.e. drivers of errant vehicles are not able to return to the roadway or come to a stop) and require a clear runout area at the bottom. TAC notes at slopes steeper than 3:1 will cause a vehicle to overturn. If an errant vehicle left the highway at these locations, the severity of the collision would be increased considerably. One such example is approximately 24 kilometres from the intersection of Route 1000 and Route 666 on the east side of the road.	Long term capitol projects should consider flattening side slopes where appropriate.	Consideration will be given during future budget allocations. Project will compete for position on priority list.

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT/OWNER RESPONSE
3. Intersections and Access		
3.1 Many private driveways are located immediately beyond the crest of vertical curves. This is particularly hazardous due to the limited sight distance of those access points.		
3.2 There are two locations at which an intersection is located on a horizontal curve–Madison Road and Locklear Drive. This results in potential stopping sight distance problems and highway access hazards. The problem increases at night (at Madison Road) due to the lack of illumination at this intersection.	Consider concealed road signs (WA-11, 12, 13), hazard markers, or illumination.	Agree. Hazard markers will be installed immediately.
3.3 The Family Campground entrance, located approximately 14 kilometres from the east end of the study section, may pose a potential hazard for motorists due to minimal sight distance	Consider installing "hidden intersection" sign.	Agree. Signs will be installed immediately.
3.4 There is insufficient stopping sight distance at the intersection of Route 1000 and Route 999. Since this intersection is located just east of the crest of a vertical curve, vehicles traveling on Route 1000 have limited visibility of the intersection.	Consider installing concealed road signs (WA-11, 12, or 13) and/or hazard markers.	Agree. Signs will be installed immediately.
3.5 There is a sight distance problem at the intersection of Route 1000 and Route 555. Since the intersection is located just east of a vertical curve, it is difficult for motorists traveling on Route 1000 to see vehicles stopped at the intersection. The sight distance problem is worse for vehicles on Route 555 that want to turn eastbound onto Route 1000. The problem is increased due to the presence of trees that block sight lines.	Consider installing concealed road signs (WA-11, 12, or 13), illumination, and/or cutting trees that block sight lines.	Agree. Signs and brush/tree cutting will be scheduled for next construction season.
3.6 There is only one location posted with a "blind hill" sign. This is located approximately 13.5 kilometres from the east end of the study section. There are no other signs that indicate that there is a potential problem with the combination of alignment and access.	Use consistent signage relative to blind crest curves.	Agree. Installation of signs will be scheduled for next construction season.

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT/OWNER RESPONSE
3.7 There is a gravel pit entrance just south of the crest of a vertical curve, near the west end of the study section. This poses a hazard since there are no warning signs in advance of this entrance, there are no auxiliary lanes for traffic entering and leaving the facility, and there is limited sight distance.	Install "truck entrance" signs (WC-8), and/or construction of an auxiliary lane.	Agree with sign installation and will be installed immediately.
4. Road Surface		
4.1 There is considerable rutting, resulting in ponding of water on roadway and there is considerable ravelling of pavement edges (photo 3). The narrow lanes become narrower at many locations, which poses a hazard when traveling at night. This is problematic when sharing the road with heavy vehicles, bicyclists and pedestrians. The condition of the road surface is poor throughout the entire road section. The worst road surface conditions are present within the eastern 20 kilometres.	Consider re-surfacing the road and grading and/or surfacing shoulders.	Project will be included in competition with similar projects for funding in next two fiscal years.
5. Visual Aids		
5.1 For most of the study section, the center line is visible but worn. In some other areas, it is not visible at all when driving at night under adverse weather conditions.	Re-stripe the road and consider bi-annual re-striping.	Agree. Striping will be carried out during next construction year.
5.2 There is no curve warning sign for traffic traveling eastbound that alerts drivers about the S-curve just east of Madison Road. There is, however, a sign for that same curve for traffic traveling westbound.	Install a curve warning sign for both eastbound and westbound traffic should ballbank readings warrant.	Agree. Will check curve and install signs immediately if warranted.
5.3 One curve sign, one information sign (maximum allowable GVW sign), and one school bus sign are obscured by tree branches.	Remove foliage. Consider increased foliage control program.	Agree. Foliage to be removed immediately.

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT/OWNER RESPONSE
5.4 There is a stop sign located at one of the intersections, about 4 kilometres from the east end of the study section, which at night sends the wrong message. This sign is intended for traffic accessing the highway at this location. However, the angle at which it has been placed makes it clearly visible to westbound traffic on Route 1000. This may create confusion.	Adjust the angle of the stop sign.	Agree. Sign adjustment to be done immediately.
5.5 The cattle crossing sign located approximately 13 kilometres from the east end of the study section has faded dramatically (photo 4). Other signs along the study section have lost retroreflectivity. Some examples are: (1) curve sign located on south side, approximately 0.5 km from the east end of study section; (2) blind hill sign located about 13.5 km from east end; and (3) curve sign located 30 kilometres from east end (photo 5). There is no cattle crossing sign for eastbound traffic, only for westbound traffic.	Replace worn signs and install cattle crossing sign for eastbound traffic.	Signs will be evaluated and upgraded as required during next construction year.
5.6 Delineation is a problem, especially at night. There are cases where it is difficult to see the road and vehicles could lose control.	Consider improving delineation with signs, chevrons and/or striping .	Agree. Signs and chevrons will be installed immediately.
5.7 Delineation is a problem with most sections of guiderail. In many cases there are missing or non-existent retro-reflective markers to provide positive guidance.	Consider inspecting all guiderail for missing or worn delineators and installing replacements where needed.	Agree. Condition of guiderail will be evaluated and improvements made where warranted.
5.8 There is no illumination at the intersection of Madison Road and Route 1000. This is particularly hazardous due to optical confusion experienced at this location when traveling in the eastbound direction. The same problem is encountered at the entrance to Royal Park.	Consider illuminating these intersections.	No. Will evaluate need for additional/improved signage.
5.9 There is no illumination at the intersection of Route 1000 with Route 555.	Consider illuminating the intersection. Increased delineation could also be achieved using post-mounted hazard markers.	Do not agree with illumination. Will consider post-mounted hazard markers.

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT/OWNER RESPONSE
6. The Roadside		
6.1 Considering the posted speeds of this road, it is evident that the clear zone provided is often inadequate. For sections of the road with a posted speed limit of 70 km/h or 80 km/h, a minimum clear zone of 2.5 metres is recommended by TAC, subject to type (fill vs. cut) and grade of slope as well as traffic volume. As the side slope steepens, the minimum clear zone increases.	Review the study area to identify long term opportunities to remove/relocate specific objects within the clear zone, to flatten slopes, or install guiderail.	Review will be undertaken. Improvement would require major expenditure and this project would have to compete Province wide for funding.
6.2 Many large trees are located very close to the edge of the pavement (well within any prescribed clear zones), for example the two trees located just west of Bridge S11 (where Control Section 006 begins–17.6 kilometres from the east end of the study section). Guy wires are located within the clear zone, and in some cases, in the vicinity of guiderail.	Consider removing problematic trees or installing guiderail.	Agree. Will review tree location and possible removal.
6.3 Most driveway culverts are exposed. Furthermore, the side slopes of driveways pose a potential hazard for motorists.	Install protection in vicinity of culverts and softening slopes for increased safety. Higher priority should be given to those located on horizontal curves.	Will review culverts located on horizontal curves.
6.4 The guiderail on the southwest corner of bridge J23 is not mounted flush with the inside of the concrete bridge endpost (photo 12). An errant vehicle striking this guiderail is in danger of not being directed away from the endpost.	Consider adjusting guiderial so that it is flush with the endpost.	Agree. Guiderails will be adjusted immediately.
6.5 There is an unprotected steep side slope on the south side of the road, approximately 20 kilometres from the east end of the study section. There is a barrier which ends just west of that location. However, that barrier does not extend far enough to prevent an errant vehicle (especially traveling in the southbound direction) from leaving the road. There are similar problems at other locations along this road segment.	Extend the barrier.	Agree. Will be adjusted during next construction year.

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT/OWNER RESPONSE
6.6 Many sections of guiderail require maintenance. Some of those barriers are not in good condition to withstand the impact of a vehicle. Examples include: (1) the south guiderail located 2.6 kilometres from the east end of the study section has two of the wooden supports broken; (2) the north guiderail located 4.3 kilometres from the east end of the study section is not visible due to trees and bushes; (3) the south guiderail located 5.0 kilometres from the east end of the study section is too low–an errant vehicle would roll over the barrier (photo 7); (4) the cable guiderail located 16 kilometres from the east end of the study section has some broken supports and loose cables (photos 8 and 9); (5) some steel flex beam rails are missing spacer blocks; (6) some of the guiderails are too short and need to be extended (photo 10); (7) the embankments of several sections of guiderail along the river's edge have partially washed away resulting in inadequate support for the wooden posts (photo 11).	Maintain guiderail.	Agree. Maintenance will be completed on guiderail.
6.7 Most mailboxes are located within 2.5 metres from the edge of the pavement. There is one particular case (approximately 28 kilometres west of the intersection of Route 1000 and Route 666) in which the mailbox is mounted on a large wooden log positioned within the clear zone (photo 6).	Have larger mailbox structures either moved outside the clear zone or replaced with "friendlier" frames.	Agree. Will discuss problem with owner.

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT/OWNER RESPONSE
7. Road Users		
7.1 This road section does not provide suitable facilities for pedestrians and cyclists. The horizontal and vertical alignment, road surface, lane width, and lack of proper shoulders reduce the level of safety afforded cyclists, pedestrians, and–to a certain degree motorcyclists–to travel on this road.	Refer to item 2.4	
7.2 Due to the limited illumination along this road section, it is difficult to see pedestrians walking at night.	Refer to item 2.4	
7.3 This road section may pose problems for vehicles sharing the road with slow-moving vehicles (eg., farm machinery), since passing opportunities are limited.	Refer to item 2.4	

Photo 1. Confusing alignment (intersection with Madison Road)

Photo 2. Confusing alignment (intersection with Royal Park)

Photo 3. Ravelled pavement edge

Photo 4. Cracked and faded sign; too much offset

Photo 5. Cracked and non-retroreflective sign.

Photo 6. Potentially dangerous mailbox


Photo 7. Guiderail too low


Photo 8. Missing post


Photo 9. Loose cables


Photo 10. Inadequate coverage of guiderail


Photo 11. Washed out shoulder


Photo 12. Guiderail not flush with bridge endpost

CITY OF FREDERICTON - SOUTH

NEW BRUNSWICK, CANADA

Audit Dates: June 29, July 6, and July 11, 1999

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Introduction

Although the concept of Road Safety Audits is relatively new in Canada, there is a strong interest in their application to develop safer road facilities. Numerous audits have already been undertaken on both existing road facilities and those in the design stage. While most audits of existing facilities have focused on rural highways the approach can easily be applied to more urban contexts. This audit is believed to be the first application of a safety audit to a municipality in Canada.

A basic objective of road safety audits is the reduction of road casualties through the adoption of a more *proactive* approach, contrary to traditional blackspot analysis which is a reactive method of identifying high accident locations. The intent is to identify and mitigate problem areas before accidents have a chance to occur.

A municipal road safety audit was conducted in the City of Fredericton, New Brunswick over a two-day period on June 29 and July 6, 1999. Safety issues associated with the study area were also investigated during night time conditions on July 11, 1999.

The audit covers physical features of the study area which may affect road user safety and it has sought to identify potential safety hazards. However, the auditors point out that no guarantee is made that every deficiency has been identified. Further, if all the recommendations in this report were to be followed, this would not confirm that the street network is 'safe'; rather, adoption of the recommendations should improve the level of safety of the street system.

The results of this audit should not be used for a comparative analysis of other municipalities. In general, the infrastructure within the study area is safe and provides an efficient transportation network. The purpose of this audit was twofold: 1. to field test a newly developing approach to safety and, 2. to provide the City with a list of safety-related issues or problem areas that should be considered and mitigated where resources allow. It must be recognized that no jurisdiction can afford to correct all infrastructure deficiencies. However, information such as that provided herewith can be used to develop prioritized work programs to more effectively manage and distribute limited resources.

Study Area

All local, collector and arterial roads were audited within a study area that extended east to west from Regent Street to Smythe Street and north to south from St. Anne Point Drive to Prospect Street (see Figure 1). Two additional blocks were included in the study: (1) Windsor Street to Regent Street and Montgomery Street to Beaverbrook Street; and (2) Waterloo Row to Regent Street and Beaverbrook Street to Queen Street.

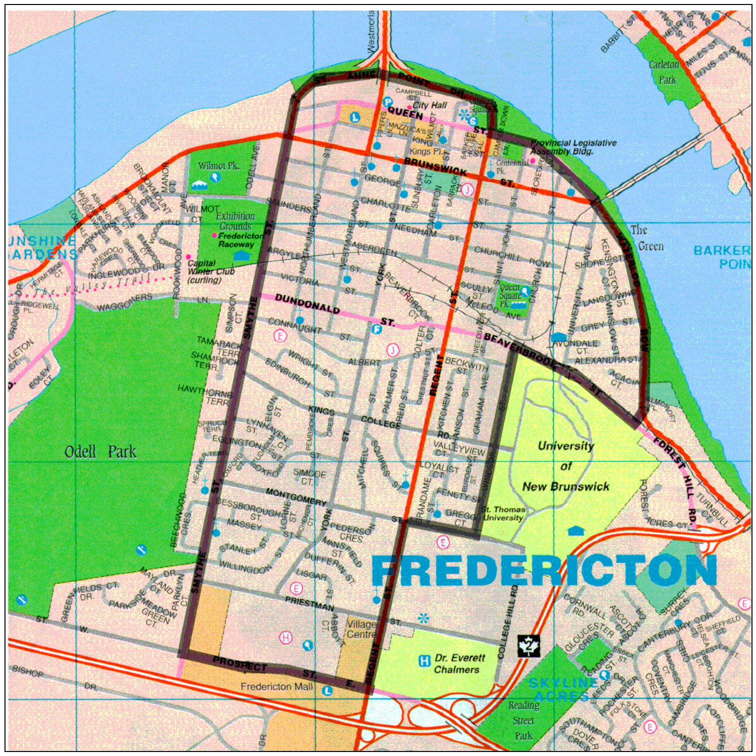


Figure 1: Study Area

This report is structured with observations listed under one of the following broad categories:

1. General
2. Alignment and Cross Section
3. Intersections
4. Road Surface
5. Visual Aids
6. Physical Objects
7. Road Users
8. Access and Adjacent Development
9. Parking

Each category is sub-divided into several sections consistent with the taxonomy presented in the University of New Brunswick Road Safety Audit Manual.

Observations are noted and possible countermeasures suggested by the audit team. The countermeasures listed are by no means all inclusive and were presented to the City as a basis for discussion. Post-audit meetings between the audit team and City officials were held to discuss findings and formulate the client responses listed in the tables.

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT RESPONSE
1. General ***Landscaping***		
1.1 Most roads within the study area are lined with trees of varying size and type. Consequently, a number of traffic signs are partially obscured or difficult to be seen by approaching traffic (photo 16). Along Priestman Street between Smythe Street and York Street, for example, a no parking and a school zone sign on the south side of the collector are blocked by tree foliage. Signage is also ineffective along the north side of Dundonald Street between Westmorland Street and Northumberland Streets as tree growth interferes with visibility.	Implement an annual foliage maintenance program that monitors and removes any foliage that interferes with the visibility of traffic control devices.	Agree. Currently exists an annual program for removal of foliage for stop/yield signs. Will consider expanding program to include all signs.
1.2 Visibility of some traffic signals is also obstructed by trees. For example, the secondary traffic signal at the southwest corner of the Montgomery Street and York Street intersection, can not be seen by approaching road users on Montgomery Street until the motorist is within 10-15 metres from the intersection. Similarly, visibility of primary traffic signals is blocked for those motorists traveling southbound on Smythe Street at the offset intersection at Priestman Street.	Implement an annual foliage maintenance program that monitors and removes any foliage that interferes with the visibility of traffic control devices.	
Temporary Work Area		
1.3 Construction is currently being conducted along the east and west sides of Smythe Street between Dundonald Street and Kings College Road. Temporary signage is adequate during construction hours (8 am to 5 pm); however, during non-operational hours, road users are not forewarned of the construction hazard.	Construction hazard signs should be installed throughout day and night time conditions. Increased use of retro-reflective markings is an alternative option.	Agree. Plan is currently in place to utilize more retro-reflective tape. A new City manual is being prepared for use with construction signing. Provincial manual will be consulted.
1.4 No signs are posted to notify approaching road users of construction at the northwest corner of the intersection of Aberdeen and Westmorland Streets (photo 1).	Construction hazard signs should be installed along all approaches to the work area.	Agree. Construction now complete but practice will change in future (see previous client response).

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT RESPONSE
1.5 Construction signs along Scully Street are pushed over at both ends of the work area.	Construction hazard signs should remain upright at all times particularly during night time conditions, in order to notify approaching motorists of the hazard such as raised manholes, depressions, etc.	Agree. Practice will change in future.
1.6 Raised manholes can be seen throughout the study area in preparation of a resurfacing program. To notify approaching road users of raised manholes on both sides of Smythe Street and along Beaverbrook Street at the intersection of Waterloo Row and Forrest Hill Road, wooden construction barriers have been placed on top of the manholes. Though these features are helpful during day-time conditions, they are difficult to see at night and create a hazard for approaching motorists.	It is recommended that warning lights be installed on top of the wooden barriers or they be replaced by barriers or cones with retro-reflective markings.	Will explore possible counter-measures including use of asphalt collars or retro-reflective markings.
Glare		
1.7 The rising/setting sun interferes with road user visibility at many intersection approaches oriented in the east/west direction. Specifically, it is difficult to see traffic signal indicators while approaching an intersection when the sun is positioned behind the signal head.	Increased use of yellow target boards for signal heads.	Target boards for signal heads have been a problem in past due to wind loadings. Have typically mitigated through increased use of auxiliary signal heads.
Congestion Areas		
1.8 During peak hours of traffic flow, congestion regularly forms on the west side of the intersection of Regent Street and Dundonald Street for traffic traveling eastbound on Dundonald Street. This area of buildup poses a safety risk to oncoming traffic further west of the approach since the sight distance is restricted due to a change in horizontal alignment prior to the congestion area.	Installing signs that notify motorists of the approaching area of congestion.	Warning signs not warranted. Long term plan is for horizontal / vertical realignment.

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT RESPONSE
1.9 The intersection at Prospect Street and Regent Street experiences large volumes of traffic on a daily basis and areas of congestion regularly form during peak hours. Congestion and high traffic volume levels will continue to pose a safety issue as the population grows south of the intersection in the neighboring community of New Maryland.	1. Long-term planning should promote alternate links to connect New Maryland with downtown Fredericton. 2. Increase signal conspicuity (eg. target boards) and crosswalk visibility (eg. zebra stripes) 3. Provide northbound double-left lanes with protected phasing or consider elimination of left-turn movement.	1. Agree 2. Will not use target boards (see above). Agree with zebra suggestion but will explore accident configurations before implementation. 3. Should be part of long-term circulation strategy for Propsect St. area. Will await results of on-going transportation study.
1.10 As congestion levels at intersections increase, driver frustration often results in increased risk-taking. It is therefore important to manage congestion as effectively as possible. Congestion on Regent Street between George and Queen Streets is particularly acute during the evening peak hour. The result is frequent running of amber signal phases, disregard of pedestrian right-of-way, and infiltration of vehicles into adjacent residential streets. Similar issues exist on Westmorland Street between Queen and Brunswick Streets.	Removal of parking on Regent Street to provide additional capacity and increased use of protected left-turn phases are but two possible mitigative measures.	Agree with strategy for parking removal. Will await results of transportation study currently underway before pursuing (i.e., may be larger issues related to bridge access). Aviod using protected left-turn phasing in CBD due to potential for pedestrian interactions.
School and Recreation Areas		
1.11 Three schools are located within the study area and each school zone is adequately signed from all approaches. In the area of the elementary school, the alignment and layout of Connaught Street are conducive to high vehicle speeds. Specifically, the local street is wide and straight.	Construction of various traffic calming measures may be appropriate such as speed humps or intersection narrowing.	Traffic calming is part of mandate for the ongoing transportation study. Will await study recommendations / strategies.
2. Alignment and Cross Section ***Classification***		
2.1 The road classification of Westmorland Street is classified as a collector road. However, traffic patterns have changed on the route since the construction of the Westmorland Street Bridge, consequently the road is effectively functioning as an arterial.	Mitigative measures may include implementing traffic calming techniques along Westmorland Street or upgrading it to accommodate current traffic flows.	Traffic calming is part of mandate for the ongoing transportation study. Will await study recommendations / strategies.

OBSERVATIONS	**POSSIBLE COUNTERMEASURES**	**CLIENT RESPONSE**
Cross Sectional Elements		
2.2 In general, the condition of much of the curbs and gutters within the study area is poor (photo 2). In some sections, particularly along Massey Avenue and Kings College Road, the roadside curb is worn down to the point where it would be ineffective at separating errant vehicles from the adjacent boulevard/sidewalk. Additional examples of roads with non-existent or poorly maintained curbs are listed in **Appendix 1**.	Implement a program where the condition of local curbs/gutters/sidewalks are evaluated and ranked; such a program helps identify those facilities that require immediate attention.	Program has recently been developed and is being implemented.
2.3 A number of pedestrian crossings at intersections do not provide drop curbs to accommodate wheelchairs or the disabled (photo 3,4,5,6). A number of these sites are listed in **Appendix 1**.	Consider implementing a program where the condition of local curbs/gutters/sidewalks are evaluated and ranked; such a program helps identify those facilities that require immediate attention.	
2.4 Along many local and collector roads, sidewalk conditions are poor (photo 7). Specifically, sidewalk conditions are notably rough on Kings College Road, Massey Avenue, and York Street. Large cracks, missing concrete sections, and separations between concrete blocks impede the movement and compromise the safety of pedestrians (particularly the disabled). **Appendix 1** lists further locations where sidewalk conditions are poor.	Consider implementing a program where the condition of local curbs/gutters/sidewalks are evaluated and ranked; such a program helps identify those facilities that require immediate attention.	Program has recently been developed and is being implemented.
Alignment		
2.5 There are a number of intersections within the downtown area with considerable alignment problems. For example, at the intersection of King Street and Westmorland Street, five lanes exist on the north side of the intersection and only three on the south side (photo 8). Vehicles proceeding through the intersection in the northbound direction are aligned opposite vehicles turning left onto King Street from Westmorland Street. This mis-alignment forces road users traveling northbound to veer around the southbound road users turning east. Further examples of intersections with alignment issues are listed in **Appendix 1**.	Correct intersection layout to align through lanes.	King / Northumberland will be addressed through new curbing project. A deferred widening bylaw is in place for King / Westmorland. Issue is linked to bridge access review which is part of the ongoing transportation study.

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT RESPONSE
2.6 A significant change in horizontal alignment along St. Anne Point Drive is not clearly visible for those approaching from the west until the curve has begun.	Installation of a curve warning sign, improved delineation, or illumination are possible mitigative measures.	Will consult with NBDoT (provincially designated road).
2.7 Along Mitchell Street, between Montgomery Street and Kings College Road, the horizontal alignment of the road is skewed resulting from an extension of a former cul-de-sac (photo 9). The mid-block remains of the cul-de-sac and houses lining the road appear hidden to approaching road users traveling in the north direction. In fact, the cul-de-sac resembles another road that intersects with Mitchell Street traveling in the east direction. This illusion proves particularly challenging to navigate during night driving conditions.	The alignment of the street should be better delineated.	Will review. Better striping may be required.
2.8 Confusing lane alignments exist between George Street and King Street for vehicles traveling northbound on Regent Street. Parking is permitted on the eastside of the road between the intersections of Regent and Brunswick Streets, and Regent and King Streets which complicates the problem. Vehicles are required to maneuver around these parked cars to gain access to the through/right turn lane (photo 11).	Removal of on-street parking between Brunswick and King Streets will permit better alignment for through movements.	See previous comments. Related to bridge access being studied through the ongoing transportation study.
2.9 Windsor Street is a straight and wide road that stretches from the top of the hill at Montgomery Street to the bottom of the hill at Beaverbrook Street. These conditions are conducive to high vehicle speeds, which pose a safety risk for the high level of pedestrian activity associated with the adjacent university and daycare facility.	Possible remedies include: 1) implementing traffic calming techniques. 2) lowering the posted speed limit or installing signs that notify road users of approaching pedestrian activity.	Will investigate possibility of crosswalk warrants. Traffic calming to be addressed by transportation study.

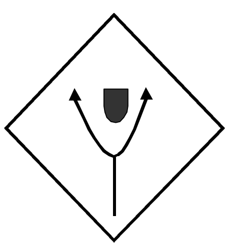
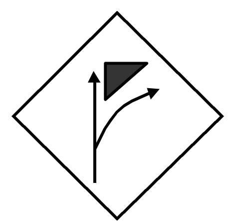
OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT RESPONSE
3. Intersections ***Layout***		
3.1 The layout of the Brunswick Street/Waterloo Row/University Avenue intersection is confusing and some traffic maneuvers are cumbersome (photo 10). In particular, road users traveling eastbound from Brunswick Street onto Waterloo Row must travel down a short hill, pass through the intersection, navigate around a support for the former rail bridge positioned over the intersection, and travel up a short hill. This manoeuver confuses motorists new to the area and adds to unsafe driving conditions generated by the intersection layout.	Long-term planning should include replacing the former heavy rail bridge with a light, clear span pedestrian bridge.	Will analyze accident patterns and consider mitigative options if warranted. Opportunities to improve signing and marking will be explored.
3.2 Queues often build during peak periods at the intersection of Beaverbrook Street/Waterloo Row/Forest Hill Road to the point where the intersection of the two connector roads becomes blocked.	Control measures should be implemented to prevent /discourage drivers from stopping within this area.	Disagree. Believe this is a non-issue.
3.3 Just east of Windsor Street, Montgomery Street forms a T-intersection with an access driveway to the University of New Brunswick's Aitken Centre. The configuration is confusing because the right-of-way is assigned in an unconventional manner such that the stem of the T is given right-of-way. This configuration can be confusing particularly to unfamiliar drivers.	Reconfiguration or better delineation would improve this intersection.	Will investigate possible solutions (including possibility of restricting access to UNB lot).
3.4 The length of turn lanes is inadequate at the intersection of Prospect and Regent Streets. Left turn lanes for northbound traffic on Regent Street and the left turn lane along the east approach on Prospect Street exceed capacity during peak hours. Traffic regularly extends beyond the length of these auxiliary lanes onto adjacent through lanes.	Consider modifying the intersection layout (see previous counter-measures).	Part of long-term circulation strategy for Propsect St. area. Will await results of on-going transportation study.

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT RESPONSE
3.5 Currently, customers using the Irving gas station at the northwest corner of the intersection of Prospect and Regent Streets can exit the facility by turning north onto Regent Street. This movement is possible because of a median opening that separates northbound and southbound traffic on Regent Street. This particular manoeuver for motorists is difficult and dangerous given sight lines and current traffic volume levels.	Consider restricting this manoeuver with regulatory signage or physical changes to the median.	Agree. Part of longer term circulation strategy for Prospect St. Will investigate accident frequency to develop short-term mitigative measures.
3.6 The design of a number of intersections does not adequately accommodate the movement of large commercial vehicles. In particular, large vehicles turning east onto Dundonald Street from northbound York Street must attempt to navigate a short radius corner. This issue is complicated by the fact that a fire station is positioned on the same corner and fire trucks must make this turn on a regular basis. The problem is repeated for heavy vehicles turning at the northwest and southwest corners of the intersection.	Modify the intersection layout to include features such as slip lanes or increased radii.	York / Dundonald scheduled to be upgraded next year.
Sight Distance at Intersections		
3.7 A number of sight lines are obstructed at intersections for a variety of reasons. In most cases, trees, parked vehicles, or houses block the line of sight. In order to see oncoming traffic in either direction, it is necessary for a vehicle to move forward well beyond the stop line or stop sign. Examples of intersections with sight distance problems are listed in **Appendix 1**.	Mitigative measures include restricting on-street parking or reducing foliage growth.	Foliage program to be revisited. Sites listed in Appendix will be visited and where possible mitigative measures implemented if warranted.
3.8 Sub-standard sight distance exists for vehicles stopped on Albert Street at its intersection with Windsor Street. A blind hill is present to the north of the intersection on Windsor Street.	Motorists should be warned of the hazard using hidden intersection warning signs.	Mitigative measures will be explored including installation of hidden-intersection sign or conversion of Albert St. to one-way in this area.

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT RESPONSE
Controls		
3.9 Approaching the intersection of Regent and Montgomery Streets from the south, the effectiveness of the auxiliary and primary signal lights is reduced due to background trees. Specifically, the green signal indication sometimes blends into the green foliage beyond the intersection when illuminated. Similar conditions are evident as road users approach the York Street and Montgomery Street intersection from the west direction.	Use of yellow target boards is an option to increase signal conspicuity.	See previous discussion of target boards. Will investigate increased use of auxiliary heads where required.
3.10 At the intersection of York and Priestman Streets, a potentially dangerous condition exists whereby the driveway to an adjacent apartment building is located on Priestman Street at the intersection. Operational conditions are exacerbated since traffic exiting the apartment parking lot are not controlled by any traffic device. Subsequently, motorists must closely monitor adjacent traffic signals and traffic from all three approaches before they can enter the intersection.	Consider providing vehicles exiting the parking lot with a signal head.	Disagree. Observation is a non-issue.
3.11 Simcoe Court is shaped like a ‘Y’ as the road splits into two separate cul-de-sacs. Though this local street receives very little traffic, no regulatory traffic signs have been installed where the road diverges (photo 12).	Consider installing regulatory signs.	Will consider installation of a yield sign for the *stem* of the “Y”.
3.12 At the intersection of Church and Brunswick Streets, stop signs have been installed too low and are difficult to see from large vehicles. Short stop signs are also present at the intersection of George and Church Streets.	Consider raising the signs.	Agree.
3.13 Terms which control the use of yield signs are outlined in the TAC Manual of Uniform Traffic Control Devices for Canada. However, the use of yield signs in Fredericton is not always consistent with the standards (photo 13). At Mitchell Street and Squires Street for example, the yield sign is not appropriate for the intersection given the poor sight distance and the skewed angle in which Squires Street intersects Mitchell Street. There are a number of other intersections within the city where yield signs and stop signs are used on opposing approaches.	A survey of regulatory signs at all intersections should be conducted; those signs inconsistent with standards should be changed.	Agree. Will change yields to stop signs were appropriate.

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT RESPONSE
4. Road Surface		
4.1 Within the study area, the condition of pavement varies according to the road classification. Generally, local roads appear to be roughest, with sections of road filled with cracks, bumps and potholes. The pavement condition is particularly poor where the edge of the pavement meets the curb. This is especially problematic for cyclists. A list of roads and intersections showing pavement distress are found in **Appendix 1**.	Consider resurfacing the pavement in areas where road conditions are particularly poor.	Currently developing a program to manage and prioritize pavement resurfacing.
4.2 The arterial roads are generally free of pavement defects. However, the pavement on the south approach of the Regent-Dundonald Street intersection has rippled as a result of vehicles, particularly heavy trucks, stopping at the base of the hill.	Consider resurfacing the pavement.	
4.3 Pavement conditions at the entrance to several parking lots along Prospect Street are deteriorating. Specifically, pavement is crumbling and cracking in areas where the edge of the arterial street connects with the entrance/exit of the access route.		
5. Visual Aids ***Pavement Markings***		
5.1 Most pavement centrelines are well defined. However, supplemental pavement markings are often faded or absent. At the intersection of Beaverbrook and Regent Streets, and also the intersection of Montgomery and Regent Streets, crosswalk markings are missing.	Consider increasing frequency of re-striping program.	Annual program is in place. May consider changing paint types (to something more durable) and/or increased use of manufactured pavement markings (eg., thermoplastics).
5.2 An issue associated with channelization measures at intersections is the condition of pavement markings within the study area. At Montgomery and Regent Streets for example, the left turn arrows are faded and their visibility from the approach is limited. Along Regent Street, the effectiveness of channelization markings are also reduced due to fading. **Appendix 1** lists additional areas where the effectiveness of channelization is reduced due to poor pavement markings.		

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT RESPONSE
5.3 The southwest corner of the intersection of Regent and Dundonald Streets has a pedestrian crossing marked despite the lack of a sidewalk adjacent to either street in this area.	Consider removing the markings.	Agree.
Lighting		
5.4 Overhead luminaires are not functionary along Regent Street between Kings College Road and Montgomery Street. Street lamps are also missing at the intersection of King and Northumberland Streets.	Maintain/repair as required.	Annual program in place.
5.5 Proper illumination is not provided at two confusing and complicated intersections; (1) at Waterloo Row/Beaverbrook Street/Forrest Hill Road, vehicles must exercise caution when using the poorly lit west corner of the intersection and (2) at Waterloo Row/Brunswick Street/University Avenue, a number of dangerous obstacles exist in and around the intersection that could be better illuminated.	Consider installing additional illumination devices.	Agree. Will investigate.
5.6 Along Dundonald Street, from Regent to Northumberland Streets, dark segments of the road exist due to a general lack of overhead lighting. Furthermore, overhanging trees reduce the effectiveness of luminaires that are present.	Installing additional luminaires or reducing foliage are possible mitigative measures.	Long term plan is to replace trees with different species (with less intrusive canopies). Will re-evaluate planting policy on arterial streets.
Signs		
5.7 An assortment of signs are improperly positioned. For example, the "*traffic signal ahead*" sign on the east side of Montgomery Street, prior to York Street, is too close to the intersection. On Connaught Street, a no parking sign is turned away from traffic flow rendering it ineffective.	All traffic signs should be positioned according to TAC standards.	Agree. The *traffic signal ahead* sign was only meant to be temporary and will be removed.
5.8 The *"no parking"* sign located on Priestman Street near Regent Street is faded. Similarly, the "*do not enter*" signs on the west side of Regent Street prior to Priestman Street are difficult to see and offer poor retro-reflectivity. **Appendix 1** lists other examples of signs that have faded and are no longer retro-reflective (photos 17 and 18).	Consider replacing the signs.	Agree.

OBSERVATIONS	**POSSIBLE COUNTERMEASURES**	**CLIENT RESPONSE**
5.9 The Dundonald and Westmorland Street intersection was reconfigured from a 4-leg intersection to a T-type. Immediately following the reconstruction, two *"no turn"* signs were placed on opposite sides of the intersection on Dundonald Street, to inform approaching motorists that left/right turns were no longer allowed to the south approach. A number of years have passed since the layout change and drivers have adjusted to the new intersection.	The signs could be removed to minimize clutter and confusion to those road users new to the area.	Agree. Will remove.
5.10 The *no right turn on red light* sign posted on the train bridge overpass at the intersection of Waterloo Row and University Avenue is difficult to see during night conditions from the Brunswick Street approach.	Reposition or enlarge the sign.	Agree. Will reposition.
5.11 One-way arrow signs installed above the primary traffic signal are difficult to see during night time conditions. Conspicuity of the one-way signs is further reduced given their small size.	Potential solutions include illuminating the sign or increasing its size.	Will investigate possible countermeasures..
5.12 A double arrow sign illustrated in photo 14 and the figure below (WA-17 of the Uniform Traffic Control Devices Manual) is often used in conjunction with an object marker sign to delineate the gore/nose of pedestrian islands where channelized right-turn lanes exist. The geometry of the sign's arrows implies that through traffic may pass on either side of the island when, in fact, those passing to the right must make a right turn at the intersection. The sign's intended use is for multi-lane roadways where a section of through lanes is separated by a median. 	Consider replacing existing signage with a warning sign that depicts the geometry more realistically; Prince Edward Island developed the following sign for this purpose: 	Will consider eliminating the use of WA-17 in favor of an object marker only.

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT RESPONSE
5.13 Crosswalk signs installed at the intersections of St. John Street-Aberdeen Street and Church Street-Aberdeen Street are non-conforming according to the Manual of Uniform Traffic Control Devices for Canada. The symbol for the 'Playground Area Sign' was used which is traditionally displayed on a yellow board and is used to indicate upcoming sections of roads adjoining public playgrounds (photo 15).	Consider replacing non-conforming signs.	Agree. Will replace with TAC standard signs.
5.14 Visual clutter exists due to the quantity of signs installed in the vicinity of the Beaverbrook Street/Waterloo Row/Forrest Hill Road intersection. Road users traveling east and west through the intersection along Beaverbrook Street can be confused/ distracted by stop signs used to control traffic along the adjacent walking/bicycle trail. Conditions are exacerbated during night time driving.	Eliminate or modify trail signs.	Will investigate use of non-reflective sheetings or alternate colours / messages. Will also consider lowering signs and angling away from adjacent motorists.
6. Physical Objects ***Medians***		
6.1 The median located at the south end of Regent Street has become cluttered with signs. The "visual noise" created by these signs can confuse approaching road users as it is difficult to process each sign individually.	Rationalize signing as much as possible in this area.	Disagree. All signing is required. No opportunities to rationalize.
Clear Zone		
6.2 There is no curb on King Street between Westmorland and Northumberland Streets. The absence of this feature creates a serious safety hazard since there are utility poles located on the south side of King Street, with no separation from eastbound traffic.	Install curbing.	Upgrading of the street is programmed.
Poles and Other Obstructions		
6.3 At the northeast corner of Regent-Montgomery Streets and the southeast corner of Aberdeen-Regent Streets, large steel utility poles stand unprotected on each island (photo 19).	Poles should be protected to help reduce the severity of accidents.	Will investigate possible countermeasures (eg., guardrail).

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT RESPONSE
6.4 The breakaway base of a number of traffic light poles have been placed on top of fixed pedestals which extend well above grade levels. On the northwest corner of York Street and Dundonald Street for example, the base of a traffic light pole is placed on a concrete foundation approximately 2-3 ft high (photo 20). Also, at the intersection of York and Queen Streets, traffic light poles were placed on stone blocks about 2 feet high (photo 21). Similar examples of elevated traffic lights and poles not protected by curbs are listed in **Appendix 1** (see also photos 22 and 23).	Fixed pedestals should be lowered so that the frangible bases may function properly if struck by an errant vehicle.	Poles with ornamental bases are in low speed areas and are not considered a hazard. Some poles are preferred to remain standing rather than endanger pedestrian bystanders. Some bases will be converted where appropriate.
7. Road Users ***Motorized Traffic***		
7.1 The bus stop on the north side of Montgomery Street east of Regent Street, is located very close to the intersection. A potential safety hazard exists for motorists using the intersection if the bus stops for passengers and a resultant queue forms.	Consider relocating the bus stop.	Disagree. Non-issue.
7.2 A bus stop is located on the east side of Regent Street between Brunswick Street and King Street. A potential safety hazard exists for both motorists and bus passengers at this location as vehicle parking is permitted directly in front of the bus stop sign.	Restricting parking or relocating the bus stop are two possible mitigative measures.	Will be considered in conjunction with possible changes to parking. Will discuss issue with Fredericton Transit.
Non-Motorized Traffic		
7.3 The slats on many storm grates are oriented parallel to the flow of traffic. Such conditions could prove dangerous as a set of bicycle tires could get caught in the slats thereby causing the user to lose control. Listed in **Appendix 1** are roads where the orientation of storm grates are hazardous to cyclists.	Slats should be oriented perpendicular to traffic flow.	Agree. Will correct where misaligned.
7.4 Poor pavement conditions along many street edges force bicycle users to travel further away from curbs closer to the flow of traffic. These conditions are dangerous to both vehicle owners and cyclists.	Resurface where necessary.	See previous comment. Pavement management program under development.

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT RESPONSE
7.5 In the downtown area, adequate space between light poles and other objects has not been provided for a wheelchair to adequately turn onto an adjacent street. An example of this is on the northwest corner of the intersection of Queen and Regent Streets.	Consider relocating objects or widen sidewalk/boulevard areas at key intersections.	Will consider when future capital projects affect applicable areas.
7.6 There are several intersections in the downtown area where traffic light poles have been located in the direct travel path of pedestrians. This represents a hazard for blind people since they are mainly guided by the location of drop curbs. Following the path directly in front of drop curbs, leads them to traffic light poles at the other end of the street. An example of this is at the intersection of Regent and Queen Streets (photo 24), and at the intersection of Regent and King Streets.		
8. Access and Adjacent Development ***Right-of-Way***		
8.1 Traffic signals are difficult to see at night when approaching the Regent-Prospect intersection from the north. Adjacent commercial signing distracts and reduces the effectiveness of signals during night-time conditions.	Install target boards on signal heads and restrict use of illuminated commercial signing adjacent to busy intersections.	See previous comments re. target boards.
Driveways/Approaches		
8.2 A number of stores, restaurants and gas stations, and their respective access points, have accumulated along Prospect Street over the years. Given the volume of traffic that use the street, left turns often prove to be difficult and unsafe. Driver frustration often leads to acceptance of smaller gaps. Along the north side of the street near Regent Street, access routes have been constructed close together and use of these facilities is frequent. Such conditions pose a potential safety risk to all road users particularly those traveling west through the Regent-Prospect intersection.	Consider installing a median barrier or using regulatory signing to restrict turning movements.	Part of overall review of circulation study of Prospect St. and hill area. Study should investigate potential use of raised median.

OBSERVATIONS	POSSIBLE COUNTERMEASURES	CLIENT RESPONSE
Building Setbacks		
8.3 Sight distance is significantly restricted at the south-west corner of Charlotte Street and University Avenue. A two-storey house is positioned directly on the corner with very little setback distance from the curb.		Non-issue given low volumes.
9. Parking ***Street Parking***		
9.1 On-street parking is permitted on a number of local and collector streets. Though approaching traffic can easily manoeuver around parked vehicles on one side of the road, it is often difficult to use the street when vehicles are parked on both sides. Such conditions are particularly apparent along Montgomery and Massey Streets.	Consider restricting on-street parking to one side of the street.	Will retain practice of reviewing on an “as-needed” basis depending on factors such as volumes and site distances.
9.2 At some locations in the downtown area, street parking exists close to intersections. For example, street parking is permitted on the west side of the intersection of Regent and King Streets. This poses a problem for commercial vehicles trying to turn from northbound Regent Street onto westbound King Street. In order for those vehicles not to encroach onto eastbound traffic stopped at the light, they must turn, making use of the first two parking spaces on King Street.	Restrict on-street parking that interferes with turning movements at intersections.	Disagree. A non-issue given the slow speeds involved and subsequent low risk. More of a nuisance issue.
9.3 In the downtown area, some restaurants/bars have extended their patio area onto the adjacent sidewalk area. This necessitates a circuitous route for pedestrians who are detoured around the eating area on a wooden sidewalk extension. This can be particularly problematic for the disabled and visually impaired. Furthermore, the detours typically occupy an on-street parking space which exposes the pedestrians to the travel lanes without the benefit of a curb and boulevard buffer.	Consider prohibition of sidewalk patios that necessitate detours for pedestrians.	Procedures are now in place to ensure patios are established at appropriate locations (low volumes and slow speeds). A non-issue for disabled users.

APPENDIX 1

A. Curb Condition Problems

1. Beaverbrook Street (no curbs on north side from Regent Street to Tweedsmuir Street)
2. Grandame Street/Fenety Street (rough curbs)
3. Windsor Street (bad curbs)
4. University Avenue (no curbs at south end)
5. Alexandra Street (low curbs)
6. Grey Street (poor curbs)
7. Charlotte Street (no curbs between St. John Street and Church Street)
8. Albert Street (poor curbs east of York Street)
9. Reid Street (no curbs at north end)
10. Dundonald Street (poor curbs)
11. Prospect Street (poor curbs)
12. Priestman Street
13. Regent Street (no curb in sections)
14. Smythe Street (poor curbs)
15. Queen Street/Westmorland Street (poor curbs on westside of intersection)
16. Westmorland Street/King Street (poor curbs on southwest side of intersection)
17. Northumberland Street/King Street (poor curbs on northeast corner)

B. Wheelchair Accessibility Problems

1. Mitchell Street and Kings College Road (at NE and NW corners)
2. Massey Street
3. Westmorland Street
4. Regent Street (west side, from Kings College Road to Montgomery Street)
5. Burden Street and Fenety Street
6. Windsor Street
7. Winslow Street
8. Charlotte Street
9. Albert Street (near York Street and near UNB)
10. Churchill Row and St. John Street
11. Kings College Road and York Street
12. Regent Street/Queen Street (northside of intersection)
13. Entrance/exit to pedestrian bridge on northside of St. Anne Drive made of gravel
14. Queen Street/York Street
15. Smythe Street
16. King Street/York Street
17. Carleton Street/King Street
18. Victoria Street
19. Argyle Street

C. Sidewalk Problems

1. Connaught Street (no sidewalk on north side, even with school nearby)
2. Dundonald Street (poor sidewalk on north side from York Street to Regent Street)
3. Smythe Street (rough sidewalks south of offset intersection)
4. Regent Street (poor sidewalk on west side, makeshift on east, north of Montgomery Street)
5. Albert Street (poor sidewalks east of York Street)
6. Argyle Street (poor sidewalks on both sides)
7. Westmorland Street (poor sidewalks in some locations)

D. Faded Channelization Markings

1. Dundonald Street at intersection with York Street
2. Dundonald Street and Smythe Street
3. Priestman Street and Smythe Street
4. Prospect Street and Smythe Street
5. Beaverbrook Street/Waterloo Row/Forest Hill
6. York Street and Montgomery Street
7. Regent Street and Montgomery Street
8. Regent Street and Prospect Street
9. Regent Street and Priestman Street
10. Regent Street and Beaverbrook Street
11. Smythe Street and Parkside Drive
12. George Street

E. Intersection Layout

1. King Street/York Street (turning radius restricted)
2. York Street/Brunswick Street (intersection offset by half a lane in northbound direction)
3. Northumberland/King Street (southbound lane aligned with opposing northbound lane)

F. Sight Distance Problems at Intersections

1. Connaught Street looking north on York Street
2. Montgomery Street at Smythe Street
3. York Street and Massey Street (NE corner)
4. Aberdeen Street and Regent Street (NE corner)
5. York Street and Albert Street (at stop sign)
6. Chestnut Street (sight distance insufficient for yield sign)
7. Squires Street and Mitchell Street (yield sign where sight distance is poor)
8. Beaverbrook Street/Waterloo Row/Forest Hill (must pull out past stop signs to see)
9. Brunswick Street and University Avenue
10. Charlotte Street/York Street (house blocks sight lines on southeast corner)
11. George Street/Northumberland Street (sightlines obstructed by trees)

12. George Street/Westmorland Street (obstructed sight line due to parked vehicles)
13. Carleton Street/Charlotte Street (sight distances are blocked by bushes)

G. Pavement Distress

1. Kings College Road (along curbs)
2. Mitchell Street (pavement bumpy north of Kings College Road, poor in general)
3. Chestnut Street (rough, bumpy pavement)
4. Edinburgh Street (rough pavement)
5. Westmorland Street (pavement edge rough near Westmorland St./Kings College Road)

H. Blocked Signs

1. Montgomery Street approaching York Street (traffic signal ahead sign)
2. Mitchell Street at Kings College Road (stop sign)
3. Massey Street (stop sign for eastbound traffic)
4. York Street at Dufferin Street (construction sign)
5. York Street approaching Priestman Street (traffic signal ahead sign)
6. Dundonald Street at Westmorland Street (pedestrian crossing sign)
7. Regent Street, west side (speed limit and pedestrian crossing signs)
8. Churchill Row and Regent Street (stop sign)
9. Gregg Court and Windsor Street (yield sign)
10. Graham Avenue and Albert Street (yield sign)
11. Smythe Street (pedestrian crossing sign and road narrowing warning sign)
12. Argyle Street/Westmorland Street (stop sign and no parking signs)

I. Faded Signs / Poor Retroreflectivity

1. Massey Street at Smythe Street (faded stop sign)
2. Priestman Street near Regent Street (faded no parking sign)
3. Regent Street south of Priestman Street (faded no entry signs)
4. Scully Street and Regent Street (faded stop sign)
5. Brunswick Street and Church Street (faded stop sign)
6. Massey Street and Smythe Street (faded stop sign)
7. Reid Street, north end (yield sign has poor retroreflectivity)
8. Elgin Street and Lynhaven Street (poor retroreflectivity of yield sign)
9. Oxford Street and Eglinton Street (poor retroreflectivity of yield sign)
10. Burden Street and Valleyview Street (poor retroreflectivity of yield sign)
11. Charlotte Street and Regent Street (stop sign has poor retroreflectivity)
12. Regent Street (some no parking signs have poor retroreflectivity)

J. Raised Traffic Poles and Unprotected Obstructions

1. Montgomery Street and Regent Street (raised traffic poles)
2. Regent Street and Prospect Street (raised traffic poles)
3. Priestman Street and Smythe Street (raised traffic poles)
4. Queen Street and York Street (raised traffic poles)
5. King Street and York Street (raised traffic poles)
6. Carlton Street and King Street (telephone pole on the southwest side unprotected)
7. Regent Street and King Street (poles located in path of pedestrians at the crosswalk)
8. Northumberland Street and King Street (exposed telephone pole)

K. Storm Grates Oriented Parallel to Traffic Flow

1. Windsor Street
2. Reid Street
3. Chestnut Street
4. Edinburgh Street


Photo 1. Unsigned construction at intersection


Photo 2. Curbs in disrepair


Photo 3. Inadequate curb cut-outs


Photo 4. Visually impaired road user


Photo 5. Physically disabled road user


Photo 6. Elderly road user

Photo 7. Poor sidewalk condition

Photo 8. Misaligned intersection

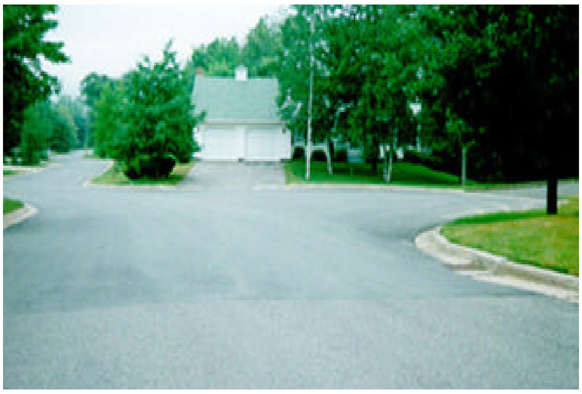


Photo 9. Unsigned confusing alignment

Photo 10. Confusing intersection

Photo 11. Congestion on a poorly aligned street

Photo 12. Unsigned intersection

Photo 13. Yield sign where local street meets arterial street

Photo 14. Communicates right-turn lane

Photo 15. Non-standard crosswalk sign

Photo 16. Blocked Stop sign

Photo 17. Faded Stop sign

Photo 18. Faded Stop sign

Photo 19. Exposed steel pole

Photo 20. Unprotected pole

Photo 21. Pole with breakaway support on granite foundation

Photo 22. Unprotected poles

Photo 23. Raised breakaway support

Photo 24. Pole in pedestrian path

Road Safety Audit Report

75% DESIGN STAGE -NEW FACILITY
ROUTE 20 HIGH SPEED CONNECTOR TO ROUTE 21 INTERCHANGE

August, 1999

Audit Team

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Client

Road Builders Inc.
Saint John, N.B.

75% DESIGN STAGE AUDIT: ROUTE 20 HIGH SPEED CONNECTOR TO ROUTE 21 INTERCHANGE

Section 1.0: INTRODUCTION

This 75% Design Stage audit is supplementary to the Preliminary Design, 50% Design, and Pre-Opening Audits completed on June 7, July 16, and August 5, 1999, respectively. The reports of those audits were previously submitted to the client. This supplementary audit was conducted by Frank R. Wilson, Eric Hildebrand, and Tammy Dow during the week of August 20-27, 1999. The audit followed the procedures used in previous audits.

The 75% Design Stage audit refers to the construction staging of the project. At the time of this audit, approximately 75% of the length of project had the detailed design work completed. The scheduled phasing of construction necessitated that audits be preformed at preset intervals to allow the project to progress efficiently toward full completion.

Material used in this initial pre-opening audit is listed in Appendix 1. In addition to these reference materials, F.R. Wilson and E.D. Hildebrand met with Messers. D. LePage, J. Miller, J. Mosser, and G. Auden prior to undertaking the audit.

Section 2.0 FORMAT OF REPORT

At the time of the audit a number of issues identified in previous audits were outstanding, or their status have changed. Table 1 presents the outstanding issues that still need to be resolved at this time, while Table 2 summaries the findings of the current audit.

> <u>Note:</u>
> The 75% design stage audit covers physical features which may affect road user safety and it has sought to identify potential safety hazards. However, the auditors point out that no guarantee is made that every deficiency has been identified. Further, if all the recommendations in this report were to be followed, this would not confirm that the highway is 'safe'; rather, adoption of the recommendations should improve the level of safety of the facility.

Section 3.0: FINDINGS AND RECOMMENDATIONS

Findings and Recommendations from this 75% Design Stage Audit completed on August 27, 1999 are presented in Table 2. This table complements those findings identified in Table 1 and from those in the previous audit reports

Dr. F. R. Wilson, P. Eng.	Dr. E.D. Hildebrand, P.Eng.	T.C. Dow, B.Sc.E.

August 31, 1999

Appendix 1: Documents Used During Audit

1. Revised signage design package prepared by builder and transmitted to F. R. Wilson on Aug. 8, 1999.

2. Detailed set of design plans for entire section under review including, cross-sections, horizontal and vertical alignments, drainage, structures, lighting, signing, and pavement markings.

3. Owner's signing plan for Route 21 interchange, dated July 19, 1999.

4. Plan of Pavement Markings, Route #20 Extension and Interchange 21 by Homer & Associates dated June 1, 1999.

Table 1A: Outstanding Issues From *Preliminary Design* Audit

Previous Audit Findings	Previous Audit's Recommendations (light) & This Audit's Findings or Recommendations (bold)	Client/Builder	
		Accept: Yes / No	Reasons/Comments
STAGE 2 (PRELIMINARY DESIGN) AUDIT OF THE PROPOSAL DOCUMENT PLANS Item 3.1(1): On the approaches to the proposed emergency crossovers, the audit called for an enhanced treatment , above that in the design guides. It will enhance safety if vehicles which use the crossovers are able to slow down clear of the left traffic lane.	(a) Widen the left shoulder to 3 m for 100 m in advance of the crossovers. **[Designs seen in this audit appear not to include this agreed change.]**	No	Emergency crossovers will be designed and constructed in accordance with client's guidelines.

Table 1B: Outstanding Issues From *Post Opening* Audit of Section A

Previous Audit Findings	Previous Audit's Recommendations (light) & This Audit's Findings or Recommendations (bold)	Client/Builder	
		Accept: Yes / No	**Reasons/Comments**
POST OPENING AUDIT OF SECTION A The comments and recommendations by the client relative to this audit are supported. The items at right appear to still require attention.	A. Further Review/Action Required:		Builder's previous response in italics:
	(a) Wrong way signs at on ramps	Yes	*Review of existing conditions will be done under scheduled future review with the owner.*
	(b) Improve guide rail end treatments	Yes	
	(c) Review length of existing guide rail	Yes	
	(d) No guide rail at a deep fill at Sta. 68 + 900 EBL and on WBL	Yes	
	(e) Guide rail too short on left side of eastbound exit ramp at Rte. 6	Yes	
	(f) Crossover at Sta. 19 + 250 requires treatment	Yes	
	(g) Eastbound Lanes at Rte. 6 Interchange require modifications	Yes	
	(h) Consider lowering the posted speed on the westbound off ramp at Rte. 10	Yes	Posted speed will be reassessed.
	(i) Review unprotected culvert near Sta. 62 + 800		Review of existing conditions will be done under scheduled future review with the owner.
	(j) Check clear zone for westbound exit ramp at Rte. 6 Interchange.	Yes	Clear zone will be confirmed.
	(k) There is evidence of pavement surface deterioration		*Review of existing conditions will be done under scheduled future review with the owner.*
	(l) Existing slopes and clear zones should be checked against TAC criteria		*Review of existing conditions will be done under scheduled future review with the owner.*

Table 1C: Outstanding Issues From *50% Design Stage* Audit

Previous Audit Findings	Previous Audit's Recommendations (light) & This Audit's Findings or Recommendations (bold)	Client/Builder	
		Accept: Yes / No	Reasons/Comments
50% DESIGN STAGE AUDIT			
2. GUIDE RAIL The following repeats the findings of the previous audit:	**The audit team considers the issues of roadworthy guide rail end treatments and protection of steep side slopes to be IMPORTANT. The issues warrant renewed consideration, as set out below.**		
2.1 End Treatments On existing sections of the project, guide rail has been installed with turned down (buried) ends, either on straight guide rail or flared ends. This practice is continuing on new sections of the project. Although this is a commonly used standard treatment (e.g. as in the current TAC Geometric Design Manual), experience has shown it to offer poor protection for the travelling public. These terminal treatments are not crashworthy. Considering the likely extent of guide rail installation over the whole project, the continued use of turned down ends presents a significant potential hazard for future users.	(a) The turned down, buried guide rail ends are not crashworthy. No end treatments of this type should be used on this project (IMPORTANT).	No	End treatments as specified in the contract documents are being used. Alternative end treatments as noted by the Audit Team are expected to be incorporated in the new TAC standard however, owner is not willing to prepare a change order for the supply and installation of alternate end treatments.
	(b) All new guide rail end treatments and existing ones in Sections A, B, C & D should be crashworthy (A guide to crashworthiness is NCHRP350 or equivalent testing) (IMPORTANT). **See recommendations in Table 2 of the 75% Design Stage Audit**	No	
2.2 Length of Guide Rail The 50% design stage audit pointed out that some guide rail in section A is too short (i.e. it starts too late) to protect some steep slopes and obstructions. The installations should meet the requirements in the TAC Geometric Design Manual.	(a) Protect all fill slopes steeper than 4:1 or flatten the slopes.		Review of existing conditions will be done under scheduled future review with the Management Group.
	(b) Where fill sections develop grades from 4:1 or steeper, ensure guide rail commences the required distance before the steepening commences (IMPORTANT).		Review of existing conditions will be done under scheduled future review with the Management Group.

Table 1C: Outstanding Issues From *50% Design Stage* Audit

Previous Audit Findings	Previous Audit's Recommendations (light) & This Audit's Findings or Recommendations (bold)	Client/Builder	
		Accept: Yes / No	**Reasons/Comments**
4. CLEAR ZONES			
Clear zones on this project appear to have been adopted as 10 m throughout on the 110 km/h roadways. The following matters should be considered in relation to this: Errant vehicles (i.e. those which run off the road) are more likely to travel a greater distance away from the road: • on the outside of a curve than on a straight tangent, • on a steeper fill batter than on a flatter one.	(a) When calculating whether hazards are within the clear zone (and thus need to be removed, relocated or shielded), take account of: • curve factoring, and • the degree of backslope - as per the TAC Geometric Design Manual.	Builder's previous response: Yes	Builder's previous response: *The owner's Highway Design Guide and TAC will be followed when calculating hazards within the clear zone. It is not expected the curves will have a bearing because of the large radius curves used in the design.*
The clear zones should meet all requirements of the TAC Geometric Design Manual. See pages F.10 to F.13. See Fig. F.2.2a for fill and cut batter slopes. See Fig. F.2.2b for widening on the outside of curves.	**Builder should check the assumption that large radius curves will address the issue at all locations. In particular, check curves with a radius between 700 m and 1,000 m.**	Yes	Guide rail has been designed with curve factoring.
6. TREATMENT OF UNDERPASS BRIDGES **6.1 On the Highway** The use of guide rail on the highway at underpass bridges in existing sections requires re-examination, with the results applied to designs for new sections. Because the toe of the underpass batter slope is within 10 m of the nearest traffic lane, the clear zone is not achieved. Apparently, because of this, guide rail has been placed at the back of the shoulder (i.e. 3 m from the traffic lane). This may not necessarily be the safest treatment - even if the guide rail ends are crashworthy.			

Table 1C: Outstanding Issues From *50% Design Stage* Audit

Previous Audit Findings	Previous Audit's Recommendations (light) & This Audit's Findings or Recommendations (bold)	Client/Builder	
		Accept: Yes / No	Reasons/Comments
Experience shows that, *on balance*, other options can provide better levels of safety, compared with guide rail 3 m from the traffic lane, because the closer the guide trail is to the road, the more likely it is to be stuck before control of an errant vehicle is recovered; also the guide rail needs to be longer to shield the same hazard. There is no single, simple solution for all sites, but options to consider could include: • Using a more 'forgiving' type of barrier than guide rail, or • Shifting the guide rail nearer the toe of the batter, where site constraints permit the necessary flattening in front of and behind the guide rail. While the angle of impact will be higher, at high speeds it is likely to be within acceptable limits.	(a) Re-examine guide rail under existing underpass bridges: • to consider options which could be safer, and • to ensure the barriers are long enough. Apply the results to the design of roadside areas under proposed underpasses. **[At the time of this audit, there were no plans showing details.]**		
6.2 On Side Roads On some side roads passing under the highway it appears that bridge abutments (vertical) or abutment toes are within the clear zone, but are not shielded.	(a) On side roads, check clear zone requirements and shield abutments within the clear zone. **[At the time of this audit, there were no plans showing details.]**	Builder's previous response: N/A	Guide rail lengths for structures under the existing highway are owner's jurisdiction. This concern will be brought to the attention of owner. At new overpass locations clear zones requirements will be maintained or hazards will be protected with guide rail.

Audit Findings	Audit Findings/Recommendations	Client/Builder Accept: Yes / No	Client/Builder Reasons/Comments
1. DESIGN ISSUES AT INTERCHANGES			
1.1 Route 20 High Speed Connector The S-W loop from Route 20 to the highway (at the east end of section 5) involves a decreasing radius curve, from 500 mR to 250 mR until end of curve is reached. It has the potential to be over-driven. In particular, experience shows that trucks can have problems with this type of curve. The Design Manager has indicated that the Builder has identified this problem and has considered ways to deal with it. We will review this further when signs and markings plans are available.	(a) Reconsider the horizontal alignment of the loop (IMPORTANT).	No	Builder plans to address this issue with flashing signs, chevrons, illumination and precautionary signage.
If the current layout of the curve is retained, some means is required to alert drivers to the tightening radius. Having slowed down, drivers will need to recognise the need to slow down further.	(b) Consider appropriate measures to advise truck and automobile drivers of the need to reduce speed to negotiate the ramp safely.	Yes	Builder plans to address this issue with flashing signs, chevrons, illumination and precautionary signage.
The Design Manager also advised that the second lane on the loop's bridge across the highway is for future E-S movements and will not be utilised at this time.	(c) Ensure pavement marking plans reflect this requirement.	Yes	Until the E-S ramp is constructed, pavement markings will be detailed to maintain two lanes of northbound traffic across the structure. The two lanes will be reduced to 1 lane north of the structure.
1.2 Route High Speed Connector, Section B This interchange also has an inner loop from S-W which has the potential to be over-driven, due to the relatively high speeds of approaching northbound traffic. We will review this further when sign and marking plans are available.	(a) Consider appropriate measures to advise truck and automobile drivers to reduce their speed.	Yes	Builder has addressed this issue with illumination and precautionary signage.
1.3 Route 21 Interchange, Section B The interchange, as designed, is considered to be capable of operating in a safe and satisfactory manner and is appropriate, given the location and the physical characteristics of the site.			

Audit Findings	Audit Findings/Recommendations	Client/Builder Accept: Yes / No	Client/Builder Reasons/Comments
The potential for the interchange to operate efficiently and safely should there be a large future traffic growth was addressed. It is concluded that such growth could be accommodated by installation of traffic signals at the Route 21 intersections. This procedure is successfully used throughout North America.	(a) Should future traffic growth warrant it, conduct an assessment of the need for traffic signals on Route 21.	N/A	Assessment of future traffic conditions at Route 21 is an owner's issue. Owner will be made aware of these issues.
1.4 Maintenance of High Mast Lighting High mast lighting poles are to be placed in the off-road areas of several major interchanges. In many locations where these poles are shown on plans, there is only a narrow shoulder on the nearest roadway. This is frequently shown in association with guide rail which would prevent a maintenance vehicle being parked clear of the traffic lanes.	(a) Provide a safe parking space for maintenance vehicles, clear of traffic lanes, near all high mast lighting poles. Consider provision of a section of wider sealed shoulder or other effective provision.	No	Temporary lane closures will be used if necessary.
2. Service Areas			
2.1 Median Service Area Exits The exit from the median service area has inadequate signs and markings and has the potential for wrong way(right turn) exits. Signs and markings are inadequate. Further, the New Jersey barrier could be mistaken for a median barrier.	(a) To face traffic returning to the main highway lanes, provide a left turn pavement arrow and mark off the right half of the road with hatched markings. Install a 'left turn only' or 'no right turn' sign under the Stop sign and consider 'wrong way' or 'no entry' signs on the back of existing signs upstream on the main highway lanes.	Yes	The revised signage design reflects this change.
2.2 Speed Limits After observing the service area in operation, we confirm our earlier recommendation that the speed limit through the service area should be a maximum of 80 km/h.	(a) Sign the maximum speed limit in the service area are at 80 km/h (IMPORTANT).	No	Owner agrees with the audit team recommendations, owner has requested that the through lane remain posted at 110 km/h. The posted speed has been temporarily reduced to 80 km/h until the revised signage design has been implemented.

Audit Findings	Audit Findings/Recommendations	Client/Builder Accept: Yes / No	Client/Builder Reasons/Comments
2.3 Road Markings at the End of the Separation Barrier On our inspection, we observed that the markings separating the through lane from the other lane were barely visible and were not installed to the design plan. To alert drivers of faster traffic in the through lane, it is important that these markings be installed to plan and maintained. Some old markings were still visible.	(a) Immediately install the required markings. Remove redundant markings which are still visible.	Yes	This issue has been addressed.
2.4 Stop Sign Ahead Signs There is a pair of these signs on the approach to the service area, on each side of the main lanes. The sign on the right side (located on the concrete separation barrier) is visible to drivers in the through lane, but is not intended to be. This condition contributes to the problems of drivers stopping in the through lane.	(a) Angle and shield the right hand Stop Sign Ahead sign to prevent through lane users from seeing it.	Yes	Stop Ahead sign removed.
3. GUIDE RAIL ENDS We understand that a decision has been made, for both the existing section A and the new sections of the project, to continue the use of flare, buried end treatment for guide rails. Given that current design trends are moving away from the buried end approach, the decision to use this standard on a new facility can be interpreted as not using currently accepted standards for safety. An argument that the adoption of a safer design could reflect adversely on recent highway projects, should not be a major consideration. Many examples exist where new designs or standards are implemented without the need to retrofit existing guide rail installations.	(a) The decision to use the flared, buried end treatment on guide rails should be re-evaluated. An end treatment such as an eccentric loader on the lead end should be used on the new section of the project (IMPORTANT). (b) The retrofit of the existing section could be a separate decision.	No	End treatment as specified in the contract documents are being used. Alternative end treatments as noted by the Audit Team are to be incorporated into the new TAC standards however, owner is not willing to prepare a change order for the supply and installation of alternate end treatments.

Audit Findings	Audit Findings/Recommendations	Client/Builder	
		Accept: Yes / No	**Reasons/Comments**
4. TRUCK OPERATION ON STEEP GRADES A number of long up-hill grades have been noted which will cause significant speed reductions to loaded trucks. No speed profiles were available, but a preliminary analysis has shown potential for speeds as low as 35 km/h in a lane with a posted speed limit of 110 km/h. Speed differentials of this magnitude are a safety concern, especially for periods of reduced visibility.	(a) Take appropriate measures to reduce the risk of high closing speed accidents, due to low truck operating speeds on the steep grades. Options could include a truck climbing lane, signs warning of slow trucks and instructions on use of hazard lights (IMPORTANT).	Yes	Vertical grades meet the requirements outlines in the specifications. Builder will review the requirement for slow truck hazard signs.
5. OTHER ISSUES **5.1 River Works Area** The pavement surface on River Route through the low areas exhibits excessive mud coverage, especially under wet conditions. This mud is likely to make the road slippery. It comes from truck activity from the borrow pit to the embankment site. At the same time, truck activity on the road due to construction is greater than normal . This creates a potential serious safety condition on the River Route.	(a) Immediately put in place a procedure to prevent mud getting on the road surface and for promptly removing any mud build up that does occur. Review the operational safety of the route in light of the increased truck movements (IMMEDIATE, IMPORTANT).	Yes	A procedure to control debris at the source is under development.
5.2 Rumble Strips We understand that a decision has been made not to install rumble strips along the shoulders on the project. Rumble Strips have the potential to increase the level of safety on The Highway by reducing the incidence of 'run off road' accidents.	(a) Given the potential for rumble strips to increase the level of safety; the decision to not install them on this project should be re-assessed by all parties.	Yes	Owner/Builder have now agreed to place rumble strips along right pavement edge for entire length of project.

ROAD SAFETY AUDIT REPORT

PRE-OPENING AUDIT

(Section P from western terminus to and including Beaver Road Interchange)

NEW BRUNSWICK

November 27 , 1999

AUDIT TEAM:

Dr. F. R. Wilson, P. Eng.
Dr. E. D. Hildebrand, P. Eng.

CLIENT:

Road Builders Inc.
Saint John, N.B.

Section 1.0 INTRODUCTION

This audit is supplementary to the 95% DESIGN STAGE AUDIT completed on Nov. 1-3, 1999 by the Audit Team. The report of that audit was dated Nov.9, 1999 and submitted to Road Builders Inc. on that date. The supplementary audit was conducted by F. R. Wilson and Eric D. Hildebrand. The audit followed the procedures used in previous audits.

At the field visit on Nov.19, 1999 of Section P (from the western terminus of the project to the Beaver Road Interchange) the work was not sufficiently advanced to complete a full audit. Before the final pre-opening audit can be conducted the following will be required:

- Plan showing closure of existing Route 15 at western terminus of the project.
- Completion of sign installations.
- Full illumination of the lighting infrastructure.
- Response to the initial pre-opening audit.

A subsequent day audit and a night time audit will be required prior to opening.

Material used in this initial pre-opening audit is listed in Appendix 1.

Section 2.0 FORMAT OF REPORT

Table 1 contains a list of the findings from the initial audit completed by F. R. Wilson and E. D. Hildebrand on Nov.19 1999. The findings of the Nov. 19 audit were given to Road Builders Inc. by conversation with Mr. Robertson on Nov. 19, 1999.

Note:
The pre-opening audit of Section P covers physical features which may affect road user safety and it has sought to identify potential safety hazards. However, the auditors point out that no guarantee is made that every deficiency has been identified. Further, if all the recommendations in this report were to be followed, this would not confirm that the highway is ‘safe’; rather, adoption of the recommendations should improve the level of safety of the facility.

Section 3.0 FINDINGS AND RECOMMENDATIONS

Findings and Recommendations from the Pre-Opening Audit of a portion of Section P are presented in Table 1, which is attached.

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Dr. F. R. Wilson, P. Eng.

____

Dr. E. D. Hildebrand, P. Eng.

Nov. 27, 1999

TABLE 1: PRE-OPENING AUDIT FINDINGS OF WEST PROJECT TERMINUS TO THE BEAVER RD.

Observations	Suggested Actions	CLIENT RESPONSE	
		Agree yes/no	**COMMENTS**
1.0 Signing			
1.1 The following locations only have a single "*Entry Prohibited*" sign [RB-23]: -westbound Route 15 off-ramp to southbound Route 25 -west terminus of project, westbound lanes (photo #1)	Install second sign on opposite side of road.	Yes	Additional signs will be installed.
1.2 Most off-ramps only have a single "*Wrong Way*" sign [RB-22] including: -westbound and eastbound Route 15 to Beaver Road -westbound Route 15 to Route 25 There are no *Wrong Way* signs at the transition zone at the west terminus of the project (photo #1).	Install second sign on opposite side of road. At the west terminus, install two *Wrong Way* signs on westbound lanes.	Yes	Wrong Way signs will be double posted on loop ramp with ramp terminals located beside on ramps (E-N/S ramp at Route 25 and E-N/S and W-N/S ramps at Howe Rd).
1.3 A "*Reverse Turn*" sign [WA-4 or WA-5] is missing prior to the transition area at the west terminus of the project on the westbound lanes.	Install appropriate sign pending results of ballbank measurement.	Yes	Signs will be installed
1.4 Green and red delineators are missing from all sections of guiderail. They are used to mark the endpoints of the guiderail sections for snowplow operators.	Install delineator signs.	Yes	Delineators to be installed.

1.5 The stop sign at the end of the eastbound offramp to Route 25 is setback 7.5 metres from the right edge of the travel lane (photo #2). T.A.C. standards specify a setback of 2-4.5 metres to meet driver expectations [M.U.T.C.D., 4th edition, September,1998]	Either re-set the sign, or install a second stop sign to the left of the offramp.	Yes	Due to wide turning radius a second stop sign will be installed to the left of the off ramp.
2.0 Pavement Markings			
2.1 The area downstream of the service areas where the through lane merges with the other leftmost lanes should be delineated with hatching. This is important to discourage motorists from prematurely merging into the higher speed through lane. This is required in both the eastbound and westbound directions	Paint hatching marks.	Yea	Hatch areas will be painted.
2.2 The acceleration lane and edge markings leading away from the westbound off-ramp to Route 25 southbound appear to be improperly marked. The right edge line for the southbound lane across the underpass deviates sharply away from the bridgerail. There is the opportunity to delineate a much more gradual transition for the acceleration lane and southbound traffic.	Repaint edge lines.	Yes	Line painting will be reviewed in the field to ensure compliance with the design drawings.
2.3 The bullnose separating the offramp and onramp from Route 25 to Route 15 westbound is setback from the stopline (photo #3). This configuration affords southbound traffic the opportunity to mistakenly enter the offramp rather than the onramp.	Extend the bullnose to the stop line similar to sketch in photo #3.	Yes	Line painting to be adjusted.

2.4 Left turn arrows have not been painted for left-turn pockets leading to Route 15 onramps at: -Route 25 -Beaver Road <u>Note:</u> The point can be made that the owner has some responsibility in this instance. The overriding factor is that the project has created these overpasses and the safety on the intersecting routes is as important as on the project road -hence, this section should be addressed prior to opening.	Paint left turn arrows.	Yes	Road Builders Inc. will paint arrows on Route 25, however Beaver Road is in the owner's jurisdiction. The owner will be notified of this requirement.

3.0 Guiderail			
3.1 Numerous sections of guiderail require additional installation work throughout the study section. Most sections have ends not properly buried in the shoulder.	Complete guiderail installations.	Yes	Guiderail installation will be completed.
3.2 A section of guiderail approximately 2 km east of Hillside Road, along the westbound lanes, has not been installed. The posts are present but the flexbeam has not been installed.	Complete guiderail installation.	Yes	Guiderail installation will be completed.
3.3 Guiderail is missing on Hillside Road prior to the Route 15 overpass abutments -on both the northbound and southbound approaches (see note in section 2.6).	Install guiderail prior to abutment wingwalls.	Yes	Hillside Road is in the owner's jurisdiction. The owner will be informed of this requirement.
3.4 Additional guiderail clean-up work is required at the first cross-over west of Hillside Road.	Complete clean-up.	Yes	Guiderail will be completed.

3.5 A short opening has been left between two sections of guiderail along the right edge of the westbound lanes, just west of Hillside Road. Although the sideslope and clear zone is within standard in this unprotected area, errant vehicles are exposed to hazards behind the protected areas.	Install additional section of guiderail to close opening.	Yes	Guiderail will be linked at this location.
3.6 Sections of guiderail are incomplete along approaches to the service area.	Complete guiderail installation.	Yes	Guiderail will be completed.

4.0 Access Roads			
4.1 Trucks accessing the temporary quarry located adjacent to the westbound lanes will pose a hazard to traffic. The sideslopes of the two driveways to the quarry need to be softened to meet standard.	A traffic management plan should be developed which outlines how the interaction of slow moving trucks with through traffic will be handled.	Yes	Traffic management plan will be developed. Sideslopes will be regarded.
4.2 Access currently exists for a gravel pit / staging yard adjacent to the eastbound lanes just west of the toll plaza.	This access should be closed and the dirveway graded to provide proper sideslopes.	Yes	Access will be closed and grading completed.
4.3 At the west terminus, a previous alignment for transition to the existing Route 15 remains open adjacent to the eastbound lanes of the new project (photo #4). This opening could confuse drivers if it were to remain open.	Either install a barricade or remove the old transition alignment.	Yes	Temporary barricades will be installed.

5.0 Lane Alignment			
5.1 There is no taper provided to reduce the two westbound lanes to a single lane at the approach to the transition to existing Route 15 (see photo #5).	Provide proper taper and install appropriate advance speed reduction and lane drop warning signs.	Yes	Tapers and advanced speed reduction and lane drop signs will be added.

6.0 Miscellaneous			
6.1 The gore between the eastbound onramp from Route 25 and the Route 15 through lanes has asphalt stockpiles.	Remove stockpile.	Yes	Debris will be removed.
6.2 Embankment. Section 8.3, page 9, Table 2 of the 50% Design Stage Audit and section 8.3, page 4, Table 1 of the 80% design audit makes reference to width of the top of the embankment.	Upon final construction, it has been noted that full width shoulders have been maintained on the existing embankment (photo #6). Disregard previous audit comments on this item.		No action required.

Photographs

Photo 1: West end of project looking east

Photo 2: Excessive offset to stop sign (Route 25) off-ramp.

Photo 3: Bullnose separating Route 25 north on and off-ramps.

Photo 4 : Eastbound lanes at west end of project

Photo 5: Westbound lane reduction at west end of project

Photo 6: Shoulder width at Hillside Road

Appendix D

Glossary

GLOSSARY

The following definitions have been collected from various sources, including the TAC Geometric Design Guide for Canadian Roads (1986) and the Highway 407 Safety Review (1996).

Acceleration lane
A lane in addition and adjacent to a through lane to enable a vehicle entering a roadway to increase speed to merge with through traffic. Used at intersections where traffic is channeled by means of islands or markings, or as a speed-change lane at interchanges.

Auxiliary lane
A lane in addition and adjacent to a through lane intended for a specific manoeuvre, such as turning, merging, diverging, weaving, and for slow vehicles, but not for parking.

Back slope
The slope between the drainage channel and the natural ground, used when a roadway is below natural elevation.

Barrier
A device providing a physical limitation through which a vehicle would not normally pass. It is intended to contain or redirect errant vehicles of a particular size range, at a given speed and angle of impact.

Breakaway
A design feature enabling such devices as signs, luminaires or traffic signal supports to yield or separate upon impact. The release mechanism may be a slip plan, plastic hinges, fracture elements, or a combination of these.

Clear Zone
The total roadside border area clear of obstacles, starting at the edge of the traveled way, available for safe use by errant vehicles. This area may consist of a shoulder, a recoverable slope and/or a clear run-out area. The desired width depends on traffic volumes and speed, and on roadside geometry.

Cross-section
The transverse profile of a road.

Deceleration lane
A lane in addition and adjacent to the through lane to enable a vehicle exiting a roadway to reduce speed after it has left the through traffic lanes. Used at intersections where traffic is channeled by islands or markings, or as a speed-lane change at interchanges.

Decision sight distance
The distance required for a driver to detect an information source or hazard in a visually cluttered roadway environment, recognize the hazard or its potential threat, select appropriate action, and complete the manoeuvre safely and efficiently.

Design criteria
A set of parameters established at the outset of the design phase for the major elements of a facility, to provide direction for the designers.

Design speed
A speed selected for designing and correlating the geometric features of a road, and used as a measure of the quality of the road's design.

End treatment
The design modification of a roadside or median barrier at the end of the installation.

Entrance
The general area where traffic turns to enter the main roadway.

Entrance terminal
The acceleration or speed-change lanes that are part of a roadway entrance, including the ramp proper up to the ramp controlling curve.

Exit
The general area where traffic departs from the main roadway.

Exit terminal
The deceleration or speed-change lanes that are part of a roadway exit, including the ramp proper up to the ramp controlling curve.

Geometric design
Selection of visible dimensions of a roadway's elements.

Grade
How fast elevation changes relative to a horizontal distance (steepness), usually expressed as a percentage.

Guiderail (guardrail)
A barrier adjacent to and in line with the roadway, which can be made of concrete, steel beam, or post and rail.

Hazard
Any obstacle or other feature, such as an embankment or a body of water deeper than 1m, which, without protection, is likely to cause significant injury to the occupants of a vehicle encountering it.

Horizontal alignment
The configuration of a road, as seen in a plan, consisting of straight lines, lengths of circular curve, and lengths of spiral or transition curves.

Horizontal curve
A circular curve, as seen in a plan, that enables a driver to change direction.

Interchange
The general area where two or more roads join or cross, within which are included the roadway and roadside facilities for traffic movements.

Intersection (at-grade)
The general area where two or more roads join or cross, within which are included the roadway and roadside facilities or traffic movements.

Lane
A part of the traveled roadway intended for the movement of a single line of vehicles.

Median
The area that separates traffic lanes carrying traffic in opposite directions. A median is described as flush, raised or depressed, referring to its general elevation relative to the adjacent edges of traffic lanes. The terms wide and narrow are often used to distinguish different types of median. A wide median generally refers to depressed medians sufficiently wide to form a channel that drains a roadway's base or sub-base. Flush and raised median are usually narrow medians.

Median barrier
A barrier in line with the roadway placed in the median to prevent a vehicle from crossing the median and encountering oncoming traffic, or to protect a vehicle from hitting a fixed object in the median.

Minimum stopping sight distance
The minimum distance a driver who sees an object ahead requires to come to a stop under prevailing vehicle, pavement and climatic conditions.

Offset
The distance between the traveled roadway and a roadside barrier or other obstacle.

Operating speed
The speed on a section of highway below which 85% of drivers are operating vehicles when there is little traffic and good weather. This speed may be higher or lower than posted or legislated speed limits, or nominal design speeds, where alignment, surface, roadside development or other features affect vehicle operations.

Ramp
A turning roadway that enables traffic to move from one highway to another.

Right-of-way
The land acquired to build a road.

Road
All the land acquired to provide a common or public thoroughfare, including a highway, street, bridge and any other structure incidental thereto.

Roadside
The area between the outside shoulder edge and the right-of-way limits.

Roadside barrier
A barrier in line with the roadway placed adjacent to the right or left edge, to prevent a vehicle leaving the roadway from encountering a hazard.

Rounding
The introduction of a smooth transition between two transverse slopes to minimize the abrupt slope change and to enable a vehicle to transverse such slopes without bottoming out or vaulting.

Shoulder
An area of pavement, gravel or hard surface placed adjacent to through or auxiliary lanes. Intended for emergency stopping and travel by emergency vehicles only, it also provides structural support for the pavement.

Slope
The relative steepness of the terrain expressed as a ratio or percentage change. Slopes may be categorized as positive (back slopes) or negative (fore slopes), and as parallel or cross slopes relative to the traffic direction.

Speed-change lane
A deceleration or acceleration lane.

Stopping distance
The distance a vehicle travels from when a driver decides to take remedial action to when the vehicles stops (total or reaction and braking distances).

Stopping sight distance
The distance between a vehicle and an object for which a driver decides stop, measured from where the object first comes into view (total of perception, reaction and braking distances).

Superelevation
The change in elevation across a roadway from the inside to the outside edge of a curve measured at right angles to the centre line.

Through lane
A lane intended for through traffic movement.

Traffic barrier
Traffic barriers are placed adjacent to and in line with a roadway to protect traffic on the roadway from hazardous objects either fixed or moving (other traffic). Barriers placed in a median are referred to as median barriers and may be placed in flush, raised or depressed medians.

Transition (spiral curve)
A curve whose radius continually changes.

Vertical alignment
The configuration of a road or roadway as seen in longitudinal section, consisting of tangents and parabolic curves.

Vertical curvature
The horizontal distance along a hill required to effect a 1% change in elevation.

Vertical curve
A parabolic curve on the longitudinal profile or in a vertical plane of a road to provide for a change of gradient.

Warrant
The criteria by which the need for a safety treatment or improvement can be determined.

Weaving section
A section of roadway between an entrance and an exit where the frequency of lane changing exceeds the frequency on the open highway.