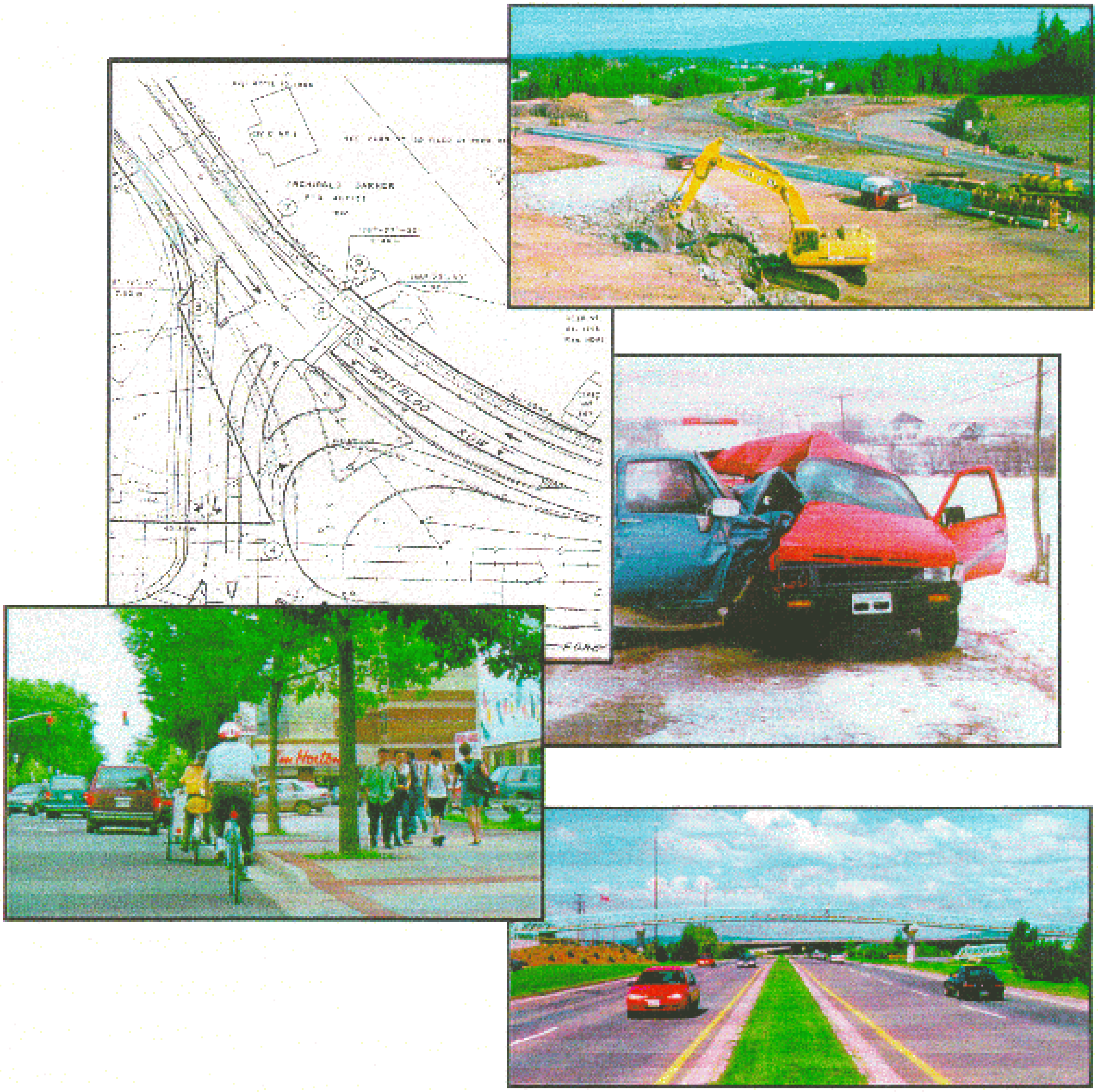
Road Safety Audit Guidelines

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



University of New Brunswick
Transportation Group

Road Safety Audit Guidelines

developed by

University of New Brunswick
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Department of Civil Engineering
Fredericton, New Brunswick

sponsored by

Maritime Road Development Corporation
National Research Council's Industrial Research Assistance Program

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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

Special thanks must be extended to a number of people who contributed to the development of these guidelines. The University of New Brunswick Transportation Group would like to first thank graduate students Tammy Dow, Stephen Ellsworth, Jennifer Mehan and Jeannette Montufar for their research, written material and editing work. Without their help, this project would not have materialized. The initiative taken by Mr. Robert Nairn, P. Eng, formerly with the Maritime Road Development Corporation (MRDC), to encourage the project and the manual is acknowledged.

Many members of the transportation community generously contributed their time and advice during the final stages of development. In particular, the comments and opinions provided by the New Brunswick Department of Transportation and the City of Fredericton enhanced the quality of materials provided in this report.

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.

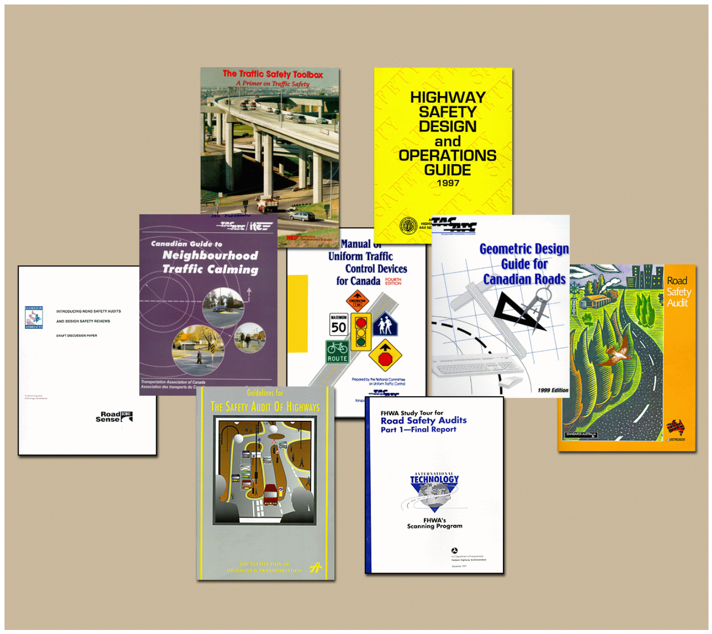
- *Traffic volumes*: Most Canadian highways experience low traffic volumes. In some provinces, a small percentage of the highway mileage accounts for approximately 90 percent of all traffic volume. This requires careful consideration when incorporating safety principles in the design of highways.

- *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.

- C ***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'.

- C ***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.

- C ***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.

- C ***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.

- C ***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.

- 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.

- 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.

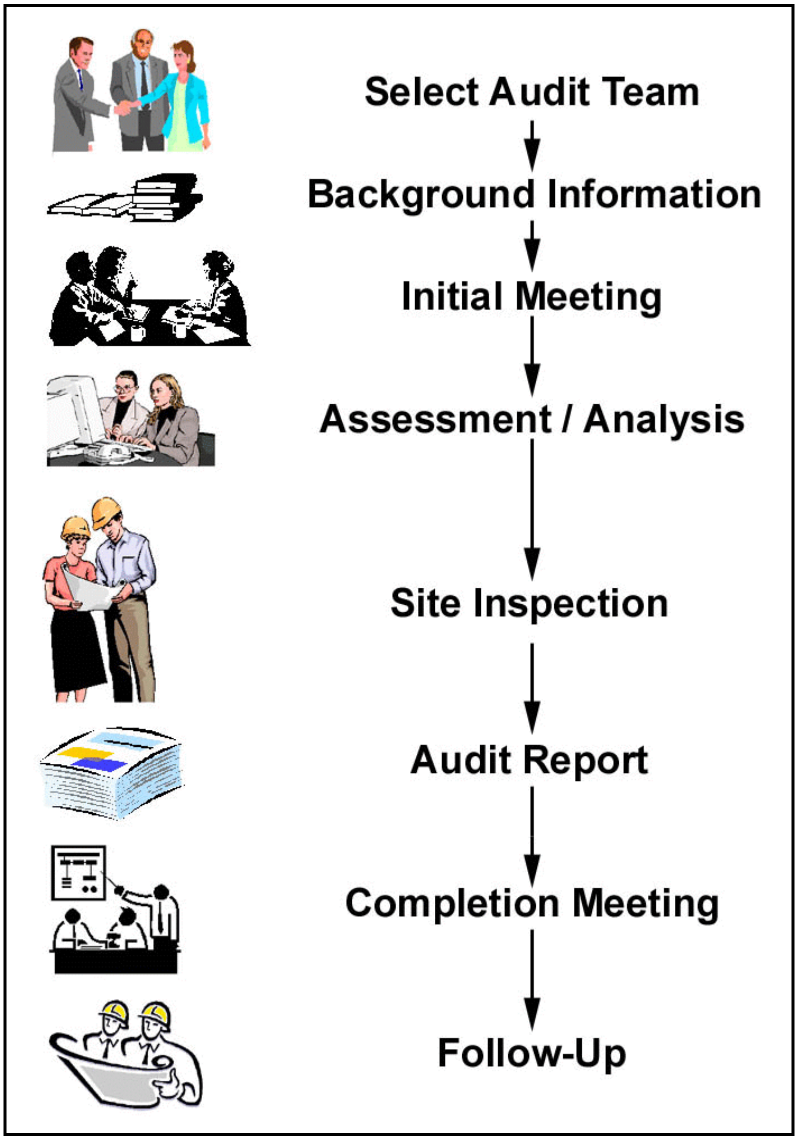


Figure 4-1: Process for Conducting Road Safety Audits

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 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?
Item	**Description**
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.

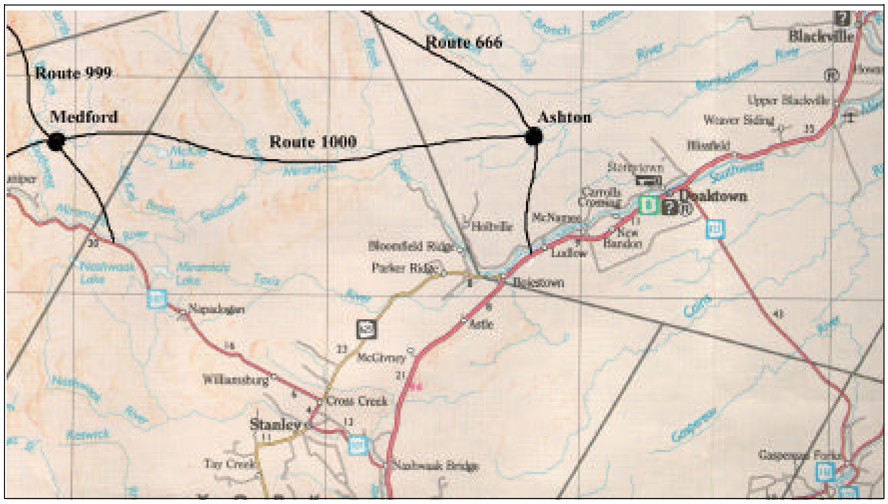

Figure 1. Study Section

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.

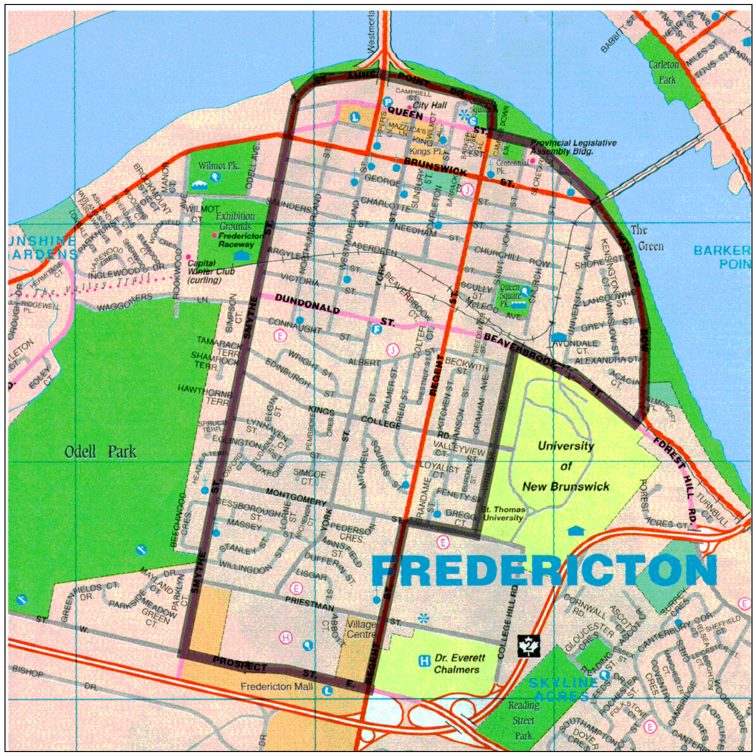


Figure 1: Study Area

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.

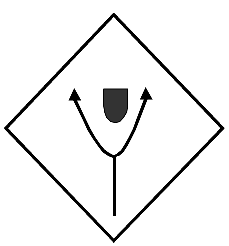
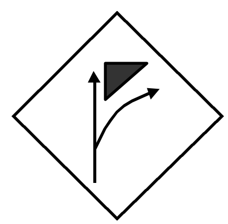
OBSERVATIONS	**POSSIBLE COUNTERMEASURES**	**CLIENT RESPONSE**
3. Intersections ***Layout***		
3.1 The layout of the Brunswick Street/Waterloo Row/University Avenue intersection is confusing and some traffic maneuvers are cumbersome (photo 10). In particular, road users traveling eastbound from Brunswick 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

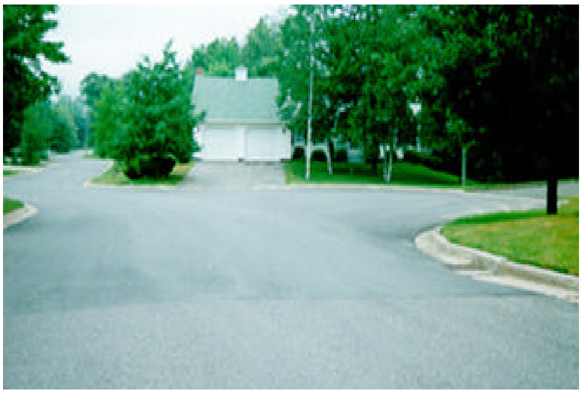


Photo 9. Unsigned confusing alignment

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.

> Note:
> 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). (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 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.
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. (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. 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	Client/Builder 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	Client/Builder: 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	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	**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	Client/Builder 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 <u>INTRODUCTION</u>

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 <u>FORMAT OF REPORT</u>

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.

<u>Note:</u>
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.

____

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 Note: 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.

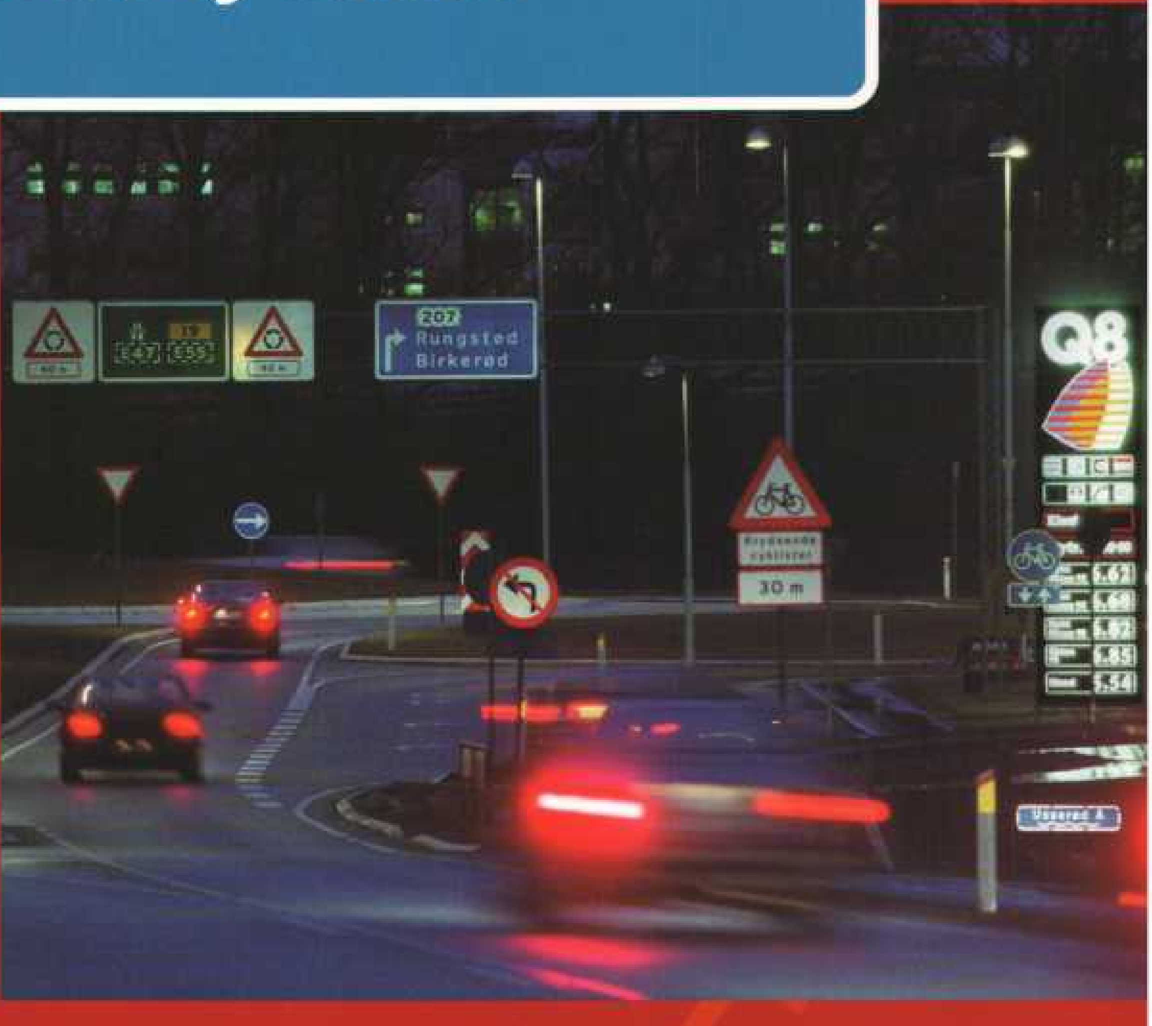
Vertical curvature
The horizontal distance along a hill required to effect a 1% change in elevation.

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.

Manual of Road Safety Audit



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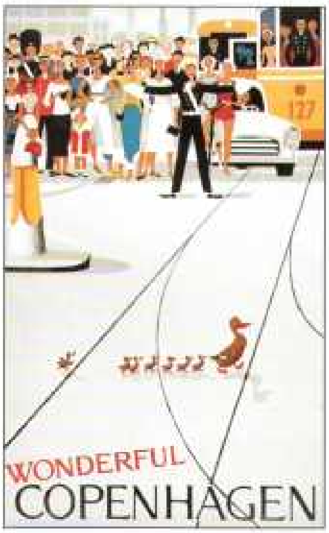

Viggo Vagnby, 1959

Manual: *Manual of Road Safety Audit, 2nd edition, 1997*

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Photography: *Lars Bahl*
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Road Directorate (pp. 3, 17, 28, 37, 39 and 42)

Translation: *Vivian Bondy and Jason King*

Copies printed: *300*

Printing: *Anton M. Jensen*

Publisher: *Road Directorate, Road Safety and Environment Division*

Price: *DKK 250, including Danish V.A.T.*

ISBN No.: *87 7491 885 0*

Manual of Road Safety Audit

Road Directorate
Ministry of Transport - Denmark

Contents

Why?

Henning Christiansen, Director General

Prevention is better than cure, as the saying goes. This also applies to road accidents. This *Manual of Road Safety Audit* presents a method for the systematic prevention of road accidents.

All highway authorities – local councils, county councils and the Road Directorate itself - have the goal of reducing the numbers of fatalities and injuries on their roads. Road safety audit gives highway authorities a vital tool for attaining this end. Road safety audit also receives prominence in the Government's new road safety action plan, *"Every accident is one accident too many"*.

The Road Directorate has developed and tested this method in collaboration with county councils and local councils. The original inspiration came from England, where the use of *Road Safety Audit* is widespread. A pilot project has tested the Danish version of the method in a number of selected construction projects.

The pilot project was a success. Its evaluation – under the leadership of Professor N. O. Jørgensen, Technical University of Denmark – recommended road safety audit as being a very useful and profitable activity. The method should be introduced by all of the country's highway authorities as soon as possible.

As the Danish road sector authority, we consider it our self-evident task to continue to develop the method and to make road safety audit available to the Danish road sector. This manual is one of the results. In 1997, a training programme for road safety auditors will also be introduced and a database containing our most up-to-date road safety expertise will be set up on the Internet.

As one of its goals, the Road Directorate intends to introduce road safety audit as a general procedure for all construction work on trunk roads during the course of 1997.

This English version of the Manual is published as a response to the lively interest from the international road safety community in the Danish experience with road safety audit.

The Manual, however, is still a specific Danish one. It deals with the Danish road safety situation, and the Danish road design standards and organisations.

I am certain that this manual will inspire highway authorities throughout the world to introduce road safety audit, and to produce their own road safety audit manuals. Your comments on the Manual, checklists, procedures, etc., are welcome. Together with other experience gained, they will be incorporated into forthcoming editions of the Manual and will form a basis on which to adjust the system and the training programme. They will thus contribute to the development and improvement of road safety audit, for the benefit of safety on Danish streets and roads.

Henning Christiansen
Director General

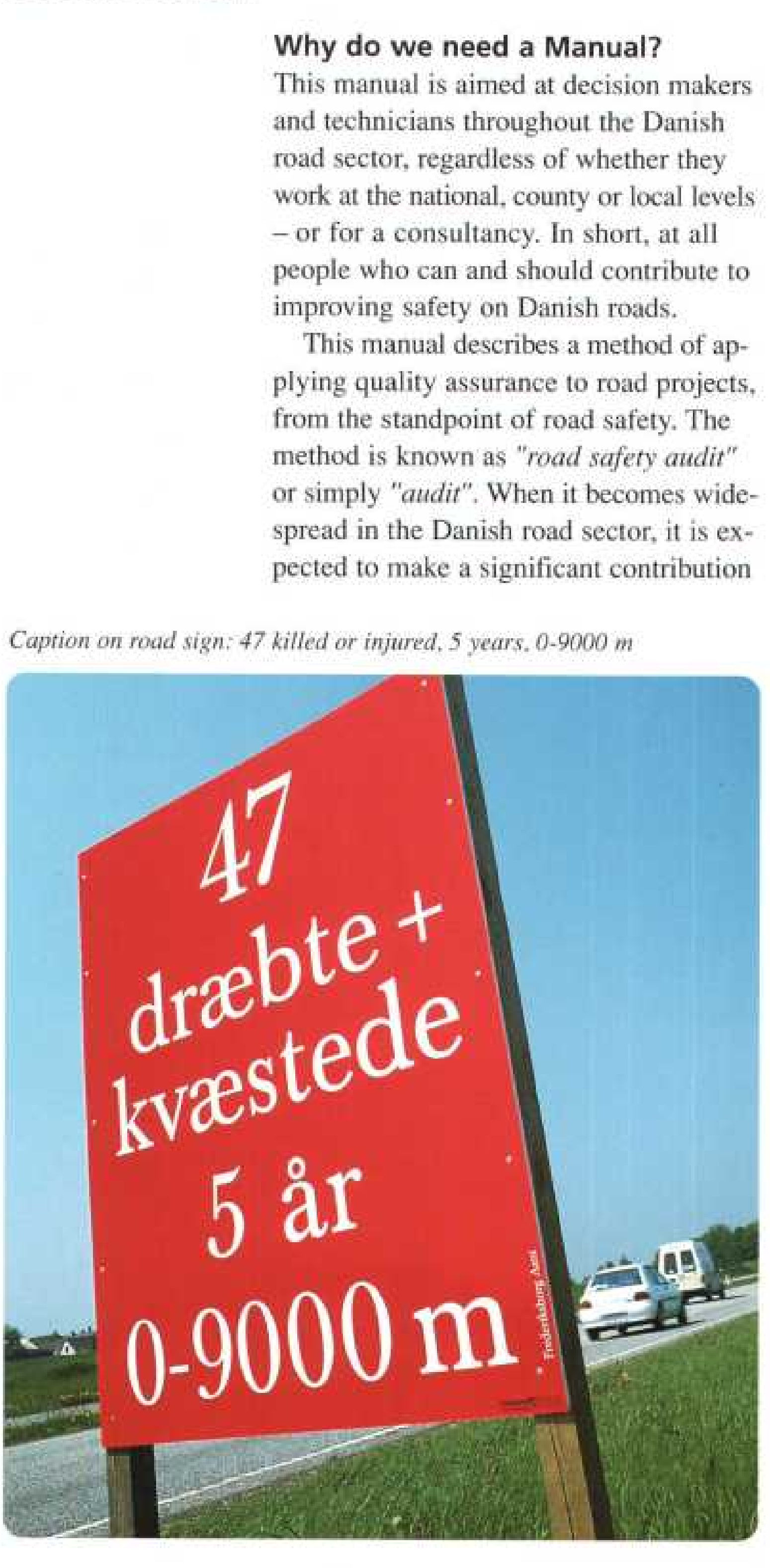
How to Use This Manual

Why do we need a Manual?

This manual is aimed at decision makers and technicians throughout the Danish road sector, regardless of whether they work at the national, county or local levels – or for a consultancy. In short, at all people who can and should contribute to improving safety on Danish roads.

This manual describes a method of applying quality assurance to road projects, from the standpoint of road safety. The method is known as *"road safety audit"* or simply *"audit"*. When it becomes widespread in the Danish road sector, it is expected to make a significant contribution to the prevention of accidents on our roads. Thus, the purpose of this manual is to provide information of the method and to make it possible for everyone to apply it. It describes, for instance, how the road sector can introduce road safety audit. It is also an important aid for the technicians who will work with road safety audit.

Caption on road sign: 47 killed or injured, 5 years, 0-9000 m



Content of the Manual

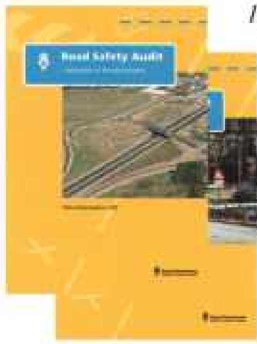
The chapter entitled *"Introduction to Road Safety Audit"* describes the concept of road safety audit. It also describes the purpose and value of conducting road safety audits.

The chapter entitled *"How to Conduct a Road Safety Audit"* details the course of a typical road safety audit and defines certain concepts. It uses examples to illustrate some of the safety problems that can be dealt with through a road safety audit.

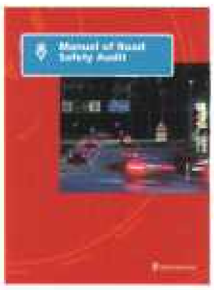
The chapter entitled *"How to Introduce Road Safety Audit"* describes the decisions that should be taken, the requirements set on organisation, procedures and qualifications and the sequence in which the various activities should be carried out.

The chapter entitled *"Principles of Road Safety Audit"* is a technical discussion of road safety. It describes the elements of road planning and design that have the greatest significance for road safety.

A number of appendices can be found at the end of the Manual. Appendix 6 reviews the 15 *checklists* that are published together with the Manual. These checklists can be used as aids when designing a road project or when undertaking a road safety audit.



Information sheets



Manual of Road Safety Audit

Loose forms for photocopying

Checklists

Status of Manual

Any highway authority can elect to avail itself in whole or in part of road safety audit. All of the Manual's instructions have the character of guidelines. The Manual does not stand alone, however. It is part of a long-term programme, the goal of which is to introduce road safety audit into as large a part of the Danish road sector as possible. Apart from the Manual, the external activities of this programme include:

- the establishment of a course on the undertaking of road safety audits,
- the establishment of a road safety database on the Internet.

In its capacity as highway authority for the trunk road network, the Road Directorate has also taken a decision in principle to introduce road safety audit. To that end, the Road Directorate is establishing its own local road safety audit system based on the general principles described in this manual. According to the plan, road safety audit will become mandatory for construction projects on trunk roads at the end of 1997.

We recommend the country's other highway authorities to set up their own road safety audit systems on the basis of the general principles of the Manual. It is our intention in the long term to establish road safety audit as a system within the Road Standards Board.

With the backing of the Road Standards Board, road safety audit could be expanded to proceed according to uniform, simple and clearly defined principles throughout the Danish road sector.

Introduction to Road Safety Audit

This chapter describes the concept, its purpose and the value of undertaking road safety audit

What is Road Safety Audit?

Road safety audit is systematic and independent assessment of the safety aspects of road projects. Its purpose is to make new and reconstructed roads as safe as possible – before construction is started and before accidents occur.

When conducting a road safety audit, individual projects are examined through "road safety glasses". Any inappropriate designs are revealed and proposals for improvements are formulated. Auditing can be carried out at one or more specific stages during the course of a project. The systematic approach taken means that consideration for road safety can be incorporated into a project at the earliest possible stage.

Road safety audit should be a self-evident phase of our highway authorities' *quality management* and it can be applied to all road projects – new constructions, as well as reconstructions. Road safety audit can also be applied to operating and maintenance activities on existing roads, to the extent that such activities can influence road safety.

> **"Road safety audit is systematic accident prevention"**

A road safety audit is carried out by one or more road safety *auditors*. One crucial factor is that the auditors be *impartial*. A road safety auditor must take no part in project design and it is not the *auditor's* task to weigh road safety considerations, for instance, against economic considerations – that is the responsibility of the client.

A road safety auditor must not question the justification for a project but must illuminate its consequences on road safety – and endeavour to ensure that the project as presented in the brief is as safe as possible.

Road safety audit must be conducted with due consideration for the abilities, knowledge and needs of the road users – and from the standpoint of all groups of road user. Road safety audit is *not* a check on the engineering quality of the project and nor is it any form of approval the project *per se*.

Accident Prevention

Road safety work is based on two main strategies: accident reduction and accident prevention.

In *accident reduction* we use our knowledge of accidents that have occurred on our existing roads to improve the design of the roads or to influence the behaviour of road users, so that similar accidents cannot occur again. Work on eliminating black spots is a typical example of accident reduction.

Accident prevention, on the other hand, is the application of our expertise in safe road design – road geometry, as well as the materials used – when we construct new streets and roads or redesign existing roads, regardless of the reasons for which an individual project has been undertaken. This expertise is the result of research and, to a significant extent, of practical experience gained in work on accident reduction.

Road safety audit is *systematic accident prevention*. It is a matter of systematically applying our present expertise in road safety – new and established expertise – to new projects, regardless of whether they are new installations, reconstructions or operating and maintenance activities.

Why Road Safety Audit?

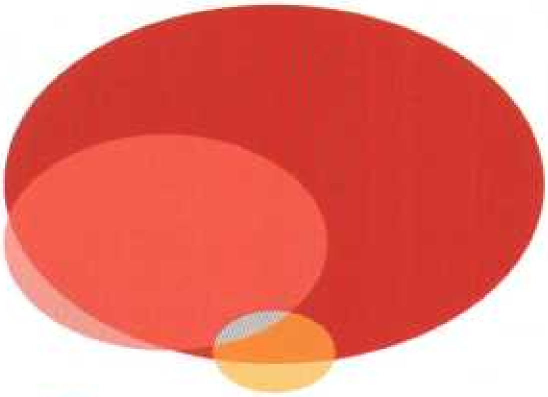
Engineers and other technicians engaged in road planning and design are aware that their projects must also be safe. That is why many new projects are already assessed from the road safety standpoint, but not all.

On many occasions, completely new projects have been designated as black spots after just a few years. There may be many reasons for this – including insufficient or absent road standards or the lack of up-to-date, easily accessible expertise in road safety. A road safety audit can be expected to correct this and, thus, to reduce the number of such black spots on new roads.

The goal of road safety audit is to ensure that all new road projects – and major operating and maintenance activities on existing roads – are assessed from the standpoint of road safety, so that any approaches that are unsuitable from this standpoint are detected and corrected in time.

In the first place, this means that we prevent people from being killed or injured on the roads before we react as a highway authority. In the second place, it is cheaper and easier to correct projects on the drawing board than it is after they have been implemented.

Road safety audit must consider the safety of all groups of road user



In road safety work, the concept of "accident factors" is applied to factors which, by their very presence, have contributed to the occurrence of an accident, or which, through their absence, could have prevented the accident in question. Such factors can be related to the road, the vehicles or to the road users. An analysis of accidents and accident data shows that such factors are distributed over accidents as shown in the figure.

Thinking in Terms of Road Safety

It should be the responsibility of any highway authority to ensure that the roads are safe. A road is considered safe when only a few – or, in the best case, no – accidents occur. If many accidents occur, a road is *not* safe, regardless of whether all standards and norms were observed during its planning and design, and regardless of whether any accidents can be attributed to contravention of the law or other inappropriate behaviour on the part of road users.

This is because road users are not perfect. Thus, the behaviour of road users appears as a contributing factor in practically all road accidents. This does not mean, however, that road engineering measures have no effect on the frequency of accidents; on the contrary, it demands that we guide road users into law-abiding and appropriate behaviour through the design of our roads.

A road safety audit cannot, therefore, take its point of departure solely in our view of how road users *may* and *shall* behave in traffic, it must also give careful consideration to experience of how road users *can be conceived* of behaving.

A road safety audit must assess projects on the basis of road users' knowledge, attitudes and skills, day and night, and in wet and dry road conditions. And it must give consideration to different groups of road users' abilities that depend on age, means of transport and any disabilities.

Road safety audit is only a study of safety aspects and an auditor may indicate road-safety problems inherent in designs that conform to our road standards. In the first place, this is due to the fact that our road standards are an expression of a socio-economic balance between road safety, accessibility, the environment and economy. In the second place, each road standard expresses our level of expertise at the time at which it was implemented and cannot allow for developments that have taken place since its implementation.

Value and Costs of Road Safety Audit

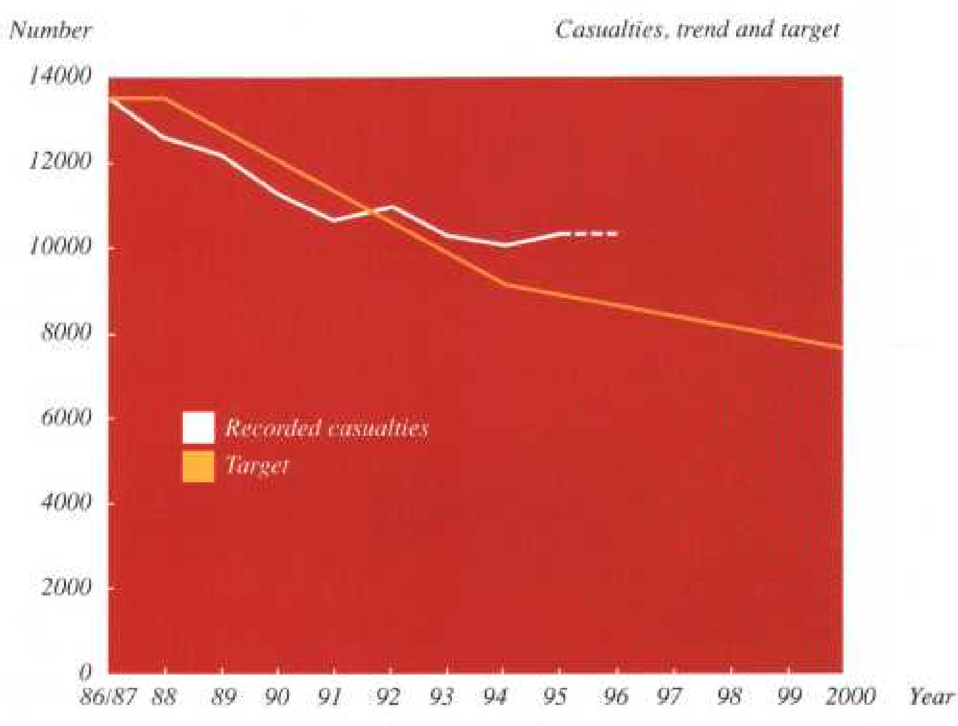
Although road safety audit can increase the costs of a project, this is far from invariably the case. And the sooner an unsuitable approach is detected and rectified, the cheaper. If we consider not only the costs of construction but also include the costs throughout a project's life cycle, including the costs of accidents, an increased construction cost can quickly prove to be a saving in the long term.

The value of road safety audit has already been ascertained. Based on the first years' experience of road safety audit in Denmark, it has been estimated, for instance, that road safety audit generates a theoretical first year's rate of return comparable to that of conventional work on eliminating black spots. And it is estimated that the cost of auditing, including the time of auditors and designers, typically amounts to about 1% of the construction costs – slightly more in the case of small projects, slightly less in the case of large projects. These estimates are taken from a report entitled *Evaluation of the Road Safety Audit Project*, written by a panel of independent experts. The main conclusions of the report are summarised in an information sheet, RSA-information 2/97, which can be ordered together with this manual.

Road Safety Audit in National and Local Perspectives

Road safety audit is a forward-looking and vital supplement to the advance work done to reduce the numbers of fatalities and injuries on our existing roads. This means that road safety audit is a tool available to individual highway authorities, in their efforts to attain the target stated in the Danish Road Safety Commission's Strategic Plan for reducing the numbers of fatalities and injuries by between 40 and 45%, starting from 1989, up to and including the year 2000.

The developments of recent years have not followed the target curve. There is, thus, a need for a renewed effort within the State, counties and municipalities, if the target is to be attained by the year 2000. This is where road safety audit can make a significant contribution and it has, therefore, been incorporated into the Government's road safety action plan, *Every accident is one accident too many.*



How to Conduct Road Safety Audit

This chapter describes how road safety audit can operate when it is carried out by a highway authority or a consultancy.

The first part describes the stages of a project at which road safety audit will be most beneficial. Next, the individual parties and their roles are described. Finally, there is a description of the typical course of a road safety audit – the individual activities during the audit process and the interactions of the parties involved.

Audit Stages

It will almost always be advantageous to undertake road safety audit on several occasions during the course of a project, except in the case of very small or very unusual projects. When constructing new roads, for instance, it is an obvious step to carry out an assessment of the impact on road safety of the planned locations and types of junction, before the individual junctions are designed and audited in detail.

For this reason, we describe five stages in the course of a project at which it can be appropriate to conduct a road safety audit – the so-called *audit stages* or simply *stages:*

Stage 1 Initial design (planning); an examination of the planning basis (such as choice of route options, standard, number of junctions and their types).

Stage 2 Draft (or preliminary) design; an examination, e.g. of alignment, cross-section and layout of junctions, before the political adoption of the project and before expropriations.

Stage 3 Detailed design; an examination conducted before tendering material is finalised (such as the detailed design of junctions, markings and equipment).

Stage 4 Opening; an examination of the completed project just before and/or just after it is opened.

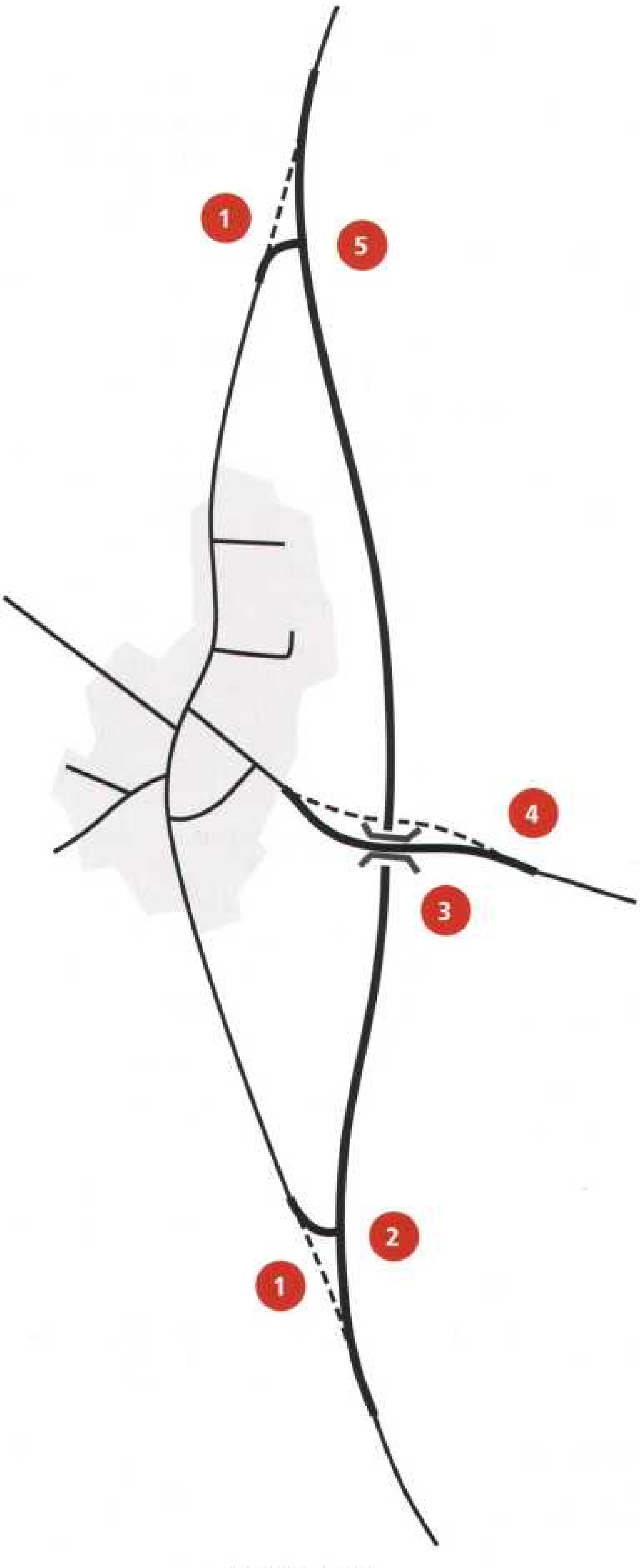
Stage 5 Monitoring (existing roads); regularly recurring assessment of the function, accident data, speed measurements, etc., of the road.

These five audit stages have been determined with a view to integrating road safety audit into the overall course of a project in the best possible way. The first three audit stages concern the project while it is still only on the drawing board. The last two stages concern the project after it has been completed. *Appendix 3* (at the back of this manual) contains more detailed descriptions of the individual stages.

In the case of small installations or reconstruction projects, separate initial, draft and detailed designs will only be prepared rarely. Thus, it can be relevant to omit auditing of the first stages or to combine it into a single audit, depending on the nature of the design process and the scope of the project.

The number of relevant audit stages will therefore depend on the *type* of project, and the auditing of all five stages will normally only be undertaken in major new projects. In the next chapter (pp. 21-24) you will find a more detailed proposal for classifying projects into categories.

The example overleaf illustrates the road safety topics that will be treated in a *Stage 1* road safety audit of a large bypass.



The figure shows an imaginary bypass project. A heavily-trafficked road passes through a small village of about 600 inhabitants and a new road is planned about 600 m to the east of the village.

The road safety audit could typically contain the following comments:

***General.** The two new junctions will increase the risk of road accidents, so that any improvement in safety gained by diverting traffic around the village will be minimal. The safety of the project as a whole would be significantly improved if there were only a single access to the village, and under no circumstances should the junctions be located on bends.*

***1.** At both ends of the bypass there is a risk that road users will not perceive the bends but will continue straight ahead, as the old road is still clearly visible in the landscape. The draft project should therefore make extensive use of plantations, markings and modification of the terrain, so that the false perspective is broken.*

***2.** Located at a bend on the bypass, this T-junction presents a risk of accident to road users turning left off the new road, into the village. It is difficult for them to assess the speeds and distances of approaching vehicles. Furthermore, all cyclists travelling towards the village must cross the new road here. This crossing should be rendered safe by installing a cycle path in a subway or, at the very least, by a traffic island.*

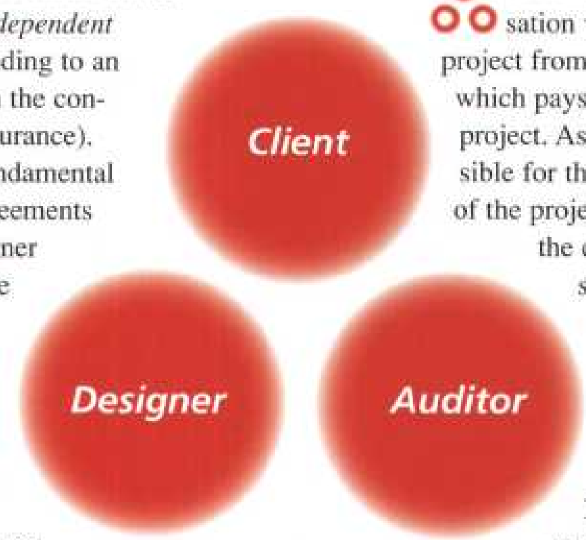
***3.** On this otherwise almost straight section of the new road, there is a risk that the bridge for the road that crosses the bypass will block the view of oncoming vehicles, thus making overtaking impossible.*

***4.** The local road that passes over the new bypass has sharp bends and steep inclines. It is dangerous for cycle traffic to and from the school. Traffic on the school road should therefore be safeguarded by cycle tracks, or at least by cycle lanes.*

***5.** At this T-junction, which is also located on a bend, there is a risk of accidents to road users who, leaving the village, turn left onto the bypass. This will be aggravated if a lane for right-turning traffic is implemented on the bypass, as vehicles in that lane could mask fast vehicles in the straight-ahead lane. This point also presents problems for cyclists crossing the road.*

Organisation – the Parties and their Roles

Any audit proceeds in interaction between different parties, whose roles are predefined at specific stages. Road safety audit is based on the principle of an *independent* review (corresponding to an *external* review in the context of quality assurance). Moreover, one fundamental idea is that disagreements between the designer and the auditor are decided not by the designer but by the client, who has ordered the project from the designer.



There are, thus, three parties to a road safety audit:

The design organisation (or simply the "designer") is the contractor, section or department responsible for planning/designing the project in hand. The designer bears the responsibility for ensuring that a road safety audit is conducted and that the necessary measures are agreed on the basis of the auditor's recommendations and/or the client's decisions.

During the course of the project, the designer is responsible for ensuring that the audit input information is unambiguously defined and that all circumstances are described in an easily-understood manner. The designer must also adopt a stand on the auditor's comments and must ensure that any disagreements between auditor and designer are presented to the *client* for a decision.

In the case of auditing at Stage 5 (roads in service), it is the operating organisation of the relevant highway authority which requests the auditor (the original auditor, if possible) to prepare an accident analysis of the project, and which arranges for the road operator to be notified of the results of the audit.

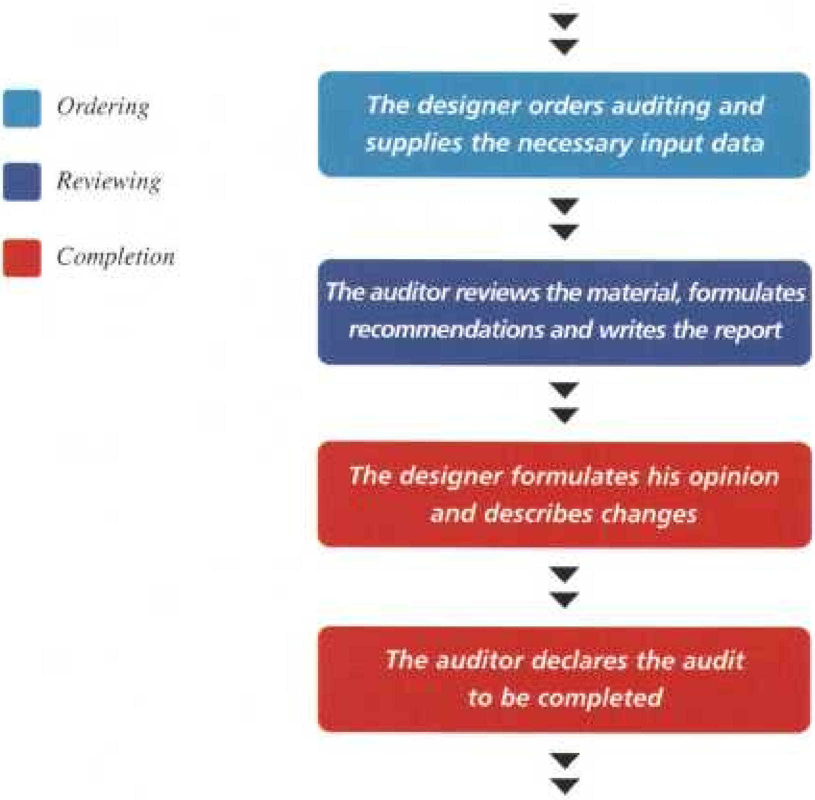
The *client* is the organisation which ordered the project from the designer, and which pays for and owns the project. As the party responsible for the basic conditions of the project, it is the task of the client (or its agent, such as a specialist consultant) to arbitrate in cases where the designer and auditor disagree. Disagreements are presented to the client, which sends its written decision to the designer and auditor. In the case of Stage 5 audits, the *road operator* assumes this responsibility.

The *auditor* is the independent organisation or person who critically reviews and tests the designer's project material. It is the auditor's responsibility carefully to review the presented project material in its entirety, in the light of our best road-safety expertise and from the viewpoints of all relevant road users. The auditor shall indicate all circumstances that can cause any misgivings concerning road safety and shall describe and state the reasons for such misgivings.

It is not the primary task of the auditor to check whether or not a project conforms to road standards. Our road standards are an important tool and a vital reference for the auditor, but as mentioned on p. 8, the auditor must sometimes go beyond the road standards. It is a basic assumption that the designers themselves adopt a position in relation to the norms, guidelines and instructions specified in the road standards, and that the designers report to the auditor in cases of non-compliance with the directives of a road standard and state the reasons therefore.

It is crucial that persons designated as road safety auditors work with, and have experience of, road accident analyses and road accident reduction. Furthermore, road safety auditors must be familiar with road planning, design, and construction work and must undertake to keep their expertise up-to-date.

In the long term, auditors should also hold a certificate. Auditor training will be offered in preparation for a forthcoming certification scheme. Apart from the above qualifications, an auditor should have completed this training and passed the final qualifying examination.



Audit Process

The organisation described in the foregoing section constitutes a vital foundation for the audit process. Starting from the fundamental principles of the organisation, road safety audit can be carried out according to the procedure illustrated on this page.

The following describes a typical audit process based on this diagram. Regardless of the scope and nature of a project, and regardless of the number of audit stages, it is always possible to conduct road safety audit as described by the diagram.

Ordering an audit

The designer gets in touch with an auditor and they enter into an agreement on auditing. Thus, it is the designer who takes the initiative, irrespective of whether the designer has personally selected the auditor or whether this was done by the client. Audits can possibly be ordered using a pre-printed requisition form, and the details of the agreement (including role assignments) can be confirmed on an agreement form. The latter could be designed, for instance, as shown in Appendix 1.

The designer then collects *all* drawings, obtains the necessary background information, etc., and provides this brief to the auditor. At the minimum, the brief should include:

- a brief project description
- an account of project conditions (design speed, radii of bends, superelevation, sight criteria, etc.)
- reasons for any departure from the road standards
- traffic-density and accident data
- set of drawings (2 copies)
- an account of project changes since the previous audit.

What should the report contain?

- Name of project
- Audit stage
- Name and position of auditor
- Date of audit and dates and times of any inspections
- Relevant information on weather conditions during inspection
- All unusual circumstances (for instance, part of the project was in use at the time of the Stage 4 audit)
- Indication of all special traffic problems
- Sketches of proposals for eliminating or alleviating dangerous factors that have been indicated as problems
- Indication of all measures considered necessary for mitigating the effects of non-compliance with road standards
- Statement of the mutual significance of the recommendations and comments
- Parts of the plan that show the problems indicated. This is vital as it saves voluminous written descriptions of the relevant locations.

But

- Avoid verbosity (keep it simple and go straight to the point)
- No CV for the auditor
- No assertions to the effect that there are no problems
- No comments that do not pertain to the road safety of the project
- No copies of the documents obtained from the designer
- No checklists (use them, but do not append them)
- No extracts from the audit manual
- No comments from the designer

Scope

- Not more than 15 pages, plus appendices

Before starting the actual analysis, the auditor studies the brief. The auditor checks that all necessary information is available and obtains any supplementary information from the designer.

Reviewing

The auditor studies the project material. The auditor uses the relevant checklists to aid this study (the checklists can be ordered together with this manual; see p. 50, for a list of the checklists and an introduction to their use).

The auditor notes any obvious problems on the drawings. These problem areas are then structured, formulated, considered and documented in the first draft of the *audit report*.

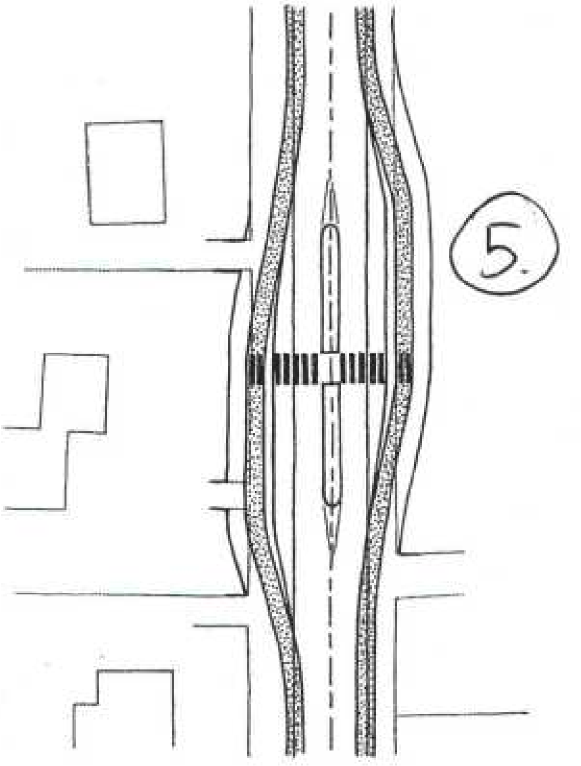
At this point in the process, the auditor gets in touch with the designer to ensure that they share an understanding of the project and its conditions.

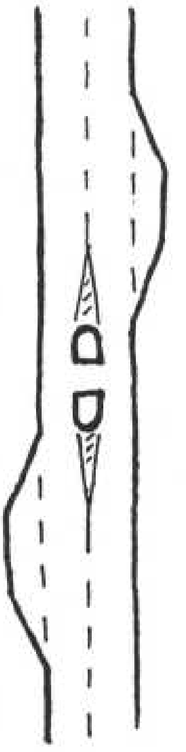
The auditor's comments should be structured on two levels: *problems and remarks*.

• The *problems* are the conditions that can be documented as entailing an increased accident risk. Problems must lead to project changes that can eliminate this risk or reduce it decisively.

It is the auditor's job to formulate proposals for alleviating problems. Such

Example - extract of an audit report
(project for reconstruction of a traffic road in an urban environment, Stage 2)





5. Bus stop and zebra crossing

Problem:
The zebra crossing (which, in itself, is a dubious measure, cf. General Comments) crosses the road where it is broadest and actually has four lanes (even though there is a traffic island).

Recommendation:
The laybys should be shifted relative to each other, so that there is a short 2-lane section which pedestrians can cross via the central island (see sketch).

proposals must illustrate that it is possible to improve the road safety of the project; however, it is not the auditor's job to design the changes.

• *Remarks* concerning the conditions that experience has shown should be given attention in continued designing, but for which it is not possible to document an increased risk to road users at the current audit stage.

The auditor then prepares proposals for possible approaches to resolving the problems ascertained. The best proposal for each individual problem is then described, justified and documented in the final draft for the audit report.

The auditor has the audit report reviewed from the standpoint of his own QA system and corrects the report.

The audit report is now finished and must be signed by the auditor (if several auditors have participated in the audit, a single auditor signs as being responsible for the audit).

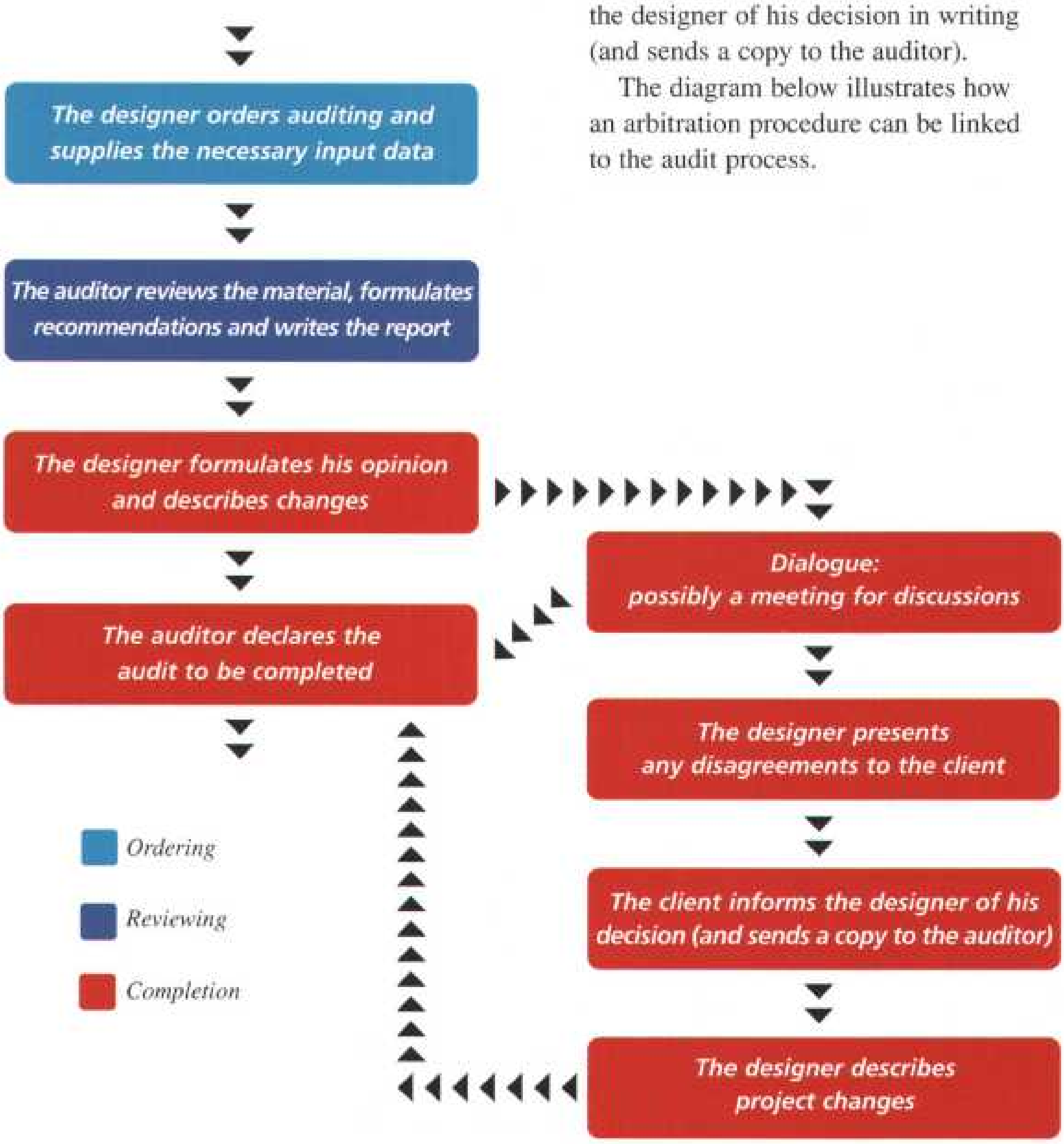
Completion

The auditor sends the audit report to the designer (and a copy to the client). The designer now formulates his opinion of each individual *problem* mentioned in the auditor's report, stating whether or not the auditor's recommendations will be adopted (the designer can possibly prepare alternative proposals for changes).

The auditor determines whether or not agreement has been reached on the problems. The auditor could possibly present the audit report to the designer at a meeting.

In the event of disagreement on the problems and/or their proposed solutions, it is the *designer's* job to inform the client in writing of the disagreement (and to send a copy to the auditor), and to request a decision. The client notifies the designer of his decision in writing (and sends a copy to the auditor).

The diagram below illustrates how an arbitration procedure can be linked to the audit process.



When the client's decision is available, the designer notifies the auditor in writing of all changes to the project.

This can mean that the audit process must be repeated for the changed parts of the project. When the audit has been completed, either through agreement or through the intervention of the client, the auditor issues a written declaration to that effect. It is, therefore, the auditor – not the designer – who formally declares that the audit is finished.

Road safety is also a question of attention to detail - such as this drain grating in a new cycle track.

When the next audit stage is to be carried out in the project, it is simply initiated by a new order, when the designer is ready. It is a great advantage to use the same auditor as was used in the earlier stages. The auditor should not under any circumstances resume a discussion that has already be decided during a previous stage – unless project changes implemented since the preceding audit stage make renewed discussion relevant.

Road safety audit is a formal process which should be documented in documents and the protocols of meetings. All of the auditor's comments and the subsequent decisions should be given in writing. In practice, we strongly recommend informal contact during the process, to obviate misunderstandings and to mitigate any conflicts.

Appendix 5 shows a suggested *audit form*. This form can be used as a requisition when ordering auditing, and as documentation of the relevant stage of the audit process. The designer can, thus, use the form to control and summarise the course of the case at the relevant stage, thereby documenting the safety-related quality assurance of the project.

How to Introduce Road Safety Audit

This chapter describes how to introduce road safety audit. What must be decided and what organisation, procedures and qualifications are needed?

Road safety audit – co-ordinated and applied in accordance with a highway authority's size and level of activity – constitutes an invaluable contribution to that highway authority's endeavours to reduce the numbers of fatalities and injuries on its roads.

As we have already mentioned, one of the goals of road safety audit is to ensure that projects are studied from the road safety angle. To qualify as a road safety audit, such a study must be conducted competently and independently and it must proceed systematically, according to an agreed procedure.

Based on these fundamental principles, a set of guidelines for implementing a road safety audit is described below. These guidelines are known as the *general system*.

The General System

It consists of three parts:

1. The necessary *organisation* (the parties);
2. The basic *procedure;*
3. A standard description of the phases in the course of a project at which auditing can be carried out, i.e. *the audit stages.*

The general system defines road safety audit. It covers the requirements that should always be satisfied, if specific road safety advice is to be called road safety audit.

When a highway authority wishes to introduce road safety audit, that authority should take its point of departure in the general system.

In the general system, the *organisation* comprises three parties, i.e. the client, the designer and the auditor, who are described in detail in the previous chapter, in the section entitled *Organisation* (p. 12). *Table 1* on the next page shows the general system's definition of the parties and the roles they play.

The division of responsibility between three parties serves several purposes. First and foremost, it makes it possible to specify the distribution of competence in advance of each individual audit, so that decisions in the event of disagreement between the auditor and designer can be resolved at the level that bears the overall responsibility, i.e. by the client. In this way the division of responsibility contributes to ensuring the independence of auditing. This is important, since it may be the case that all three parties are to be found within the same highway authority. As we have already mentioned, *Appendix 1* shows a suggested agreement form, which can be signed by the parties in confirmation of the agreement and of the roles assigned to them, This form has been designed so that it can be used for the individual audit stages or as a "standard agreement" for several projects and audits.

The procedure of the general system is shown in *Table 2* on the next page. The procedure is simple and should be suited to any highway administration. *Appendix 2* shows a proposal for a more detailed description of the procedure, which corresponds to the process description of the previous chapter, under the section entitled *Audit Process* (p.13).

A preliminary description of the five *audit stages* is given in the previous chapter, under the section entitled *Audit Stages* (p. 10). This description corresponds

Table 1

General System: Organisation (parties and role distribution)	
Parties	*Role*
Client (operator)	Orders and finances the project. Responsible for project pre-conditions. Decides disagreements between the designer and auditor.
Designer (operating organisation)	Designs the project according to the pre-conditions. Responsible for initiating the audit and for modifying the project according to the auditor's recommendations. In the event of disagreement, presents the case to the client for a decision.
Auditor	Reviews the project. Indicates road safety problems and formulates recommendations.

Table 2

General System: Procedure	
Phase of process	*Activities*
Ordering	The designer gets in touch with an auditor, orders audit and dispatches all necessary material. Possibly sends supplementary material, should the auditor so desire.
Reviewing	The auditor examines the supplied brief and carries out any eventual inspection. The auditor indicates any problematic parts of the project and develops proposals for remedial approaches. The results are collected in a report which is sent to the designer, with a copy to the client.
Completion	The designer notifies the auditor in writing of his opinions. A clarifying meeting may be needed. The designer presents any remaining disagreements to the client, who makes the decisions and notifies the designer of them in writing, with a copy to the auditor. The designer then describes modifications to the project to the auditor, who subsequently declares the audit completed.

Table 3

General System: Audit stages		
Stage No.	*Designation*	*Content*
Stage 1	Initial design (planning)	Review of the brief (such as choice of route options, standard, number of junctions and their types).
Stage 2	Draft design	Examination, e.g. of alignment, cross-section and junction layout, prior to political adoption of the project and prior to expropriations.
Stage 3	Detailed design	Review before tendering material is finished (e.g. detailed design of junctions, road markings and equipment).
Stage 4	Opening	Examination of the finished construction immediately before or after opening.
Stage 5	Monitoring (existing roads)	Regular reassessment of the function, accident data, speed measurements, etc.

to the definition of the general system, which can be seen from *Table 3*. *Appendix 3* gives a more detailed description of the content of the individual stages.

It is now possible to establish a *local system* on the basis of the guidelines of the general system. While doing this, the highway authority should decide which types of project to audit, at which stages and by whom. The procedure is stated in the general system.

Highway authorities' local systems should also be arranged so that they can be included in the particular authority's present or forthcoming QA system.

Implementation

Once a highway authority has taken the decision to introduce road safety audit, we recommend the following approach when setting up a local system.

1. Appoint a project leader

We recommend that a project leader be appointed prior to the introduction of road safety audit. The project leader will be responsible for the progress of the project, prepare budgets, time schedules, etc., and deal with information intended for employees affected by the project and for the organisation in general. It can be highly advantageous for a project leader to ally himself with a highway authority that has already introduced road safety audit.

2. Specify stages and project types

The types of project of relevance to a highway authority should be defined and the stages at which the individual types of project will be audited should be described. More detailed guidance in this can be found in the next section (p. 21). The description of project types and stages should be approved by the management – as when introducing quality management, the support of the management is quite decisive.

3. Specify local organisation
Draft a description of the persons, sections and departments in the local highway authority that can fill the individual roles in the local organisation. When doing this, consider whether or not one or more of the highway authority's own employees should be trained and take the examination to qualify as auditor(s).

Within a highway authority, it will rarely be possible to find qualified employees, who are at all times independent of the sections or departments which plan or implement projects. If the highway authority's own employees are used it is therefore necessary to specify when (on which project types and audit stages) a particular auditor can be considered to be impartial. Employees should be involved in the specification of the local organisation, and the organisation plan should be approved by the management.

4. Prepare a list of auditors
To assist the designers, draw up a list of potential auditors. This list can include the highway authority's own road-safety workers, consultants or, for instance, road-safety workers from another highway authority with which an agreement – possibly reciprocal – could be made.

5. Draft a local road safety audit manual
It should describe the local system, its organisation, types of project and stages, etc.

6. Complete the instruction and training of all concerned employees
It is vital that the employees be thoroughly informed about the audit system, including its background, purpose and its expected effect. It is important in this context to clarify all questions of competence (powers of decision) before taking the system into operation.

Even minor measures can be significant - in this case, a recessed stop line.

7. Evaluate and adjust the local system
Routines should be established for regular evaluation of the local system.

Choice of Project Types and Stages

We recommend that road safety audits be implemented on all new constructions and reconstructions of a certain size. These choices should compare the degree of complexity of the projects to the highway authority's level of experience.

Even small and relatively inexpensive projects can be audited to advantage if experience of their design is only limited. An auditor will always be able to indicate the most recently documented safety-related experience of specific designs.

We also recommend you to ensure the quality (from the road safety standpoint) of a number of types of project other than projects for new constructions and reconstructions. We recommend that all major maintenance works, existing roads, road safety improvement schemes, as well as regional, municipal and local development plans that presume road and path accesses or other traffic-related changes, be included in road safety audits.

New motorway - a typical major project

We thoroughly recommend all five audit stages, from planning, to monitoring of the roads after opening. In the case of minor projects and projects of a special nature, however, it is often advantageous to merge several stages.

Appendix 4 clarifies when and where road safety audit is recommended. The projects are subdivided into types in the overview. They include new constructions and reconstructions, regardless of whether they are financed through a construction or maintenance grant.

Major projects
This type includes schemes for large, new roads, i.e. motorways, expressways and other major installations, such as bypasses. Auditing should be carried out at all stages.

Medium-sized projects
This type covers schemes for the reconstruction and widening of existing roads (such as traffic calming on roads through urban areas) new constructions and major reconstruction of existing junctions and interchanges. Audits should be carried out at Stages 1/2, 3, 4 and 5.

Minor projects
This type covers schemes concerning minor widenings and remodeling (such as where a bend is straightened or where road width is changed), lateral expansion, the construction of cycle paths, minor traffic-calming projects, minor recon-

struction of junctions, etc. Audits should be carried out at Stages 1/2/3, 4 and 5.

Operating and maintenance work
Operating and maintenance consists of many widely diverging activities, which include everything, from extensive maintenance work on existing roads, to everyday maintenance.

In all maintenance projects that entail permanent changes to roads, it is desirable to apply road safety audit as a means of ensuring that all aspects of road safety are taken into consideration.

This serves a dual purpose: in the first place, it is necessary to ensure that any road safety problems on the existing road are not still present after renovation, and in the second place, the implementation of the project must be prevented from introducing new road safety problems.

Our pilot project has not tested road safety audit on existing roads, including the operating and maintenance of such roads. This means that we have not yet studied the optimum extent of road safety audit in conjunction with specific operating and maintenance work.

For the time being, we recommend the following guidelines for road safety audit in maintenance work on existing roads.
a) Road safety audit is carried out on all operating and maintenance guidelines applied by the individual highway authority (road standards, tendering and maintenance directives, working instructions, etc.).
b) Road safety audit is carried out on maintenance works which can be considered as independent projects and which have a significant effect on road safety. For instance, resurfacing and reinforcement work, restoration after work on underground cables or pipes, plantation projects, renewal of road equipment (such as guardrails, lighting installations and gantry signs), and all traffic management schemes (such as carriageway markings, signs and traffic signals).

Any road accesses included in local plan proposals should be audited.

Road safety audits of operating and maintenance work can be carried out at one or more stages, depending on the scope and nature of the work being done.

Regional, municipal and local development plans
Physical planning (regional, municipal and local development plans) can have significant consequences for the traffic conditions of existing roads and, thus, for road safety. We therefore recommend that a road safety audit (Stage 1) be carried out prior to the public hearing phase. This audit should be arranged by the relevant planning authority, regardless of whether the concerned highway authorities present comments on the plan.

Any projects included in the plans for new installations and reconstruction on roads and junctions should subsequently be audited at the relevant stages when the project is implemented.

Traffic calming – typical minor or medium-sized project

Road safety improvement schemes
In this context, road safety improvement schemes refers to projects that have the improvement of road safety as their sole purpose, such as proposals for the reconstruction of black spots. Such projects are often decided on the basis of systematically assigned priorities and it is vital that these priorities be assigned on the firmest possible basis; for this reason, the proposed reconstruction of black spots and other road safety improvement schemes should be subjected to road safety audits, even though the projects are in principle "born safe". A Stage 1 audit should be conducted, with the sole purpose of assessing whether or not the proposals serve the desired purpose – i.e. aim to resolve the ascertained safety problems without creating fresh ones – and are in fact the best possible from the standpoint of road safety. The individual projects should subsequently be audited at the relevant stages when they are implemented.

Existing Roads

Our expertise in safe road design undergoes constant development and even relatively new roads do not always attain the desired standard of safety recommended for new schemes today. Vehicle designs and traffic flow patterns change over the years, so that many roads are used today in ways that diverge from the original plans. A programme of continuous monitoring and improvement of our road network offers enormous potential for accident prevention.

Road safety audits of existing roads correspond to – and are conducted according to the same principles as – the auditing of new roads at Stage 5. As in the case of new projects, the purpose is to indicate elements of the existing design, layout, and road equipment, which are incompatible with the way in which road users use the road – and which can be expected to cause, or have been ascertained as causing, accidents.

The result of auditing is a report that is sent to the operating organisation and – in the case of recent constructions – with a copy to the designers.

When there is agreement on any problems, or when any disagreements have been resolved, the operating organisation can set the priorities (i.e. times) of implementation, depending on how serious the problems are. This can be a question of conditions that must be corrected immediately, conditions that must be corrected at the first convenient opportunity in connection with continuous maintenance, and changes that will be included when deciding the priorities of construction works.

It can be advantageous to incorporate road safety audits of existing roads into a highway authority's action plans for road safety, in the form of a special programme in which the entire road network is examined according to set priorities and which is repeated at regular intervals.

Principles of Road Safety

This chapter summarises the technical content of the audit process - what will be the impact of giving consideration to road safety?

Where road safety audit (as described in the foregoing chapters) is the formal framework which describes *how* road safety considerations are brought into scheme design at the proper time and how road safety is weighed against other considerations at the correct level of the responsible organisations, the principles of road safety form the basis of the technical *content* of the design and audit process. This chapter deals with the conditions which are of particular significance to road safety when designing road geometry and traffic regulation.

This description does not delve into the details. That would be far beyond the scope of this manual, and the collected body of expertise in this area undergoes constant development, anyway. We must instead refer interested readers to the *database*, for specific, up-to-date, situation-related information on road safety.

Road safety is a result of the complicated interaction that occurs between many elements, and the literal application of norms and rules certainly does not always lead to the safest possible design. This is particularly the case where the rules (also) take into account conditions other than safety.

"Road users make mistakes: minimise the opportunities for errors! If mistakes are still made, minimise the consequences!"

The safest road designs are obtained if, during designing (and even before auditing enters the picture), constant consideration is given to road safety, by asking:

- can the road design be misunderstood by road users?
- can the design cause confusion?
- can it give rise to ambiguity?
- does the road design give insufficient information?
- does it give too much information
- does the road design give insufficient visibility or does it obstruct the view of the road?
- does the project include obstructions or "traps"?

If the answer is yes, the source of the problem should be sought by asking a number of open questions (such as "How?", "Why?", "When?", "Where?", etc.).

Road Users as Pre-conditions

As we have already mentioned, road users and their behaviour are a contributory cause in by far the greater part of all road accidents. Road users represent a broad cross-section of the public and there are limits to what we, as road users, can cope with when converting information – from the layout of the road, signs and road markings, other road users and conditions in general – into action. As is the case with anyone else, road users overestimate their own abilities and misunderstand each other's intentions when the situation becomes too complex, unclear or unusual and there is too little time in which to think and react. It is therefore a vital task of the designers and road safety auditors to design our road installations according to human criteria and not to demand too many actions per unit time, first and foremost by avoiding:

- excessive speed differentials,

• differences in direction,
• high absolute speed,
• unpredictable situations.

To put it another way, road users must perceive and process information, make decisions and react, all within a limited time. Comfortable, safe driving is obtained when road users can do these things at a tempo which is well below the stress level, but which is sufficiently high to be stimulating. This is one of the fundamental conditions for establishing and maintaining safe road environments.

Safe road environments
• warn road users of all conditions that do not conform to the norm or are in any way unusual,
• inform road users of the conditions they will encounter,
• guide road users through unusual sections,
• guide road users through conflict points or areas,
• forgive road users' errors and inappropriate behaviour.

"Avoid overloading road users"

Situations that are similar must be treated in similar ways. It is important to avoid:
• insufficient or deficient treatment (something is done about a situation, but not enough),
• incorrect or misplaced treatment (the wrong treatment is applied to a situation),
• exaggerated treatment (too much is done to ensure safety, with the risk that other, similar situations that have been correctly treated become veiled).

Avoid overloading road users. Overloading can cause vital information to be overlooked. Overloading can be caused by a plethora of traffic signals, conflicting messages and a lack of clarity about the course of the road. A safe road environment is therefore one which:
• does not contain surprises from the standpoint of road design or traffic regulation (i.e. which lives up to the expectations of the road users),
• gives a controlled stream of relevant information (not too much at once),
• gives repeated information when a danger factor is to be emphasised.

Planning of the Road Network

When planning and auditing at Stage 1, careful consideration should be given to the principles of planning the road network in its entirety with consideration for road safety. Consideration should be given to the special needs of the different groups of road user, e.g. the need for facilities for pedestrians and cyclists, especially in urban areas. This can be done by establishing appropriate traffic routes, imposing restrictions on vehicles and separating different types of road user. Effects caused by the project on neighbouring road networks (such as noticeable increases in traffic volumes) should also be assessed. See *Road Standards for Urban Traffic Areas, Volume 0 (1)*.

Geometric Design

The geometric design elements that have special influence on road safety can be roughly divided into:
• design of junctions,
• access control,
• alignment (layout, vertical alignment and their mutual interaction),
• cross-section.

Road users' correct use of road installations is normally conditional on the presence of markings. All markings and road equipment must therefore be included as an integral part of the geometric design project. This also ensures that the geometry is designed so that it is possible to apply clear, easily-understood markings.

Overloading can cause vital information to be overlooked

Junctions

A very large proportion of accidents occur at junctions (up to 60% in urban areas and 40% in rural areas). The road network should therefore be planned so that the number of junctions is as limited as possible. The choice of junction type, design and regulation should be governed by:

- the fact that the number of possible conflict points must be minimised. T-junctions have lower accident rates than four-armed junctions, and junctions with four or more arms must either be avoided or they must be designed as roundabouts;
- the avoidance of recognition problems. Junctions must be clearly visible to road users approaching the junction. Be attentive to the vertical alignments of intersecting roads as they approach the junction. To avoid misleading visual impressions, it may be necessary to emphasise the presence of a junction with a plantation, extra signs and traffic signals or background markings;
- the need to ensure adequate visibility and a good overview. Acute angles at Y-junctions, and skewed junctions with a limited sight distance in the direction of travel, pose greater accident risks than regular junctions, especially for elderly road users. Junctions at which the visibility splay is highly asymmetrical lead to an increased accident risk and must be avoided;
- the establishment of facilities for traffic turning off the major road. Protected lanes for left-turning vehicles can reduce the number of accidents. On the other hand, dedicated lanes for right-turning

traffic do not necessarily improve safety. See *Road Safety Manual (2)*.

- the number of gaps in the central reserve (on dual carriageway roads). These should be restricted to the places where left turns and U-turns can be executed with the greatest safety, e.g. at roundabouts;
- use of the most appropriate form of junction control commensurate with attaining the optimum road safety for all road users – see pp. 39-40;
- care to provide safe crossing opportunities for pedestrians and cyclists at places where pedestrian and cycle traffic warrant such care – for instance, through the use of islands. See *Road Standards for Urban Traffic Areas, Volume 5 (1)*.

Visibility obscured by road equipment

Access control

The regulation of access conditions and control of the areas adjoining roads are important means of minimising accidents. Roads with direct frontage access generally have accident rates of almost double those of roads from which there is little access *(2)*. In areas where there is intensive frontage development, accident rates can be up to 20 times higher than on roads with little access. See *Guidelines for The Safety Audit of Highways (3)*.

a) Access to new traffic roads should be subject to restrictions, which should also cover private accesses.

b) New local distributor roads should only be accessible from frontage if, in each individual case, there are special reasons for such access.

c) The number of access points to a road must be kept to the minimum. Accident rates on rural roads can increase by 5% for each new access/kilometre of road. See *Safety Effects of Highway Design Features, Vol I (4)*.

d) To limit the number of conflict points, connections to local roads should be avoided in the vicinity of junctions between main roads.

e) Regardless of whether access points are access to property or junctions, they should not be located on or near sharp bends of limited sight distance. This applies equally to horizontal and vertical bends. The visibility requirements set on private accesses are the same as those set on junctions.

f) Side roads which are cul-de-sacs should incorporate turning space, to obviate the need for reversing out onto the main roads.

Alignment

Road alignment standards are only set on roads in urban areas. See *Road Standards for Urban Traffic Areas, Volume 2 (1)*. In the case of roads in rural areas, highway authorities apply their own internal "standards" (i.e. the Road Directorate's design rules for motorways) and older works (the 1964 draft road standards) or various text books.

Applying road delineation to improve an unpredictable alignment

Accident rates are affected by horizontal and vertical alignment and the interaction between them.

a) Sudden changes of alignment standards should be avoided. If tight horizontal and vertical bends are unavoidable, road users must be prepared for them by reducing the radii of bends smoothly along a section on both sides of the sharpest bends.

Vertical alignment: the risk of accident is greatest at the profile's crests and dips and is especially well correlated to long sections with steep gradients.

b) Due consideration must be given to slow-moving vehicles on ascending gradients. Advance warning should be given of steep gradients on fast roads.

c) Any limitation on sight distances should be reduced as much as possible at the crests of hills.

Horizontal alignment: the number of accidents increases as bends become sharper. This is a significant factor in rural areas when bend radii are less than about 450 metres. The sight distance is the critical factor here.

d) The horizontal alignment must be suited to the desired speed level. But horizontal bends with radii of less than about 300 metres should only be used with caution and should be avoided outside urban areas.

e) Combinations of horizontal and vertical alignment that can lead to misunderstandings and optical illusions should be avoided. For instance, accident rates are higher at places where a horizontal bend starts just after a peak in the vertical alignment.

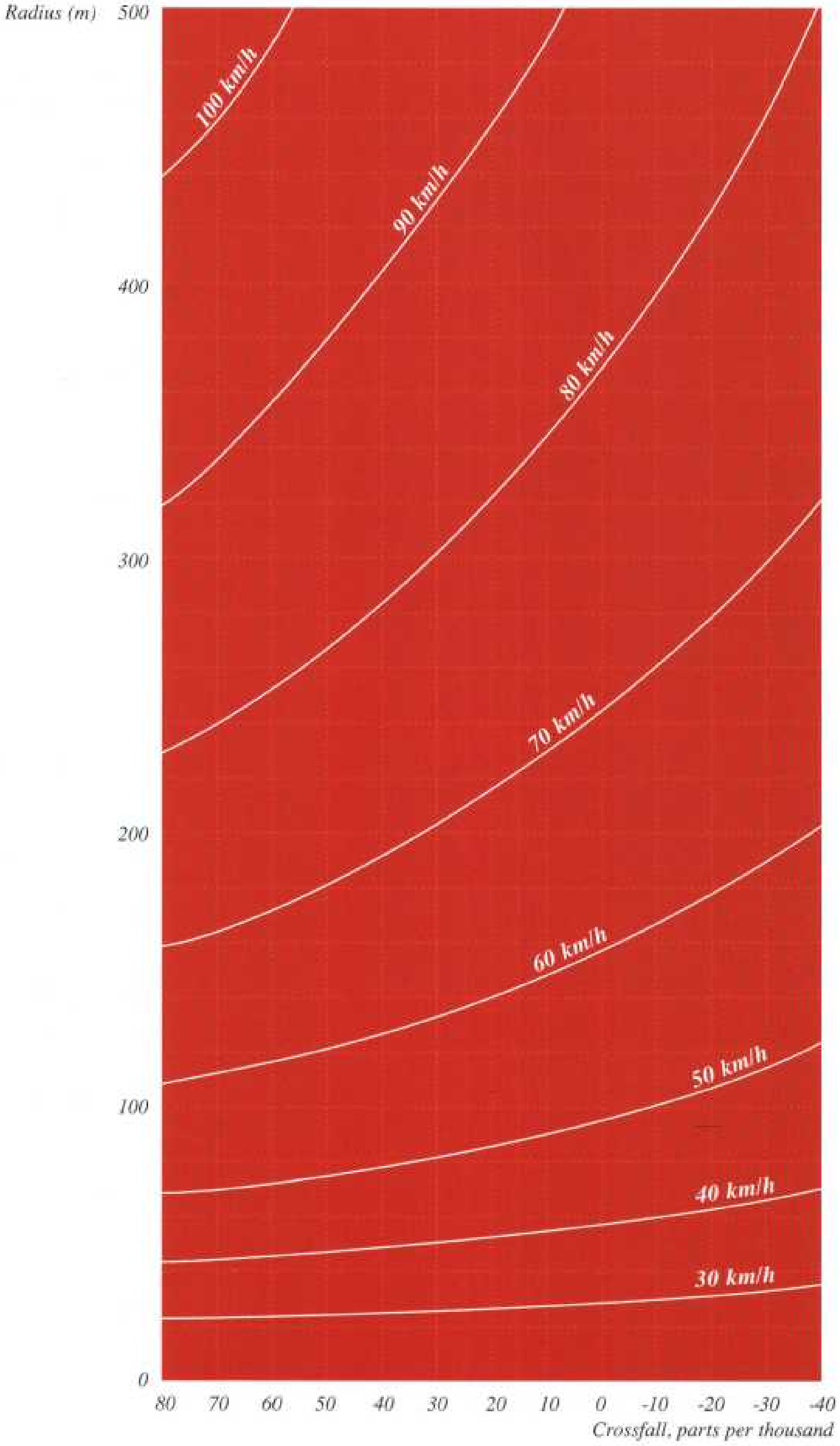
Crossfall

Crossfall is provided to lead water away from the road surface and to counteract centrifugal forces on bends. See *Road Standards for Urban Traffic Areas, Volume 2 (1).*

a) Crossfall on straight sections, established solely for the purpose of drainage, should be a minimum of 20‰ and a maximum of 30‰, depending on the type of surface. 25‰ is normally used. Crossfall should also be constructed on roads with longitudinal gradients. Double-sided crossfall gives the best drainage.

b) A gutter gradient of at least 5‰ (artificial gutter gradient) should be constructed on kerbed sections of road which have longitudinal gradients of less than 7‰.

Relationship between bend radius (m), crossfall (‰) and maximum justifiable speed (km/h).



c) The resulting gradient should not exceed 60‰.

d) The one-sided crossfall necessary to ensure safe use of the road on bends is determined by the design speed and friction of the road surface when wet. See *Road Standards for Urban Traffic Areas, Volume 2 (1).*

e) The best drainage is obtained where a superelevation ramp is constructed as a "moving crown line". Revolving of carriageway edges results in large areas of the carriageway that are almost entirely without a crossfall. This leads to the accumulation of water, even on sections with longitudinal gradients, and should therefore be avoided. See *Road Standards for Urban Traffic Areas, Volume 2 (1).*

Cross section

Road safety is affected by the number and width of lanes, the central reserve, presence of cycle tracks or lanes, as well as by the design of parking lanes, hard shoulders, banks, etc. The interaction between these parameters and the traffic density is complex and the advice given in the road standards should be studied carefully. A few general principles are:

a) The more lanes on a road, the lower the increase in the number of accidents as traffic increases. Where significant increases in traffic volume are expected, rural roads should therefore be planned so that it is possible to expand them to accommodate more lanes than were originally planned, unless completely new roads are also being planned;

b) Lane widths in urban areas are determined on the basis of the desired speed. See *Road Standards for Urban Traffic Areas, Volume 3 (1).* Lanes that are too wide lead to speeds that are too high and should therefore be avoided. Passage for large vehicles can be ensured through the partial or total paving of verges and islands, over which such vehicles can drive at low speed;

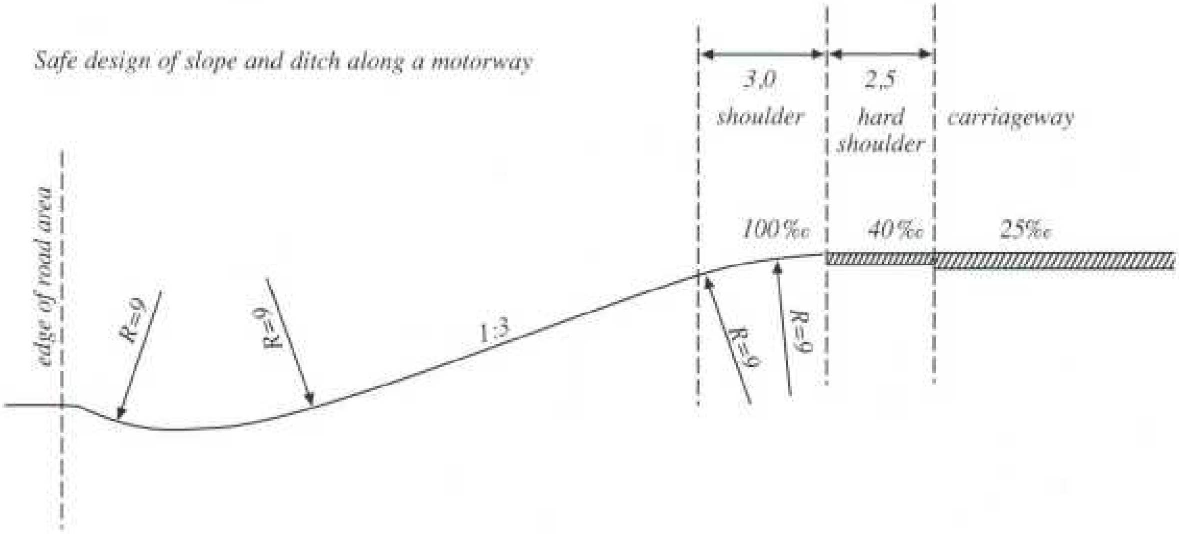
c) The construction of cycle tracks and cycle lanes on streets and roads can reduce the number of accidents in which cyclists and moped riders are involved by 35 to 50% on road stretches between junctions. However, what is gained on such stretches is lost again at the junctions. See *Cycle Tracks in Urban Areas, the safety effect (5), Safety of Cyclists in Urban Areas (6) and Road Safety Effect of Cycle Lanes in Urban Areas (7).* All things considered, junctions must be made safer if the construction of cycle tracks or cycle lanes is to improve road safety; see pp. 39-40. You should also be aware that:

- conflicts can occur at bus-stops and where vehicles are parked on or beside cycle lanes;
- fewer serious accidents involving personal injury occur on cycle tracks than on cycle lanes. Cycle tracks work better for children than for adults;
- bi-directional cycle tracks along roads invariably lead to unconventional manoeuvres at junctions and where such paths terminate. These situations entail a significant risk of accidents. Bi-directional paths along roads should be avoided wherever possible;

d) There is a safety advantage in striving for 3.5 m wide lanes on two-lane roads in rural areas, although wider lanes offer no advantage.

e) Three-lane roads should be avoided, unless the overtaking sections are limited and are protected by appropriate carriageway markings, such as 2+1 markings. See *Tests of 2+1 layout (8).*

2+1 is a safe type of road layout



f) Surfaced edge strips contribute to road safety in rural areas, irrespective of whether the road has a central reserve:

- surfaced edge strips narrower than 0.5 m increase the risk of accidents and should be avoided. See *Edge Lines Improve Safety of Motorists and Cyclists (9).*
- surfaced edge strips still reduce the risk of accidents, even when they reduce the lane width to 3 m *(9).*

g) The installation of central reserves on roads with four or more lanes reduces accident rates. The following applies to central reserves:

- widths of less than 3 m should be avoided. Where guardrails are installed on motorways, the width should not be less than 4 m,
- greater widths are beneficial, although only limited extra benefit is given by widths of over 10 m,
- the use of guard rails on central reserves narrower than 10 m is determined by the quantity of traffic and the actual width of the central reserve itself. See *Road Standards for the Erection of Guard Rails on Roads and Bridges (10).*

h) It can be advantageous to omit the kerb where the width of the central reserve is sufficient, as this makes it easier and safer for drivers who have temporarily lost control to regain control over their vehicles.

i) Shoulders should slope away from the carriageway.

j) As far as possible, slopes and ditches should be designed so that guard rails can be avoided:

- slopes should be as flat as possible (gradient 1:3 or flatter),
- ditches should be formed as rounded troughs,
- the transition between the shoulder and slope should be rounded.

Road Surfaces

The nature of the road surface is of particular importance to road safety. The accident risk can be considerably reduced through the use of surfaces that have good friction when wet *(2).* The visibility of markings in wet conditions can be improved and the dazzle due to shifting reflections in the dark can be reduced through the use of a suitable surface structure. Unevenness in surface structure, such as depressions and rutting, undermine road safety. The relevant road standard requirements on road surfaces (coefficient of friction, deviations in cross-sectional profile, rutting and light properties) are described in *Tender and Construction Precepts for Hot-Mixed Asphalt;* see *Guidelines, Section 8 (11) and General Specification of Works, Sections 2, 3 and 4 (12).*

Markings on carriageway should be designed and implemented in such a way that their message is always obvious.

Carriageway Markings and Reflector Posts

Carriageway markings and reflector posts at the edge of the carriageway reduce the number and severity of accidents at a comparatively low cost. Markings serve three primary purposes:

- to guide traffic by showing the direction and use of roads and their lanes.
- to warn road users of dangerous or unusual conditions in the geometric design of the road.
- to regulate traffic.

Markings on carriageway

Carriageway markings should:

a) Be visible under all conditions, in daylight and darkness. This demands good colour and structural contrast and good retro-reflecting properties. Vibralines are easier to see in wet weather than smooth markings, and vibralines emit sound when vehicles drive over them. They should not be used in the vicinity of residences, however, because of the noise, and they can be difficult to see when the light is behind them.

b) Be durable, to avoid frequent maintenance. Worn markings should be replaced as soon as possible.

c) Not be slippery in wet weather, not even for pedestrians or cyclists. See *Tender and Construction Precepts for Carriageway Markings (13).*

d) Be designed and implemented in such a way that their message is clear.

Reflectors and studs

Studs can be used to improve the effect of traditional markings. They are more visible than ordinary markings under the combined conditions of wet weather and darkness, and they warn motorists who have inadvertently wandered from their lane. The requisite properties are:

• Visibility under all conditions;

• Correct location, to ensure that they do not present difficulties for two-wheeled vehicles;

• Durability and security of fastening.

Reflector posts

Road standards for edge and background markings are in preparation. See *Proposed Road Standard for Edge and Background Markings (14).* Studies have not been able to demonstrate that there is any clear safety advantage in the installation of reflector posts alone; but reflector posts can reinforce the effect of carriageway markings where it is necessary to emphasise peculiarities in the design of a road – a sharp bend, for instance – or to indicate the direction of the road under special circumstances, such as in snow or flooding. Special requirements are:

• they must not be so robust that they can cause personal injury in the event of a collision;

• good visibility in bad weather – which can necessitate much cleaning;
• withstand vandalism and the climate.

Road Equipment: Traffic Signs, Street Furniture, Cabinets, etc.

Road equipment covers a broad range of road-safety elements. Road lighting, antidazzle screens, islands and warning signs assist road users to comprehend and recognise the traffic situations in which they find themselves, and they are warned against potential hazards. Guard rails and bridge parapets are protective measures that limit the severity of collisions, protect vehicles from plummeting from the road and prevent inappropriate behaviour. It is vital to position road equipment so that it does not, itself, constitute an unnecessary hazard.

Frangible lighting column.

Road lighting

The road standards for road lighting describe a number of lighting classes, which should be used according to the class of the road, the design speed and expected traffic conditions. Ideally, road lighting should give a uniformly illuminated road surface, against which cyclists, pedestrians and objects can be seen in silhouette. To attain optimum lighting quality and optimum levels of lighting, the design of the light fittings and the geometry of the lighting installation should be matched to the reflective properties of the road surface.

a) Lighting installations should be planned in conformity with the road standards for road lighting.

b) When renovating a road surface, take care that the light properties of the new surface correspond to the conditions for which the lighting installation was planned.

c) The location of lighting columns should not create unnecessary hazards. This can be ensured by locating them away from the edges of the carriageway and cycle path, the use of frangible columns, protective guard rails and the installation of catenary lighting, to limit the number of columns needed.

Antidazzle screens

On unlit roads, the dazzle caused by oncoming vehicles is a nuisance and a potential hazard to road users. These problems can be mitigated by the use of sufficiently broad central reserves (over 10 m), by installing road lighting or by plantations.

Proper treatment of the exposed end of a guardrail is important - this untreated end should be buried.

It may be relevant to counteract this problem through the use of screens installed on the central reserve (where they can be mounted on the guardrail) and where roads merge or approach each other. The design of the screens should leave a reasonably unobstructed view across the road, while offering screening against opposing traffic – closed screens should not be used.

Traffic islands

Traffic islands delineated by kerbstones should generally be of a design that facilitates the location of signs and other road equipment on them. They should also be spacious enough to accommodate cyclists wheeling their bicycles and pedestrians with perambulators. Traffic islands can be used to advantage:

- On roads where it is desirable to separate the opposing streams of traffic and to prevent overtaking.
- When channeling traffic on major roads, in order to guide and protect the intersecting traffic stream and turning traffic, and to make it possible for cyclists and pedestrians (including passengers going to and from bus-stops) to cross the road.
- Where it is desirable to prevent certain turning manoeuvres.
- At busy junctions on minor roads, to emphasise the major road ahead.

Warning signs, informatory signs and bollards

If a project includes potentially hazardous places or situations that cannot be modified in any other way, the use of signs to warn road users of the hazard can still yield a safety advantage. Signs and bollards should have reflecting surfaces and/or be appropriately illuminated. Where signs are mounted on gantries, care should be taken to ensure suitable, safe access for maintenance, preferably by ensuring that a maintenance vehicle can be parked off the carriageway.

It is important for signs to be designed and installed in a way that avoids creating a hazardous situation and, therefore, so that they are clearly legible, thus assisting drivers to plan and execute their manoeuvres with the greatest possible safety.

Guardrails

"Remove-soften -protect"

The purpose of guardrails is:

a) to prevent head-on collisions;

b) to prevent vehicles from colliding with rigid obstacles. Such obstacles include, for instance:

- retaining walls and other walls,
- most types of noise screen,
- bridge pylons and bridge abutments,
- concrete foundations, wells/drains or large rocks, the tops of which are more than five cm above the ground,
- concrete posts, regardless of their dimensions,

Crash cushion

- steel posts (road lighting columns, traffic-signal posts, gantry pylons and suchlike) with diameters in excess of 60 mm, without breakaway safety devices,
- trees and wooden columns with diameters in excess of 110 mm as measured at ground level,
- electrical distribution cabinets permanently mounted on concrete foundations or other buried foundations,
- anything that can unseat a cyclist;

c) to protect vehicles from plummeting from the road, which includes protecting the driver and passengers from drowning;

d) to protect other vehicles against vehicles which are out of control.

Although guardrails should be strong enough to prevent vehicles from breaking through them, they must not be so rigid or robust that they cause as much damage in a collision as whatever they protect against.

Alternatives to guardrails

Guardrails are, themselves, rigid obstacles and should therefore only be used when a problem cannot be solved in any other way, e.g. by:

- moving the road,
- straightening sharp bends,
- constructing less steep slopes,
- rounding the feet and crowns of slopes,
- removing ditches and replacing them with some other type of drain,
- widening the central reserve,
- removing rigid obstacles, or by moving them further from the carriageway,
- incorporating breakaway safety devices into columns and posts, or by making them from more yielding materials,
- improving road markings,
- imposing speed limits.

Crash cushions can be used as an alternative to guardrails. Despite their high cost, crash cushions give very effective protection against personal injury in collisions with rigid obstacles.

Railings

Pedestrians railings can be used in urban areas to separate pedestrians from the vehicles on the carriageway, although they cannot be used to halt runaway vehicles. Railings should not be so high or so opaque that they obstruct drivers' view of pedestrians waiting at crossings or of the end of the railing. Special measures must be adopted to ensure the visibility of children.

Cabinets, etc.

It is necessary to ensure that cabinets, cable wells and other technical installations that require periodic attention are located on or beyond the footway or behind guard rails. Where this is not possible, inspection wells and suchlike should either be located on, or protected by, islands, which makes them safer for service personnel and road users alike.

Traffic Regulation

The aspects of traffic regulation of relevance to road safety are primarily speed limits and physical speed reduction measures, junction control, pedestrian crossings, one-way systems and the regulation of parking.

Speed limits and speed reduction

Speed reduction leads to a drop in the number of serious accidents. The way in which speed limits affect speed is however more complex. It depends on the geometric design of the roads, the density and composition of traffic and the method and intensity of surveillance. Although these relationships are not yet fully understood, experience has produced certain practical criteria that can provide a basis for determining speed limits.

a) With consideration for the land use along the roads, the geometric standard of roads and accident rates on comparable roads, speed limits should be set to the 85th-percentile speed (V_{85}), i.e. the speed which is not exceeded by 85% of private cars in wet weather. The applicable general speed limits are 50 km/h in urban areas, 80 km/h in rural areas and 110 km/h on motorways.

b) The desired travel speed (V_d) should be the point of departure during planning. It is vital that the stated speed correspond to individual road users' perception of the road and traffic conditions and that it be used with full consideration for road safety. The parameters of geometric elements, which are specified from the standpoint of comfort, should be specified directly on the basis of the desired speed. This applies, for instance, to:

- the relationship between radius and crossfall,
- clothoid parameters,
- vertical gradient.

c) For geometric elements which are specified with consideration for safety, a planning speed (V_p) is used, which is obtained by adding a safety factor to the desired speed. This applies to such geometric elements as:

- visibility at junctions,
- sight distance for overtaking,
- sight distance for stopping,
- distance to rigid obstacles.

Thus, the planning speed (V_p) is calculated as follows:

$V_p = V_d + 10$ km/h for $V_d > 80$ km/h

$V_p = V_d + 20$ km/h for $V_d \leq 80$ km/h

$V_p = V_d$ on all roads in urban areas.

Thus, V_p corresponds to V_{85}.

d) Higher local speed limits (i.e. 60-70 km/h) than the general speed limit in urban areas should only be used in special circumstances on a few main roads. Such roads should:

- have restricted frontage access,

Complex traffic-signal control can confuse road users

- have roadside development which, by virtue of its character or distance, is insensitive to the noise generated by such fast vehicular traffic,
- only permit vulnerable road users to cross at another level or at traffic signals,
- no unregulated four-armed junctions,
- only permit left turns at signalised junctions or at roundabouts,
- have a kerb, at the minimum, to separate light road users from other traffic on the road.

e) On local roads in urban areas and on streets in the centres of urban areas, where a speed level of 40 km/h or less can be appropriate, physical speed reducers are usually a necessary means of encouraging observance of the desired speed. See *Road Standards for Urban Traffic Areas, Volumes 0 and 7 (1).*

Junction control

The right of way at junctions can be regulated with give-way signs or stop signs, roundabouts, traffic signals or by the use of exit constructions. The general rule of giving way to traffic from the right can confuse road users and create conflicts that lead to accidents. It is therefore decisive at all road junctions that the right of way be indicated by marking the carriageway with give-way lines ("shark's teeth"), at the minimum.

a) Give-way signs are appropriate on less busy roads and where visibility is good.

b) Stop signs should be used in cases where the traffic situation or design of the road demands that road users on the minor road come to a total stop, so that they can take proper stock of the situation. See *Effect of Stop Signs (15).*

c) Cycle tracks or cycle lanes which continue right up to a junction can cause safety problems for cycle and moped traffic (5, 6 and 7). See also *Cycle Crossings – Safety Effect at Signalised Junctions (16):*

- at priority-controlled junctions, the number of accidents involving cyclists and moped riders increases when the cycle track continues all the way up to the junction,
- tests in progress at priority-controlled junctions, of the special marking of cycle tracks/lanes, have demonstrated behavioural changes which could prove to result in fewer accidents,
- at signalised junctions, the installation of blue cycle crossings can reduce the numbers of cyclists killed or injured, especially in connection with accidents when turning left,
- recessed stop lines at signalised junctions exert an influence on accidents occurring between vehicles turning right and cyclists travelling straight ahead, when these accidents occur at the start of the green period,
- truncated cycle tracks at signalised junctions also result in fewer accidents involving vehicles turning right, although cyclists consider this approach insecure,
- tests in progress at signalised junctions, of the special marking of cycle tracks/lanes, have demonstrated behavioural changes which could prove to result in fewer accidents.

d) Junctions on high-speed roads should not be controlled by traffic signals. When traffic signals are installed at such junctions, make sure that the speed limit is not greater than 60 km/h. Under no circumstances should traffic signals be installed on roads where the average speed, or speed limit, is greater than 70 km/h See *Speed and Accident Risk at Junctions (17).*

e) At signalised junctions, special phases – e.g. for turning traffic – can improve safety; but complex traffic-signal programming, with many phases, long waiting times and a dense population of traffic signals, can confuse road users and thus contribute to an increased risk of accidents.

Roundabouts can play an important part in limiting the number of personal injuries at junctions – provided that the design rules can be observed, especially from the standpoint of the curvature of access roads and suitable visibility splays. The installation of small or mini-roundabouts at junctions can be particularly effective, and roundabouts are always better than traffic signals, from the standpoint of road safety in rural areas. As far as motorists are concerned, roundabouts reduce the risk of accidents involving personal injury by 85%. Roundabouts do not reduce the number of accidents involving cyclists and moped riders, but they do reduce the severity of such accidents.

When designing roundabouts, give due consideration to cycle and moped traffic. More than a single lane in the entry, the exit, or in the circulating carrigeway is irreconcilable with the presence of cyclists and moped riders (on the circulating carrigeway itself or on tracks/lanes around it); separate path systems should be established for cycle and moped traffic at such roundabouts. It has not been possible to ascertain any differences in the level of safety for cyclists and moped riders on roundabouts with cycle paths, with cycle lanes and without any cycle installation. See *Road Standards for Urban Traffic Areas, Volume 4, Section 3.6 (1) and Road Safety at 82 Danish Roundabouts (18).*

Traffic island as a refuge for pedestrians

Crossings for pedestrians and cyclists
Suitable crossing facilities should be established on road stretches and at crossings where pedestrian and cycle traffic is not insignificant. See *Road Standards for Urban Traffic Areas, Volume 5 (1).*

a) Although zebra crossings and signalised crossings can improve road safety on road stretches, stretches that have pedestrian crossings (with or without traffic signals) do not generally have lower accident rates than comparable stretches that lack such facilities *(2)*. The establishment of zebra crossings on road stretches should therefore be replaced by, or combined with, other measures, such as:

- the installation of traffic islands as refuges,
- the installation of plinths, which reduce the width of the carriageway
- the reduction of vehicle speeds.

b) The construction of bridges or subways should be considered at crossings where the flows of pedestrians and vehicles are high.

c) In general, the section of road within 50 m of signalised junctions is the most dangerous for pedestrians to cross. The installation of pedestrian railings can be beneficial in such places.

d) Special, conflict-free, phases for pedestrians are desirable for improving road safety at signalised junctions.

One-way systems
The establishment of one-way road systems can limit road accidents, although such plans should be implemented with great care. Diversions for cyclists, increasing speeds

It is important to consider all groups of road user where road works are in progress (the caption on the road-works sign asks pedestrians to use the other footway).

or the removal of traffic to roads which have higher accident rates are typical examples of undesired effects – and are particularly detrimental to the safety of cyclists and pedestrians.

One-way systems should normally only apply to vehicular traffic; the disadvantage of permitting bi-directional cycle traffic – with appropriate markings and protection – is usually less than the disadvantage of compelling them to take a diversion or of having them cycle in contravention of the rules.

Parking at kerb

Parked vehicles affect road safety in two ways:

a) Through the risk of collision between driving and parking or manoeuvring vehicles.

b) By masking pedestrians, cyclists or other vehicles. The relegation of parking to laybys on the approaches to junctions or pedestrian crossings can prove beneficial to road safety if parking is absolutely necessary at these places. But it still does not resolve the problem of cyclists on cycle tracks hidden behind parked vehicles.

Road Works and Maintenance

Places where road works are in progress should be considered to be potential accident sites. It is vital at road works to ensure the safety of all groups of road user, including the disabled and the works crew. It is therefore necessary to pay special attention to the road standards governing the marking of road works. However, the standards cannot provide off-the-shelf solutions, as individual situations differ so widely. See *Road Standards for Marking of Road Works (19)*. Road works demand close and frequent supervision, which also includes on-site inspection. Traffic regulation should be implemented with sufficient flexibility to permit changes for reasons of road safety – at short notice, if necessary.

Agreement on road safety audit

Parties

Client ....

Designer ....

Road safety auditor ....

Scope of agreement

Project(s)	**stage 1**	**2**	**3**	**4**	**5**
....	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐

☐ **or see appended list** ....

Comments on agreement ....

....

Date and signatures

Client ....

Designer ....

Road safety auditor ....

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Procedure

Order	Designer's tasks	Auditor's tasks	Client's tasks
1. A. Requisitioning	• Complete the requisition form • Give a precise specification of what is to be audited • Be careful to state all of the project's conditions: – design speed – radii of bends – superelevation – areas of visibility – departures from road standards (state reasons) – accident and traffic data, etc. • Send all drawings in duplicate	Receipt of requisition	
B. Any supplementary information	Supply the auditor with any desired supplementary information	Ordering of supplementary information, as needed	

Review	Designer's tasks	Auditor's tasks	Client's tasks
2. Analysis		• Choice of relevant checklists • Analysis/examination of the project • Inspection, if necessary	
3. Structuring		• Summing up/structuring • General or specific? • Problems or comments? • Reasoning *1st draft of audit report*	
4. Proposed approaches		Develop proposals for alleviating problems *2nd draft of audit report*	
5. Quality assurance		Assurance of audit report quality, according to the auditor's QA system *Final audit report*	

Procedure

Completion	Designer's tasks	Auditor's tasks	Client's tasks
6. A. Delivery	Report received from the auditor	Deliver report to planner. Send a copy to the client	Receive a copy of the audit report
B. Consideration of audit report	• Does the designer agree with the auditor's assertions? • Formulate and notify the auditor of the planner's opinions	Receive the designer's comments	
C. Dialogue	Joint review of the audit report. In the event of disagreement, go to Item D.		
D. Arbitration of any disagreements	• Present disagreements to client and request a decision • Receive the client's written decision	Receive a copy of the client's written decision	Notify the designer in writing of the decision (send a copy to the auditor)
7. Finalisation		Feedback from the designer on any changes to the project (this can lead to repetition of part of the process). The auditor declares the audit finished	

Audit stages

Audit stage	Designation	Description
Stage 1	Initial design (planning)	Review of initial project/planning study. Important subjects for assessment at this stage could include: – choice of route options – standard and cross-section – effects on existing network – number of junctions and their types (typically 1:25,000, 1:10,000 or 1:4000) The road safety auditor should not question planning information or reassess matters of strategy. The auditor should only concern himself with the presented planning information.
Stage 2	Draft design	Examination when draft design is completed, i.e. where the alignment has largely been decided, but can still be modified, and before the political adoption of the project and expropriations. Important subjects for assessment at this stage are: – project changes since stage 1 – alignment (layout, vertical alignment and visibility conditions) – cross-section (including ditches and banks) – arrangement of junctions (including visibility conditions) – ramps and lay-bys – any interim measures (typically 1:4000, 1:1000 eller 1:500) All groups of road user, including those who have special needs, and users of the adjoining areas should be taken into consideration. If there is any risk of special road safety problems occurring during the construction phase, this risk must be assessed.
Stage 3	Detailed design	Examination when the detailed design is finished and the limits of expropriation have been set, but before the tendering material is completed and before tenders are invited. Vital subjects for assessment at this stage are: – project changes since stage 2 – detailed design of junctions – crossfall (driving and drainage characteristics) – markings and signs – traffic signals – lighting and other equipment – plantations – interim measures (interim regulation and marking) (typically 1:1000, 1:500, 1:200) Tendering material must not be sent out until auditing at this stage has been completed and all agreed changes have been incorporated into the project.

Audit stages

Audit stage	Designation	Description
Stage 4	Opening	a) A final review of the finished construction, to check from the standpoint of road safety that it is ready to be opened for traffic. It is particularly important to check the locations and visibility of markings, especially where changes were made during the construction period. The finished scheme should be assessed from the viewpoints of all road users, in daylight and darkness. b) After opening (within one or two months, in the case of large projects, and before application of the wearing course, for small and medium-sized projects), the auditor should examine the scheme to determine whether or not road users are using it in an appropriate manner. Many schemes are constructed with the road open to traffic throughout the entire construction phase. When there is no question of an actual opening for traffic, an overall examination can be *carried* out when the markings are in place (e.g. when temporary lane markings have been made). This examination can be carried out by the auditor alone, or in collaboration with the police, site engineer or the designer.
Stage 5	Monitoring (existing roads)	An analysis of any accident data and inspection of the scheme every third year, with a view to determining whether or not road users use the scheme appropriately. Subjects for monitoring include, e.g: - does the prevailing speed correspond to the design speed? - are the visibility criteria still satisfied? - do vulnerable road users use the installation as expected? - have any changes been made which could affect road safety? The monitoring of new installations should start after about one year.

Types of project and audit stages

<table>
<tr><th>Types of project</th><th>Stage 1: planning</th><th>Stage 2: [illegible]</th><th>Stage 3: detailed design</th><th>Stage 4: opening</th><th>Stage 5: [illegible]</th></tr>
<tr><td>New schemes and reconstructions</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>major</td><td>•</td><td>•</td><td>•</td><td>•</td><td>•</td></tr>
<tr><td>medium</td><td colspan="2">•</td><td>•</td><td>•</td><td>•</td></tr>
<tr><td>minor</td><td colspan="3">•</td><td>•</td><td>•</td></tr>
<tr><td>Operating and maintenance work</td><td>•</td><td colspan="2">•</td><td>•</td><td></td></tr>
<tr><td>Regional, municipal and local development plans</td><td>•</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Road safety improvement schemes</td><td>•</td><td></td><td></td><td></td><td></td></tr>
</table>

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Audit form

Ordering of road safety audit — to be completed by designer

Project .... **Stage** ....

Designer ....

Client ....

Auditor ....

☐ **cf. agreement** .... **Reply preferably before** ....

Material (see any appended) ....

....

Comments ....

Date and signature .... **Ref. No.** ....

Result of audit — to be completed by auditor

Date of receipt of material .... **Ref. No.** ....

Audit comments (see any appended) ....

....

Date and signature ....

Effect of audit — to be completed by designer

Project changes (see any appended) ....

....

Date and signature ....

Declaration of completion — to be completed by auditor

Date and signature ....

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Checklists

Checklists have been prepared to assist the designers and auditors. These checklists describe the problems and situations that can affect the road safety of selected types of project and audit stage.

Although the checklists are conceived of as *aides memoire*, using the relevant lists simply as "tick" lists cannot replace a road safety audit.

You should not expect these checklists to be all-embracing, neither within the individual types of project and stage nor for the set of all possible types of project. It can be advantageous for the individual highway authority to supplement and/or add to the lists on the basis of its own choice of types of project and audit stages.

Overview of checklists

References

(1) (1) Byernes Trafikarealer
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volumes 0, 4, 7 and 10:
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Road Directorate - Road Standards Board, March 1992

(2) Trafikksikkerhetshåndbok
(Road Safety Manual,
Norwegian-language only)
Transportøkonomisk Institutt – TØI, Oslo 1989

(3) Guidelines for The Safety Audit Of Highways
The Institution of Highways and Transportation, September 1990

(4) Safety Effects of Highway Design Features
Volume I: Access Control
Volume II: Alignment
Volume III: Cross Sections
Volume IV: Interchanges
Volume V: Intersections
Volume VI: Pedestrians and Bicyclists
U.S. Department of Transportation; Federal Highway Administration, 1992

(5) Cykelstier i byer – den sikkerheds-mæssige effekt
(Cycle Tracks in Urban Areas, the safety effect; Danish-language only)
Road Directorate, SSV, 1985

(6) Safety of Cyclists in Urban Areas
Report No. 10, Road Directorate, TSM, 1994

(7) Trafiksikkerhedseffekten af cykelbaner i byområder
(Road Safety Effect of Cycle Lanes in Urban Areas;
Danish-language only)
Report No. 50, Road Directorate, TSM, 1996

(8) Forsøg med 2+1-afstribning, indvirkning på uheld
(Tests of 2+1 layout, Effect on Accidents;
Danish-language only)
Report No. 71, Road Directorate, TSM, December 1996

(9) Kantlinier forbedrer både bilisters og cyklisters sikkerhed
(Edge Lines Improve Safety of Motorists and Cyclists;
Danish-language only)
Ole Rosbach, Dansk Vejtidskrift nr. 11, 1984

(10) 9.30.02 Udstyr, Autoværn, Vejregler for opsætning af vej- og broautoværn,
(Equipment, Guard Rails, Road Standards for the Erection of Guard Rails on Roads and Bridges;
Danish-language only)
Road Directorate - Road Standards Board, September 1987

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(Tender and Construction Precepts, Hot-Mixed Asphalt, Guidelines;
Danish-language only)
Road Directorate - Road Standards Board, November 1990

(12) Udbuds- og anlægsforskrifter, Varmblandet asfalt, Almindelig arbejdsbeskrivelse (AAB) (Tender and Construction Precepts, Hot-Mixed Asphalt, General Specifications of Works)
Road Directorate - Road Standards Board, November 1990

(13) Udbuds- og anlægsforskrifter, Kørebaneafmærkning (Tender and Construction Precepts, Road Markings; Danish-language only)
Road Directorate - Road Standards Board, August 1993

(14) Vejudstyr
Vejregler for kant- og baggrundsafmærkning (Road Equipment Road Standards for Edge and Background Markings; Danish-language only)
Proposed Road Standard, Road Directorate - Road Standards Board, August 1994

(15) Effekt af stoptavler
Effektvurdering af forsøgsopstilling i 4-benede kryds i åbent land (Effect of Stop Signs Assessment of tests at 4-armed junctions in Rural Areas; Danish-language only)
Working report 8/1996, Danish Road Safety Research Council, August 1996

(16) Cykelfelter - Sikkerhedsmæssig effekt i signalregulerede kryds (Cycle Crossings - Safety Effect at Signalised Junctions; Danish-language only)
Report No. 51, Road Directorate, TSM, 1996

(17) Hastighed og ulykkesrisiko i kryds, signalregulerede kryds med forskellige hastighedsgrænser (Speed and Accident Risk at Junctions; Danish-language only)
Memorandum No. 28, Road Directorate, 1996

(18) Trafiksikkerhed i 82 danske rundkørsler (Road Safety at 82 Danish Roundabouts; Danish-language only)
Else Jørgensen and N. O. Jørgensen, Report No. 4, Road Directorate, 1994

(19) 9.10.05 Udstyr, Afmærkning, Vejregler for afmærkning af vejarbejder (Equipment, Markings, Road Standards for Marking of Road Works; Danish-language only)
Road Directorate - Road Standards Board, January 1987

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Agreement on road safety audit

Parties

Client ....

Designer ....

Road safety auditor ....

Scope of agreement

Project(s)	stage 1	2	3	4	5
....	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐
....	☐	☐	☐	☐	☐

☐ **or see appended list** ....

Comments on agreement ....

....

Date and signatures

Client ....

Designer ....

Road safety auditor ....

Audit form

Ordering of road safety audit [illegible]

Project .... **Stage** ....

Designer ....

Client ....

Auditor ....

☐ **cf. agreement** .... **Reply preferably before** ....

Material (see any appended) ....

....

Comments ....

Date and signature .... **Ref. No.** ....

Result of audit [illegible]

Date of receipt of material .... **Ref. No.** ....

Audit comments (see any appended) ....

....

Date and signature ....

Effect of audit [illegible]

Project changes (see any appended) ....

....

Date and signature ....

Declaration of completion [illegible]

Date and signature ....

Manual of Road Safety Audit

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Checklist 1

***Stage 1** – initial design*

Project ....

Auditor .... **Date** ....

No.	Description	O.K.	Comments
1.	Do the chosen type of road and the standards, alignment and cross-section offer optimum road safety to all groups of road user in combination with the expected traffic density and speeds?	☐	
2.	Has access control been proposed?	☐	
3.	Will the proposed project be compatible with the standard of conjoining road sections?	☐	
4.	Will there be sufficient opportunities for overtaking?	☐	
5.	Are the number and distribution of intersections appropriate in relation to: a) The desired function of the new road? b) Effects on the surrounding, conjoining and/or off-loaded road network (does the project simply move present problems?)? c) Accessibility for public transport and emergency vehicles?	☐	
6.	Considered in relation to the expected traffic density (especially turning manoeuvres) and density of any vulnerable road-users, do the proposed types of junction offer the highest degree of safety? – 4-armed junctions should be avoided, traffic signals or not – fast approach speeds can cause difficulties at signalised junctions (70 km/h, maximum) – roundabouts can cause difficulties for cycle traffic.	☐	
7.	Has lighting been planned? If so, does the lighting offer maximum safety, both on links and at junctions?	☐	

Checklist 1

***Stage 1** – initial design*

Project ....

No.	Description	O.K.	Comments
8.	Will the project have any effect on existing pedestrian and cycle routes?	☐	
9.	Does the project include measures for vulnerable road-users and if so, do these measures offer maximum safety?	☐	
10.	Do the accident data for the existing/conjoining road network give reason to expect particular road safety problems in the proposed project?	☐	
11.	Can any agricultural accesses and manoeuvres with agricultural machinery be expected to cause problems?	☐	

Checklist 2

Stage 2 – draft design

Project ....

Auditor .... **Date** ....

No.	Description	O.K.	Comments
1.	Have all recommendations from the previous stage been followed? If not, why not? a) Have any changes been made which should be audited at the previous stage?	☐	
2.	Is the desired speed compatible with the cross-section and other design elements and is the desired speed realistic?	☐	
3.	Cross-section: a) Has delineation of the carriageway with a kerb been proposed? b) Is there adequate space for all groups of road user? c) Is there appropriate separation between all groups of road user?	☐	
4.	Horizontal and vertical alignment and visibility: a) Do the proposed alignment satisfy any demands on visibility at junctions and sight distances on free sections? b) Will sight distances/visibility be blocked by traffic signs, guardrails, bridge parapets, buildings, rigid obstacles or plantations (now and in the future)? c) Can parts of the project constitute a risk, especially in combination (e.g. peaks in the vertical alignment plus sharp horizontal bends, crests of hills plus traffic signals)? d) Take a "drive" through the installation in both directions. (Is it possible to obtain 3-dimensional drawings or photographs?)	☐	

Checklist 2

Stage 2 – draft design

Project ....

No.	Description	O.K.	Comments
5.	Junctions, interchanges and their design: a) Will road users coming from all directions (including side roads) be able to see that they are approaching a conflict area? Are give-way lines, turning lanes and ramps clearly visible? b) Are existing conjoining and intersecting roads appropriately adjusted and matched to the new road (without sharp bends and gradients)? c) Do the routes of road users through the junction seem clear for all directions and manoeuvres? d) Is there sufficient space for all types of vehicle to undertake all manoeuvres (check if swept paths are adequate)? e) Are the crossing facilities for pedestrians and cyclists adequate and safe? f) Can parking cause problems? g) Have roundabouts been considered? In urban areas, ghost markings and left-turning lanes with islands are safest; they prevent overtaking and assist pedestrians and cyclists who are crossing the road.	☐	
6.	Decide whether or not old, unremoved alignment can give undesired optical directions.	☐	
7.	Special points at roundabouts: a) Are all entrance lanes curved and is speed adequately reduced? b) Will the central island be visible? c) Are any measures taken for the benefit of pedestrian and cycle traffic adequate?	☐	

Checklist 2

Stage 2 – draft design

Project ....

No.	Description	O.K.	Comments
8.	At the junction/transition to existing roads (especially from multi-lane to two-lane, dual to single carriageway): a) Are there sudden changes of alignment? b) Does the road standard change too rapidly, or can road users clearly see and recognise the transition in good time? c) Would a roundabout be able to mitigate any sudden changes in standard and alignment? d) Will road users be able to drive to the left of a splitter island/start of a central reserve?	☐	
9.	Are existing junctions and intersections adjusted and matched to the new road appropriately (without sharp bends and gradients)?	☐	
10.	Are there any constructions that will be difficult to drain and are the crossfall and any gutter gradient adequate at the critical spots? a) Are there places where there is a risk of flooding?	☐	
11.	Will overtaking be prevented at all of the critical places (not simply be restrictions, but also by making it quite apparent that overtaking is prohibited)?	☐	
12.	If signs and road markings have been proposed: a) Are the markings consistent and are they adequate? b) Has the quantity of information been kept at a reasonable level (not more than 4 items)?	☐	
13.	If markings have not been proposed: will special markings be necessary?	☐	
14.	Is there any risk that cannot be "marked out of existence"?	☐	

Checklist 2

Stage 2 – draft design

Project ....

No.	Description	O.K.	Comments
15.	Will there be any large sign constructions? If so, will they be protected by guardrails or breakaway safety devices?	☐	
16.	Has it been proposed that lighting be located on the outside or inside of bends?	☐	
17.	Will it be possible to carry out maintenance work (on lighting, gantries, plantations, etc.) safely and without using the carriageway or cycle path?	☐	

Checklist 3

Stage 3 – detailed design

Project ....

Auditor .... **Date** ....

No.	Description	O.K.	Comments
1.	Have all recommendations from the previous stage been followed? If not, why not?	☐	
2.	Cross sections: a) Are crossfalls appropriate? b) Is there a suitable gutter gradient or is the carriageway laid at a suitable height above the shoulder?	☐	
3.	Lighting columns, traffic signals, sign standards, etc.: a) Have reqirements on safe distances to carriageway and cycle path been observed? b) Have breakaway safety devices or suchlike been proposed?	☐	
4.	Signs and road markings: a) Are markings consistent along the entire road section? b) Is the information clear? c) Are there enough signs, but not too many? d) Will signs mask each other or traffic signals (be sure to include *all* plans for signs and markings in your assessment)? e) Are the signs correctly positioned, without obstructing sight distances/visibility in any way?	☐	
5.	Are the proposed types of kerbstone/edge marking appropriate?	☐	
6.	Lighting: a) Is there any risk that the lighting can be optically misleading and will it have any detrimental effects on traffic signals and signs? b) Are there any unlit areas that could conceal hazards?	☐	

Checklist 3

Stage 3 – detailed design

Project ....

No.	Description	O.K.	Comments
	c) Will an illuminated side road be able to mislead road users on the planned, unlit road?	☐	
	d) Will an illuminated side road at a 4-armed junction create an impression of continuity across the new road?		
	e) Are all pedestrian crossings illuminated (not merely the formally-marked crossings, but also unmarked places where pedestrians could be expected to cross)?		
	f) Will powerful illumination of adjoining areas (illuminated buildings, squares, sports arenas, paths, etc.) or strongly illuminated advertisements be able to cause problems?		
7.	Guardrails, hedges and railings:	☐	
	a) Are all vulnerable areas protected?		
	b) Are bridge pillars, steel posts, etc., protected by guardrails where necessary?		
	c) Are there places where hedges are necessary to prevent pedestrians from crossing?		
	d) Are the chosen hedges/guardrails "light" enough?		
8.	Plantations:	☐	
	a) Will plantations obscure visibility (also the possibility of seeing pedestrians) and has a maximum height been specified?		
	b) Will plantations be able to encroach on markings or lighting?		
	c) Will fully-grown trees constitute a hazard (have the requirements on distances to rigid obstacles be observed?)?		
	d) Can maintenance be carried out safely?		
9.	Cabinets, inspection wells, etc.	☐	
	a) Are cabinets and inspection wells installed safely (requirements on distances to rigid obstacles), and will it be safe to inspect and maintain them?		

Checklist 3

Stage 3 – detailed design

Project ....

No.	Description	O.K.	Comments
10.	Road surface: a) Has a porous type of surface been chosen? b) Will an exceptionally high-friction surface be necessary in especially exposed places? c) Would a change of surface as a purely visual signal to road users be of benefit? d) Used in this way, could a change of surface be misunderstood by road users?	☐	
11.	At junction/transition to existing road network (especially from multi-lane to two-lane, end of central reserve) a) Is there sufficient advance warning? b) Consider reflecting studs or vibralines c) Are reflector posts correctly positioned? d) Will road users be able to drive to the left of a splitter island/start of a central reserve (clear no-entry markings)? e) Are ghost markings appropriate in connection with the merging of two lanes? f) Is there continuity of edge markings?	☐	
12.	For two-lane sections prepared for expansion to four lanes with central reserve (e.g. expressways built as "semi-motorways") a) Will road users be clear everywhere that they are not on a one-way, two-lane carriageway? b) Should night illumination of signs be of extra high standard? c) Is overtaking prevented at all points where prevention is necessary? d) Should special measures be adopted at bridges built with a view to future expansion?	☐	

Checklist 3

Stage 3 – detailed design

Project ....

No.	Description	O.K.	Comments
13.	Examine adjoining areas for potential safety problems (airfields, signals for maritime traffic and railways, flying golf balls, etc.)	☐	
14.	Additional temporary signs will be necessary for most new constructions. Black text on a reflecting yellow ground gives the best contrast. a) Is the text, etc., comprehensible and correct? b) Have all signs, etc., been positioned safely? c) When will they be removed? Be sure also to use the separate checklists for specific facilities and measures.	☐	

Checklist 4

Stage 4 – opening

Project ....

Auditor .... **Date** ....

No.	Description	O.K.	Comments
1.	Have all recommendations from the previous stage been followed? If not, why not?	☐	
2.	Involve the site engineer, the maintenance authorities and the police.	☐	
3.	Use Checklist 3 as an aide memoire.	☐	
4.	Test the installation as a road user: by car, cycle and on foot. Also in the dark.	☐	
5.	Examine the carriageway for defects, especially at junctions to existing roads.	☐	
6.	Has the opening of the scheme been publicised?	☐	
7.	How will the transition phase proceed?	☐	
8.	Additional temporary signs will be needed at most new constructions. Black text on a reflecting yellow ground gives the best contrast. a) Is the text, etc., comprehensible and correct? b) Have all signs, etc., been positioned safely? c) When will they be removed?	☐	

Checklist 5

Stage 5 – monitoring

Project ....

Auditor .... **Date** ....

No.	Description	O.K.	Comments
1.	Carry out an inspection. – don't forget to take the results of accident analysis and relevant checklists with you.	☐	
2.	Does the actual function of the road correspond to its intended function?	☐	
3.	Is the prevailing speed level as desired?	☐	
4.	Do the equipment and standard of the road (including geometry, cross-section, markings and alignment) correspond to its function, speed level and classification? – use Checklists 2 and 3, as well as any specific checklists which are relevant.	☐	
5.	Do road users park in ways that could constitute hazards?	☐	
6.	Do plantations obscure visibility or mask the view of signs?	☐	
7.	Are the surface and carriageway markings in good condition (signs of rutting, poor drainage)?	☐	
8.	Are there any signs that road users drive over islands or kerbs or that the routes taken by motorists through junctions and bends are less than ideal?	☐	
9.	Are there signs of other conflict situations and minor accidents (skid marks, broken glass/plastic, etc.)?	☐	

Checklist 5

Stage 5 – monitoring

Project ....

No.	Description	O.K.	Comments
10.	Are the specified distances to rigid obstacles maintained (plantations and road equipment, etc.) for all groups of road user?	☐	
	Pedestrians and cyklists:		
11.	Are there signs of pedestrian traffic in places that seem hazardous to pedestrians?	☐	
12.	Does there appear to be a need for more or better crossing facilities for pedestrians?	☐	
13.	Does there appear to be a need for more or better facilities for cyclists?	☐	
14.	Has all necessary consideration been given to children, the elderly, people with mobility impairments and the disabled?	☐	

Checklist 6 – *minor improvements on road sections*

Project ....

Auditor .... **Date** ....

No.	Description	O.K.	Comments
1.	This type of project will not always demand the systematic application of all stages during the project process. Use Checklists 1-4 to the extent relevant.	☐	
2.	Be sure also to use the checklists for relevant specific measures.	☐	
3.	Will the proposed improvements have a beneficial effect on actual accident figures on the relevant road section?	☐	

Checklist 7 – *speed reduction*

Project ....

Auditor .... **Date** ....

No.	Description	O.K.	Comments
1.	What is the purpose of speed reduction and has the right type of speed reducer been chosen? – some speed reducers (such as narrowing the carriageway from the side of the road) have no effect during periods of low traffic density or on roads that carry only little traffic – humps are the most the most effective speed reducer (always effective) – single-lane speed reducers can be used on local roads and on traffic roads carrying only light traffic – on their own, speed reducers only discourage a moderate amount of traffic	☐	
2.	Has sufficient consideration been given to vulnerable road users in selecting, locating and designing speed reducers? – staggering and point narrowings without special passage facilities for cyclists and moped riders can cause significant problems of safety and personal security on roads that lack cycle tracks – low-speed shopping streets and other approaches without the physical separation of vulnerable roadusers and vehicular traffic can only be recommended where speeds are very low and the quantity of vehicular traffic is low	☐	
3.	Are the speed reducers designed and located sensibly in relation to the desired speed level?	☐	
4.	Have combined approaches ("combi-humps") been considered?	☐	
5.	Is there adequate advance warning and are the speed reducers in all other respects designed and located so that they do not surprise road users?	☐	

Checklist 7 – *speed reduction*

Project ....

No.	Description	O.K.	Comments
6.	Should the locations of speed reducers be emphasised by plantations or by some other visual means?	☐	
7.	Are plantations or other visual measures installed so that they do not obscure visibility, e.g. of cycle paths?	☐	

Checklist 8 – *priority-controlled junctions*

Project ....

Auditor .... **Date** ....

No.	Description	O.K.	Comments
	Geometry:		
1.	Is the number and width of entrance and exit lanes appropriate?	☐	
2.	Is there adequate storage for waiting/turning traffic in the channelisation island (either ensure that there is sufficient space or make it absolutely clear that there is not)?	☐	
3.	Are islands located so that they protect and guide the traffic optimally? a) Is there storage space for left-turning vehicles; how many vehicles can be expected to turn left and will this cause difficulties for other manoeuvres?	☐	
4.	Are the area needs of large vehicles satisfied?	☐	
5.	Is an acceleration lane needed for entering the major road? If such a lane is planned, can traffic be safely merged?	☐	
6.	Are the crossfall and drainage characteristics satisfactory? a) Are there any inspection wells/drains on the pedestrian routes?	☐	
7.	Are visibility conditions satisfactory for all types of manoeuvre and for all groups of road user? a) Asymmetrical visibility splays should be avoided.	☐	

Checklist 8 – *priority-controlled junctions*

Project ....

No.	Description	O.K.	Comments
	Lighting/markings:		
8.	Should columns/posts be equipped with breakaway safety devices?	☐	
9.	Is lighting necessary?		
10.	Are signs and lighting columns correctly located? a) Check distances, sizes of signs, view of signs. b) Do signs affect visibility (for truck drivers as well as motorists)? c) Will signs/columns on traffic islands mask the view of/for pedestrians and cyclists?	☐	
11.	Is there adequate advance warning? – map type direction signs are recommended – stack direction signs should be avoided on secondary roads	☐	
12.	Is particularly high-friction surfacing needed? – is the existing surface in order, or will resurfacing be necessary?	☐	
13.	Has the use of a change in surface, or of special surface colours, been contemplated (assess its friction)?	☐	
14.	Are carriageway markings satisfactory? – through-lanes should normally cross junctions in straight lines – separate turning lanes should be drawn from the kerb or centre line/central reserve – consider the use of studs at ghost markings	☐	

Checklist 8 – *priority-controlled junctions*

Project ....

No.	Description	O.K.	Comments
	General:		
15.	Do existing/planned plantations permit adequate visibility?	☐	
16.	Do the existing/planned plantations give appropriate optical directions?	☐	
17.	Are crossing facilities for pedestrians satisfactory? a) Is there a need for pedestrian islands and are any such islands broad enough? b) Is there a need for a hedge or railing and are visibility and overview adequate?	☐	
18.	Should the vertical offset of kerbstones be reduced by ramps for wheelchair users, and have any such ramps been correctly designed?	☐	
19.	Will access to cabinets, etc., be secured and will they (the cabinets) be hedged in or protected by guardrails?	☐	
20.	Has all necessary consideration been given to children, the elderly, people with mobility impairments and the disabled?	☐	
21.	Are there facilities for bus traffic and are pedestrian access and routes to bus-stops satisfactory?	☐	
22.	Will access to private property be affected?	☐	

Checklist 8 – *priority-controlled junctions*

Project ....

No.	Description	O.K.	Comments
23.	Is there a need for tactile paving at established pedestrian crossings?	☐	
24.	Will parking and bus-stops cause problems in the vicinity of junctions?	☐	
25.	Are there school crossing patrols? If so, has sufficient consideration been given to them?	☐	
26.	Additional temporary signs will be needed at most new constructions. Black text on a reflecting yellow ground gives the best contrast. a) Is the text, etc., comprehensible and correct? b) When will they be removed?	☐	

Checklist 9 – traffic signals

Project ....

Auditor .... **Date** ....

No.	Description	O.K.	Comments
	Visibility of traffic signals:		
1.	Assess the positioning of the primary signal in relation to the vertical alignment and layout. a) Is there adequate stopping distance at the desired speed? b) Are all traffic signals installed where they will be most clearly visible? c) Advance warning? Can the state of the signal be seen from a distance? Traffic island for installing additional primary signal?	☐	
2.	Assess the prevailing speed level. Is the desired speed realistic? Should there be warning signs or a speed limit?	☐	
3.	Assess co-ordination with other traffic signals in the neighbourhood.	☐	
4.	Are the signals immediately visible to all who enter the relevant road in the vicinity of the junction (from side roads or private accesses)?	☐	
5.	Can plantations, objects or road equipment at the side of the road or on the footway mask drivers' view of the traffic signals?	☐	
6.	Is it likely that there will often be temporary obstructions on the carriageway, e.g. stopped buses or goods vehicles? Should stopping be prohibited?	☐	

Checklist 9 *– traffic signals*

Project ....

No.	Description	O.K.	Comments
7.	Assess the visual background of the primary traffic signals. Should backing boards be installed? Are there two sets of signals on a single post? Should their height be adjusted? Traffic island for installation of extra primary signals or overhead signals?	☐	
8.	Will there be any risk of dazzle or "phantom lights" at sunrise/sunset?	☐	
9.	Will existing or planned road lighting cause difficulties in perceiving the state of traffic signals?	☐	
	Counteracting red light violations:		
10.	Should warning signs be equipped with supplementary signs stating the distance?	☐	
11.	Would a traffic island with additional traffic signals help?	☐	
12.	Can any spurious impression of continuity be disrupted?	☐	
13.	Is co-ordination necessary (poor co-ordination increases the risk of red light violations)?	☐	
14.	Would contrasts help (surface/lighting)?	☐	
15.	Can the intergreen period be increased or are speed-limiting measures necessary? Assess the evacuation time of cyclists and pedestrians, also uphill and against the wind.	☐	
16.	Can the signals for the intersecting stream of traffic be seen and misinterpreted?	☐	

Checklist 9 – *traffic signals*

Project ....

No.	Description	O.K.	Comments
17.	Will other traffic-signal control in the immediate vicinity be able to induce road users to pass the stop line? (Will there be times during the day at which normally co-ordinated sets of signals are not co-ordinated?)	☐	
18.	Will a green light for the "neighbour" (e.g. signalised left turns at T-junctions) be able to induce drivers waiting at a red light to pass the stop line?	☐	
	Counteracting left-turning accidents:		
19.	Will traffic-signal posts on the channelisation island be able to obscure visibility?	☐	
20.	Where are "repeater" signals (auxiliary signals showing state of lights for the oncoming traffic stream) mounted? Can "repeater" signals in the far left corners cause confusion?	☐	
21.	Will it be possible to control left turns separately?	☐	
22.	Would a left-turn phase help (right-turn phases should be avoided)?	☐	
23.	Can carriageway markings be improved?	☐	
24.	Should left turns be forbidden? Assess alternative routes.	☐	
	Pedestrians:		
25.	Do the zebra crossings cover the logical route for pedestrians to take from footway to footway? Is the entire crossing controlled by traffic signals??	☐	

Checklist 9 – *traffic signals*

Project ....

No.	Description	O.K.	Comments
26.	Are hedges or railings needed to guide pedestrians?	☐	
27.	Should stop lines be recessed?	☐	
28.	Assess green and intergreen periods. Will U-turns and left-turning vehicles leaving the junction in the intergreen period constitute a danger to pedestrians?	☐	
29.	Does the traffic-signal programming give enough consideration to pedestrians? Consider the evacuation time for pedestrians. Can crossing be completed within a single phase? Can pedestrians be given more green time?	☐	
30.	Consider an all-red phase for vehicular traffic, with green for pedestrians. What will be the maximum duration of the period for which pedestrians must wait? The pedestrian phase should ensue immediately after the green phase of the primary stream (the stream that has the longest green period).	☐	
31.	Are the islands large enough to protect waiting pedestrians? Are railings needed? Can an island be extended? Should staggering be used and is any existing staggering correct (towards the right)?	☐	
32.	Will drivers' views of pedestrians crossing from the left be obstructed by objects on the central reserve or on a traffic island?	☐	
33.	Can motorists clearly see pedestrians waiting on the traffic islands?	☐	
34.	Is control equipment located so that it does not obstruct visibility or prevent eye-contact between motorists and pedestrians?	☐	

Checklist 9 – *traffic signals*

Project ....

No.	Description	O.K.	Comments
35.	Does the lighting illuminate footways and paths at zebra crossings?	☐	
36.	Is there space for prams and cycles where pedestrians must wait (on footways and traffic islands)?	☐	
	Cyclists:		
37.	How has any cycle track been brought up to the junction (verges between the carriageway and cycle track should be avoided at junctions)?	☐	
38.	Is there a recessed stop line for vehicles?		
39.	Are cyclists controlled separately? a) Are the traffic signals for cyclists correctly located? – estimate the evacuation time required for cyclists, also uphill and against the wind – right-turn phases should be avoided	☐	
40.	What will be the maximum duration of the period for which cyclists must wait? Can cyclists be wholly or partly excepted from traffic-signal control?	☐	
	General:		
41.	Have all markings from the old layout been removed? Is new surfacing necessary?	☐	
42.	Will there be a relatively large number of heavy vehicles at the junction and if so, has due allowance been made?	☐	

Checklist 9 *– traffic signals*

Project ....

No.	Description	O.K.	Comments
43.	Is the number of entrance lanes the same as the number of exit lanes?	☐	
44.	What surface material is used on the entrance lanes and in what condition is it?	☐	
45.	Has sufficient consideration been given to the elderly, people with mobility impairments and wheelchair users, people with impaired vision and the blind?	☐	
46.	Additional temporary signs will be needed at most new constructions. Black text on a reflecting yellow ground gives the best contrast. a) Is the text, etc., comprehensible and correct? b) When will the signs be removed.	☐	

Checklist 10 – *roundabouts*

Project ....

Auditor .... **Date** ....

No.	Description	O.K.	Comments
	Geometri:		
1.	Does the design give the desired speed reduction? – are the widths and directions of entrance and exit lanes appropriate? – does the location of the central island give a suitable curvature? – is the size of the central island reasonable? – are the widths of the circulation lanes appropriate?	☐	
2.	Is the number of entrance and exit lanes appropriate to the capacity requirements and does it agree with the number of circulation lanes?	☐	
3.	Is the central island circular?	☐	
4.	Are the space needs of large vehicles satisfied (shortcut areas are mostly unnecessary and should be avoided)?	☐	
5.	Are the crossfall and drainage characteristics satisfactory?	☐	
6.	Will the crossfall constitute a hazard for specific types of vehicle (sideslip or rolling)?	☐	

Checklist 10 – *roundabouts*

Project ....

No.	Description	O.K.	Comments
	Cyclists and pedestrians:		
7.	Should special measures be introduced for cyclists and are the proposed measures the safest? – cyclists should always be conducted outside high speed roundabouts – cyclists should always be conducted outside roundabouts which have more than one entrance or exit lane – will cyclists have long detours?	☐	
8.	Do pedestrians have satisfactory crossing facilities? – is there any need for zebra crossings and are splitter islands broad enough to accommodate waiting pedestrians (including cycles and prams)? – is there a need for a hedge or railing and will visibility and overview be sufficient? – will pedestrians have long detours?	☐	
9.	Should the vertical offset of kerbstones be reduced by ramps for wheelchair users and have any such ramps been correctly designed?	☐	
10.	Has all necessary consideration been given to children, the elderly, people with mobility impairments and the disabled?	☐	
11.	Are there facilities for bus traffic and are pedestrian access and routes to bus-stops satisfactory?	☐	

Checklist 10 – *roundabouts*

Project ....

No.	Description	O.K.	Comments
	Lighting/markings:		
12.	Is there adequate advance warning? – will it be necessary to erect warning signs or advance warning of the major road ahead? – will give-way signs be needed at the left-hand side of the road? – map-type signs are recommended – we recommend that stack direction signs not be used at roundabouts	☐	
13.	Do carriageway markings afford all groups of road user the highest possible degree of safety?	☐	
14.	Has lighting been proposed and if so, does it make the roundabout visible? – in rural areas, where there is no road lighting, at least the central island should be illuminated – contrast illumination of zebra crossings conceals roundabouts and should be avoided	☐	
15.	Are cyclist and pedestrian areas adequately illuminated?	☐	
16.	Is the optical guidance given by any road lighting sufficiently disturbed at the roundabout?	☐	
17.	Are signs and lighting columns located correctly? – check distances, sizes of signs, view of signs – do signs affect visibility (check this from the standpoints of truck drivers and motorists)? – will signs/columns on splitter islands obscure visibility of/for pedestrians and cyclists?	☐	

Checklist 10 – *roundabouts*

Project ....

No.	Description	O.K.	Comments
	General:		
18.	Should columns/posts be equipped with breakaway safety devices?	☐	
19.	Does the landscaping (including existing/planned plantations) help make the roundabout more visible?	☐	
20.	Does the landscaping (including existing/planned plantations) permit adequate visibility	☐	
21.	Has the use of a change in surface or of special surface colours been contemplated?	☐	
22.	Is the surface of any shortcut areas sufficiently uneven to discourage small vehicles?	☐	
23.	Will private accesses be affected and could they possibly be connected as extra arms?	☐	
24.	Additional temporary signs will be needed at most new constructions - especially in the case of roundabouts. Black text on a reflecting yellow ground gives the best contrast. a) Is the text, etc., comprehensible and correct? b) When will the signs be removed.	☐	

Checklist 11 – *junctions between paths and roads*

Project ....

Auditor .... **Date** ....

No.	Description	O.K.	Comments
	Choice of crossing type:		
1.	Has the best type of crossing been chosen (which vulnerable road users will use the crossing)?	☐	
2.	Assess the proposed design in relation to the road or carriageway width (e.g. with and without the traffic island, islands in zebra crossings/at traffic signals, staggering through the use of islands)?	☐	
3.	Is the speed limit at the crossing less than 60 km/h (if not, there should be a traffic island)?	☐	
	Location:		
4.	Are crossing aids on the logical route of vulnerable road users? Can their location be improved?	☐	
5.	Assess the locations of pedestrian signs, flashing yellow lights, and traffic signals in relation to the alignment. a) Is visibility adequate to permit stopping at the planning speed? b) Should the crossing be moved? Advance warning? High traffic signals or signals visible at a distance?	☐	
6.	Assess the practicability of the planning speed. Will a speed limit or warning signs be necessary?	☐	

Checklist 11 — *junctions between paths and roads*

Project ....

No.	Description	O.K.	Comments
7.	Is the crossing close to traffic signals? Are they co-ordinated? Does the programming vary?	☐	
8.	Are the traffic signals/signs immediately visible to all who enter the relevant road in the vicinity of the crossing (from side roads and private accesses)?	☐	
9.	Can plantations, objects or road equipment at the side of the road or on the footway prevent drivers from seeing the traffic signals/signs or pedestrians/cyclists on their way to the crossing (including children)?	☐	
10.	Assess the visual backgrounds of traffic signals/signs. Should backing boards be installed? Are there two sets of traffic signals on a single post? Should their height be adjusted?	☐	
11.	Will private accesses be affected by the scheme?	☐	
	Lighting:		
12.	Is the road suitably illuminated? Does the level of illumination ensure sufficient visibility of light road users crossing the carriageway?	☐	
13.	Does the lighting also illuminate footways and paths at the crossing?	☐	
14.	Will the illumination of lighting columns improve the visibility of the crossing at night?	☐	

Checklist 11 – junctions between paths and roads

Project ....

No.	Description	O.K.	Comments
	Especially for zebra crossings:		
15.	Is there adequate space for pedestrians to wait on the footway? Can space be saved by not installing traffic signals/signs on posts but, e.g. on the walls of buildings?	☐	
16.	Is there space for pedestrians with prams to wait on the footway and do they have satisfactory visibility?	☐	
17.	Is the kerb height reduced or is there tactile paving at the zebra crossing?	☐	
18.	Are there any inspection wells/drains on the pedestrian route?	☐	
19.	Are there school crossing patrols in the neighbourhood? If so, should they be moved to the new crossing?	☐	
20.	Should there be a hedge or railing (if the crossing does not lie on the pedestrians' logical route)?	☐	
	Especially for signalised crossings:		
21.	Determine the duration for which vulnerable road users can risk waiting at signalised crossings.	☐	
22.	Estimate the evacuation time required for vulnerable road users. Can they cross within a single phase?	☐	
23.	Would an extended green period or reprogramming be preferable?	☐	

Checklis 11 – *junctions between paths and roads*

Project ....

No.	Description	O.K.	Comments
	General:		
24.	Has sufficient consideration been given to the elderly, children, people with mobility impairments and the disabled?	☐	
25.	Have any control cabinets been installed where they cannot obstruct visibility or prevent eye-contact between motorists and vulnerable road users (including children)?	☐	
26.	In the case of reconstruction or installation on existing roads: a) What surface material is used on the entrance lanes and in what condition is it? b) Have all necessary changes of road markings been implemented?	☐	
27.	Should the surface be given special antiskid treatment or should a visual surface change be used?	☐	
28.	Additional temporary signs will be needed at most new constructions. Black text on a reflecting yellow ground gives the best contrast. a) Is the text, etc., comprehensible and correct? b) When will the signs be removed.	☐	

Checklist 12 – cycle paths and pedestrian areas

Project ....

Auditor .... **Date** ....

No.	Description	O.K.	Comments
	Paths in general:		
1.	Has there been proper planning for vulnerable road users? – have the densities of present cycle and pedestrian traffic been measured? – is there information on any significant excursion resorts? – is the project appropriate to vulnerable road users' normal routes and resorts?	☐	
2.	Will the project alleviate any of the vulnerable road users' particular problems of safety or security?	☐	
3.	Do the paths have the necessary width?		
4.	Do cyclists and any moped riders have adequate visibility/sight distance everywhere for meeting and for stopping?	☐	
5.	Are visibility conditions satisfactory at the junctions of paths?	☐	
6.	Are there any places where the right of way should be marked and possibly emphasised by some sort of installation? – "give way to traffic from the right" is normally the best mutual rule for cyclists/moped riders	☐	
7.	Are there any excessively steep inclines or declines?	☐	

Checklist 12

– cycle paths and pedestrian areas

Project ....

No.	Description	O.K.	Comments
8.	Are there places where the vertical gradient demands more stringent requirements on sight distances?	☐	
9.	Are paths adequately illuminated?	☐	
10.	Are there any steep inclines or declines, high kerbs or inappropriate changes of surface?	☐	
11.	Have the requirements on distances to rigid obstacles been observed (as far as cyclists/moped riders are concerned, practically all road equipment constitutes a "rigid obstacle")?	☐	
12.	Are there places where more stringent requirements should be set on distances to rigid obstacles?	☐	
13.	Are the paths drained sufficiently?	☐	
14.	Has all necessary consideration been given to children, the elderly, people with mobility impairments and the disabled?	☐	
	Cycle tracks and shared paths along roads:		
15.	Is the width of paths sufficient? – space for cyclists to overtake each other, and for mechanical sweeping/snow clearance, normally requires a minimum width of 1.75 metres on a one-way path	☐	

Checklist 12 – *cycle paths and pedestrian areas*

Project ....

No.	Description	O.K.	Comments
16.	Is there adequate separation between the carriageway and path (especially on high-speed roads)? – the minimum values of the road standards should never be applied to all cross-sectional elements at the same time – the use of stick-on kerbstones and asphalt ridges should be avoided – in the case of bidirectional cycle tracks, verges should have a minimum width of 3 metres	☐	
17.	Is there a need for additional separation between cycle track and parked vehicles?	☐	
18.	Is any road lighting installed so that it also illuminates the path satisfactorily?	☐	
19.	General points concerning junctions, including private accesses and side roads with exit constructions: a) Is the cycle route through the junction logical and adequately marked? b) Is there sufficient space for cyclists who are waiting to turn left? c) Is the visibility of the cycle track satisfactory (from the major and minor roads)? d) Will road users coming from the minor road be able to recognise the give-way sign and stop line at the cycle track? e) Have any surface changes been implemented without high edges and steep rises, and with a sufficiently smooth material (avoid cobblestones)? Be sure also to use relevant parts of the checklists for the specific types of junction!	☐	

Checklist 12 – *cycle paths and pedestrian areas*

Project ....

No.	Description	O.K.	Comments
20.	Specific to bidirectional cycle tracks at junctions: a) Will road users coming from both side roads be aware that they are crossing a bidirectional cycle track? b) At signalised junctions, is there a special phase for the cycle track? In cases where there are more than a small number of side roads/accesses, bidirectional tracks along roads should be avoided!	☐	
21.	Specific to cycle tracks drawn back at junctions: a) Is it clear who must give way, and where? b) Is there space for a vehicle to wait between the cycle track and major road?	☐	
22.	Bus-stops: a) Are bus-stop islands sufficiently broad (should be at least 1.5 metres) and are they obviously not a part of the cycle track? b) Do bus passengers have an adequate view of cyclists on the cycle track? c) Is the layout of the cycle track past the bus-stop reasonable (sudden changes, narrowing and sharp bends should be avoided)? d) Is there any need for special measures to indicate right of way? Bus-stop islands should always be constructed in new installations.	☐	
	Pedestrian streets, low-speed shopping streets, and squares:		
23.	Is the surface sufficiently smooth and without steep kerbs or suchlike?	☐	

Checklist 12 – cycle paths and pedestrian areas

Project ....

No.	Description	O.K.	Comments
24.	Has all necessary consideration been given to children, the elderly, people with mobility impairments and the disabled?	☐	
25.	Is drainage adequate?	☐	
26.	Are all areas adequately illuminated?	☐	
27.	If cycle traffic is permitted: a) Are pedestrian and cyclist areas clearly marked and separated? If this is not the case, will both groups of road user be able to differentiate between them? b) Are there any rigid obstacles in or beside the cycle area? c) Is there any risk that other objects (tables outside cafés, clothes racks, etc.) will be placed in or beside the cycle area?	☐	
28.	If through vehicular traffic is permitted: a) Are the areas for the individual groups of road user clearly marked and separated? If this is not the case, will all classes of road user be able to differentiate between them? b) Will it be possible to ensure a sufficiently low volume of through traffic? c) Will it be possible to ensure a sufficiently low speed level - also in the evening/at night?	☐	

Checklist 13 – *maintenance work*

Project ....

Auditor .... **Date** ....

No.	Description	O.K.	Comments
1.	Have the road works, including applicable speed limits and diversions, been publicised to the necessary extent?	☐	
2.	Are the markings adequate (including advance warning) and does the message reach all road users?	☐	
3.	Has a temporary speed limit been suggested and is it sufficient?	☐	
4.	Is there any need for temporary traffic-signal control and the associated markings?	☐	
5.	Will it be possible for unaffected road users to see (and misunderstand) temporary traffic signals?	☐	
6.	Is the standard of the proposed signs adequate (not too improvised, with good optical characteristics)?	☐	
7.	Will it be necessary to illuminate critical points (such as enclosed excavations)?	☐	
8.	Is the safety of the road-works crew in order?	☐	
9.	Will the enclosing material, etc., behave as a rigid obstacle?	☐	
10.	Are the start and end of diversions, staggering and temporary traffic signals located sensibly in relation to horizontal and vertical bends and existing junctions?	☐	

Checklist 13 – *maintenance work*

Project ....

No.	Description	O.K.	Comments
11.	Has due consideration been given to all groups of road user in the layout of staggering and diversions? Also from the standpoint of road users' navigation of the work site?	☐	
12.	Will there be safe access to the work place?	☐	
13.	Has a safety zone been proposed and is it adequate?	☐	
14.	What signposting (speed) is used outside working hours?	☐	

Checklist 14 – *local development plan proposals*

Project ....

Auditor .... **Date** ....

No.	Description	O.K.	Comments
1.	Should the area covered by the development plan have direct access to the primary road network? If so, Why?	☐	
2.	Will the plan have any *significant* impact on the traffic density of the surrounding road network?	☐	
3.	Will the plan affect existing pedestrian or cycle routes?	☐	
4.	Will vulnerable road users have safe access to the development plan area?	☐	
5.	Is there any need for new facilities for vulnerable road users?	☐	
6.	What will be the effect of new accesses to the development plan area on the speed limit, marking, traffic-signal co-ordination, etc., of the surrounding road network?	☐	
7.	Be sure also to use the relevant parts of Checklists 1 and 2 when assessing the safety of new paths and accesses (location, visibility, choice of junction type, etc.).	☐	
8.	Will activities/functions in the development plan area have any impact on safety in the surrounding road network (powerful lighting, transporting of hazardous materials, flying golf balls, etc.)?	☐	
9.	Will the plan entail parking on adjoining roads?	☐	

Checklist 14 – *local development plan proposals*

Project ....

No.	Description	O.K.	Comments
10.	Will loading and unloading proceed safely?	☐	
11.	Will large vehicles be able to turn in the area (without needing to reverse out onto superior roads)?	☐	
12.	Will any lighting, plantations and alignment in the area be able to have an optically misleading effeot for road users on the surrounding road network?	☐	
13.	Will buildings and plantations (also when fully grown) in the development plan area have any impact on visibility/sight distances on the surrounding road network?	☐	
14.	Does the development plan area adjoin the surrounding road network at places where there is a significant risk of vehicles inadvertently driving off the road?	☐	
15.	Do the accident data for the surrounding road network give any other reason for comment?	☐	

Checklist 15 – road safety improvement schemes

Project ....

Auditor .... **Date** ....

No.	Description	O.K.	Comments
1.	Have existing conditions at the site been satisfactorily described? – plan – geometry – location – status of road – buildings – marking and traffic regulation – are photographs of the site available? If so, do they show anything of relevance?	☐	
2.	Has the analysis of relevant "stick" diagrams been carried out correctly? – have all relevant accidents been taken into consideration, and only such accidents? – are clear, comprehensible collision diagrams available? – have any hypotheses on the problems been formulated? If so, is their scope sufficiently broad? – are the conclusions drawn from accident analysis correct?	☐	
3.	Has an inspection been carried out? If so, is its description relevant? – is the time of the inspection stated? If so, is it correct in relation to the accident analysis? – have observations from testing of the relevant manoeuvres been noted? – is the behaviour of the road users described? – have all hypotheses been tested in relation to the observations made during inspection?	☐	

Checklist 15 – *road safety improvement schemes*

Project ....

No.	Description	O.K.	Comments
	– have any conclusions been drawn? If so, are they correct?	☐	
	– have additional investigations been proposed? If so, are they relevant?		
4.	Have any remedial measures been proposed? If so, how do they relate to the problems described?	☐	
5.	Are the proposed meassures uniformly described and assessed?	☐	
	– sketches?		
	– assessment of costs?		
	– assessment of the expected reduction in the accident figures?		
6.	Do the proposed remedial messures create new problems or do they "solve problems" which cannot be derived from the accident analysis?	☐	
7.	Has any choice been made between different approaches? If so, is that choice correct	☐	

ROAD SAFETY AUDIT AND SAFETY IMPACT ASSESSMENT

August 1997

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ISBN: 90-76024-02-2

Acknowledgements

ETSC gratefully acknowledges the contributions of members of ETSC's Road Infrastructure Working Party to this review and, in particular, the work of Professor Richard Allsop, Chairman of the Working Party and editor of the review:

Prof. Richard Allsop (WP Chairman)
Prof. Werner Brilon
Mr Finbarr Crowley
Mr Dominique Fleury
Prof. Siegfried Giesa
Dr Lene Herrstedt
Prof. António Lemonde de Macedo
Mr Geoff Maycock
Prof. Jef Mortelmans
Dr Aristoteles Naniopoulos
Mr Fred Wegman
Prof. Aniceto Zaragoza
Mrs Ingrid van Schagen (WP Secretary)

ETSC is grateful for the financial support provided by DGVII of the European Commission and for the contribution towards the printing and dissemination costs of this review provided by 3M Europe, Ford Europe, BP, KeyMed and KLM Royal Dutch Airlines. The contents of this review are the sole responsibility of ETSC and do not necessarily reflect the view of sponsors nor organisations to which research staff participating in the Working Party belong.

The European Transport Safety Council

The European Transport Safety Council (ETSC) is an international non-governmental organisation which was formed in 1993 in response to the persistent and unacceptably high European road casualty toll and public concern about individual transport tragedies. Cutting across national and sectoral interests, ETSC provides an impartial source of advice on transport safety matters to the European Commission, the European Parliament and, where appropriate, to national governments and organisations concerned with safety throughout Europe.

The Council brings together experts of international reputation on its Working Parties, and representatives of a wide range of national and international organisations with transport safety interests and Parliamentarians of all parties on its Main Council to exchange experience and knowledge and to identify and promote research-based contributions to transport safety.

Contents

Executive Summary

Road safety audit is a formal procedure for independent assessment of the accident potential and likely safety performance of a specific design for a road or traffic scheme - whether new construction or an alteration to an existing road.

Road safety impact assessment is a formal procedure for independent assessment of the likely effects of proposed road or traffic schemes, or indeed other schemes that have substantial effects on road traffic, upon accident occurrence throughout the road network upon which traffic conditions may be affected by the schemes.

These two procedures enable the skills of road safety engineering and accident analysis to be used for the prevention of accidents on new or modified roads. They thus complement the use of these same skills to reduce the occurrence of accidents on existing roads by means of local safety schemes, in many cases in the form of low-cost measures (ETSC, 1996).

This review aims to describe and illustrate the use of safety audits and safety impact assessment in helping to design and build safe road and traffic schemes, and at the planning stage in choosing which schemes to progress from among a range of possibilities.

Both procedures have strong contributions to make to rational and effective decision-making when considering alternative options, and safety audit is important to the achievement of a safe design for a chosen alternative. The two procedures are complementary - the aim is similar and the difference is in scope and timing.

The scope of safety audit is usually confined to an individual road scheme, which may be a new road or modification to an existing road. The basis for safety audit is the application of safety principles to the design of a new or a modified road section to prevent future accidents occurring or to reduce their severity. The procedure is usually carried out at some or all of five stages in carrying out a scheme: feasibility study, draft design, detailed design, pre-opening and a few months after opening. An essential element of the process is that it is carried out independently of the design team. It should be undertaken by a team of people who have experience and up-to-date expertise in road safety engineering and accident investigation.

The scope of safety impact assessment is dependent on the scale of the schemes being considered. For small-scale schemes, the impact of change can usually be expected to be confined largely within the scheme itself. In this situation safety impact assessment and safety audit share many procedural characteristics. For larger schemes, the impact on accident occurrence can be expected to be felt over a larger part of the road network. In that case, the impact may be estimated using a scenario technique. By considering different road types, the corresponding values of relevant safety indicators and the forecast traffic volumes, the impact on accident occurrence can be estimated for different alternatives.

The development of safety audit for road and traffic schemes, and especially the fifth stage of monitoring the operation of such schemes after they have been open to traffic for some months, raises the question of the role of safety audit or analogous safety checking in respect of existing roads. There is a *prima facie* case that an independent assessment of conditions on an existing road would be likely to reveal deficiencies indicating scope for cost-effective measures for accident prevention additional to the accident remedial measures that are routinely identified by investigation of accident occurrence.

The benefits of safety audits and safety impact assessment are in:

- minimising the risk of accidents occurring in the future as a result of planning decisions on new transport infrastructure schemes;
- reducing the risk of accidents occurring in the future as a result of unintended effects of the design of road schemes;
- reducing the long-term costs associated with a planning decision or a road scheme;
- enhancing the awareness of road safety needs among policy-makers and scheme designers.

Well-documented experience in Europe and elsewhere shows that formal systematic safety audit procedures are a demonstrably effective and cost-beneficial tool to improve road safety. But they are used so far by only a minority of Member States. ETSC believes that sufficient information is available to warrant the EU and Member States taking a series of measures leading to routine application of safety audit procedures to schemes for new road construction and modification of existing roads in order to realise the full contribution that road infrastructure schemes can make to casualty reduction. Consideration should also be given to systematic safety checking of existing roads to complement accident investigation work.

Safety impact assessment procedures are not yet carried out anywhere on a national basis, although there has been some initial experience in The Netherlands and some aspects of safety impact assessment are included in appraisal procedures in some other Member States. Some Member States, however, have valuable experience in safety auditing techniques for road infrastructure projects and for these, the next step is to take a more strategic approach by looking at safety effects on the wider road network by means of safety impact assessment. There is also an important role for the EU in encouraging work in this area.

In urging action by Member States, ETSC wishes to emphasise that although the procedures of safety audit and safety impact assessment are complementary, neither is dependent upon the other. Early action to implement safety audit can therefore go ahead and be yielding benefits whilst work proceeds on the lengthier task of establishing procedures for safety impact assessment.

In relation to safety audit ETSC recommends that Member States should:

(a) examine their own procedures for the assessment of safety in road infrastructure projects to see how they can be made more effective in the light of practice in other Member States;

(b) where no formal procedure for safety audit exists, introduce a mandatory requirement that all major new road schemes be subjected to an independent safety audit;

(c) in time, extend formal procedures to smaller schemes and the safety checking of existing roads;

(d) prepare guidelines for use at national and local level laying down the terms of reference for safety audit including the roles and responsibilities of all concerned, with the help of experience in countries where safety audit is already practised;

(e) prepare a detailed manual of good practice which may be used in conjunction with the guidelines;

(f) send technically trained road safety professionals and their managers to learn at first hand from their counterparts in other Member States about their application of safety audit, and be ready to receive such visiting professionals from other Member States; and

(g) reconsider their allocation of trained staff and finance within their highway budgets to application of safety audit in the light of the benefit to cost ratios that it offers.

Regional and local authorities should:

be ready to share their experience of applying safety audit procedures with their counterparts in other Member States and to learn from them in return, especially by contributing to and drawing upon the EU's documentation of best practice and by exchange of visits by road safety engineers and managers.

In relation to safety impact assessment, ETSC recommends that Member States should:

(a) consider to what extent their existing arrangements for the appraisal of transport infrastructure projects take account of the likely impact of each project on accident occurrence throughout the affected road network;

(b) enhance their procedures for such appraisal so that they include all aspects of safety impact assessment.

Any new scheme on the TERN will, at the stage of feasibility study, be subject to mandatory Environmental Impact Assessment (EEC, 1985). ETSC believes that they should in a comparable way be subject to safety impact assessment covering the likely effects on accident occurrence, injury and damage not only on the relevant section of the TERN itself but also on all local roads on which traffic will be affected by the scheme. ETSC therefore welcomes the Commission's stated intention in its new action programme (CEC, 1997) to prepare new guidelines on safety impact assessment which would be applied in a first stage to the TERN and other EU financed projects.
The chosen scheme that emerges from the feasibility study should then be subject to safety audit at the stages of preliminary design and detailed design, and on site just before opening to traffic and after several months of operation.

In the context of its responsibility for transport safety, the EU can add value to the efforts of the Member States by acting to accelerate the rate at which citizens of the EU can benefit from more widespread and effective use of safety audits within each Member State.

Further steps by the EU which ETSC believes would be useful are as follows:

(a) as a first step promote international best practice by producing technical guidelines on safety audit;

(b) as a second step introduce an EU Directive requiring that all major new road schemes be subject to an independent safety audit;

(c) establish a European network of training in safety audit for road safety professionals and managers;

(d) encourage the transnational mobility of technically trained road safety professionals and their managers to accelerate the transfer among Member States of successful techniques and procedures for applying safety audits; and

(e) look for mechanisms by which its own allocation of funds to Member States for investment in roads can be used to encourage the recipient states to allocate funding within their highway budgets to programmes of safety audit.

ETSC believes that the promotion of safety impact assessment through the establishment of guidelines for the TERN and all EU funded projects would be a helpful first stage in integrating safety considerations into the relevant decision-making processes.

As a second stage, ETSC recommends that a mandatory requirement for safety impact assessment covering all new transport infrastructure projects should exist alongside EU procedures for environmental impact assessment with immediate application to the TERN and subsequent application to all transport infrastructure projects in all Member States.

Eventually, safety impact assessment should extend to all land use planning decisions as is envisaged for the developing environmental impact assessment.

1. Introduction

Road safety audit is a formal procedure for independent assessment of the accident potential and likely safety performance of a specific design for a road or traffic scheme - whether new construction or an alteration to an existing road.

Road safety impact assessment is a formal procedure for independent assessment of the likely effects of proposed road or traffic schemes, or indeed other schemes that have substantial effects on road traffic, upon accident occurrence throughout the road network upon which traffic conditions may be affected by the schemes.

These two procedures enable the skills of road safety engineering and accident analysis to be used for the prevention of accidents on new or modified roads. They thus complement the use of these same skills to reduce the occurrence of accidents on existing roads by means of local safety schemes, in many cases in the form of low-cost measures (ETSC, 1996).

This review aims to describe and illustrate the use of safety audits and safety impact assessment in helping to design and build safe road and traffic schemes, and at the planning stage in choosing which schemes to progress from among a range of possibilities. Generally, roads are designed with a large number of criteria in mind, such as travel time, user comfort and convenience, fuel consumption, construction costs, environmental impact and objectives of urban or regional planning. Safety is one of the criteria, but is often implicitly assumed to be achieved by adhering to prescribed standards of alignment and layout for each element of the design. These standards are indeed laid down with safety in mind, and some of these include explicit safety checklists (e.g. FGSV, 1988), but experience shows that adherence to them is not sufficient to ensure that a resulting design is free from avoidable hazardous features. Formal safety audit and safety impact assessment procedures ensure that independent expertise is used to make explicit the safety implications of an entire design and, in doing so, lead to safer designs of both new and modified roads.

Both procedures have strong contributions to make to rational and effective decision-making when considering alternative options, and safety audit is important to the achievement of a safe design for a chosen alternative. The two procedures are complementary - the aim is similar and the difference is in scope and timing.

The scope of safety audit is usually confined to an individual road scheme, which may be a new road or modification to an existing road. The basis for safety audit is the application of safety principles to the design of a new or a modified road section to prevent future accidents occurring or to reduce their severity. The procedure is usually carried out at one or all of five stages in carrying out a scheme: feasibility study, draft design, detailed design, pre-opening and a few months after opening. An essential element of the process is that it is carried out independently of the design team. It should be undertaken by a team of people who have experience and up-to-date expertise in road safety engineering and accident investigation.

The scope of safety impact assessment is dependent on the scale of the schemes being considered. For small-scale schemes, the impact of change can usually be expected to be confined largely within the scheme itself. In this situation safety impact assessment and safety audit share many procedural characteristics. For larger schemes, the impact on accident occurrence can be expected to be felt over a larger part of the road network. In that case, the impact may be estimated using a scenario technique. By considering different road types, the corresponding values of relevant safety indicators and the forecast traffic volumes, the impact on accident occurrence can be estimated for different alternatives.

The following two Sections deal in more detail with safety audit and safety impact assessment respectively, presenting information on procedural, methodological and organisational aspects, illustrated by means of specific case studies. Section 4 provides some information about the cost-effectiveness of safety audit as estimated in different countries where this approach has already been in use for some time. Section 5 considers the role of Member States and the European Union in promoting safety audit and safety impact assessment. Direct implementation could play an important role in the further development of the Trans-European Road Network, and implementation in Member States could be promoted in similar ways to that of the now mandatory environmental impact assessment procedures. In the last Section, the main conclusions are set out.

2. Road safety audits

2.1 The aim and nature of a safety audit

In safety audits "The main objective is to ensure that all new highway schemes operate as safely as is practicable. This means that safety should be considered throughout the whole preparation and construction of any project" (IHT, 1996). More specific aims are:

- to minimise the number and severity of accidents that will occur on the new or modified road;

- to avoid the possibility of the scheme giving rise to accidents elsewhere in the road network; and

- to enable all kinds of users of the new or modified road to perceive clearly how to use it safely.

Whatever the reason for the scheme, a safety audit always begins with a road design. An audit is intended to identify potential road safety problems by looking at the scheme as if through the eyes of the potential users of all kinds, and to make suggestions for solving these problems by applying the principles of road safety engineering (AUSTROADS, 1994; Danish Road Directorate, 1993; IHT, 1996). This means that an audit goes much farther than just assessing whether or not the relevant design standards are properly applied. An example of the application of safety audit in the work of a British local authority is given in Annex 1.

By minimising at the design stage the risk of accidents during the lifetime of a road scheme, there is less likelihood of having to take accident remedial measures later, and the whole-life cost of the scheme can be reduced.

Road safety audit is an important means for paying explicit attention to road safety during the design of road schemes. This explicit attention should help everyone involved in making decisions regarding changes to road infrastructure to assess the safety implications of the many choices that arise during the design process, and thus increase the road safety awareness of infrastructure planners, designers and authorities.

2.2 Organising and carrying out an audit

The process of safety audit as applied to an individual road scheme can be seen as taking place at up to five stages (Wrisberg and Nilsson, 1996), some of which can be combined for smaller schemes:

- *The feasibility stage*. During this stage, the nature and extent of the scheme are assessed, and the starting points for the actual design are determined, such as route options, the relevant design standards, the relationship of the scheme to the existing road network, the number and type of intersections, and whether or not any new road is to be open to all kinds of traffic.

- *The draft design stage.* Horizontal and vertical alignments and junction layout are broadly determined. At the completion of this stage, the design should be well enough established so that, if necessary, decisions can be made about land acquisition.

- *The detailed design stage*. Layout, signing, marking, lighting, other roadside equipment and landscaping are determined.

- *The pre-opening stage.* Immediately before the opening, a new or modified road should be driven, cycled and walked. It is advisable to do this under different conditions such as darkness and bad weather.

- *Monitoring of the road in use.* When a new or improved road has been in operation for a few months, it is possible to assess whether it is being used as intended and whether any adjustments to the design are required in the light of the actual behaviour of the users.

Checklists have been designed for use during each stage of auditing (AUSTROADS, 1994; IHT, 1996). In practice, these checklists have proved very useful as reminders for the auditors, but there is also a risk that they are used too blindly as recipes without sufficient consideration for individual situations. What is required is a combination of judgement, skill and systematic working.

The essence of road safety audit is that it is carried out by auditors who are independent of the design team, have expertise in both highway design and road safety, and are properly trained and experienced in carrying out audits. This means that not only must they possess sufficient specialised professional knowledge and have the required experience, but they must also possess the communication skills necessary to present audit results constructively and encourage a positive response to them from the design team. Experience has shown that it is preferable to hire a small auditing team rather than a single auditor. The members of an auditing team can jointly offer more skills than an individual, and a team can operate its own system of checks and balances and thus be less susceptible to its assessments being swayed by personal preferences.

The results of audit should be documented and reported at each stage to the design team and in turn to the client for the scheme. They will usually include recommendations for improvements to the design. There is much to be said for linking a form of certification to the entire auditing process, and having the audit results made public so that citizens, prospective users of the new or modified road, and other interested parties can make informed contributions to further decision-making. Whether this can be done or not depends greatly on the way in which the decision-making process relating to the scheme is organised. It is therefore impossible to give a generally applicable rule in this regard.

The conduct of safety audits can sometimes lead to tensions between the audit team, the design team and the client for the scheme. What is necessary from the start, therefore, is to create a sufficiently solid, formal basis (whether or not anchored in law) that enables safety audits to be carried out successfully and the recommendations based on the audits to be implemented. There also needs to be commitment to the procedures on the part of the organisations involved. The procedures should include arrangements for dealing with situations in which the design team and the audit team are nevertheless at odds about carrying out the audit recommendations. What is required in these cases is a decision by the client for the scheme, and this may be assisted by some form of arbitration.

2.3 Safety audit and existing roads

The development of safety audit for road and traffic schemes, and especially the fifth stage of monitoring the operation of such schemes after they have been open to traffic for some months, raises the question of the role of safety audit or analogous safety checking in respect of existing roads. There is a *prima facie* case that an independent assessment of conditions on an existing road would be likely to reveal deficiencies indicating scope for cost-effective measures for accident prevention additional to the accident remedial measures that are routinely identified by investigation of accident occurrence. Yet the task of checking all existing roads is demanding in terms of scarce resources of expertise.

This issue has been investigated in France (Machu, 1996) by means of a pilot study covering nearly 2,000 km of roads ranging from motorways to local roads. The results provide useful indications concerning complementarity between safety checking and accident analysis, the range of deficiencies which it is practicable for the checking to cover, and ways of putting road sections of different kinds into an order of priority for checking during the many years it is likely to take to cover the whole network.

3. Road safety impact assessment

3.1 The aim and nature of safety impact assessment

Being able to estimate explicitly the impact on road safety that results from building new roads or making substantial modifications to the existing road infrastructure that alter the capacity of the road network in a certain geographic area is of crucial importance if road safety is not to suffer unintentionally from such changes. The same applies to other schemes and developments that have substantial effects on the pattern of road traffic. The procedure that has been designed for this purpose is known as road safety impact assessment (Wegman *et al*, 1994). This procedure is intended to be applied at the planning stage, often proceeding to a definite design for the scheme. Safety impact assessment thus precedes and complements the eventual safety audit of any specific design for the scheme. A parallel to these two procedures can be seen in the Strategic Environmental Impact Assessment and the ordinary Environmental Impact Assessment (OECD, 1994). The two procedures together first provide an estimate of the impact of possible schemes on safety for an entire geographic area at the strategic level and then follow this with an audit of the safety of the specific design of the chosen scheme. For smaller schemes, the two procedures can be combined by extending the feasibility stage of the safety audit to include the likely effects of the scheme on accident occurrence in the surrounding network.

The results of safety impact assessment should be considered in the planning process alongside other information relevant to decision-making about which schemes should be implemented, and thus improve the quality of such decision-making.

3.2 Carrying out a safety impact assessment

A scenario method is used to carry out a safety impact assessment. The starting point is the existing road network, the current pattern of traffic on that network, and the level of reported road accidents there. It is helpful, though not essential, to have the information in a digital form within a geographic information system (GIS), as in the German system Euska (GDV, 1997). This information relates to a road network which is made up of roads of a number of types that have different road safety characteristics. Each road consists of junctions and stretches of road between the junctions, with associated traffic volumes, and numbers of accidents and casualties. Alternative scenarios to this current situation are the possible changes being studied in respect of the physical infrastructure and the associated traffic volumes in the road network in the future. If, for example, a new road is to be added to the existing network, the traffic and transport models can be used to estimate what this will mean for the traffic volumes throughout the network in the future.

The central step is to interpret these changes in terms of the impacts they will have on the numbers of accidents and casualties. To accomplish this, what are needed are quantitative indicators of risk (such as casualty rates per million vehicle-km) for each type of road, supplemented if possible by corresponding indicators for each main type of junction. One way of obtaining such indicators is to estimate them at a national level and adjust them if necessary using data for the area in question. In addition, thought should be given to any expected changes over time in the level of risk for each type of road or junction. These kinds of information enable safety impacts to be estimated. An example from The Netherlands is given in Annex 2.

If the various data are accessible from a computer, calculations of safety impacts for a range of scenarios and comparisons between impacts of different scenarios can be made quite readily. The procedure can be adapted in order to help to identify what changes are needed in a given scenario in order to bring its safety impact within some target range.

When implementing this scenario technique it is important to bear in mind the quality of the information being used. It is also important for the information to be accessible in such a way that calculations for a range of scenarios can be elaborated at relatively modest costs within a short period of time. For this purpose, the traffic and transport models should be set up in such a way that a road safety impact assessment module to apply the relevant indicators of risk for future years can be linked up with them readily.

4. Cost-effectiveness

The cost-effectiveness of road safety audits and safety impact assessments are at present difficult to quantify rigorously. Both techniques are relatively recent, and it is difficult to find well documented cases in which both the benefits and the costs of the procedures have been established, but there is nevertheless useful evidence of the cost-effectiveness of safety audit. Whereas it is not too difficult to assess the costs of carrying out either procedure, estimating the benefits requires an estimate to be made of difference in the accident costs occurring on schemes which have been subject to impact assessment and/or audit, compared with the costs on similar schemes which have not.

The main immediate benefits of the procedures will be accident savings. In principle however, there are other longer term and more broadly based potential benefits; these include not just the immediate accident savings on the schemes subjected to the procedures, but more generally, improvements to the management of design and construction, reduced whole-life cost of road schemes, the development of good safety engineering practice, the explicit recognition of the safety needs of road users, and the improvement of design standards for safety (Ogden and Jordan, 1993).

As regards the quantification of the immediate road safety benefits, there has been some experience in the UK, Denmark, Australia and New Zealand, which can give a broad indication of the value of road safety audit (AUSTROADS, 1994; IHT, 1996; Schelling, 1995; Transit New Zealand, 1993).

In 1994 a study was undertaken in an English county in which two groups of matched schemes, one group having been audited and the other not, were compared (Surrey County Council, 1994). This study estimated that the audited schemes showed a saving of about 1 accident per site per year compared with the schemes which were not audited - a saving which represents an accident cost saving per scheme well in excess of the cost of auditing the schemes.
Estimates have also been made of the benefits to a local highway authority of applying road safety audits to all of its road schemes. The Lothian Regional Council (a former local highway authority in Scotland) which had about 3,000 injury accident per year, estimated that the consistent application of road safety audits would give a 1 per cent accident saving, and that such a saving would represent a benefit to cost ratio of about 14:1. In New Zealand a potential benefit to cost ratio of 20 has been estimated for the application of road safety audit procedures (Transit New Zealand, 1993).

One way of forming a judgement about the likely cost-effectiveness of road safety audits in the absence of objective accident savings data, is to compare the costs of carrying out an audit with the economic cost of a single injury accident. It then becomes apparent how large an accident saving would be needed to cover the audit costs. In 1995, a review of road safety audit practice was undertaken by the Institution of Highways and Transportation (IHT) and the University of Southampton (Crafer, 1995). This review estimated that an average of 25 hours of the time of professional road safety engineers was required to complete an audit; 21 per cent of schemes took less that 10 hours and 7 per cent took more than 40 hours. Audit costs were estimated to be in the range of from £ 100 to £ 6,000 (at 1993 prices). In the UK, the 1994 value of preventing an injury accident was £55,650 , so the actual cost of carrying out a relatively extensive audit is a fraction of the value of preventing a single injury accident. In Australia, each stage of an audit of a scheme typically costs between AUS $ 1,000 to AUS $ 4,000 depending on the size of the scheme (Jordan, 1994).

It has to be borne in mind however, that the actual costs of safety audit are not only the costs involved in completing the audit itself. Having audited the scheme, it is necessary in those cases where a design change is recommended, to make the appropriate design changes. The extent of such changes depends upon the quality of the original design. In the IHT review mentioned above, some redesign was required in about half of the schemes audited. Although the actual cost of redesign varied considerably from scheme to scheme, it was estimated that redesign costs ranged from about 0.5 per cent of the cost for the larger schemes to about 3 per cent of the cost for the smaller schemes. Australian and New Zealand experience suggests that safety audit adds about 4 per cent to road design costs (ITE, 1994). Even including the costs of both the audit and any subsequent redesign, it is clear from these figures that the saving of only one injury accident will more than repay the cost of the audit and its redesign consequences.

Both the actual costs of the audit process and the redesign costs were included in a study conducted in Denmark in which the usefulness of safety audits was assessed in cost-benefit terms by a panel of experts (Schelling, 1995). The panel considered 13 schemes with construction costs ranging from 2M DKK to 400M DKK. To assess the safety benefits of the audit process, the auditors estimated to the satisfaction of the panel the number of accidents which would be expected on the schemes with and without the changes in design recommended by the audit. The total reduction on the 13 schemes was estimated to be 34.5 accidents per year involving 21.3 casualties. The time costs involved for those carrying out the audits and for the resulting redesign amounted to about 0.5 per cent of the scheme costs - the proportion being rather larger for the small schemes and considerably smaller for the larger schemes. Construction costs were estimated to increase by about 1 per cent as a result of the audit. As is to be expected, the rate of return varied considerably from scheme to scheme, but overall the cost involved in auditing the 13 schemes amounted to 13.5M DKK and the resulting design changes were expected to lead to a reduction in casualty costs of 20M DKK per year, giving a first year rate of return of well over 100 per cent. The study therefore concluded that safety audit is very effective in cost-benefit terms.

5. The roles of the EU and Member States

Well-documented experience in Europe and elsewhere shows that formal systematic safety audit procedures are a demonstrably effective and cost-beneficial tool to improve road safety. But they are used so far by only a minority of Member States. ETSC believes that sufficient information is available to warrant the EU and Member States taking a series of measures leading to routine application of safety audit procedures to schemes for new road construction and modification of existing roads in order to realise the full contribution that road infrastructure schemes can make to casualty reduction. Consideration should also be given to systematic safety checking of existing roads to complement accident investigation work.

Safety impact assessment procedures are not yet carried out anywhere on a national basis, although there has been some initial experience in The Netherlands and some aspects of safety impact assessment are included in appraisal procedures in some other Member States. Some Member States, however, have valuable experience in safety auditing techniques for road infrastructure projects and for these, the next step is to take a more strategic approach by looking at safety effects on the wider road network by means of safety impact assessment. There is also an important role for the EU in encouraging work in this area.

5.1 Implementation in Member States

In urging action by Member States, ETSC wishes to emphasise that although the procedures of safety audit and safety impact assessment are complementary, neither is dependent upon the other. Early action to implement safety audit can therefore go ahead and be yielding benefits whilst work proceeds on the lengthier task of establishing procedures for safety impact assessment.

5.1.1 Safety audit

In relation to safety audit ETSC recommends that Member States should:

(a) examine their own procedures for the assessment of safety in road infrastructure projects to see how they can be made more effective in the light of practice in other Member States;

(b) where no formal procedure for safety audit exists, introduce a mandatory requirement that all major new road schemes be subjected to an independent safety audit;

(c) in time, extend formal procedures to smaller schemes and the safety checking of existing roads;

(d) prepare guidelines for use at national and local level laying down the terms of reference for safety audit including the roles and responsibilities of all concerned, with the help of experience in countries where safety audit is already practised.

(e) prepare a detailed manual of good practice which may be used in conjunction with guidelines;

(f) send technically trained road safety professionals and their managers to learn at first hand from their counterparts in other Member States about their application of safety audit, and be ready to receive such visiting professionals from other Member States; and

(g) reconsider their allocation of trained staff and finance within their highway budgets to application of safety audit in the light of the benefit to cost ratios that it offers.

Regional and local authorities should:

be ready to share their experience of applying safety audit procedures with their counterparts in other Member States and to learn from them in return, especially by contributing to and drawing upon the EU's documentation of best practice and by exchange of visits by road safety engineers and managers.

5.1.2 Safety impact assessment

In relation to safety impact assessment, ETSC recommends that Member States should:

(a) consider to what extent their existing arrangements for the appraisal of transport infrastructure projects take account of the likely impact of each project on accident occurrence throughout the affected road network.

(b) enhance their procedures for such appraisal so that they include all aspects of safety impact assessment.

5.2 EU responsibilities and opportunities

5.2.1 Implementation in the TERN

The Trans-European Road Network (TERN), established by the Maastricht Treaty in 1993, provides an opportunity for the EU to promote best practice in road safety engineering work.

By its very nature, each section of the TERN will be used not only by residents of the Member State in which that section lies, but also by an appreciable proportion, on some sections a substantial proportion, of cross-border traffic from other Member States. The vision of the TERN as a unified European road network implies that cross-border users can expect to find levels of risk at least as low as on comparable roads in their home country, and concern for safety in the provision and operation of the network at least as great.

In July 1996, a decision by the Council of Ministers and the European Parliament authorised the European Commission to propose guidelines such that the TERN should "guarantee users a high, uniform and continuous level of services, comfort and safety" on this network (European Parliament and Council of the European Union, 1996).

Any new scheme on the TERN will, at the stage of feasibility study, be subject to mandatory Environmental Impact Assessment (EEC, 1985). ETSC believes that they should in a comparable way be subject to safety impact assessment covering the likely effects on accident occurrence, injury and damage not only on the relevant section of the TERN itself but also on all local roads on which traffic will be affected by the scheme. ETSC therefore welcomes the Commission's stated intention in its new action programme (CEC, 1997) to prepare new guidelines on safety impact assessment which would be applied in a first stage to the TERN and other EU financed projects.

The chosen scheme that emerges from the feasibility study should then be subject to safety audit at the stages of preliminary design and detailed design, and on site just before opening to traffic and after several months of operation.

5.2.2 Promotion of safety audit

In the context of its responsibility for transport safety, the EU can add value to the efforts of the Member States by acting to accelerate the rate at which citizens of the EU can benefit from more widespread and effective use of safety audits within each Member State.

This has been acknowledged to some extent already by the Commission in the support given to the SAFE STAR Fourth Framework project which aims to document best practice in safety audit from all the Member States and in its support for this ETSC review.

Further steps by the EU which ETSC believes would be useful are as follows:

(a) as a first step promote international best practice by producing technical guidelines on safety audit;

(b) as a second step introduce an EU Directive requiring that all major new road schemes be subject to an independent safety audit;

(c) establish a European network of training in safety audit for road safety professionals and managers;

(d) encourage the transnational mobility of technically trained road safety professionals and their managers to accelerate the transfer among Member States of successful techniques and procedures for applying safety audits; and

(e) look for mechanisms by which its own allocation of funds to Member States for investment in roads can be used to encourage the recipient states to allocate funding within their highway budgets to programmes of safety audit.

5.2.3 Promotion of safety impact assessment

ETSC believes that the promotion of safety impact assessment through the establishment of guidelines for the TERN and all EU funded projects, as indicated in Section 5.2.1 would be a helpful first stage in integrating safety considerations into the relevant decision-making processes.

As a second stage, ETSC recommends that a mandatory requirement for safety impact assessment covering all new transport infrastructure projects should exist alongside EU procedures for environmental impact assessment with immediate application to the TERN and subsequent application to all transport infrastructure projects in all Member States.

Eventually, safety impact assessment should extend to all land use planning decisions as is envisaged for the developing environmental impact assessment.

6. Conclusions

The road safety implications of planning decisions and infrastructure projects need to be taken explicitly into account in general policy-making at Community, national and local levels. The purpose is to avoid the cost of any unnecessary future accident and casualty problems.

At the strategic level, this entails assessment of the road safety implications of planning decisions that relate to modal choice, land use, the characteristics of city centres, transport infrastructure and services, and the interaction between public provision and private choice. Formal safety impact assessment procedures provide an appropriate mechanism to this end but, as yet, they have not been adopted in their entirety in any Member State.

Road safety impact assessment procedures are designed to assess the likely effects of the scheme or transport planning decision on accident occurrence, injury and damage over the whole of the road network which will be affected. Following this procedure, any highway scheme that emerges from the feasibility study should then be subject to safety audit at the stages of preliminary design and detailed design, and on site just before opening to traffic and after several months of operation.

Safety audit of a specific design for a new or modified road assesses the accident potential and likely safety performance of the design with a view to enabling the scheme to operate as safely as is practicable by identifying and recommending any necessary changes to the design.

For both safety impact assessment and safety audit, the application of safety principles is achieved through formal audit procedures carried out by expertise independent of the planning or road infrastructure project design team. Experience shows that audit work is best carried out as a team task with the team having specialist expertise in the road safety engineering and accident investigation and prevention fields.

Mandatory and cost-beneficial safety audit procedures programmed at well-defined stages during the planning, design and construction of road schemes have been used in the UK, Denmark, Australia and New Zealand for several years and have contributed to identifiable improvements in road safety. Experience has shown that on most schemes it is necessary to prevent only one injury accident to more than repay the cost of the audit itself and any consequential design changes.

The benefits of safety audits and safety impact assessment are in:

- minimising the risk of accidents occurring in the future as a result of planning decisions on new transport infrastructure schemes;

- reducing the risk of accidents occurring in the future as a result of unintended effects of the design of road schemes;

- reducing the long-term costs associated with a planning decision or a road scheme;

- enhancing the awareness of road safety needs among policy-makers and scheme designers.

Recommendations to the EU and Members States to realise these benefits throughout the EU have been set out in Chapter 5.

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Annex 1: Safety Audit: a British example

This example describes the road safety audit arrangements for roads in the English County of Staffordshire, where the County Council contracted a small independent road safety consultancy firm, TMS Consultancy, to carry out audits throughout the county. The firm initially carried out audits on schemes on roads of national importance in Staffordshire, and currently produces reports on all local road schemes in the county.

1. The safety audit process in Staffordshire

Requests for safety audit are sent to the consultant through the County Council. The design teams for the schemes come from a variety of backgrounds within the County and its District Councils.

One of the main advantages of this method of operation is that the audit team is completely independent, not only of the design team but also of the organisation responsible for the scheme. The consultants use a minimum of two experienced safety auditors for each scheme. For stages of audit prior to construction the process is as follows:

- audit brief and scheme plans sent to consultant, together with accident and traffic records as appropriate;
- site visit by at least one member of audit team;
- detailed examination of scheme plans by audit team members using in-house checking procedures;
- audit team discussion to determine which items should go forward into audit report;
- production of audit report in 'problem and recommendation' format dealing only with easily identified road safety problems; and
- submission of report to the County Council.

The audit report to the client is accompanied by feedback forms on which the client can record action taken in response to each recommendation.

For post-construction stages of audit, the consultants arrange a site visit with members of the police and the authority responsible for maintaining the road. At least two audit team members visit the site and record all comments made during the visit. A report in 'problem and recommendation' format is provided to the client together with feedback forms.

2. Audits carried out

Between 1994 and 1997 the consultant has carried out a total of 166 stages of road safety audit in Staffordshire, on a wide range of schemes. Scheme types include new bypasses, cycle routes, junction improvements, installation of traffic signals, installation of roundabouts, traffic calming, bend realignment, safety fence schemes and pedestrian crossing facilities. Schemes have been undertaken in both urban and rural situations.

The number of schemes for each stage of audit is as follows:

- Stage 0 - Feasibility: 5
- Stage 1 - Draft design: 18
- Stage 1/2 - Draft/detailed design: 28
- Stage 2 - Detailed design: 46
- Stage 3 - Pre-opening: 69

A total of 32 schemes have been audited at more than one stage. Fifteen of schemes audited at Stage 3 have also been audited by the consultants at previous stages. Continuity has been provided by the same audit team working on subsequent stages of the same scheme.

3. Case study of stages of audit

An example of a scheme audited at Stages 1, 2 and 3 is the implementation of a complex set of traffic signals at a staggered four-arm junction between a dual carriageway main road and two minor roads. The scheme was audited at these stages during a design and implementation process that took fifteen months.

A total of fourteen safety comments were made at Stage 1, fourteen at Stage 2, and just four at Stage 3.

The Stage 1 (draft design) audit commented on some of the fundamental aspects of the scheme, such as the need for the speed discrimination equipment at the signals, for traffic orders to prohibit potentially dangerous turning movements, and for changes to kerb lines to accommodate safer positions for bus lay-bys and pedestrian movements.

The Stage 2 (detailed design) audit looked at the detail of the scheme, commenting particularly on road markings, signs and pedestrian signal positions.

The Stage 3 (pre-opening) audit made comments on surfacing, signing and markings.

Many of the comments made at Stages 1 and 2 were acted upon by the design team. For example, at Stage 1, it was suggested that a bus lay-by should be moved, and this was carried out by the time the detailed design had been prepared. A pre-Stage 3 visit showed that nine of the fourteen points raised by the audit team at Stage 2 had either been implemented or were about to be implemented on site. Where action was not taken, the audit team consistently repeated their concern throughout the process. For example at all three stages the team repeated their concern that U-turning should be prohibited at the signals.

4. Wider implications

Two more general aspects of the safety audit process arise in relation to this example. Litigation following accidents on road schemes has concentrated the minds of both auditors and designers. The consultancy has taken legal advice and improved its in-house procedures as a result.

Secondly, and more importantly, safety audit should be seen as part of a road safety culture within design organisations. It is hoped that designers learn to build in safety features through having schemes audited. At the start of the firm's work with Staffordshire, the consultants put on a series of safety audit seminars for County highways staff. Over 100 members of staff attended the seminars which were aimed at raising awareness of safety issues and explaining safety audit procedures.

Annex 2: Safety impact assessment: a Dutch example

If new stretches of road are added to the existing network or if traffic management measures are considered to reduce traffic volumes on a certain stretch of road, or if measures are taken to improve the capacity of a junction, the consequences in terms of traffic volumes and, consequently in terms of road accidents, could well extend to other parts of the road network. This is because the choices of the individual road users might lead them to select another route, or another time to travel, or another means of transport.

By influencing traffic flows over a network, road safety consequences may well occur throughout that network. A safety impact assessment uses the well-known fact that physical features of a road network and its component elements together with the associated traffic volumes are the main explanatory factors for the average numbers of accidents happening on the components of that network. Different road types could be characterised by different average levels of accident risk, for example different average numbers of accidents per million kilometres driven. For the Dutch road network, safety indicators have been estimated for each type of road. These estimates are given in Table 1.

Road type	Speed limit (km/h)	Mixed traffic	Intersecting or oncoming traffic	Injury rate per 10^6 km
Residential areas	30	yes	yes	0.20
Urban street	50	yes	yes	0.75
Urban artery	50 / 70	yes / no	yes	1.33
Rural road	80	yes / no	yes	0.64
Express road or road closed to slow moving vehicles	80	no	yes	0.30
Motor road	100	no	yes / no	0.11
Motor way	100 / 120	no	no	0.07

Table 1. *Injury rates on different road types in The Netherlands in 1986.*

A road safety impact assessment, as carried out in The Netherlands, contains three steps. First of all basic data have to be collected on the network to be studied: the categorisation of roads and streets of that network, traffic volumes, road safety indicators, and their development over time. This requires a consensus on how to categorise roads. Furthermore, relevant data have to be collected for a certain administrative area.

In the second step the possible changes to the existing network are defined. This, again, will be done in terms of network composition, traffic volumes for the different network components and the road safety indicators. An important step is to compare regional road safety indicators with the national indicators and to draw conclusions on the differences which are found. Sometimes the national indicators are used because their quality is higher than is currently practicable for the regional indicators. Sometimes regional indicators are used because the national indicators do not offer a correct picture for a region.

In the third phase the possible future network, traffic volumes and road safety indicators are described or estimated in order to compare the existing situation with different scenarios in the future. The results of this comparison (the existing situation with at least one situation in the future) can be brought to the consideration of those who have to decide on the basis of all kinds of impacts of each scenario. In other words: safety impact assessments allow for a better consideration to be given to safety implications of possible measures in the context of their other effects.

The results of safety impact assessments can be translated into monetary terms by using values attached to preventing accidents and casualties, and thus provide an input to monetary cost-benefit analysis.

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SYNTHESIS 336

Road Safety Audits

A Synthesis of Highway Practice

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

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SUBJECT AREAS
Safety and Human Performance

Research Sponsored by the American Association of State Highway and Transportation Officials
in Cooperation with the Federal Highway Administration

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2004
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communication and cooperation with federal, state, and local governmental agencies, universities, and industry; its relationship to the National Research Council is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

NCHRP SYNTHESIS 336

Project 20-5 FY 2002 (Topic 34-02)
ISSN 0547-5570
ISBN 0-309-07015-5
Library of Congress Control No. 2004096315

Price $20.00

Published reports of the

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Transportation Research Board
Business Office
500 Fifth Street
Washington, D.C. 20001

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Printed in the United States of America

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The **Transportation Research Board** is a division of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering. The Board's mission is to promote innovation and progress in transportation through research. In an objective and interdisciplinary setting, the Board facilitates the sharing of information on transportation practice and policy by researchers and practitioners; stimulates research and offers research management services that promote technical excellence; provides expert advice on transportation policy and programs; and disseminates research results broadly and encourages their implementation. The Board's varied activities annually engage more than 5,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

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FOREWORD

By Staff
Transportation Research Board

Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice*.

The synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

This synthesis report provides a review of the state of the practice of road safety audit (RSA) and road safety audit review (RSAR) applications for U.S. states and Canadian provinces. Transportation safety professionals with these agencies and with local and regional entities, as well as others in both the public and private sectors, may be interested in this documentation of international, state, and some local agency approaches to the use of these tools in comprehensive safety programs. This synthesis of the Transportation Research Board places emphasis on North American applications. However, this document also discusses international practice as RSAs were first introduced in the United Kingdom more than 20 years ago, and RSAs have been extensively applied in New Zealand and Australia since the 1990s. This document promotes the use of RSAs and RSARs. The increased use of these applications may help reduce roadway crashes and fatalities.

For this synthesis report of the Transportation Research Board survey responses were received from 38 state departments of transportation (DOTs) and 6 Canadian provinces. The state of the practice was developed based on this 2003 survey, state, and local agency practices, Federal Highway Administration- and National Highway Institute-sponsored training for state DOTs, local agency training experiences, international practices, literature, and personal contacts.

A panel of experts in the subject area guided the work of organizing and evaluating the collected data and reviewed the final synthesis report. A consultant was engaged to collect and synthesize the information and to write this report. Both the consultant and the members of the oversight panel are acknowledged on the title page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

ROAD SAFETY AUDITS

SUMMARY

Road safety audits (RSAs) and road safety audit reviews (RSARs) are two safety tools that offer promise to help reduce roadway crashes and fatalities. Globally, these tools have been used by transportation safety professionals since the 1980s and are beginning to emerge as proactive safety tools in U.S. practice.

The purpose of this synthesis is to describe RSA and RSAR processes and to summarize their current usage. It is anticipated that this document will promote increased use of RSAs and RSARs and, as a result of the increased use, a reduction in roadway crashes and fatalities.

The internationally accepted definition of an RSA as used in this synthesis comes from *The Canadian Road Safety Audit Guide* and is as follows: "An RSA is a formal and independent safety performance review of a road transportation project by an experienced team of safety specialists, addressing the safety of all road users." An RSAR is defined for use in this synthesis as "an evaluation of an existing roadway section by an independent team, again focusing solely upon safety issues" and comes from NHI Course 380069 ("Road Safety Audits and Road Safety Audit Reviews").

Internationally, the distinction between the evaluation of a plan or a design (RSA) and the evaluation of a roadway section or intersection (RSAR) either just before opening or already open to traffic is becoming more pronounced. Terms such as RSAR, road infrastructure assessment, road review, roadway assessment, and roadway inspection have been used to differentiate an RSAR of an existing roadway from an RSA of a plan.

RSAs were introduced in the United States in 1996 as a result of an FHWA-sponsored scanning tour of Australia and New Zealand. The FHWA contacted all state departments of transportation (DOTs) to solicit interest in applying the concepts as a pilot study. In 1997, it sponsored a workshop in St. Louis to discuss the practice and pilot activities. Thirteen states and two local governments participated in this pilot project, marking the beginning of U.S. practice.

This synthesis was developed using a comprehensive literature review, a survey of state and provincial DOTs by means of a structured questionnaire, and the authors' personal contacts and experiences in providing RSA team leadership and training worldwide.

The questionnaire was designed to elicit responses related to key RSA issues defining DOT practices and to clarify and identify possible DOT concerns when agencies consider implementing these proactive safety tools. The survey responses indicated that by mid-year 2003, only seven state DOTs were using both RSAs and RSARs in their safety programs. An additional 10 states indicated that they were using one but not both of these tools. Most of these states indicated that their use was best described as a beginning program to determine the benefits of incorporating the tools into their safety programs. That is not surprising, for the initial exposure of most state DOTs to RSAs was relatively recent, in 1997, compared with international practices, which date from the 1980s.

The survey identified several issues that affect the use of RSA processes and the way in which they are applied, including

- Institutional issues—agency culture, staff interests, manpower, expertise availability, financial resources, liability, and management acceptance.
- Audit team composition—size of team (three to five members were recommended) and team skills—most states identified a core related to traffic operations, design, and safety, with additional skills related to construction, maintenance, law enforcement, planning emergency medical services, and human factors depending on the audit stage and scope of the project.
- In general, the benefits of conducting RSAs during an early project stage were identified as a key to maximizing their impact or effectiveness. The advantage of identifying the safety issues before the project's footprint has been developed was seen as an important benefit of the RSA approach.

Several states have advanced beyond the initial assessment stage. Specifically, Iowa, Pennsylvania, New York, South Carolina, and South Dakota were identified as having developed programmed approaches for including proactive safety assessments.

Training was a major component of the South Carolina program, and two workshops were held to provide a core group of trained auditors.

The number of countries worldwide using the tools of RSAs and RSARs is growing rapidly. Historically, the most advanced countries have been involved in applying these techniques since the mid-1980s. The United Kingdom, Australia, and New Zealand are leaders in refining and advancing the state of the practice. It is noteworthy that these three countries have active and extensive programs, are requiring audits to be undertaken, and are conducting RSAs during different project stages. In some cases, multiple audits are required, and the monitoring of RSA audited projects is becoming a mandatory activity in the United Kingdom program. Auditor certification is beginning to emerge as an international issue.

In the United States, more and more states are learning of RSAs through a National Highway Institute training course. Local agencies are also beginning to explore and develop programs based on applying RSARs. The value added in using RSAs and RSARs will continue to grow in the United States as more state DOTs and local agencies try these safety tools on their roadways.

CHAPTER ONE

INTRODUCTION

Roadway crashes and fatalities in the United States continue to be a major health and safety issue. In 2002, almost 3 million injuries and 42,815 fatalities occurred on U.S. roads. In all, the 6 million crashes in the United States in that year resulted in an estimated $230 billion financial loss (*1*). Worldwide the estimates of annual road fatalities are in excess of 1 million. Road safety audits (RSAs) and road safety audit reviews (RSARs) are two safety tools that offer promise in reducing roadway crashes and fatalities. Globally, these tools have been in safety practice since the 1980s and are beginning to emerge as proactive safety tools in the United States.

PURPOSE AND METHODOLOGY

This synthesis provides a review of the state of the practice of RSA applications for state departments of transportation (DOTs) in the United States and provincial transportation agencies in Canada. Also included are summaries of some local agency approaches to the use of these tools in comprehensive safety programs. The purpose of this synthesis is to describe RSA and RSAR processes and to summarize their current usage. Emphasis is placed on applications in North America. However, this document also discusses international practice, because RSAs were first introduced in Great Britain more than 20 years ago, and have been extensively applied in New Zealand and Australia since the early 1990s. In those countries, the extent of application and the level of maturity of usage exceed that of the United States. Practices are evolving in the United States as more states receive training and are beginning to implement audit programs. It is anticipated that this document will promote increased use of RSAs and RSARs and, as a result of the increased use, a reduction in roadway crashes and fatalities.

The state of practice was developed based on the following:

- A 2003 survey of state DOTs and Canadian provinces,
- State and local agency practices,
- Training for state DOTs sponsored by the FHWA and the National Highway Institute (NHI),
- Local agency training experiences,
- International practices, and
- Literature and personal contacts.

The survey questionnaire is contained in Appendix A. A list of the 38 states and 6 governmental agencies in Canada that responded to the survey is included in Appendix B.

International practices are described to illustrate the global acceptance of RSA practices and advancements that have been made worldwide. Recent progress in countries that have a long history of applying RSAs is highlighted. Examples of other countries where RSA and RSAR practices are in the initial stages are provided. The most current information on these international practices was obtained from presentations delivered at an international forum on RSAs sponsored by the Institute of Highways and Transportation (IHT) held in London, England, in October 2003.

Chapter four provides an update on international applications. Included in that chapter are survey inputs from Canadian cities and provinces that also responded to the DOT survey. The final chapter contains a summary of key issues associated with these safety tools. References, a bibliography, and appendixes conclude the report. The appendices include the synthesis DOT survey, sample RSA and RSAR reports, sample RSA and RSAR checklists, and an example of a DOT RSA program.

INTERNATIONAL DEFINITION OF ROAD SAFETY AUDITS AND U.S. DEFINITION OF ROAD SAFETY AUDIT REVIEWS

The internationally accepted definition of an RSA as used in this synthesis is as follows: "An RSA is a formal and independent safety performance review of a road transportation project by an experienced team of safety specialists, addressing the safety of all road users" (*2*). An RSAR is defined as "an evaluation of an existing roadway section by an independent team, again focusing solely upon safety issues" (*3*). Internationally, this distinction between the evaluation of a plan and the evaluation of a roadway already open to traffic is becoming more pronounced. Terms such as RSAR, road infrastructure assessment, road review, roadway assessment, and roadway inspection have been used to differentiate an RSAR of an existing roadway from an RSA of a plan.

In 1996, an FHWA-sponsored U.S. scanning tour visited Australia and New Zealand to investigate their applications of RSAs and to determine if that tool would have added value in advancing U.S. safety practices. The proactive RSA practice and its wide acceptance were recognized by the team as adding value to road safety practices. It is hoped that this synthesis will continue to advance U.S. acceptance and implementation of both safety tools.

CLARIFYING EXISTING U.S. SAFETY PRACTICE

There is a great deal of confusion and misunderstanding regarding these proactive tools and existing safety practices. Although most state DOTs currently include some elements of these tools, implementation of the RSA and RSAR processes to achieve full benefit is not occurring. The following are typical first reactions to the application of the process to an audit of a plan and an audit of an existing roadway.

- "We already do RSAs and RSARs."

  The perception of many individuals involved with roadway safety in the United States is that they are already applying RSA processes in their work. However, most are not. Although most DOTs are conducting comprehensive project scoping reviews that include many of the aspects of the RSA or RSAR process, those scoping reviews do not involve review examinations by an independent team focusing solely on safety. A common response from individuals who have received RSA and RSAR training has been that those two tools are best used in the early stages of a project. Another primary response to the training is that the RSA would provide excellent input into project scoping and preliminary project design.

- "We already do RSARs."

  Most state DOTs have a reactive component in their safety programs that focuses on high-crash locations. Although these analyses may include evaluations and input from several people, they do not constitute an RSAR. An RSAR is not a reactive tool drawing conclusions from crash histories. Instead, it focuses on safety issues associated with the roadway, all road users (e.g., drivers, pedestrians young and old, and bicyclists), operating under all environmental conditions (e.g., day versus night and wet versus dry), to identify the safety issues associated with the existing facility. It includes evaluations from an independent team and results in a formal report. Iowa, New York, and South Dakota are three DOTs leading RSAR activities. Iowa and New York have incorporated RSARs into their resurfacing, restoration, and rehabilitation/resurfacing, restoration, rehabilitation, and reconstruction (3R/4R) programs.

U.S. ROAD SAFETY AUDIT AND ROAD SAFETY AUDIT REVIEW CONCERNS

There are many implementation issues identified by state DOTs and local agencies in the United States. First and foremost is a general concern about the rigidity of the process as practiced internationally. Second is a concern about how best to integrate the audit approach into existing safety practices and programs. Related are concerns about liability, audit process and procedures, identifying projects to audit, and auditor skills and training. These issues and the details associated with conducting both RSAs and RSARs are addressed in chapters two and three. Chapter two provides a detailed discussion of the RSA and RSAR process. An overview of the survey results from state DOTs in the United States is presented in chapter three. A section focusing on local agency issues concludes that chapter. A more complete focus on local safety tools is provided in *NCHRP Synthesis of Highway Practice 321*, published in 2003 (*4*).

U.S. ROAD SAFETY AUDIT AND ROAD SAFETY AUDIT REVIEW STATUS IN 2003

The application of RSAs and RSARs is in its infancy in the United States, with only a few states having safety programs that include either an RSA or RSAR component. However, as a result of training, more states appear to be willing to try these approaches to enhance safety. In Canada, RSAs are being evaluated for use in value engineering processes and in design-build projects.

The philosophy behind RSAs and RSARs is to be proactive in independently evaluating safety issues and recommending alternative applications or technologies where appropriate. At the completion of the audit process comes the implementation of selected alternatives to improve the safety of the roadway and then to evaluate the benefits associated with those safety improvements.

FUTURE ISSUES OF ROAD SAFETY AUDIT AND ROAD SAFETY AUDIT REVIEWS

The application of RSAs is in its earliest stages in the United States. To advance and expand the application of the concept and to enhance safety benefits the following activities are needed:

- Training programs should be continued to introduce more state DOT personnel to RSA practices and how these safety tools can be applied.
- A compendium of best practices could be developed and disseminated to state DOTs, cities, and local road agencies. Local transportation assistance program (LTAP) centers or technology transfer (T^2) centers could assist in the distribution of this information.
- RSA training courses might be developed to focus on urban applications such as at intersections or on RSA and RSAR aspects of access management.

- A study is needed to establish the benefits of audits based on U.S. practice. This could include a quantitative evaluation to establish the economic benefits of audits.
- A forum on RSA and RSAR to advance U.S. practice could be held.

Time, training, and a record of successful applications will be the keys to making RSAs and RSARs a common safety practice in the United States. Agencies can stay up to date on RSA and RSAR activities by visiting the website www.roadwaysafetyaudits.org.

CHAPTER TWO

ROAD SAFETY AUDIT PROCESS

WHAT IS A ROAD SAFETY AUDIT?

An RSA as applied in the United States is a formal examination of a future roadway plan (or project plan) by an independent, qualified audit team, which then reports on safety issues. The key elements of this definition are that the RSA

- Is a formal examination with a structured process and not a cursory review;
- Is conducted independently, by professionals who are not currently involved in the project;
- Is completed by a team of qualified professionals representing appropriate disciplines; and
- Focuses solely on safety issues.

The RSA is proactive, done before a crash history indicates a problem exists. It considers all road users—for example, drivers, pedestrians, and bicyclists—and it considers all environmental conditions, including daylight, nighttime, and inclement weather.

The RSA is not a means to rank or rate a project, nor is it a check of compliance with standards. In addition, the RSA does not attempt to redesign a project; it results in recommendations or findings that should be considered when a project is reviewed. Audits conducted early in the life of a project—in the planning or initial design stages—have been shown to be the most beneficial and the easiest to integrate with an agency's existing safety program.

WHAT ARE THE BENEFITS OF ROAD SAFETY AUDITS?

The safety benefits of RSAs have been documented primarily in international applications, which are summarized in chapter four. International assessments focus on the value added by proactively implementing the RSA findings. Several studies compared benefits of similar projects where RSAs were conducted with projects in which RSAs were not conducted. In the United States, where RSA tools have only recently been introduced, the quantitative benefits of RSAs have been difficult to document because the RSA is a proactive rather than a reactive safety tool. An analogy can be made to the medical field. It may be difficult to prove the benefits of preventive medicine, yet it is generally accepted that exercise, proper diet, and other measures can help reduce long-term medical costs.

Nevertheless, in an unpublished study of RSA pilot studies assessed in 1997 by the FHWA, a number of important benefits were identified. Audits were found to

- Provide safety beyond established standards;
- Identify additional improvements that can be incorporated into the projects;
- Create consistency among all projects;
- Encourage personnel to think about safety in the course of their normal activities, throughout all stages of a project;
- Invite interdisciplinary input;
- Enhance the quality of field reviews;
- Provide learning experiences for the audit team and design team members;
- Provide feedback to highway designers that they can apply to other projects as appropriate;
- Provide feedback that helps to affirm actions taken and to work through outstanding issues; and
- Ensure that high quality is maintained throughout a project's life cycle.

WHAT ARE THE STAGES OF A ROAD SAFETY AUDIT?

RSAs can be performed at one or more stages of a new roadway project (*3*):

- Planning,
- Draft design,
- Detail design,
- Traffic control device (TCD) construction planning, and
- Construction.

The different emphasis at each stage principally relates the level of detail addressed. Each stage is described in the following sections.

Planning

RSAs conducted during the planning stage occur early in a project and generally evaluate the basic project scope, route location and layouts, intersection types, access control, interchange locations and types, and impacts on the existing infrastructure. Some of those items also receive attention during audits conducted during other stages. As more details of the project become available, safety considerations become more focused.

Draft Design

During the draft—or preliminary—design stage, the audit team evaluates general design standards. Some factors that the team might consider include horizontal and vertical alignment; intersection and interchange type and layout; sight distances; lane and shoulder widths; superelevation; and provisions for pedestrians, including children, the elderly, the disabled, and bicyclists.

Detail Design

All elements of the final design should be in place during the detail design stage. During this stage, the audit team reviews the final geometric design features; traffic signing and pavement marking plans; lighting plans; landscaping; and intersection and interchange details such as tapers, lengths of acceleration and deceleration lanes, and turning radii. The team also reviews provisions for special users such as elderly pedestrians, children, the disabled, and bicyclists; drainage, guardrails, and other roadside objects; and constructability.

TCD Construction Planning

An RSA conducted during this stage focuses on the development and implementation of the traffic control plan. It evaluates the implications of alternative TCDs, use of various types of devices, impact of temporary geometric changes, and implementation of changes that might occur as the project progresses.

Construction

During this stage, the audit team focuses on safety issues during construction and looks at how a new construction project interacts with utilities, railroads, businesses, maintenance, and other parts of the existing infrastructure. The team also considers the safety impacts of alternative staging plans.

HOW IS A ROAD SAFETY AUDIT CONDUCTED?

Conducting an RSA requires that a formalized, systematic process be followed. However, each agency may tailor the process to satisfy specific organizational and safety goals. Generally, the following steps are followed in conducting an audit.

Select the RSA Team

The RSA team consists of trained and experienced transportation professionals and others with special skills. The team members also should be chosen independent of the project being audited and therefore able to look at the project without bias. A team leader who has experience in conducting audits is identified. A core team comprising a highway and traffic safety specialist, highway designer, and traffic engineer is usually used effectively on most projects. To that core team others may be added as needed to provide expertise pertinent to the project being audited. Specific disciplines that can be added include experts in planning, enforcement, pedestrians and bicyclists, and human factors, as well as local residents. Diverse perspectives of the team members foster the exchange of ideas that can enrich the audit. Of utmost importance, the audit team members should have the time and desire to conduct the audit.

Provide Relevant Data and Documentation

The project designer or an appropriate internal client who is requesting the audit provides all available relevant data and documents to the audit team, as well as a statement of the scope of the audit. The individual supplying the information reflects the type of project being audited, the stage of the audit, and the organization of the audit process within each agency.

Relevant data and documentation include, but are not limited to the following:

- Plans and drawings;
- Design standards used;
- Traffic volume data;
- Crash records, if applicable (only on a redesign or an RSAR);
- Public input;
- Videotapes; and
- Data concerning utilities, railroads, schools, and businesses, among others.

Hold Kick-Off Meeting

The project designer or internal client calls the kick-off meeting to launch the audit. The audit team members, designer or internal client, and any others who have knowledge of the project that the audit team needs should attend. During this meeting, the designer or client turns over the relevant data and documents. The participants discuss the purpose and conduct of the audit, scope, roles, and responsibilities, as well as the desired presentation format for the audit report.

Assess Data and Documents

After the kick-off meeting, the audit team reviews the data and documentation, records its initial impressions, and plans the site inspection(s). Team members consider appropriate checklists and prompt lists to refer to during the site visit. From these data and documents, the team begins to identify safety-related issues and concerns.

Inspect Site

After reviewing the relevant data and documentation, the RSA team inspects the site. Team members bring the data and documentation with them and review the site from all possible perspectives (e.g., planning, design, construction, and maintenance), considering all possible road conditions (e.g., sunshine, darkness, rain, snow, sleet, and hail), and users (e.g., motorists, both elderly and inexperienced drivers, motorcyclists, bicyclists, children, and elderly pedestrians). Any checklists or prompt lists selected are used during the site visit to assist in evaluating safety issues. The team also considers factors such as glare from headlights and the sun, external lighting, and existing infrastructure (e.g., railroad crossings, industry, schools, businesses, parks, and recreation). The team looks at adjacent roadways that transition into the site as well. More than one visit might be necessary, with both nighttime and daytime visits beneficial.

Discuss Audit Safety Issues with the Designer or Internal Client

There are two alternative formats to presenting the audit report. First, before writing the report, the audit team and designer or internal client meet to discuss the issues and concerns raised during the audit. Doing so establishes an atmosphere of cooperation and encourages the sharing of knowledge and perspectives on the project being audited. This gives everyone an opportunity to brainstorm conclusions, solutions, and recommendations and have input into the audit report. The second approach is to write the report and then to present the audit report findings. Whatever format is used should be defined in the initial meeting with the client.

Write RSA Report

The audit report documents the results of the RSA. Several examples of RSA and RSAR reports are included in Appendix C. These are actual reports that have been edited to eliminate references to specific agencies or locations. In general, the RSA report

- Identifies all safety issues and deficiencies, noting those that require immediate attention; and
- Draws conclusions in the form of recommendations or suggestions for possible corrective actions if requested.

An audit report has no set format, but at a minimum it should include the following sections:

- Project description—Describe the project being audited, summarize its background, and state why the audit is being performed.
- Audit team members—Identify each team member by name and title. If consultants are used, describe their credentials.
- Data and documentation—Identify all data and list all documentation reviewed. If appropriate, indicate the usefulness of each.
- Assumptions—List any assumptions relied on, if applicable.
- Site visits—Identify the dates and times when visits have been conducted. Also, identify any conditions present at the time of the visit (e.g., bright sunshine versus clouds and heavy versus light traffic flow). Describe the site's layout and physical characteristics. Identify anything that the site inspection reveals that the data and documentation do not. Identify any checklists or prompt lists that were used.
- Findings—Clearly state safety-related observations, identifying in detail all safety issues and concerns.
- Conclusions—State the recommendations, suggestions, alternatives, implementation strategies, etc., that relate to the scope of the audit. Present the content in a format established by the agency. Some agencies prefer to include recommendations, whereas others prefer findings.

Hold Completion Meeting

During the completion meeting, the audit team presents its findings orally and answers any questions that the stakeholders might have. To get the most from the meeting, the report should be distributed in advance so that it can be reviewed by the attendees who can then formulate their questions and comments. The meeting should be an open, positive, and constructive discourse that is free of criticism. All parties should work together to be proactive, not adversarial, in their approach to safety.

Respond to Report

The project designer, internal client, or other stakeholder responds to the audit report. Audit reports generally include corrective actions; for example, recommendations or suggested safety improvements. A written documented response indicates which corrective actions are accepted and which are rejected, as well as reasons associated with the decisions made. Including an implementation plan may also be of value. An official with authority to make decisions should sign the report.

Implement Agreed-on Changes

Because the whole point of conducting an RSA is to improve safety, an important step is to actually implement the changes that the audit team and stakeholders agree to implement. That implementation also should be documented and made part of the total audit file.

Share Lessons Learned

The final step of an RSA is to share the lessons learned with all the stakeholders and with the planning, design, construction, operations, and maintenance teams. Those lessons then can be applied to all future projects as appropriate. A project that has been audited also should be monitored to determine if the audit and implementation of findings have been successful. The agency that requested the audit maintains the audit records

KEY ISSUES TO CONSIDER IN AUDIT REPORTS

Because the audit report is important, it deserves special attention. The audit report should be concise and to the point. It should contain at least the elements that were listed earlier. However, the audit report need not be too long; 2 to 10 pages would be ideal for most projects. Agencies appear to be divided on whether the reports should contain findings or recommendations. Recommendations suggest further specific actions or improvements, whereas findings address the results of the audit. It is important that the report's contents be discussed during the kick-off meeting to determine the objectives of the client. Sample audit reports are included in Appendix C.

Another consideration is the disposition of the report after the audit has been completed. Each agency should establish procedures for maintaining RSA reports. If the agency has a central RSA coordinator, that person should maintain the records. Another option is to house the reports at a district office. In all cases, a copy of the audit report should be included with the documentation of the specific project that is audited.

USING CHECKLISTS AND PROMPT LISTS

One tool that has been a key component in conducting RSAs is a checklist. Checklists have been developed to aid auditors in reviewing projects to ensure that all issues that can affect safety are addressed. Both *Road Safety Audit* from Austroads (*5*) and *Guidelines for the Safety Audit of Highways* from IHT (*6*) contain extensive checklists that can be used for each audit stage. In the United States, Pennsylvania has developed checklists for use in its audit process. These checklists can be viewed at the previously mentioned website, www.roadwaysafetyaudits.org.

Checklists should not be used so rigidly that the audit team allows the checklist to dictate the audit. Instead, the checklists should be flexible guidelines and reminders of things to look for in steering the team to a comprehensive evaluation of the project. Checklists should be viewed as only one tool available to the audit team, just as the project data and documentation are tools.

Many international agencies are now using prompt lists. Those tools are less prescriptive than checklists and identify broader areas for the audit team to examine during the field review. *The Canadian Road Safety Audit Guide* (*2*) contains an example of a prompt list.

It is recommended that an audit team develop a checklist or prompt list tailored to the specific project and stage of the audit being conducted. This should be accomplished during the kick-off meeting and the list then taken to the site inspection. The team can use an existing list and modify it to fit the project. Appendix D contains samples of audit checklists. Checklists have been developed for specific audit stages and for specific types of projects. The appendix provides several different RSA checklist styles. Essential to using a checklist or prompt list is to include relevant local safety concerns and issues. Tailoring a checklist to specific facility types or project types may have benefits in advancing the application of RSAs and RSARs.

WHAT IS A ROAD SAFETY AUDIT REVIEW?

An RSAR is a safety assessment of an existing street or roadway section or a newly completed section before opening. An independent, qualified audit team reports, in an RSAR, on the safety issues of these road or street sections. The RSAR is a practical safety tool for local rural road agencies with typically limited resources, whose primary responsibilities are the maintenance and operation of existing roadway networks. The RSAR can also be used as part of an agency's overall safety program or in conjunction with other ongoing activities such as a 3R/4R program. The RSAR differs from the conventional safety analysis and scoping study because it is proactive and not dependent solely on crash statistics. The RSAR concentrates on a specific roadway section to address safety issues and therefore is different from traditional U.S. and Canadian scoping studies. RSARs may be used as planning tools to identify safety issues to be considered in improvement projects.

State DOTs and local agencies are continuously faced with the need to consider how the safety of an existing road or street may be enhanced. Because the uses of a roadway change over time, roads that fully complied with all safety standards at the time they were built may no longer provide a high degree of safety for the traveling public. Typical approaches used by most DOTs include an analysis of crash data, generally focusing on high-crash locations. Applying proactive evaluations through the use of the RSAR is another method. The RSAR may be performed

- During the preopening stage of a new project to ensure that the safety concerns of all road users have been addressed,
- On a road section just opened to traffic, and
- On an existing road to identify safety deficiencies.

The concept of the RSAR is based on an analysis technique that formalizes documentation of safety issues. Proactively considering safety is the value of the RSAR tool. Iowa, New York, and South Dakota have integrated RSARs into their safety programs. In Michigan, an RSAR approach is being used to evaluate safety issues in regard to urban intersections.

The use of the RSAR by rural local agencies was identified in Arizona, South Dakota, and Wyoming in surveys used to develop an NCHRP synthesis on safety tools for local agencies (*4*). The RSAR concept is being used by more local agencies each year. Depending on resources, there are a number of different ways to use the RSAR concept to develop a local safety program.

An important subject in the low-volume rural road environment is that improving so many miles of roadway to current standards would be neither economical nor practical. For rural local governments, a proactive program involving a functional classification of their rural roadway system and the use of an independent peer group of auditors is both practical and affordable.

The classification system helps to guide the improvements of the identified safety issues into alternatives by considering the use of the roadway section being evaluated and the ability to apply the improvements incrementally. Such decisions are made in light of the classification and the safety issue involved, as well as by applying a value judgment to the urgency of the improvement and the resources available.

Because there are several key elements to the RSAR that provide value beyond an unstructured safety review, locally needed modifications to the concept are encouraged. The RSAR results in a formal written report that is short, simple, and proactive. Orally communicating the report is also important, as is the local agency's formal written response to the report. Independence is another key to the RSAR. The local agency becomes the client for the RSAR report and provides the review team with the roads and streets to be audited, plus information on their functional classification.

The review team reflects a blend of background and expertise. Core knowledge is generally considered to be knowledge of local road safety and maintenance skills. Other skills of team members may vary depending on the issues associated with the road users and/or the complexity of the facility. Review team member's skills could include traffic engineering, human factors, construction, design, and operations. Team members may also have knowledge about pedestrians, bicyclists, and trucks.

There are a number of different ways to undertake an RSAR and to develop a team. One suggested methodology is that one county audit another county's network. A system to classify existing roads, examine their current usage, identify deficiencies, and prioritize needed safety improvements is the goal of an RSAR program. The premise is that local agencies can best achieve needed safety improvements by prioritizing activities and chipping away at problems as resources allow.

CHAPTER THREE

U.S. PRACTICE OF ROAD SAFETY AUDITS AND ROAD SAFETY AUDIT REVIEWS

EARLY DEVELOPMENT IN THE UNITED STATES

The initial exposure to RSAs and RSARs in the United States was the result of the 1994 FHWA safety management scanning tour and the 1996 RSA FHWA scanning tour that assessed the practice in Australia and New Zealand. The FHWA then contacted all state DOTs to determine interest in applying the concepts as a pilot study. In 1997, a workshop was held in St. Louis to discuss the practice and pilot activities. The pilot DOTs were from 13 states, with local governments in 2 states also participating in the pilot program. That marked the beginning of U.S. practice.

The pilot studies identified issues, concerns, successes, and limitations pertaining to the application of RSA concepts in the United States. In an unpublished assessment of the pilots performed for the FHWA Office of Highway Safety, issues and challenges identified included how to obtain a funding commitment, costs associated with performing the audits, costs of implementing suggested changes, costs associated with liability, and ways to best balance costs of safety with costs of other project factors?

Concerns were also expressed about the environment in which the audit would be conducted. Questions included

- Is an audit a criticism of the design?
- Will the designer feel threatened by audit findings?
- What is expected in an audit?

Other concerns were associated with administrative and personnel matters. Administratively, issues such as the unknown value and benefits of an audit, selling management on audits, overcoming such reactions as “the way we always have done it” or “we are already doing it,” and the control of the design process were identified. Personnel issues reflected the availability of staff time, peer-to-peer problems, and training and education in the process. One principal issue raised was the training of auditors.

Collectively, these responses indicated that agencies needed additional information and guidance concerning the application of an RSA. In response, the FHWA developed a training course to raise awareness of the concepts, identify RSA issues, and provide ways to make the RSA and RSAR practice work for state DOTs. The FHWA course was initially presented in Kentucky in August 2000. It was also later presented in Georgia, Mississippi, Missouri, New York, South Dakota, Utah, and Vermont. In 2001, that course was then developed into an NHI course (*3*). The pilot of the NHI RSA course was held in Maine in June 2002. By the end of 2003, the course had been presented in Delaware, Indiana, Maine, Massachusetts, South Carolina (twice), and Wyoming, as well as in Puerto Rico. By the end of 2003, this training course had been given to 13 different state DOTs.

Additional training has taken place in the United States, including a rural course for local county governments in three states and other training provided by international RSA experts in several other states. Courses have also been presented in Kansas and Maryland by internationally based instruction and locally by the Pennsylvania DOT (PennDOT). Local rural RSAR training courses have been presented in Arizona, South Dakota, and Wyoming.

Awareness presentations have also been made at both the local rural RSAR workshop and the DOT workshop in a number of different forums, both internationally and within the United States. It is generally recognized that the proactive RSAs and RSARs, internationally, have the potential to advance safety in the United States.

To assess the current state of the practice, a survey was developed and distributed to all state DOTs. Surveys were also sent to Canadian provinces and selected local governments. Canadian responses are discussed in chapter four.

The survey was designed to determine the extent to which safety audits were being used, identify advancements since 1997, determine if states that received training have implemented RSA or RSAR processes, and gather information on issues that were raised in the summary of the pilot programs. The survey questionnaire is contained in Appendix A.

SUMMARY OF SURVEY RESPONSES

Thirty-eight states and six Canadian agencies responded to the survey. Seven states indicated that both RSAs and RSARs were being conducted by their DOTs. Ten states indicated that either RSAs or RSARs, but not both, were being used by their DOTs. A total of 22 states responded that neither safety tool was being used. Responses to the survey are discussed in the following sections and summarized according to by the key issues. A list of states and Canadian provinces that responded to the survey is contained in Appendix B.

Also included in the following sections is information provided from various states that hosted RSA training courses. These state responses are not specifically referenced, but all information provided has an origin of a training course, either during the course or follow-up activities or as given in survey responses.

Institutional Issues

All respondents were asked to complete the section on institutional issues. Seventeen states indicated that safety management planning was part of their safety program. Of these, only five states indicated that RSAs or RSARs were part of their safety management plan.

Sovereign Immunity

In regard to this issue, there appeared to be no specific trend in applying RSAs and RSARs and whether or not the state had sovereign immunity. Two states that were applying both tools indicated full immunity and three indicated partial immunity. For states that apply one of the tools but not both, two indicated full immunity, four had partial immunity, and four had no immunity.

The issue of using the RSA tools and not implementing the changes was also raised. It is related to organizational issues addressed later in this chapter. This issue has been a major focus during the training courses. Local legal staffs have presented a variety of positive statements supporting the use of RSAs and minimizing the fear of liability. Common responses by the DOT legal staffs are that RSAs will help in the defense of tort liability, engineers should do the engineering and leave the liability issues to the legal staff, and RSAs can only help the DOT.

Measurable Safety Goals

Most states indicated that measurable safety goals were associated with rate-based crash statistics, although several states noted that crash numbers or both were included in their measures of accountability. The following list gives several examples of specific state responses:

- South Dakota indicated a desire to keep the crash rate below 200 per 100 million vehicle miles traveled and 2 crashes per 1 million vehicles entering or leaving a spot location.
- Michigan stated that their goal was to "ensure that highway safety is considered in the development and implementation of all department projects for the purpose of reducing deaths, injuries, and total accidents occurring on the state's highways. All actions should result in an average annual reduction of 1,500 crashes occurring at identified high crash locations."
- The Alabama DOT adopted the FHWA goal of a 20% reduction in crashes and fatalities in 10 years.
- The Washington State DOT tied its safety goals to a benefit–cost ratio method that considers projected versus actual benefit–cost aimed at reducing societal costs of collisions at both specific locations and statewide.
- Louisiana stated that their goal was to reduce the crash rate for fatal and injury crashes by 4% each year.
- Iowa's goal was to have a 10% reduction in run-off-the-road crashes on roadways on which 4-ft paved shoulder and shoulder rumble stripes are installed.

Institutional Barriers

Overcoming institutional barriers associated with the practice of implementing RSAs or RSARs was an important consideration for many states. States implementing both RSAs and RSARs highlighted issues such as agency culture, staff interests, manpower, expertise, and financial factors. One response was that "Questions were raised if we were duplicating the efforts of our Roadway Safety Improvement (RSI) program. Once the difference was defined, the barriers seemed to disappear." Another response was that "Some local governments had reservations about identifying safety concerns and not doing anything about them for an extended period of time."

Other issues were raised by states that applied one but not both of the tools. Comments included questions and statements such as:

- When is an audit most beneficial?
- Is this a necessary addition to the core project team?
- Is a formal implementation policy needed?
- Where are the staff resources?
- There is a need for more timely crash data.
- There is a competition issue with present practice.
- RSAs need to have champions with the facts.
- We don't have sovereign immunity.
- Turf issues are a problem.
- Design and operation conflicts will expand.
- How does the prior investment in current safety needs process fit into the practice?

- There is a lack of a clear link from RSA to tort liability issues.

States that do not apply either tool provided these comments:

- What are these tools?
- NHTSA (National Highway Traffic Safety Administration) program assessment and annual plan already requires this.
- There is no requirement to do them.
- There is a perception that we already have a relative safe roadway system.
- Behavioral factors account for 85% of the crashes; these tools will not provide a good return given this fact.
- Training is inadequate.
- Labor is lacking.
- We don't need another layer of bureaucracy.
- We do safe design.
- Limited funds exist to respond to audits.
- What is the appropriate lead agency?

All of these issues, whether raised by states applying the tools or not, point to the continuing need to raise awareness, to provide benefit assessments when the tools are used, to provide models of how various states have developed a framework for applying the tools, and to provide training and share experiences. Only three state DOTs that had some RSA training indicated that neither safety tool was being applied in their DOT safety practice. One of those states indicated a local application focus and another indicated the training was not based on U.S. practice. The training developed in the NHI course addressed these issues as well as the concept that both tools need to be examined in light of how they can be made to work for a given agency. Several examples of the latter are provided here to show how these issues have been addressed and how the RSAs and RSARs have been tailored to fit and improve current safety practices. The following two sections address specific issues for states that indicated that RSAs or RSARs are part of their safety tools.

Road Safety Audit Issues

Only 11 states indicated that RSAs were being used. Most of these states were in the initial stages of assessing the benefits and had conducted only a handful of audits. Most indicated that fewer than six audits had been conducted by the time the survey was taken in the summer of 2003. The primary stages audited were planning and preliminary design. One state indicated that after evaluating different stages of audits, future audits would focus on preliminary design stage audits. Three states had conducted one final design stage audit. Pennsylvania has conducted the most audits. That state started a program to evaluate the benefits and issues in 1997, had management support, and selected two districts in the state to evaluate the issues. Although only one of the districts became a proponent of the tool, today the RSA is being used as a statewide safety tool and this state (Pennsylvania) has an RSA coordinator.

Audit Team Size and Skills

Audit team size and skills were of interest. Many states indicated that large teams were used, perhaps associated with the desire to have a broad base of evaluation for future applications. Teams ranged from 4 to 10 members. Team member skills included traffic engineering, final design, construction, maintenance, local law enforcement, human factors, and Americans with Disabilities Act and emergency medical service specialists. The audit team members were from the FHWA, state DOT headquarters and districts, local governments, and transportation consultants. Six states indicated that audits were conducted by in-house personnel, and five states indicated the use of both in-house personnel and consultants in conducting audits.

Types of RSA Projects

Projects audited included interchange modifications, expressway widening projects, reconstruction and expansion projects, intersections, bridge projects, and railroad grade crossing projects. Most audits involved projects to improve existing facilities. There were also RSAs for projects involving urban arterial cross sections and alternative rural highway cross sections.

Implementation of Audit Findings

Most states responded that the audit recommendations were used in scoping the project for some of the planning stage audits, were carried over to the final design stage for some preliminary stage audits, or were implemented. An important finding was that the audit did raise issues and present recommendations that would most likely have not been considered without an audit.

RSA Checklists and Prompt Lists

RSA checklists and prompt lists were used by most of the audit teams. Additional information used in various audits included:

- Crash data;
- Past plans;
- Scoping reports;
- Field visits;

- Alternative layouts;
- Area maps;
- Traffic volume data, including, when appropriate, current and projected average daily traffic;
- Turning movement counts;
- Zoning information;
- Program funding;
- Accident analysis and plans from previous projects; and
- Modal data.

Furthermore, all states indicated that the needs of pedestrians and bicyclists were specifically considered in the audits. Also, all states noted that other modes of transportation were considered by addressing access and public input and by using a multidisciplinary audit team.

Organizational Issues

Internal organizational issues were also investigated, such as those posed here by the following questions:

- How supportive is top management to the audit process?
- Does your state have an audit coordinator?
- How are RSA reports maintained?
- How are projects selected for audits?
- How is the audit program administered in your agency?
- How is the audit program funded?
- How are institutional issues addressed?
- What are the benefits of RSAs?
- What is your program's biggest success?
- What are the shortcomings of RSAs?
- What are the liabilities of RSAs?

How Supportive Is Top Management to the Audit Process? Top management support was indicated by all states that are conducting RSAs. "Yes, the director of program development said that we should do RSAs for all roadway projects"; "Believe so, they have agreed to RSA training of more than 15 individuals"; "Approval of the program implementation and approved funding for the effort was given after a presentation was made to the state highway engineer, deputy director for strategic planning, finance and administration, and the FHWA division engineer."

Does Your State Have an Audit Coordinator? Only two states, Pennsylvania, which has the longest history of RSA involvement in its safety program, and South Carolina, which developed an organizational framework for their RSA program, have RSA coordinators.

How Are RSA Reports Maintained? RSA reports are maintained at a wide variety of locations. They may be with the safety management coordinator, division traffic safety engineer, project manager, headquarters traffic engineering department, roadway design, or RSA coordinator.

How Are Projects Selected for Audits? Criteria used to select projects to be audited varied by state, with project size as one criterion. Among others were large projects with complex traffic control; regionally requested projects; controversial projects; projects with a high rate of accident and/or congestion problems; and projects with internal DOT differences of opinion as to the safest alternative.

How Is the Audit Program Administered in Your Agency? Program administration varied widely. In one state, the traffic safety engineer was the coordinator and responsible for assembling an audit team. In other states, the audit activities were driven by the regional traffic or district safety engineers or by the state's assistant chief engineer for preconstruction. Most states did not have an audit coordinator.

How Is the Audit Program Funded? Funding for audits came from a variety of sources, including maintenance program funds, FHWA support of audits on any federally participated projects, federal safety set-aside funds, and funding of the consultant/team leader using contractual services funds. On occasion, no separate special funding was provided because the project is charged as a preliminary engineering expense or as an overhead expense.

How Are Institutional Issues Addressed? Responses pertaining to institutional barriers to implementation of audit recommendations included the expected issues of funding as well as environmental and political considerations. One response was "The town did not want the improvement." Another response, however, was very positive and also demonstrated the benefit of an audit: "We have not encountered any institutional barriers. The DOT has been receptive to the audit findings and has made changes to designs of projects accordingly. The biggest barriers are budget constraints."

Two states indicated that RSAs were formally included in their programs. Pennsylvania responded that audits were included in its design manual, and South Carolina reported that audits were included in the safety office's business plan. The newness of audit activities in most states brought in responses that indicated the audits were not being used to check against safety performance goals.

What Are the Benefits of RSAs? The newness of the audit process was also a factor in assessing the benefits. Factors under consideration were to assess benefits using a benefit–cost approach, evaluating accident reductions, before-and-after analysis, and evaluating potential cost savings of implementing audit findings. One state commented that it did not have any formal assessment of success to date, except the positive responses associated with the revised plans. Another stated, "None yet, except doing what is right within ultimate budgetary and other constraints."

What Is Your Program's Biggest Success? The following were responses that addressed the program's biggest success:

- "Explicit consideration of safety for the projects and being able to portray the safety considerations to other engineers, the public, and public officials."
- "Having issues identified that were not thought of before because we had outside eyes looking at the project."
- "Cooperation among the division and districts to determine the best options for roadway improvements."
- "Reduced fatalities and crashes."
- "Since we are in the first year of our program I think the biggest success is gaining agencywide support for the effort, including the commitment of time for RSA team members to travel the state to conduct audits."
- "Only one done and the recommendations were accepted."

What Are the Shortcomings of RSAs? The following responses addressed some of the more common shortcomings of RSAs:

- "Finding time to do more audits may be a problem.
- "Not enough RSAs being conducted due to funding issue."
- "Need to have formal RSA training and knowledgeable people to do this specialized analysis."
- "Following through to determine the benefits and successes; not done on a mass basis."
- "Would like to see the program formalized as a valid project activity."

What Are the Liabilities of RSAs? Liability assessment resulted in the following typical responses:

- "Liability is one of the major driving factors in performing a good audit."
- "It demonstrates a proactive approach to identifying and mitigating safety concerns."
- "When findings cannot be implemented an exception report is developed to address liability and mitigating measures."
- "Our attorneys say that once safety issues are identified, and if we have financial limitations on how much and how fast we can correct the issues, then the audit will help us in defense of liability."
- "Liability is not considered as an issue."
- "The RSA process is not discoverable in court as excluded from evidence by 23 USA Code 409."
- "Chief Counsel has reviewed the process and checklists."

Although the number of states conducting RSA activities is small, the responses as summarized illustrate a very positive acceptance of the concept. The agencies' comments also indicated the need to expand the training to more states and to promote the benefits of RSAs in the United States to help heighten the awareness and ability of state DOTs to assess their own acceptance of RSAs in their safety programs.

Road Safety Audit Review Issues

Thirteen states indicated that RSARs were part of their state's safety program. This section highlights the questionnaire responses of these state DOTs. The modifications of RSAR practice in Iowa, New York, and South Dakota are detailed in the next section. Those states have tailored their programs for 3R/4R projects.

Types of RSAR Projects

RSARs have been conducted on transportation corridors, intersections, interchanges, and special areas such as school zones. Facility types ranged from two-lane county roads to multi-lane divided urban freeways. Among the bases for selection of roadway sections for RSARs were general safety concerns, sections with high crash levels, high traffic volumes, geometric roadway and associated design issues, sections scheduled for overlay projects, and including an RSAR as part of the project scoping process. Four states indicated that they had safety performance planning and that their RSAR activities were part of that process. One state was evaluating RSARs to determine if they should be part of its program.

RSAR Team Expertise

The various skills reported for the team members included traffic engineering, design, maintenance, and safety engineering, as well as expertise in pedestrians and bicyclists, young and older pedestrians, older drivers, local knowledge, human factors, law enforcement, and project scoping. There were also representatives from local and federal government.

Typically, teams were tailored to the type of facility being reviewed. In South Dakota, a review team for county road sections consisted of FHWA and state DOT traffic safety engineers, an independent county highway superintendent, and a representative from the LTAP. The review team for state roads consisted of a visiting regional traffic engineer, visiting area engineer, road design engineer, South Dakota Highway Patrol officer, and traffic safety engineers from the DOT and FHWA. In another state, a three-person team consisted of a specialist in highway design, one in traffic operations with expertise in pedestrians and bicyclists, and one in project scoping.

Administration of RSAR Activities

RSAR activities were administered by the state traffic engineer, regional and local traffic engineers, and a statewide RSA coordinator. There was no consensus about any specific location within the DOT. The RSAR reports were maintained at both headquarters and district levels of the DOT. Generally, the branch involved traffic engineering or safety engineering, although in some states the roadway design division maintained the RSAR reports.

Number of RSAR Projects, Team Size, and Data Issues

Various numbers of audits were conducted in the last 5 years, with Pennsylvania conducting the largest number. Most respondents indicated that fewer than a dozen RSARs were undertaken. Most states indicated that only a few audits had been conducted because they were just beginning to assess the use of RSAs and RSARs. Typical responses indicated on the order of four to six audits during the initial year.

Audit teams consisted of both in-house teams and consultants. Seven states reported using only in-house teams. In some cases, a consultant was added to the team to provide specialized input. Consultant activities included leading the team, writing the report, and providing expert input on issues related to older drivers.

Team sizes vary from state to state and for different projects. RSAR teams had as few as 2 and as many as 6 members. Typically, an RSAR team has 4 to 5 members, although several states indicated that teams can be made up of as many as 12 to 15 individuals. These were teams most likely formed to assess the issues of an RSA practice or involved in a learning exercise.

Ten states indicated that they used prompt lists and/or checklists during their reviews. Other information used by various states included detailed geographic information system crash data, collision diagrams, detailed traffic volume data, past plans, and site evaluations.

RSAR Implementation Issues

Various states indicated that their RSARs identified a number of ways to make safety issue improvements, which were then implemented. Spot improvements, such as signing, markings, and the addition of turning lanes were made. Other states indicated that low-cost safety improvements were added to maintenance activities and resurfacing projects. Still others mentioned that the RSAR resulted in design alternatives that addressed the findings. The major limitations to implementing an RSAR program were a lack of funding, manpower issues, and project schedules. One state identified the idea of another district telling them what to do as a point of controversy. In another state, the effects of budget cutting had limited its ability to continue the RSAR activity to the desired level. Top management was identified as supporting the RSAR activities in all but two of the states using the RSAR process.

RSAR Liability Issues

Liability was addressed in a number of different ways. Among the statements received were that there is no liability concern, the reports include a disclaimer statement, reports are not discoverable, the legal department handles this issue, and the agency has discretionary immunity.

Benefits and Successes of RSARs

The evaluation of the successes and benefits of RSARs brought responses that pertained to the willingness of agencies to incorporate the safety improvements suggested in the audit and that there are repeat requests for more RSARs. In one case, a benefit–cost analysis was undertaken before recommendations were finalized through historical data associated with the recommended improvements. Another response reported that safety has acquired greater emphasis; there is now a better understanding of law enforcement and human resource issues.

As for the success of RSAR activities, district and central office design staffs are now looking for opportunities to incorporate low-cost safety improvements following RSA and RSAR training. Personnel now have a better understanding of why specific safety enhancements are being suggested.

The diversity of the team was viewed as both a benefit and success of the program. One state reported, specifically as a result of the RSAR, "being able to identify a location with an accident problem or potential safety issue and recommending changes to actually reduce the number of accidents."

ROAD SAFETY AUDIT AND ROAD SAFETY AUDIT REVIEW PRACTICES OF MODEL STATES

Five states that have adapted either an RSA or RSAR program or have developed a tailored approach for their DOTs to assess those safety tools are highlighted in this section. These states provided specific details that should help others considering developing RSA and RSAR programs.

Iowa

Iowa has developed a modified approach to employing RSA concepts. The program is administered by the Office of Traffic and Safety. The state safety engineer has program responsibility. Audits are conducted in conjunction with corridors scheduled for resurfacing. The audits focus on 3R projects. Project concept statements are reviewed and a detailed summary of the corridor's crash history is prepared. The crash history in each corridor includes geographic information system analyses of fatal and injury crashes, fixed-object crashes, crashes grouped by roadway characteristics, crashes linked to geometric features, and crashes by type—single vehicle, rollover, right angle, etc. Collision diagrams are also prepared.

The audit consists of a field review by central office safety staff and district personnel. A typical team may consist of safety personnel from the DOT and FHWA, as well as district design, maintenance, and construction staffs. Local law enforcement is asked to identify any perceived safety deficiencies, but those officials are not part of the audit team. In addition, an older driver (an outside paid consultant who is a retired safety engineer) is added to the team to provide a unique perspective. A trip summary is prepared for the FHWA district administrator and the DOT district engineer. The FHWA safety engineer has the lead program responsibility.

Before initiating the RSAR program, district staff participated in a 3R safety workshop. This workshop was developed and is presented in-house by Iowa DOT and Iowa State University Center for Transportation Research and Education staff.

Both the proposed and recently completed 3R projects are reviewed in each district. These district RSARs are proposed as being completed once every 3 years in each district.

Among the safety deficiencies and recommended treatments identified in the audits are

- Substandard curves—add or correct superelevation, add pavement, remove fixed objects, delineate curves, pave shoulders, install shoulder rumble strips, and use larger or brighter chevrons.
- Safety dikes (escape ramps)—install opposite "T" intersections and remove fixed objects.
- Daylighting of intersections and driveways—cut vegetation, remove fixed objects, and flatten driveway cross slopes.
- Other intersection needs—add turn lanes and signal enhancements.
- Roadside features—add or undertake guardrails, culvert and inlet modifications, cattle crossings, tree removal, and improvements of cross slopes, and riprap; relocate and delineate utility poles.
- Other—install larger stop signs and center and shoulder rumble strips.

The audit team uses a checklist to identify key safety issues to be evaluated during the field inspection.

The audits have identified low-cost safety improvements. As a result, district and central office personnel have a greater awareness about safety.

The 3R safety workshop will be offered to county staff. Iowa has also proposed to conduct an RSA of a major corridor project at the planning stage.

New York

The state of New York has developed and implemented a comprehensive, modified RSAR process to incorporate safety considerations in its existing pavement preventive maintenance program. The program, SAFETAP (Safety Appurtenance Program), involves maintaining existing safety features and adding appropriate, implemental, low-cost safety features at preventive maintenance project locations before, during, or after resurfacing as part of a joint effort (*7*).

The impetus for the project was the observation in the 1980s that simple resurfacing without roadside improvements contributed to increases in the number of crashes in the 3 years following resurfacing. The program existing at the time did include a safety screening process, but safety improvements were not implemented so that funds would be conserved for maximizing the number of miles resurfaced.

The SAFETAP initiative included the following elements:

- Team of auditors with the expertise to assess existing and potential crash problems,
- Review of existing crash data and a site inspection,
- Recommendations of cost-effective solutions by the audit team to agency leaders with the responsibility for implementing crash countermeasures, and
- Reports to the Traffic Engineering and Highway Safety Division describing the disposition of recommendations and implemented actions.

Program Implementation Issues

Given the limited resources and the competing concerns of different elements within the New York State DOT, an implementation strategy was developed to obtain management buy-in for the program. The chief engineer's support was an essential factor in the program's success. The program was first presented to main office managers, then to regional managers, and then to executive management. In this manner, the supporters of the program were able to address the concerns of affected parties.

Audit Process

Projects are selected in accordance with the criteria established for pavement resurfacing priorities. When a site is selected, the regional director assigns an RSA team consisting of experts from the regional traffic, design, and maintenance groups and others as appropriate. The team analyzes crash data, makes a site visit, and develops recommendations for safety work. The team uses a checklist for guidance in identifying potential safety issues. Safety treatments identified include those necessary to avoid degrading safety and those that are practical and necessary to address existing and potential safety problems. Procedures are established for conducting the audit and reporting the audit results. The audit forms become part of the paving project file and are also maintained at regional offices.

The timing of safety work is coordinated with the paving process on the basis of need, complexity, and resource availability. In general, recommendations pertaining to sign replacement are done before paving. Superelevation, shoulder treatments, and edge of pavement drop-off problems are addressed during the paving contract; pavement markings, rumble strips, guiderails, delineation, fixed objects, and new signing are done during or as soon as possible after completion of paving. Other items such as guide signing, major treatment of fixed objects, and other features of concern not specifically covered are done in a timely manner following the completion of paving.

SAFETAP Results

During the first year of the program, 216 safety treatment sites were identified, and 107 safety improvements were implemented. Predictions based on past safety activities were that the program would cost from $15 to $25 million each year, would result in 1,000 fewer crashes per year, and would result in a savings of $25 to $50 million in crash costs. The actual results after the first few years indicated that the estimated savings were conservative. Crash reductions occurred at more than 300 high-crash locations treated with low-cost improvements; crash reductions ranged from 20% to 40% depending on the type of improvement implemented (*8*).

South Dakota

Since South Dakota received RSA and RSAR training in July 2001, its DOT has conducted three RSAs on projects during the preliminary design stage and two RSARs on projects in the planning stage on the state trunk and Interstate systems. The South Dakota DOT has also assisted in five RSARs on county road systems since the initial training. The region traffic engineer initiated and organized the RSAs on the state trunk and Interstate systems, and has been the keeper of the master report and file. The county highway superintendents initiated RSARs through the South Dakota LTAP (SDLTAP). The SDLTAP in turn asked for assistance from the DOT traffic and safety engineer in the DOT Office of Local Government Assistance. A checklist as an inspection guide was used to ensure that safety issues were not overlooked when observing any of the roadway features.

The South Dakota DOT has conducted three RSAs on projects during the design stages. One was on a U.S. highway in an urban setting; one on an Interstate interchange and a state highway, where the state highway portion of the project intersects the interchange in an urban setting; and one on a state highway in a rural setting. The teams consisted of the DOT region traffic engineer, DOT road design engineer, FHWA traffic and safety engineer, city engineering staff member, city commissioner, business owner, city traffic engineer, guest region traffic engineer, assistant public works director, FHWA pavement and materials engineer, law enforcement, and DOT traffic and safety engineer. Not all of those individuals participated in each RSA, but a team of five to six people with the such backgrounds were selected for each RSA. The information gathered from RSAs was given to the DOT road designer or the consultant engineer designing the project. In all cases, there were changes made in the design as a result of the RSA inspection.

The South Dakota DOT has conducted two RSARs for planning purposes. One was on an Interstate interchange, which is in the long-range State Transportation Improvement Program (STIP). The Interstate interchange RSAR was organized by the region traffic engineer with the team consisting of the region traffic engineer, DOT operations engineer, DOT traffic and safety engineer, FHWA traffic and safety engineer, county highway superintendent, city engineer, and city council member. The crossroad over the interchange is a city street feeding an industrial area on one side of the interchange, and a county road through a housing area along a lake on the other side of the interchange. The information from the RSAR will be used as input into the planning process.

The second planning RSAR was on a tourist-oriented/scenic road in the Black Hills. The RSAR was organized by a region traffic engineer from a different region than the one mentioned earlier. The team consisted of a guest region traffic engineer, guest area engineer, FHWA traffic and safety engineer, DOT road design engineer, DOT traffic and safety engineer, and South Dakota Highway Patrol officer. As a result of this RSAR, there was a project incorporated into the STIP. The information from the RSAR is to be used as a design guide for the improvements to be done on the project.

There were five RSARs conducted on the local county road systems. They were organized by the SDLTAP after being contacted by the county highway superintendent. The SDLTAP requested assistance from the DOT traffic and safety engineer in the DOT Office of Local Government Assistance. That engineer served as the team leader with the remainder of the team consisting of an SDLTAP representative, FHWA traffic and safety engineer, and a guest county highway superintendent. The county highway superintendent responsible for the roadway classifies the roadways to be inspected using the local classification as given in the RSAR section of *NCHRP Synthesis of Highway Practice 321*(*4*). For the final report, the team classified the items for improvement:

- Items where immediate safety improvements should be made,
- Items where low-cost improvements could have a positive impact on safety and should be considered in a reasonable period of time, and
- Items identified as high-cost improvements that should be considered as funds become available for a major rehabilitation or reconstruction of the roadway.

Ultimately, the items listed in the report are reviewed in a closeout meeting with the highway superintendent responsible for the roadway. The traffic and safety engineer then writes the final report and forwards it to the highway superintendent. The traffic and safety engineer keeps the master copy in the files at the Office of Local Government Assistance.

Pennsylvania

PennDOT began a pilot program of RSAs in 1997. The goals of this program were to answer these questions:

- Does the RSA process add value?
- Can the RSA process be implemented by using existing resources?
- Will the RSA process delay project delivery?

The pilot project was initiated in one district with procedures developed based on the Australian audit model. Particular attention was paid to developing a process that differentiated the audit process from safety reviews.

For the pilot projects, a safety audit team of five people was selected from the following six discipline areas: traffic engineer (coordinator), construction services, project design, highway safety maintenance, risk management, and comprehensive safety (human factors). All were in-house, except for the human factors person. Projects to be audited were selected by the RSA coordinator and the assistant district engineer for design. Eleven projects were selected in all phases of project development. To date, 60 projects have been audited.

Typical safety issues identified in the audits included the need for left-turn lanes, daylighting of intersections, presence of fixed objects, roadway realignment, lengths of acceleration and deceleration lanes, pedestrian needs, and sight distance. The estimated costs of the audits, exclusive of the cost of the improvements, ranged from $2,000 to $5,000.

The recommendations developed by the audit team were submitted to the audit coordinator, who reviewed the report, forwarded the report to the assistant district engineer for design, and met with the project manager to discuss concerns and possible improvements.

Numerous benefits were identified as a result of the audit process, including

- Maintaining a safety focus,
- Identifying safety concerns early in the design process,
- Achieving interdisciplinary cooperation,
- Developing consistency in design,
- Enhancing communication, and
- Recognizing safety improvements that were beyond the scope of the original project.

The pilot projects generated a number of challenges and opportunities related to implementation of the audit process. Some of the major challenges were time demands on the coordinator, team members' changing positions, the need for audits to be conducted early in the design process, dealing with changes that affect the project's environmental footprint, dealing with stakeholders and controversial recommendations, identification and selection of projects to be audited, liability concerns, and gaining buy-in from top administrators and others involved in the process.

A set of recommendations was developed that included the following:

- Get buy-in at all levels early in the process,
- Establish a coordinator's position,
- Select an audit team that is interdisciplinary and has the required expertise,
- Provide training to team members,
- Separate the audit process from safety reviews,
- Conduct the audits early in the design process,
- Cite audit safety concerns and not provide recommendations, and

- Ensure that the process involves multiple opportunities for communication.

The pilot audit project concluded that:

- The RSA process definitely added value by identifying safety issues,
- RSAs could be completed without draining existing resources—not accounting for the additional cost of the safety improvements that were identified, and
- RSAs will not affect project delivery time if conducted early in the process.

Since the pilot program, PennDOT has continued its audit program. The agency has conducted audits in its 11 districts. The central office has an RSA coordinator who provides training to the districts. There is also an open-ended consulting contract to provide assistance to the districts. Funding difficulties have constrained the conducting of more RSAs but, with FHWA's commitment to the program, PennDOT anticipates expanding the program.

South Carolina

The RSA program in South Carolina is administered by the South Carolina DOT safety office. The program has buy-in from top administrators, because they approved implementation and funding for the effort. The director of safety is responsible for the overall program administration. The program is housed in the safety program unit of the safety office and the director of safety is responsible for the overall administration of the program. The RSA coordinator handles the day-to-day operations of the program. The RSA program is supported by an RSA advisory committee that includes the deputy state highway engineer, the engineering directors (e.g., traffic, construction, maintenance, pre-Construction, etc.), and the director of safety. The committee approves operating procedures for the program and selects projects for audit.

The South Carolina DOT has established a procedures manual for the audit process. That manual includes information on the management of the process, procedures for selecting projects to be audited, and instructions for distributing audit results.

The program is funded with federal set-aside monies. Projects are solicited annually by the RSA coordinator from the deputy state highway engineers, the engineering directors, the district engineering administrators, and the director of safety. The RSA coordinator compiles a list of the project's along with additional information on the project cost and crash history, if available. The coordinator prepares a prioritized list of recommended projects for approval by the RSA advisory committee. Project selection includes new infrastructure projects, projects under construction, and existing infrastructure projects. Projects include Interstate projects, rural and urban system upgrades, and innovative projects listed in the STIP pertaining to existing roads.

The RSA plan calls for 10 audits to be conducted each year; 11 audits were conducted in 2003. These were in the process of being finalized. Five audits were conducted on projects under construction, two on new infrastructure projects in the final design stage, and four on existing roadways (RSARs). Each audit involved a team of four to five people representing construction, road design, traffic engineering, maintenance, and safety. The teams used checklists to aid in conducting the audits. Because the projects have not yet been finalized, benefits have not been documented. However, it is anticipated that the response to the audit reports will address benefits. A more complete discussion of the South Carolina RSA program is provided in Appendix E.

CHAPTER FOUR

INTERNATIONAL PRACTICE OF ROAD SAFETY AUDITS AND ROAD SAFETY AUDIT REVIEWS

INTRODUCTION

The first documented use of RSA practices was in the United Kingdom in the 1980s. It involved the modification of a tool used by railway engineers at the turn of the century to examine safety issues on railways. The United Kingdom published the first set of road safety guidelines in the early 1990s. The use of RSAs followed shortly after in Australia and New Zealand. It was the applications in these countries that attracted the attention of the United States and other countries. They perceived the RSA as a tool that could enhance safety and reduce the number and severity of roadway crashes.

During the past decade, the global application of RSAs has expanded. The United Kingdom, Australia, and New Zealand have continued to refine, modify, and enhance their RSA practices. Much of the information provided in this chapter is based on an international conference sponsored by the United Kingdom's IHT held in London, England, in October 2003. Although information on international practices has come from a variety of sources, that conference provided an excellent assessment of the state of practice in many countries around the world.

UNITED KINGDOM

It is important to remember that RSAs have been used for more than 20 years, beginning with the United Kingdom. There are consulting firms in the United Kingdom that have conducted literally thousands of RSAs. The United Kingdom has advanced the applications of RSAs to the point where it is mandatory for all trunk road highway improvement projects and also mandatory to conduct an RSA monitoring process of all projects that have involved an RSA. Monitoring the effects of RSAs on those facilities began in 1990. The requirement to monitor the effects of RSAs was added to the 2003 edition of the *Design Manual for Roads and Bridges* in the "Road Safety Audit" section, HD 19/03, which became effective in November 2003 (*9*). Projects are now required to be monitored after 12 and 36 months.

Several practice issues of the HD 19/03 section on RSAs are briefly highlighted here. There are three stages of audits required separately or in combination for improvement projects, unless excluded for small projects within the same alignment. The required U.K. audit stages are

- Completion of the preliminary design,
- Completion of the detailed design, and
- Completion of construction (in the United States, referred to as an RSAR).

In addition to those three types of audits, an interim stage audit has been being introduced as a new concept for RSA application anytime during the first two audit stages. The interim audit is not a requirement. The concept is to provide input into the design process while the plans are being developed. The independence of the formal audit process is still stressed. The trial applications of an interim audit have been found to aid in reducing road safety problems earlier and thereby reducing program and design costs.

The requirements for an accident monitoring report using both 12- and 36-month crash data have also been introduced as part of HD 19/03 (*9*). Such a monitoring process focuses on linking crash characteristics and audits to help future RSA activities to reduce crashes.

Through HD 19/03, many issues of practice can be recognized that should aid in RSA applications worldwide. HD 19/03 also offers samples of all audit stage reports, stage checklists, issues and monitoring reports. The checklists for each audit stage are contained in Appendix D.

In the United Kingdom, audit teams are identified as requiring minimum of two members. Suggested guidelines specify that the team leader have these qualifications:

- A minimum of 4 years of accident investigation or road safety engineering experience;
- Completion of at least five audits in the past 12 months;
- A minimum of 2 days of continuing professional development in the field of RSA, accident investigation, or road safety engineering in the past 12 months; and
- Meets the requirements of a team member.

Suggested guidelines concerning qualifications for team members are:

- A minimum of 2 years of the previously cited associated skills;
- Completion of at least five audits in 24 months as a member, leader, or observer in the past 24 months. The audit team member should have undertaken at least 10 days of the previously cited skills; and
- A minimum of 2 days of professional development.

Two additional categories of expertise are identified to assist in auditing, although they are not specifically identified as being possessed by team members. They are an observer and a specialist. It is suggested that the observer have a minimum of 1 year experience and a minimum of 10 days of formal training. The observer assists in the audit process; the intent is to develop the pool of new audit team members. In addition, there is provision for specialist advisors. The use of a specialist requires approval of the project sponsor. The specialist is not a member of the team but advises the team on matters relating to their expertise. Such requirements indicate that the audit process is very formal, which certainly is the case (*9*).

The design team provides a brief to the project sponsor, who may instruct the design team to delete unnecessary items or to add information. Any changes must be documented. In the United Kingdom the RSA information proceeds from the team that designs the project to a supervisor or project sponsor. The brief consists of the following 10 items:

1. The alternative design showing full geographical extent and including areas beyond the project;
2. Details of the approved departures and relations from standards; that is, design exceptions;
3. General details, purpose, speed limits, forecasts of traffic flow, nonmotorized flows, and desired lines and environmental constraints;
4. Other relevant factors such as adjacent land uses, proximity to schools, and emergency vehicle accesses;
5. Accident data for design alternative and adjacent sections;
6. Details of changes introduced at previous audits;
7. Plan sheets;
8. Previous RSA reports and a copy of the interim file if an interim audit has taken place;
9. Contact details for transmitting maintenance defects (telephone call or separate written message from audit report); and
10. Details of appropriate police contact (*9*).

The audit team submits the RSA report to the project supervisor, not directly to the design team. The initial submittal is in draft form so that any issues agreed to be outside the scope of the project can be identified and removed. The audit team includes only issues relevant to safety. Any items such as observed maintenance defects are addressed separately.

The detailed requirements of the audit report are also specified in 10 separate items:

1. Brief project description;
2. Audit stage team members and other members;
3. Site details, who was present, and conditions of weather and traffic on day of site visit;
4. Specific road safety problems identified, with supporting documentation;
5. Recommended actions for removal and mitigation;
6. Location maps marked and referenced to problems;
7. Statement signed by the audit team leader, in a required format;
8. List of documents and diagrams considered for the audit;
9. Separate statement for each identified problem describing the location, nature, and types of accidents likely to be considered as a result of the problem; and
10. Associated recommendations (checklists are not to be included) (*9*).

An example of the audit report from HD 19/03 is included in Appendix C. Integral to the audit process are the implementation of the audit recommendations and identification of the exceptions, to ensure that the problems raised by the audit team were given consideration.

> The project team may wish to consult the design team at this stage of the audit. If the Project Sponsor considers any problem to be outside the scope of the project or not suitable given the relevant environmental or economic constraints, the project sponsor shall prepare an Exception Report giving the reasons and proposed alternatives for submission to the Director, with whom the final decision rests. The project sponsor shall provide copies of each approved Exception Report to the Design Team and to the Audit Team Leader for action and information respectively (*9*).

Finally, the project sponsor instructs the design team with respect to any changes required resulting from the audit. Prompt action and continued communication are required. Closing the loop is feedback to the auditors regarding the actions taken as a result of the audit.

This brief overview of U.K. practice indicates the strong history, continuing belief in the benefits of the RSA safety tool, and continued commitment to advancing the state of the practice. For additional information, a 2001 U.K. publication entitled *Practical Road Safety Auditing* (*10*) as well as other works previously mentioned (*6,9*). In the United Kingdom, RSA practice has continually led to safety improvements implemented in projects as an initial safety benefit and not as a needed safety retrofit after a project has been completed.

The following snapshots of various countries' experiences raise key issues for advancing the U.S. practice of RSAs and RSARs.

AUSTRALIA AND NEW ZEALAND

The experiences of Australia and New Zealand formed the basis for audit practices in the United States. It is interesting to follow the development in those countries and contrast their progress with that of the United States. In 1990, Transit New Zealand (Transit), which is responsible for managing the national road network (state highways), began examining the RSA. The initial efforts emphasized awareness programs, which were followed by pilot RSA exercises. Experienced auditors from the United Kingdom and Australia assisted the pilot audits, which were used as training exercises. Australia underwent a similar but earlier development in the states of Victoria and New South Wales.

U.S. states were encouraged to pilot the RSA. Approximately 20% of the states did so in the first years after the FHWA's 1996 scanning tour in Australia and New Zealand. The scanning tour focused on the development activities of the states of New South Wales and Victoria in Australia and of Transit in New Zealand (*11*). New South Wales, VicRoads, and Transit all had RSA Manuals, and by 1993 had all adopted RSA practice. Australia and New Zealand worked together in 1994 developing the Austroads *Road Safety Audit Manual*, which was the focus of the U.S. scanning tour. The second edition of the Austroads guide, Road Safety Audit, was completed in 2002 (*5*).

Transit's policy in 1993 was to apply RSAs to a 20% sample of its state projects. By 1993, the United Kingdom, New South Wales and Victoria in Australia, and Transit were the world leaders in RSA practice. That statement applies today, although other countries including the United States are actively following similar paths to RSA development. Other international activities are highlighted later in this chapter.

As RSA development continued in New Zealand, there was no initial requirement for local agencies to undertake audits. However, Transit demonstrated RSAs using several local authority projects in the early learning stages (pre-1993) and encouraged local agencies to adopt RSAs. Transit has incorporated a revision to its early RSA practice by now referring to RSAs as audits of projects being developed to project construction; audits of existing roads are now excluded in the revised manual. This is similar to the current U.S. philosophy and the use of the term "RSAR" for the audits of existing roadways.

Today in New Zealand, the current policy of Transit is to apply RSAs to all projects and to allow for exceptions if the project manager believes that an RSA is not necessary. Documentation is required if the decision not to conduct an RSA is made. In the United Kingdom, the RSA Standard HD 19/03 has a similar provision.

The similarities of development patterns for those countries that are the world leaders in RSA practice is continuing. Today, auditor certification, continuing requirements for auditor training, and liability are common issues.

A major reason for the international acceptance of RSA activities is that accident investigators initially found design faults that should have been identified before new facilities were built. The added value of proactively preventing crashes is the primary reason that the two Australian states and the United Kingdom continue to apply RSAs as an operational practice. In New Zealand, the RSA is recognized as an essential safety management tool.

CANADA

Canada has been a leader in North America in the implementation of RSA concepts. The first formal audit was completed in Vancouver, British Columbia, in 1997. Since that initial audit, several provinces and local governments have conducted audits. One impetus for their use was the support of the Insurance Corporation of British Columbia in the development and application of audit techniques as a tool to reduce the number and severity of traffic crashes. The Transportation Association of Canada (TAC) has developed *The Road Safety Audit Guide* to aid safety professionals in the application of the audit process (*2*).

For this synthesis, four Canadian provinces and two Canadian cities completed and returned survey questionnaires. One city and two provinces have conducted RSAs, and two cities and two provinces have conducted RSARs. One province indicated that it had conducted many safety reviews, although not by an independent team. Those agencies that conducted audits reported that the number they did varied from a single preliminary design stage audit to 10. The audits were done about equally during the planning, preliminary design, and design stages. Two current issues of concern in Canada are using RSAs in design-build projects and in value engineering.

Institutional Issues

Only one agency had a safety management plan and only one other agency had measurable safety goals. None of the provinces or cities reporting had sovereign immunity. Major barriers to implementation that were identified included inadequate funding, lack of staff, and difficulty in achieving buy-in, although two agencies did indicate support from senior management. Four of the agencies had used modified concepts of RSAs or RSARs, and three used the RSA guide developed by the TAC as the basis for their work (*2*). Four agencies had participated in some training provided in-house, by consultants, or by the TAC.

Additional Findings

Audit Team Size and Skills

The typical size of an audit team was five to six people. Disciplines represented included planning, design, construction, and traffic engineering. Consultants were used by one agency as part of the audit team.

Types of RSA Projects

Projects audited included interchange design, freeway design, and upgrading a two-lane arterial to a four-lane arterial.

Implementation of Audit Findings

Agencies indicated that some of the recommendations were implemented and that concepts identified in the audits were incorporated into the design.

Use of Checklists

One province used checklists and two used prompt lists.

Organizational Issues

The resources made available to the team included staff time and funding for external consultants. Two agencies used consultants. Two agencies maintained audit reports locally, and one city had an RSA coordinator. Projects were selected both on an ad hoc basis and according to a defined selection process. Institutional barriers mentioned included the lack of staff resources and difficulty in implementation if the recommendations were considered too costly or impractical. The audits did address the needs of pedestrians and bicyclists, except on freeway projects. Road user input was part of the audit process for three agencies. No agency used cost-effectiveness procedures to evaluate the benefits of the RSA process. Success was measured by increased awareness of safety and the establishment of a process for identifying tangible safety benefits. Shortcomings mentioned were inadequate funding and a lack of integration with other safety programs. Programs were funded through a municipal tax base and capital budgeting.

Administration of RSAR Activities

Most of the RSARs were conducted in urban areas, with two agencies focusing their reviews on intersections. The size of the audit teams varied from two to eight individuals. Disciplines included traffic operations, planning, police, and consultants with RSA expertise. Two agencies used prompt lists rather than checklists in their RSARs.

The RSARs were carried out with both local staff and consultants and resulted in spot improvements. Projects were selected on the basis of crash data and operational concerns. Institutional barriers encountered included inadequate resources, some confusion among the various existing safety programs, resistance to accept a new procedure, and concerns over legal implications.

Only one agency had RSARs as part of its overall safety program. In one city, the audit included input from motorists, bicyclists, pedestrians, and the handicapped as observers.

Benefit–cost evaluations of RSARs are just beginning to be developed, but one agency uses published data on projected safety benefits resulting from various safety enhancements. All established RSAR programs have top management support. The biggest successes identified to date included buy-in from engineers and management, identification of tangible safety benefits, and increased visibility and acceptance by the public and at the political level.

IRELAND

In Ireland nationally and 33 major cities in the country, the design manual procedures have incorporated RSAs. The RSA process is required for all projects involving a change, and approximately 75 projects are audited each year. Training of auditors is stressed in the program. The subject of international auditor training is presented in a separate section in this chapter.

ITALY

In 2000, a pilot program to assess RSAs in Italy was undertaken. From 2001 to 2003, the emphasis has been on existing routes. Currently, a process is being developed to combine crash data and safety inspections. Design stage audit RSAs are required for urban areas with populations of greater than 30,000 and in high-risk areas. Education is another major area of focus.

OTHER COUNTRIES WITH ROAD SAFETY AUDITS

A number of other countries are involved in conducting RSAs. The World Bank has championed the use of RSAs, providing funding for consultants, performance of audits, and training. The following list is not intended to be all inclusive, but is provided to indicate global acceptance of the practice. Other RSA participants include

- India, Thailand, and others in Southeast Asia;
- South Africa;
- Eritrea in Northeast Africa; and
- Denmark, Finland, Germany, Italy, Norway, The Netherlands, and Switzerland in Europe.

ROAD SAFETY AUDIT BENEFITS

RSAs are internationally viewed as inexpensive to conduct (*5*). Furthermore, studies of the benefits of RSAs have indicated high positive benefits. At the 2003 IHT Conference on Road Safety Audits, Phillip Jordan of VicRoads in Australia summarized the studies of RSA benefits as part of his presentation. Highlights of his presentation follow.

- Typical costs of audits were estimated to range from $1,000 to $8,000 U.S. dollars, depending on the size of the project. Several examples of benefits were based on the analysis of similar projects with before-and-after crash data. One report examined crash data over a 2-year period for 19 audited and 19 nonaudited project sites in the United Kingdom. The audited sites had a casualty savings of 1.25 per annum, whereas the nonaudited sites exhibited a savings of only 0.26 per annum. In another U.K. study that examined 22 audited trunk road sites, the cost of implementing the recommendations was compared with the cost of rectifying the sites after the project was constructed. The average savings per site was 11,373 British pounds sterling or about $19,600 per site.
- Austroads described an analysis of nine audit sites reporting 250 different design stage audit findings that resulted in benefit–cost ratios ranging from 3:1 to 242:1. As for audits of existing roads, benefit–cost ratios ranged from 2:1 to 84:1.
- In other studies that presented the audit results in the form of a rate of return, figures such as a 120% rate of return in the first year were reported. In Denmark, analyses of 13 projects provided a first-year rate of return of 146%. Recognizing that these types of analysis are often questioned, a sensitivity analysis of input data was conducted. That analysis involved multiplying the input data by magnitudes of 2 and 4. The following conclusions were given: With a sensitivity of input estimate of 4, a 7% positive benefit still occurred. When a factor of 2 was applied as a multiplier to the input estimates, the analysis resulted in a positive benefit of 37%.
- If one life is saved as a result of an audit, the benefits will far exceed the audit costs. It is, however, difficult to attribute saving lives to any one audit or audit recommendation or action. Over time, monitoring audited projects and the actions taken should help to reinforce the value of an audit.

When the benefits and costs of audits were discussed during the IHT 2003 conference, several factors were generally accepted. Analysis of audit costs generally included the audit fee or personnel costs, costs of changes required as a result of the audit, and any costs associated with additional project delays and audit time. To date, studies that have used benefit–cost analyses have compared the accident characteristics of designs that have audit recommendations with those of designs that do not have such recommendations. The approach of monitoring, which is beginning to occur in the United Kingdom, should advance the state of RSA benefit–cost project analysis. The crash data from the U.K. requirement to monitor RSA projects after 12 and 36 months should become key input to future analyses and to providing the benefits of the RSA, at least internationally.

It is important to note that no negative benefit–cost analysis results of RSAs were presented during the IHT conference. Internationally, there is increasingly strong acceptance of the benefits of audits.

INTERNATIONAL TRAINING

The following points primarily highlight the RSA training as reported at the 2003 U.K. conference. It is included to show the importance that various countries have placed on audit activities as well as the level of effort. Several courses have been offered in Australia, and New Zealand has a 5-day course. In the United Kingdom there are courses for basic and advanced audits consisting of 3-day workshops for each; in Germany a 10-day training program over a 6-month period; and in Ireland 3-day courses on auditor training.

Two related topics being discussed are auditor skills requirements and certification of auditors. Several countries have skill guidelines for auditors, which are similar to those discussed previously in the U.K. section.

CHAPTER FIVE

CONCLUSIONS

This synthesis provides a snapshot of the state of the practice for road safety audits (RSAs). It was developed through a comprehensive literature review, a survey of state and provincial departments of transportation (DOTs) by using a structured questionnaire, and the authors' personal contacts and experiences in providing RSA team leadership and training worldwide.

The questionnaire was designed to elicit responses related to key RSA issues defining DOT practices. It was also designed to clarify and identify possible DOT concerns considered in implementing this proactive safety tool, as well as the road safety audit review (RSAR). The survey responses indicated that by mid-year 2003, only seven state DOTs were using both RSAs and RSARs in their safety programs. An additional 10 indicated that their state was using one but not both of the tools. Most of these states indicated that their use was best described as a beginning program to determine the benefits of incorporating these tools into their safety programs. Exposure of most state DOTs to RSAs was relatively recent and came about as the result of a 1996 international scanning tour by the FHWA to Australia and New Zealand. The scanning report was published in 1997, and the first U.S. conference on this topic was held that year.

Several states have advanced beyond the initial assessment stage. Specifically, Iowa, New York, Pennsylvania, South Carolina, and South Dakota have developed programmed approaches for including proactive safety assessments. Kentucky, Maine, and Mississippi are others that have participated in audit training and then conducting RSAs.

A major concern of RSAs and RSARs is the issue of liability. The National Highway Institute training course clarifies the liability issues associated with conducting RSAs and RSARs. In all states where training was provided, local DOT legal counsels sounded a common message—that audits are a positive approach and do not increase the agency's liability.

Ideal or required auditor skills were identified when a team approach was taken to conducting RSAs and RSARs. Core disciplines specifically included on the team were identified by most DOTs as traffic operations, design, and safety. Additional team members included individuals with expertise in construction, maintenance, law enforcement, planning, Americans with Disabilities Act, emergency medical services, pedestrians, and bicyclists. Individuals with local knowledge and other expertise were included on teams depending on the type of project and audit stage. The recommended size of an audit team was three to five persons.

In general, there were advantages to conducting RSAs at an early project stage and identifying the safety issues before the project's footprint has been developed. Using the RSA tool at multiple stages of the same project was not identified as a U.S. practice—perhaps owing to the relatively recent introduction of the concept in this country. Management buy-in and support of the tools and practice were viewed as necessary ingredients for successful programs.

The number of countries worldwide using the tools of RSAs and RSARs is growing rapidly. Historically, the most advanced countries have been involved in applying these techniques since the mid-1980s. The United Kingdom, Australia, and New Zealand are leaders in refining and advancing the state of practice.

Other countries are actively advancing their safety practices by using RSAs and RSARs. No country was identified as abandoning the use of these proactive safety tools nor were any negative benefits identified during this state-of-practice assessment. However, liability issues are a concern both within the United States and worldwide. At the international level, the most important statement concerning liability repeated by many RSA users is that these safety tools add value to the decisions being made in projects and the consideration of safety when projects are implemented.

Documentation of the audit findings and requiring a response from the client to the issues identified were commonly used and recommended practices internationally. Detailed record keeping was common practice in international RSA activities; however, the reporting documentation is kept simple. Building a knowledge base by continuing to learn from the application of audit findings was also identified as adding value to improving project design and safety considerations. It is widely accepted that RSAs reduced the need for adding safety improvements at a later date. The independence of the RSA is a common feature of international audits. Recent analytical studies have identified the benefit–cost ratio of RSA applications to be as low as 3:1 for some RSAs and RSARs to as high 240:1 for others.

Local U.S. agency applications have generally concentrated on using the RSAR. Most rural local agencies have many miles of roadway in need of a large number of safety improvements. Rural U.S. governments are becoming increasingly aware of the value of the proactive tools. Applications by rural agencies are being advanced by training.

The application of RSAs is in the earliest stages in the United States. To encourage and expand the application of the concept and to enhance safety benefits the following actions are needed:

- Training programs should be continued to introduce more state DOT personnel to RSA practices and how the safety tools can be applied.
- A compendium of best practices could be developed and disseminated to state DOTs, cities, and local road agencies. Local transportation assistance program centers [also known as technology transfer (T^2) centers] could assist in the distribution of this information.
- RSA training could be developed to focus on urban applications such as at intersections or on RSA and RSAR aspects of access management issues.
- A study is needed to establish the benefits of audits based on U.S. practice. It could include a quantitative evaluation to establish the economic benefits of audits.
- A forum on RSA and RSAR could be held to advance U.S. practice.

Time, training, and a record of successful applications will be the keys to making RSAs and RSARs a common safety practice in the United States. Agencies can stay up to date on RSA and RSAR activities by visiting the website www.roadwaysafetyaudits.org.

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APPENDIX A

Survey Questionnaire

TRANSPORTATION RESEARCH BOARD
NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
Project 20-5, Topic 34-02

Road Safety Audits: State of the Practice
Questionnaire

Name of respondent: ______________________________

Agency: ______________________________

Title: ______________________________

Telephone: ______________ Fax: ______________ E-mail: ______________

INSTRUCTIONS

The information collected will be used to develop a National Cooperative Highway Research Program (NCHRP) synthesis report on "Road Safety Audits: State of the Practice." If you or your agency has conducted any Road Safety Audits or Road Safety Audit Reviews, or conducted related safety assessments, please review and respond to this survey.

The purpose of this survey is to document information on existing experiences and planned activities in the application of road safety audits and related proactive safety programs. For the purpose of this survey, the following definitions are used:

Road Safety Audit—An RSA is a formal examination of a future roadway project by an independent, qualified audit team that then reports on potential safety issues.

Road Safety Audit Review—An RSAR is a road safety audit of an existing roadway made by a qualified independent audit team that reports on the potential safety issues on the existing roadway section.

There are three parts to this survey. All DOTs are asked to please respond to Part I (10 questions). Please respond to Parts II and III if your state is using RSAs or RSARs.

The survey should be completed by the person(s) with knowledge of the agency's activities related to safety evaluations. You may skip any questions that are not applicable. Attach additional sheets, if necessary. Please send the completed survey and additional documentation to:

Eugene M. Wilson
3212 Reynolds Street
Laramie, WY 82072

If you have any questions, please contact Dr. Wilson by telephone: (307) 766-3202 or by e-mail at: wilson@uwyo.edu, or Dr. Martin Lipinski by telephone: (901) 678-3279 or by e-mail at: mlipinsk@memphis.edu.

WE APPRECIATE YOUR RESPONSE—THANK YOU

PART I—INSTITUTIONAL ISSUES

1. Does your agency have a safety management plan? ___ Yes ____ No
(Please provide a copy if possible.)

2. Is a road safety audit/road safety audit review program part of the safety management plan? ____Yes ___ No

3. Does your state have sovereign immunity? _____ Full ____ Partial _______ None

4. Does your agency have measurable safety goals? Are these goals specific to reduction in numbers of fatalities_____ or are these goals rate-based _____? (Please provide a copy if possible.)

5. What are the measures of accountability used for the achievement of these goals?

6. What are the institutional barriers to implementing a road safety audit/road safety audit review program?

7. If your agency has developed and used modified concepts of road safety audit and road safety audit reviews, please provide examples of these changes.

8. Has your agency participated in any road safety audit training? Please describe.

9. Please provide any additional information that you feel would be helpful to improve the understanding of the state of the practice of road safety audits and road safety audit reviews.

10. Does your agency have case studies of actual audits/reviews that you would provide for use in the synthesis? If Yes, please check if you want them returned________. Please return all information provided to:

PART II—ROAD SAFETY AUDITS

Road Safety Audit—An RSA is a formal examination of a future roadway project by an independent, qualified audit team who then reports on potential safety issues.

11. Has your agency conducted any road safety audits?
    - ☐ Yes
    - ☐ No

    If No, go to question 35.

12. How many audits have you conducted in the past five years?

    ____

13. How many were conducted in the following stages of the design process?

    ____________ Planning
    ____________ Preliminary Design
    ____________ Final Design
    ____________ Traffic Control Planning During Construction
    ____________ Construction

14. How many people were on the audit teams and what disciplines did they represent?

    ___Planning Stage Audit ____
    ___Preliminary Design Stage Audit ____________________________________
    ___Final Design Stage Audit ____
    ___Traffic Control Planning Audit ____________________________________
    ___Construction Stage Audit ____

15. What types of projects were audited?

    ____
    ____
    ____
    ____

16. Did the team use the following?
    - ☐ Checklists
    - ☐ Prompt Lists
    - ☐ Neither

17. Were the results of the audit implemented? Please explain and if possible please provide sample audits. (If provided, these will be used only in a generic fashion.)

    ____
    ____
    ____
    ____

18. What resources were made available to the audit program?

    ____
    ____
    ____
    ____

19. Where are the audit reports maintained? (Is there a central road safety audit coordinator?)

20. Were the audits done in-house or with outside consultants, or both?

21. How are audit projects selected? (Please provide any selection criteria used and/or any overview characteristics of audit projects.)

22. What are the institutional barriers encountered that hindered implementation of audit findings?

23. Is there a road safety audit component specified in your agency's safety performance plan? (Please provide a copy if possible.)

24. Are the results of the audits checked against safety performance goals?
____Yes_____ No. Please explain.

25. Do the audits address the needs of pedestrians, bicyclists, or other road users?
____Yes_____ No. Please explain.

26. How do you gain knowledge of road users' needs on projects being audited?

27. How is the audit program administered in your agency?

28. How do you evaluate the success/benefits of the road safety audit program? Do you use any cost-effectiveness or cost–benefit methods of analysis? Please explain.

29. Does your agency have buy-in from the top administration for the road safety audit program?

30. How are liability issues addressed in your road safety audit program?

31. What is your biggest success with the road safety audit program?

32. What is the major failure or shortcoming of your road safety audit program?

33. How is the road safety audit program organized in your state?

34. How is your road safety audit program funded?

PART III—ROAD SAFETY AUDIT REVIEWS

Road Safety Audit Review—An RSAR is a road safety audit of an existing roadway made by a qualified independent audit team that reports on the potential safety issues on the existing roadway section.

35. Has your agency conducted any road safety audit reviews?
    - ☐ Yes
    - ☐ No

    If No, please return your responses and thanks for your help!

36. How many audit reviews has your department of transportation conducted in the past five years? (Please provide a best guess.)

    ____

37. What types and locations of roadways were reviewed?

    ____
    ____
    ____
    ____

38. How many people were on the audit review and what disciplines did they represent?

    ____
    ____
    ____
    ____

39. Did the team use the following?
    - ☐ Checklists
    - ☐ Prompt Lists
    - ☐ Neither

40. Were the results of the audit review implemented? (Please explain; for example, did the road safety audit review result in a project or were spot improvements made?)

    ____
    ____
    ____
    ____

41. What resources were made available to the audit review program?

    ____
    ____
    ____
    ____

42. Where are the audit reviews maintained?

    ____
    ____
    ____
    ____

43. Were the audit reviews done in-house or with outside consultants, or both?

    ____
    ____
    ____
    ____

44. How are roadway sections to be reviewed selected? (For example, are crash data considered in the roadway selection?)

45. What are the institutional barriers encountered that hindered implementation of the review program?

46. Is the audit review program part of your agency's safety performance plan?

47. Are the results of the audit reviews checked against safety performance goals?
____Yes_____ No. Please explain.

48. Do the audit reviews specifically address the needs of pedestrians, bicyclists, or other road users?
____Yes_____ No. Please explain.

49. How do you gain knowledge of road users' needs on roadway sections being reviewed?

50. How is the road safety audit review program administered in your agency?

51. How do you evaluate the success/benefits of the road safety review program? Do you use any cost-effectiveness or cost–benefit methods of analysis? Please explain.

52. Does your agency have buy-in from the top administration for the road safety review program?

53. How are liability issues addressed in your road safety review program?

54. What is your biggest success with the road safety review program?

55. How is the road safety review program organized in your state?

Thanks for your cooperation and assistance. If you know of any other agency within your state or international contacts that you feel would provide information that would improve the synthesis, please provide contact information.

APPENDIX B

Survey Respondents

State DOT Survey Respondents	
Alabama	Missouri
Alaska	Nebraska
Arizona	Nevada
Arkansas	New Hampshire
Colorado	New York
Connecticut	North Carolina
Delaware	North Dakota
Hawaii	Oregon
Idaho	Pennsylvania
Illinois	Rhode Island
Indiana	South Carolina
Iowa	South Dakota
Kansas	Tennessee
Louisiana	Texas
Maine	Vermont
Maryland	Virginia
Michigan	Washington
Minnesota	West Virginia
Mississippi	Wyoming

Canadian Survey Respondents
Alberta Transportation
Calgary
New Brunswick
Newfoundland and Labrador
Saskatchewan
Toronto

APPENDIX C

Sample Audit Reports

The following four audit reports are included in this appendix:

1. Sample road safety audit report, National Highway Institute
2. HD 19/03 reports
3. Sample road safety audit tool kit
4. Sample state road safety audit reports

Sample RSA Report

The following is a sample RSA report. This sample has been created using reports submitted by students of the RSA course.

Road Safety Audit Report on the Preliminary Design of the Proposed Widening of Route 60 between Milepost 8.7 and 10.4

PROJECT DESCRIPTION

Route 60 is currently a two-lane rural/suburban highway that traverses a two-mile portion of Henderson. The existing speed limit on Route 60 is 45 miles per hour. Adjacent land uses include industrial, commercial, and farming. Major intersections along the corridor include:

- US 60/Borax Drive/US 41A
- Ohio Drive/Collier Spur Road
- Old Corydon Road/Community Drive/Route 60
- Dana Drive/Route 60.

There are numerous driveway accesses and "wide open" driveways on this section of Route 60. Concerns have been raised in terms of the number of crashes throughout the corridor. Crashes in parts of this section are substantially greater than the statewide average.

We have reviewed the three alternative designs to upgrade Route 60 from east of Dana Drive to west of US 41A. All alternatives assume an upgrade of Route 60 from a two-lane section to a five-lane, curb and gutter section (four through lanes plus one two-way center left-turn lane). The proposed typical section also includes a five-foot sidewalk on both the north and south sides of the highway.

AUDIT TEAM MEMBERS

The following members comprise the audit team.

- John Smith, Highway Designer
- Mary Jones, Transportation Engineer
- Juan Lopez, Highway/Traffic Safety Specialist
- Sue Ling, Project Manager

DATA AND DOCUMENTATION

We have reviewed the following data and documentation during the conduct of this audit:

- Transportation Cabinet Conceptual/Location Plan for the Corridor/Aerial Mosaic
- Typical Section
- Profiles
- Crash Data

ASSUMPTIONS

We have based our audit on the following assumptions:

- The existing highway is built to design standards current at the time.
- The plans for the proposed widening are according to current design standards.
- Some entrances and driveways to Route 60 will be eliminated.
- Utilities are outside clear zone or underground.
- Project can be extended to highway 425.
- Pedestrian and bike traffic have been considered.
- All major intersections will be signalized.

SITE VISIT

From the documentation, we have identified the following potential safety concerns to concentrate on during the site visit:

- The number of accesses
- Center turn lane
- Railroad crossings
- Surface drainage
- Lack of pullout area for bus service
- Speed limit
- Pedestrian mobility

We visited the site on May 2, 2001 from approximately 1 PM to 3 PM to extrapolate the effects of the proposed plans in light of the current roadway. The weather at the time of our visit was partly cloudy.

The existing roadway appears to be well maintained. It is located in an area that is a mix of residential, commercial, and industrial. In fact, the area is transitioning from a rural to urban development. Trucks account for 15 percent of total traffic volume. Pedestrian and bicycle traffic is moderate.

In two groups, we drove the two-mile stretch of the proposed project several times and walked portions of it. We then compared and contrasted our observations before compiling this report.

FINDINGS

Our findings and observations are identified below. These findings are the consensus of the team.

- Overall Concerns
- Two-Way Center Left Turn. This type of design is used in highly developed, urban commercial areas. Historically, this design type has higher crash rates, including a higher level of head on collisions.
- Five feet of separation between sidewalk and through traffic lane. Our concern is that pedestrian separation is inadequate.
- No shoulders for disabled vehicles to pull off.
- The team does not have any background information to justify the provision of sidewalks in the corridor.

- Due to the flat grade of profile, a curb and gutter drainage system might not be adequate and, consequently, water might spread into traffic lane.
- Morning and evening sunlight glare interferes with traffic signals due to east-west alignment.
- Existing parking adjacent to the mainline causes potential sight distance issues.
- Snow removal and future maintenance issues might arise due to lack of shoulders.
- Better access management would minimize number and width of driveways.

US 60/Borax Drive/US 41A

Blue Alignment

- Offset to Borax Avenue. The creation of two intersections within close proximity has the potential to increase traffic conflicts.
- Separate access to Wye Road. Numerous private access points onto Relocated roadway.

Green Alignment

- Skew to Borax Drive
- Reverse curve
- Spur from US 60 is not permanently closed
- Skewed left turn from eastbound US 60 to northbound Borax Drive

Red Alignment

- Access Road from US 41A is too close to the Borax Drive/US 60 intersection.

Borax Drive to Ohio Drive

- Too many driveways
- Develop collector road between Station 1075 and Ohio Drive for 6 properties (north side of US 60)
- South side of US 60 buildings, utilities, signs, objects are within clear zone.

Ohio Drive/Collier Spur Road

- Traffic queuing due to railroad grade crossing.
- No major differences between red and green alternatives.
- Review detailed traffic studies to determine turning lane requirements.
- The entrance to Audubon Metals is within the Route 60 intersection.
- Railroad crossing has no cross arms.
- Need access management. Reduce wide-open entrances.

Community Drive/Old Corydon/US 60

- Entrance to Gibbs into Community Drive is too close to US 60 intersection.
- Proposed intersection alignments do not eliminate skew.

Community Drive to Dana Drive

- Eliminate church accesses onto US 60. Consider access on Dana Drive.
- Access Management Needed. Eliminate wide-open entrances.
- Move entrance to Service Tool and Die Company as northwesterly as possible.

CONCLUSIONS

In our judgment, consideration of the findings should improve the overall safety of the US 60 corridor in Henderson. We also suggest that a subsequent road safety audit take place after the preliminary plans have been completed.

ANNEX E:

ILLUSTRATIVE REPORT
A795 AMBRIDGE BYPASS
ROAD SAFETY AUDIT STAGE 2

EWING AND BARNES PARTNERSHIP **November 2004**

1 INTRODUCTION

1.1 This report results from a Stage 2 Road Safety Audit carried out on the A795 Ambridge Bypass at the request of the Design Organisation: Ambridge Bypass Design Team, DLS Partnership (Highways Division), 12-14 Cathedral Close, Borchester. The Audit was carried out during November 2004.

1.2 The Audit Team membership was as follows:

I K Brunel	(Ms) BSc, MSc, CEng, MICE, MIHT Ewing and Barnes Partnership (Traffic and Accident Investigation Division)
T MacAdam	IEng, FIHIE Ewing and Barnes Partnership (Traffic and Accident Investigation Division)
Eur Ing. C Chan	MEng, CEng, MICE Road Safety Engineering Consultant

1.3 The audit took place at the Erinsborough Office of The Ewing and Barnes Partnership on 17 and 18 November 2004. The audit was undertaken in accordance with the audit brief contained in Highways Agency letter reference HA/11.10.04/001. The audit comprised an examination of the documents provided by the Highways Agency's Project Sponsor, South Midlands Regional Office, and listed in the Annex. These documents consisted of a complete set of the draft tender drawings, a summary of the general details of the scheme including traffic flows, predicted queue lengths, non-motorised user counts and desire lines, an A3 plan for the Audit Team's use, a copy of the Stage 1 Road Safety Audit Report dated June 2003, details of the response to the issues raised in the Stage 1 Audit, details of other changes to the design since June 2003 and a schedule of Departures from Standards and the relevant approvals contained in the design. A visit to the site of the proposed bypass was made on the morning of Wednesday 17 November 2004. During the site visit the weather was fine and sunny and the existing road surface was dry.

1.4 The terms of reference of the audit are as described in HD 19/03. The team has examined and reported only on the road safety implications of the scheme as presented and has not examined or verified the compliance of the designs to any other criteria.

1.5 All comments and recommendations are referenced to the detailed design drawings and the locations have been indicated on the A3 plan supplied with the audit brief.

1.6 The proposed A795 Ambridge Bypass incorporates the provision of 2.3km of 7.3m wide single carriageway between Station Road to the south of the A827 and Ambridge Road to the north east of Ambridge village. The scheme includes the provision of 5 priority junctions and a roundabout at the A827 dual carriageway junction. The improvement also encompasses the provision of two lay-bys, the diversion of a footpath and the stopping up of Old Church Lane.

2 ITEMS RAISED AT THE STAGE 1 AUDIT

2.1 The safety aspects of the Ambridge Road Junction were the subject of comment in the June 2003 Stage 1 Road Safety Audit Report. (Items A3.1 and A3.2) These items remain a problem and are referred to again in this report (paragraph 3.13 below).

2.2 All other issues raised in the Stage 1 Audit have been resolved.

3 ITEMS RAISED AT THIS STAGE 2 AUDIT

3.1 GENERAL

3.2 PROBLEM

Locations: A and N (drawing RSA/S2/001) —Adjacent to the Ambridge railway station.

Summary: Risk of an accident between a pedestrian and a vehicle due to potential shortcut to bus stop.

A cross-section departure (in that there is no room for provision of a footway) on the existing railway bridge at location A has been reported. The departure has been introduced since the Stage 1 Audit. Although pedestrians have been rerouted to cross the railway using the renovated station footbridge they may still be tempted to use the road bridge as this will provide a much shorter route to the adjacent bus stop (location N). Pedestrians using the road bridge would have to walk on the carriageway and therefore there would be an increased risk of an accident between a vehicle and a pedestrian.

RECOMMENDATION

Relocate the bus stop currently on the bypass to Station Road. In addition provide pedestrian deterrent paving on the verges on the immediate approaches to the bridge (both sides).

3.3 PROBLEM

Locations: B and C (drawing RSA/S2/001)—Northern verge of Home Farm Road.

Summary: Open ditch is a potential hazard to an errant road user.

An open ditch is proposed to run along the side of Home Farm Road on the outside of the bend. This ditch is the main outfall for the storm water drainage from much of the bypass and in places is more than 1.5m deep. It is likely to carry substantial quantities of water following heavy rainfall and represents a danger to errant motorists and cyclists. This problem could increase the severity of an accident involving a vehicle or cyclist leaving the carriageway in this location.

RECOMMENDATION

Provide a safety fence at the back of the grass verge between location B and location C.

3.4 PROBLEM

Locations: D and E (drawing RSA/S2/001)—Lay-bys north of Old Church Lane.

Summary: Lay-by positions provide an increased risk of shunt and right turn accidents.

Drivers travelling north will reach the lay-by at location D on their right before the lay-by at location E on their left. Similarly vehicles travelling south will reach the lay-by at E on their right first. Since the lay-bys are not inter-visible and there are no advance signs, drivers could be tempted to cross the carriageway to use the first lay-by that they reach. This problem would increase the number of right turning manoeuvres and therefore increase the potential for accidents between right turning vehicles and vehicles travelling ahead in the opposite direction. It could also increase the likelihood of shunt accidents involving vehicles running into the back of other vehicles waiting to turn right into the lay-by.

RECOMMENDATION

Reposition the lay-bys so that drivers encounter a lay-by on their nearside first. When relocating the lay-bys ensure that adequate visibility is provided for a driver both entering and leaving the facility. In addition, provide advance signing of both facilities.

3.5 PROBLEM

Location: F (drawing RSA/S2/001)—Junction between Old Church Lane and the bypass.

Summary: Downhill gradient and limited visibility on sideroad approach increases the risk of overshoot type accidents.

The realigned section of Old Church Lane where it meets the bypass has a downhill longitudinal gradient of 7% and limited forward visibility. There is danger of traffic failing to stop at the give way line and skidding into the bypass in bad weather conditions. This feature could result in vehicles on Old Church Lane overrunning the give way line and colliding with through traffic on the bypass.

RECOMMENDATION

Provide the realigned section of Old Church Lane with a high grip surfacing and additional signs to warn traffic of the give way junction ahead.

3.6 PROBLEM

Location: G (drawing RSA/S2/001)—On the bypass midway between Old Church Lane and Home Farm Road adjacent to the northbound lane.

Summary: Unprotected embankment could increase the severity of an accident in this location.

The safety fence on the west side of the bypass between chainage 1+550 and 1+650 leaves some embankment unprotected. This could increase the severity of an accident involving a vehicle or cyclist leaving the carriageway.

RECOMMENDATION

Extend the safety fence back to chainage 1+500.

3.7 PROBLEM

Locations: H to I (drawing RSA/S2/001)—On the bypass adjacent to the Westlee dairy.

Summary: Headlights of vehicles on the parallel dairy access road could distract and disorientate drivers on the bypass.

The access road to the Westlee Diary Depot runs parallel to the bypass for about 250m. We understand that there is considerable vehicular activity on this road at night. The headlights of traffic using this road could be very confusing when viewed from the bypass. This could distract and disorientate drivers on the bypass to the extent they lose control of their vehicles.

RECOMMENDATION

Provide earth bund, solid fence or similar screen adjacent to Westlee Diary boundary.

3.8 PROBLEM

Location: Q (drawing RSA/S2/001)—Entrance to the electricity sub-station north of Home Farm Road.

Summary: No provision for service vehicles to stop off the bypass when accessing the sub-station.

The entrance gates to the electricity sub-station at chainage 1+900 (location Q) are located such that drivers wishing to enter the compound would have to park on the bypass whilst they unlock the gate. This could result in a vehicle travelling on the bypass colliding with the parked vehicle. It could also encourage vehicles to overtake parked vehicles increasing the risk of head-on collisions.

RECOMMENDATION

Relocate the gates further back from the edge of the carriageway. If, however, the location of equipment in the compound precludes the relocation of the gates, provide a lay-by or hardstanding area to allow vehicles to wait off the road while the gates are being opened or secured.

3.9 THE ALIGNMENT

3.10 PROBLEM

Location: J to L (drawing RSA/S2/001)—Crest to the north of Old Church Lane.

Summary: Proposed hazard road marking is not sufficient to discourage drivers from overtaking in this area.

The entire length of the bypass between the Ambridge Road Junction (location J) and the Bull Roundabout (location L) is marked with hazard lines (to Traffic Signs Regulations and General Directions diagram 1004.1) indicating the lack of full overtaking sight distance. The meaning of this lining is not understood by the general public and there is no indication that the visibility reduces appreciably over the crest at chainage 1+250. This problem could increase the potential for accidents involving inappropriate overtaking.

RECOMMENDATION

Provide 1m carriageway hatch markings (to Traffic Signs Regulations and General Directions diagram 1013.1B) over the crest. The use of this marking must be coordinated with recommendation 3.13 below.

3.11 THE JUNCTIONS

3.12 PROBLEM

Location: L (drawings RSA/S2/001 and RSA/S2/002)—North from the Bull Roundabout.

Summary: Confusion over the layout of road north of the roundabout may result in inappropriate overtaking.

Traffic originating from the existing dual carriageway A827 Borchester Road (which has a mature quickthorn hedge in the central reserve) and turning onto the new bypass (northbound) may be confused into thinking that the new bypass is a dual carriageway, particularly as the old field hedge to the west could be assumed to be in a central reserve and concealing a northbound carriageway. Traffic on the access road to the Westlee Diary could further confuse traffic in this location unless the recommendation at paragraph 3.7 above is implemented. This problem could increase the potential for accidents involving vehicles overtaking in an inappropriate location.

RECOMMENDATION

Redesign the splitter island and associated hatch markings shown on drawing RSA/S2/002 to accentuate that the bypass is a single carriageway. In addition provide two-way traffic signs (to diagram number 521 of The Traffic Signs Regulations and General Directions) on the northbound bypass immediately after the roundabout.

3.13 PROBLEM

Location: J (drawings RSA/S2/001 and RSA/S2/003)—Northbound approach to Ambridge Road Junction.

Summary: The road layout on the approach to the junction does not discourage overtaking on this straight downhill section of the bypass.

The approach to this junction along the proposed bypass from the south is via a straight downhill section of about 1km length and traffic speeds are likely to be high. The necessity of making sure that overtaking manoeuvres are complete in good time before the central reserve at the junction commences was flagged at the Stage 1 Audit. The current design does not adequately address this issue. As a result there is a potential for overtaking accidents and side impact accidents as overtaking vehicles abruptly move back into the northbound lane before the junction.

RECOMMENDATION

(a) Provide a continuous prohibitory double white line to diagram 1013.1 from the southern end of the central reserve (location M drawing RSA/S2/003) for a distance of about 340m uphill (FOSD/4 before the nosing), to replace the proposed hazard marking. This will force drivers into a single line well before the junction. Coordination with the recommendation in paragraph 3.10 above is necessary.
(b) Reposition the advanced direction sign ADS6 approximately 150m from the junction to warn traffic travelling at higher speeds.
(c) Provide "SLOW" carriageway markings on the approaches to the junction from both the north and south direction to moderate speeds through the junction.
(d) Provide hatching within the hard strip to further discourage drivers from attempting to overtake in the short single lane dual carriageway section through the junction.

3.14 NON-MOTORISED USERS

3.15 PROBLEM

Locations: O and P (See drawing RSA/S2/001)—Former line of the footpath at the crest to the north of Old Church Lane.

Summary: The former footpath alignment may still attract pedestrians to cross at a location with limited visibility.

The scheme allows for the diversion of Footpath No 12 so that it crosses the bypass away from the crest curve at location K. The old route may, however, be more attractive to pedestrians. This could result in an accident between a vehicle and pedestrian due to the reduced visibility at the crest curve.

RECOMMENDATION

Modify landscaping with heavy planting to block old route at the edge of the bypass (location O) and remove the old stile at the field boundary (location P) and replace with solid wall to match existing.

3.16 PROBLEM

Location: Throughout the length of the bypass.

Summary: The proposed raised ribbed edge line may be hazardous to cyclists at junctions.
It is not uncommon for cyclists to use the marginal strip provided along busy bypasses to avoid being intimidated by other vehicles. The drawings indicate that road markings to Diagram 1012.3, raised ribbed markings, will be used as edge line markings. These markings may cause difficulties for cyclists entering or leaving the marginal strip near junctions and result in cyclists losing control of their bicycle.

RECOMMENDATION

Replace markings to Diagram 1012.3 by those to Diagram 1012.1 for a length of 20m on the approach and exit sides of any junction.

3.17 SIGNING AND LIGHTING

3.18 PROBLEM

Location: L (drawings RSA/S2/001 and RSA/S2/002)—westbound approach to the Bull Roundabout.

Summary: The risk of errant vehicle colliding with a lighting column located in front of the safety fence.
On the A827 Borchester Road dual carriageway approach to the Bull Roundabout a length of safety fence is proposed to protect a large advance direction sign in the nearside verge. The drawings provided show a lighting column approximately 60 metres from the roundabout located in front of the proposed safety fence. A vehicle leaving the carriageway in this location could run along the length of safety fence into the lighting column, this could significantly increase the severity of an accident occurring in this location.

RECOMMENDATION

Relocate the proposed lighting column behind the length of safety fence.

4 AUDIT TEAM STATEMENT

I certify that this audit has been carried out in accordance with HD 19/03.

AUDIT TEAM LEADER

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Signed *I K Brunel*

Date *22/11/04*

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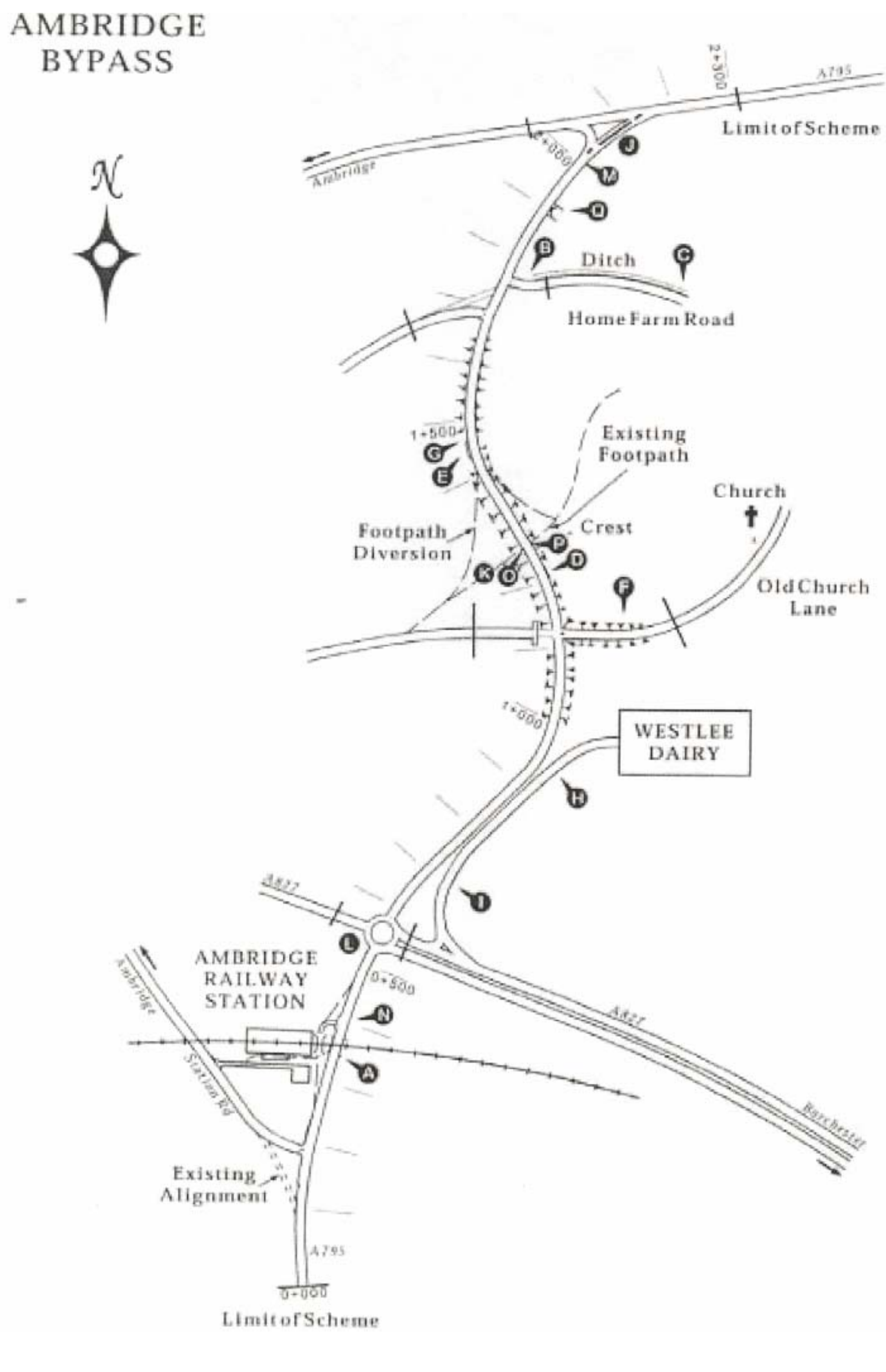
AMBRIDGE
BYPASS
N
2+500
A795
Limit of Scheme
Ambridge
2+000
Ditch
Home Farm Road
1+500
Existing
Footpath
Church
Crest
Footpath
Diversion
Old Church
Lane
1+000
WESTLEE
DAIRY
A827
AMBRIDGE
RAILWAY
STATION
0+500
Ambridge
Station Rd
Barchester
Existing
Alignment
A795
0+000
Limit of Scheme

ANNEX F:

ILLUSTRATIVE REPORT
A795 AMBRIDGE BYPASS
ROAD SAFETY AUDIT STAGE 4
12 MONTH MONITORING REPORT

DLS PARTNERSHIP **May 2007**

1 INTRODUCTION

1.1 This report results from the Road Safety Audit Stage 4 - 12 month monitoring carried out on the A795 Ambridge Bypass Scheme as part of DLS Partnership (Maintenance Division) maintenance agreement with the Highway Agency. The report has been produced as part of a routine accident monitoring/Road Safety Audit procedure and the terms of reference for this monitoring report are described in HD 19/03.
1.2 A site visit was conducted on Monday 7th May 2007, during which the road surface was wet as it was raining heavily.

2 SCHEME DETAILS

2.1 The A795 Ambridge Bypass was completed in March 2006 and involved the provision of 2.3km of 7.3m wide single carriageway between Station Road to the south of the A827 and Ambridge Road to the north east of Ambridge village.

2.2 The scheme included the provision of 5 priority junctions and a roundabout at the A827 dual carriageway. The improvement also encompassed the provision of two lay-bys, the diversion of a footpath and the stopping up of Old Church Lane.

2.3 The scheme was subjected to a Stage 1 Road Safety Audit in June 2003, a Stage 2 Audit in November 2004 and a Stage 3 audit prior to opening in March 2006.

3 ANALYSIS OF ACCIDENTS

3.1 During the period 1st April 2006 to 31st March 2007 a total of 3 personal injury accidents were recorded throughout the 2.3km length of the scheme. The severity of all three accidents was slight.

3.2 The accident frequency on Ambridge bypass has been briefly compared with values predicted in the Design Manual for Roads and Bridges COBA manual. The COBA manual predicts an accident frequency of 3.48 accidents a year based on the Annual Average Daily Traffic (AADT) flow of 18500 vehicles in 2006.

3.3 All three accidents have occurred at different locations throughout the scheme. The location and a brief description of each accident has been included below:

- Accident Ref. 1—A827/A795 roundabout. Vehicle 1 from A827 fails to give way at roundabout and
- runs into vehicle 2.
- Accident Ref. 2—N/bound approach to Old Church Lane. M/cycle loses control on a patch of oil.
- Accident Ref. 3—S/bound lay-by north of Old Church Lane. Vehicle 2 travelling north waiting to turn
- right into lay-by struck in rear by vehicle 1.

3.4 Two of the accidents (references 2 and 3) occurred during the daytime in fine weather on a dry road surface. The remaining accident (reference 1) occurred during the daytime in a period of rain on a wet road surface.

4 TRAFFIC CONDITIONS

4.1 Traffic count data has been obtained from an Automatic Traffic Counter (ATC) located on the A795 north of Home Farm Lane. The ATC indicates that the traffic flows along the A795 are 18500 vehicles AADT in 2006.

4.2 No significant congestion has been recorded throughout the scheme in its first year of opening. However, some queuing has been observed on the A827 westbound approach to the A827/A795 roundabout during the am peak period.

5 CONCLUSIONS

5.1 A brief assessment of the 12-month accident history of the Ambridge Bypass has indicated that the accident frequency is lower than the predicted national average and no common factors or trends have been identified in the data. However, it has been noted that one of the three accidents that have occurred has resulted from a vehicle travelling northbound waiting to turn right into the southbound lay-by being struck from behind. This problem was raised in the Stage 2 Audit report, however there were difficulties in acquiring the land necessary to relocate the lay-by so an Exception Report was approved.

5.2 As this report considers only 12 months of accident data and no common factors or trends have been identified at this early stage no firm conclusions can be drawn from the accident information.

ANNEX G:

ILLUSTRATIVE REPORT
A795 AMBRIDGE BYPASS
ROAD SAFETY AUDIT STAGE 4
36 MONTH MONITORING REPORT

DLS PARTNERSHIP **May 2009**

CONTENTS

1 INTRODUCTION

1.1 Background to the study

1.1.1 This report results from the Road Safety Audit Stage 4 - 36 month monitoring carried out on the A795 Ambridge Bypass Scheme as part of DLS Partnership (Maintenance Division) maintenance agreement with the Highways Agency. The report has been produced as part of a routine accident monitoring / Road Safety Audit procedure and the terms of reference for this monitoring report are described in HD 19/03.

1.1.2 A site visit was conducted on Friday 8th May 2009, during which the weather was overcast and the road surface was dry.

1.2 Study purpose

1.2.1 The purpose of this study is as follows:

- to undertake an in-depth study of the accidents that have occurred on the scheme during the three years since opening;
- to identify any road accident problems;
- to suggest possible measures that would contribute to accident reduction on the scheme;
- to review the recommendations from the Road Safety Audit Reports at Stages 1 to 3 and the Exception Reports to identify if they had any effect on the scheme.

2 SCHEME DETAILS

2.1 Description of the scheme

2.1.1 The A795 Ambridge Bypass was completed in March 2006 and involved the provision of 2.3km of 7.3m wide single carriageway between Station Road to the south of the A827 and Ambridge Road to the north east of Ambridge village.

2.1.2 The scheme included the provision of 5 priority junctions and a roundabout at the A827 dual carriageway. The improvement also encompassed the provision of two lay-bys, the diversion of a footpath and the stopping up of Old Church Lane.

2.1.3 The road is subject to the national speed limit and with the exception of the A827 / A795 Bull Roundabout the scheme is unlit.

2.1.4 The scheme was subjected to a Stage 1 Road Safety Audit in June 2003, a Stage 2 Audit in November 2004, a Stage 3 Audit prior to opening in March 2006 and a Stage 4 12 month monitoring report in May 2007.

3 ANALYSIS OF ACCIDENTS

3.1.1 During the 36 month period between 1st April 2006 to 31st March 2009 a total of 11 personal injury accidents were recorded throughout the 2.3km length of the scheme. There have been 2 (18%) serious accidents and 9 (82%) accidents that were slight in severity. No accidents involving fatalities have been recorded during the 36 month period. These figures are generally consistent with national average values taken from the DfT publication "Road Accidents in Great Britain" (RAGB) which indicates that on major roads with a 60mph speed limit 4% of accidents were fatal, 21% were serious and 75% were slight in severity.

3.1.2 Stick diagrams for these accidents together with a breakdown of accident types are included in Appendix I.

3.1.3 Appendix II shows a plot of the location of each of the accidents. Generally this diagram shows that the accidents are evenly distributed throughout the scheme, however there is a cluster of 4 accidents at the A827/A795 roundabout and two accidents at the lay-by north of Old Church Lane.

3.1.4 The information contained in the accident data has been compared to national averages from the DfT publication "Road Accidents in Great Britain" (RAGB) and the "Design Manual for Roads and Bridges COBA manual" below and in Appendices III to V:

3.1.5 Accident Frequency (see Appendix III)

	Year (01/04/06 to 31/04/09)			Total
	2006/2007	2007/2008	2008/2009	
Number of Accidents	3	3	5	11

3.1.6 The above table indicates that there have been on average 3.67 personal injury accidents a year along the Ambridge bypass. The COBA manual predicts an accident frequency of 3.76 a year based on the year 2008 AADT traffic flow of 19000 vehicles.

3.1.7 Accidents by Weather, Road Surface and Light Conditions (see Appendices IV & V)

Weather Conditions	Ambridge Bypass		National Average (RAGB)	
	No. of Accidents	%	No. of Accidents	%
Fine	8	73%	40173	75%
Rain	3	27%	10568	20%
Snow	0	0%	338	1%
Fog	0	0%	580	1%
Unknown	0	0%	1726	3%
Total	**11**	**100%**	**53385**	**100%**

Road Surface Conditions	Ambridge Bypass		National Average (RAGB)	
	No. of Accidents	%	No. of Accidents	%
Dry	7	64%	27660	52%
Wet	4	36%	23301	44%
Snow/Ice	0	0%	1751	3%
Unknown	0	0%	673	1%
Total	**11**	**100%**	**53385**	**100%**

	Ambridge Bypass		National Average (RAGB)	
Light Conditions	No. of Accidents	%	No. of Accidents	%
Daylight	8	73%	38788	73%
Darkness	3	27%	14597	27%
Total	**11**	**100%**	**53385**	**100%**

3.1.8 The above tables indicate that the weather conditions, road surface conditions and lighting conditions recorded in the accident data for the Ambridge bypass are generally consistent with national averages for 2008. Statistical tests carried out for the weather, road surface and lighting condition information indicate that there are no significant differences between the site data recorded in the personal injury accident reports and national data.

3.1.9 Accidents by Manoeuvre

Manoeuvre	No. of Accidents	%
Loss of control	2	18%
Side impact—failed to give way	2	18%
Nose to tail shunt impact	4	36%
Side Impact—Changing lanes	2	18%
Car hit Pedestrian	1	9%
Total	**11**	**100%**

3.1.10 Further analysis of the accident types indicate that 1 of the nose to tail shunt accidents and 1 of the failure to give way accidents occurred on the A827 dual carriageway approach to the A827/A795 roundabout. In addition, 2 of the nose to tail impacts occurred at the lay-by north of Old Church Lane while a vehicle was waiting to turn right into the facility. Finally, 2 of the 4 accidents that have occurred at the A827 / A795 roundabout have involved cars leaving the roundabout crossing the path of pedal cyclists negotiating the circulatory carriageway.

4 TRAFFIC CONDITIONS

4.1 Traffic Flows

4.1.1 Traffic count data has been obtained from an Automatic Traffic Counter (ATC) located on the A795 north of Home Farm Lane. The ATC indicates that the traffic flows along the A795 in 2008 were 19,000 vehicles AADT. This compares to the AADT flow recorded in 2006 of 18,500 vehicles.

4.1.2 The daily flow profile suggests that the Ambridge bypass has pronounced peaks in both the AM and PM periods and the traffic volumes are tidal, the high volumes occur in the southbound direction in the AM period and in the northbound direction in the PM period.

4.2 Traffic Speeds

4.2.1 Traffic speeds were measured during January 2009 and the results are shown below:

	Southbound		Northbound	
Location of Survey	85% ile speed (mph)	Speed range (mph)	85% ile speed (mph)	Speed range (mph)
100 m South of Old Church Ln	52	41–65	51	41–62
100 m North of Old Church Ln	54	44–66	55	40–66

4.2.2 The results show that speeds along the Ambridge Bypass are typical of those with a 60mph speed limit. A small proportion of drivers exceed the speed limit by more than 5mph.

4.2.3 No significant congestion has been recorded throughout the scheme. However, some queuing has been observed on the A827 westbound approach to the A827 / A795 roundabout during the am peak period. This congestion generally occurs between 08:30 and 09:00 in the morning on weekdays and extends for a length of approximately 15 vehicles in each lane.

5 STATEMENT OF SAFETY PROBLEMS ON THE AMBRIDGE BYPASS

5.1 Problems Identified

5.1.1 Although the accident rate along the Ambridge bypass is consistent with the national average for the type of road, this study has shown that there are a number of specific safety problems along the route:

- Two accidents on the A827 dual carriageway approach have involved drivers failing to appreciate the
- A827/A795 roundabout.
- Two accidents at the A827/A795 roundabout have involved car drivers exiting the junction across the
- path of cyclists.
- A cluster of two accidents have occurred at the lay-by north of Old Church Lane.

5.2 Review of Previous Road Safety Audit Reports and Exception Reports

5.2.1 None of the previous Road Safety Audits raised a specific problem in respect of either the potential for accidents involving drivers approaching from the A827 not appreciating the A827/A795 roundabout or for accidents involving car drivers exiting the junction across the path of cyclists. However, the potential for accidents involving vehicles turning right into the lay-by to the north of Old Church Lane was identified in the Stage 2 Road Safety Audit undertaken in November 2004.

5.2.2 The following problem and recommendation was raised in the Stage 2 Road Safety Audit report:

PROBLEM

Locations: D and E (drawing RSA/S2/001) – Lay-bys north of Old Church Lane.

Summary: Lay-by positions provide an increase risk of shunt and right turn accidents.

Drivers travelling north will reach the lay-by at location D on their right before the lay-by at location E on their left. Similarly vehicles travelling south will reach the lay-by at E on their right first. Since the lay-bys are not inter-visible and there are no advance signs drivers could be tempted to cross the carriageway to use the first lay-by that they reach. This problem would increase the number of right turning manoeuvres and therefore increase the potential for accidents between right turning vehicles and vehicles travelling ahead in the opposite direction. It could also increase the likelihood of shunt accidents involving vehicles running into the back of other vehicles waiting to turn right into the lay-by.

RECOMMENDATION

Reposition the lay-bys so that drivers encounter a lay-by on their nearside first. When relocating the lay-bys ensure that adequate visibility is provided for a driver both entering and leaving the facility. In addition, provide advance signing of both facilities.

5.2.3 The recommendation of repositioning the lay-bys was not implemented by the Project Sponsor as it would involve the costly acquisition of third party land and therefore an Exception Report was prepared by the Project Sponsor and approved by the Director. However, in mitigation, the design was amended to include the provision of signing of the lay-bys ½ mile in advance of each of the facilities.

6 OPTIONS FOR TREATMENT

6.1 Accidents Occurring on the A827 dual carriageway approach to the A827/A795 roundabout

6.1.1 Two of the accidents that have occurred on the A827 westbound approach to the roundabout appear to have involved a driver travelling too fast or not comprehending the junction layout ahead. A remedial measure option to reduce this problem would be to provide Transverse Yellow Bar markings on this approach. This road marking has been shown to have a significant effect in reducing accidents associated with inappropriate approach speeds.

6.1.2 Economic Assessment

The cost of providing Transverse Yellow Bar markings is estimated to be £4000. A study undertaken by the TRRL[(1)] has shown that this improvement could result in an overall reduction in speed related accidents in the order of 57% on fast dual carriageway approaches to junctions. However, the TRRL study does identify that the accident saving in relation to accidents occurring during the hours of darkness would be less. Therefore as one of the two accidents on the A827 westbound approach to the junction has been during the hours of darkness an accident saving of 25% has been assumed. Therefore this measure could provide a saving of 0.17 accidents per year, which is equivalent to £18,697 based on the national average cost of £109,983 for an injury accident (including an allowance for damage only accidents) taken from Highways Economic Note No. 1 (HEN1).

6.1.5 The First Year Rate of Return (FYRR) for this improvement is estimated at 467%.

6.2 Accidents Involving Cyclists at the A827/A795 roundabout

6.2.1 Two of the four accidents that have occurred at this junction have involved car drivers leaving the roundabout across the path of cyclists negotiating the circulatory carriageway. Site observations have indicated that numerous cyclists use the roundabout to access the Westlee Dairy from the residential areas to the west and south. It is therefore recommended that a segregated off-road route is provided around the junction to assist these vulnerable road users.

[(1)] Transport Research and Road Laboratory Report LR 1010 "Yellow bar experimental carriageway markings – accident study"

6.2.2 Economic Assessment

The estimated cost of providing a segregated cycle track/footpath around the junction would be £60,000. Both the Department for Transport publication "A Road Safety Good Practice Guide"(2) and the MOLASSES(3) database indicate that cycle schemes have produced a 58% reduction of injury accidents overall. As some cyclists will continue to use the circulatory carriageway it is estimated that this improvement could save 50% of the accidents involving cyclists coming into conflict with motorised vehicles on the carriageway. Therefore this measure could provide a saving of 0.33 accidents per year, which is equivalent to £36,294 based on the national average cost of £109,983 for an injury accident (including an allowance for damage only accidents) taken from HEN1.

6.2.3 The First Year Rate of Return (FYRR) for this improvement is estimated at 60%.

6.3 Accidents Occurring at the Lay-by

6.3.1 The accident data indicates that there have been 2 accidents involving northbound vehicles waiting to turn into the lay-by north of Old Church Lane. The potential for this type of accident was identified in the Stage 2 Road Safety Audit Report. As highlighted in Section 5.2 above the Project Sponsor was unable to implement the full recommendations as included in the Audit Report due to problems with land ownership. However the design did include the provision of signing of the lay-bys ½ mile in advance of each of the facilities.

6.3.2 It is considered that on both approaches to the lay-bys some drivers may mistake the lay-by on the other side of the road as the facility signed at ½ mile. Therefore it is recommended that a second advance sign is placed on the opposite side of the road to each lay-by informing drivers of the distance to the lay-by on their side of the road.

6.3.3 Economic Assessment:
The cost of providing the two extra signs is estimated to be £500. It is estimated that this improvement could save 10% of the accidents involving vehicles turning right into the lay-bys. This saving equates to a reduction in 0.07 accidents per year, which in turn is equal to a saving of £7,699 based on the national average cost of £109,983 for an injury accident (including an allowance for damage only accidents) taken from HEN1.

6.2.4 The First Year Rate of Return (FYRR) for this improvement is estimated at 1539%.

7 CONCLUSIONS

7.1.1 An analysis carried out on the 3-year period 1 April 2006 to 31 March 2009 has revealed a total of 11 reported personal injury accidents.

7.1.2 The study has shown that there are a number of specific safety problems on the route and that there are several options for treatment. As all the measures considered give a high First Year Rate of Return it is recommended that all are considered for implementation.

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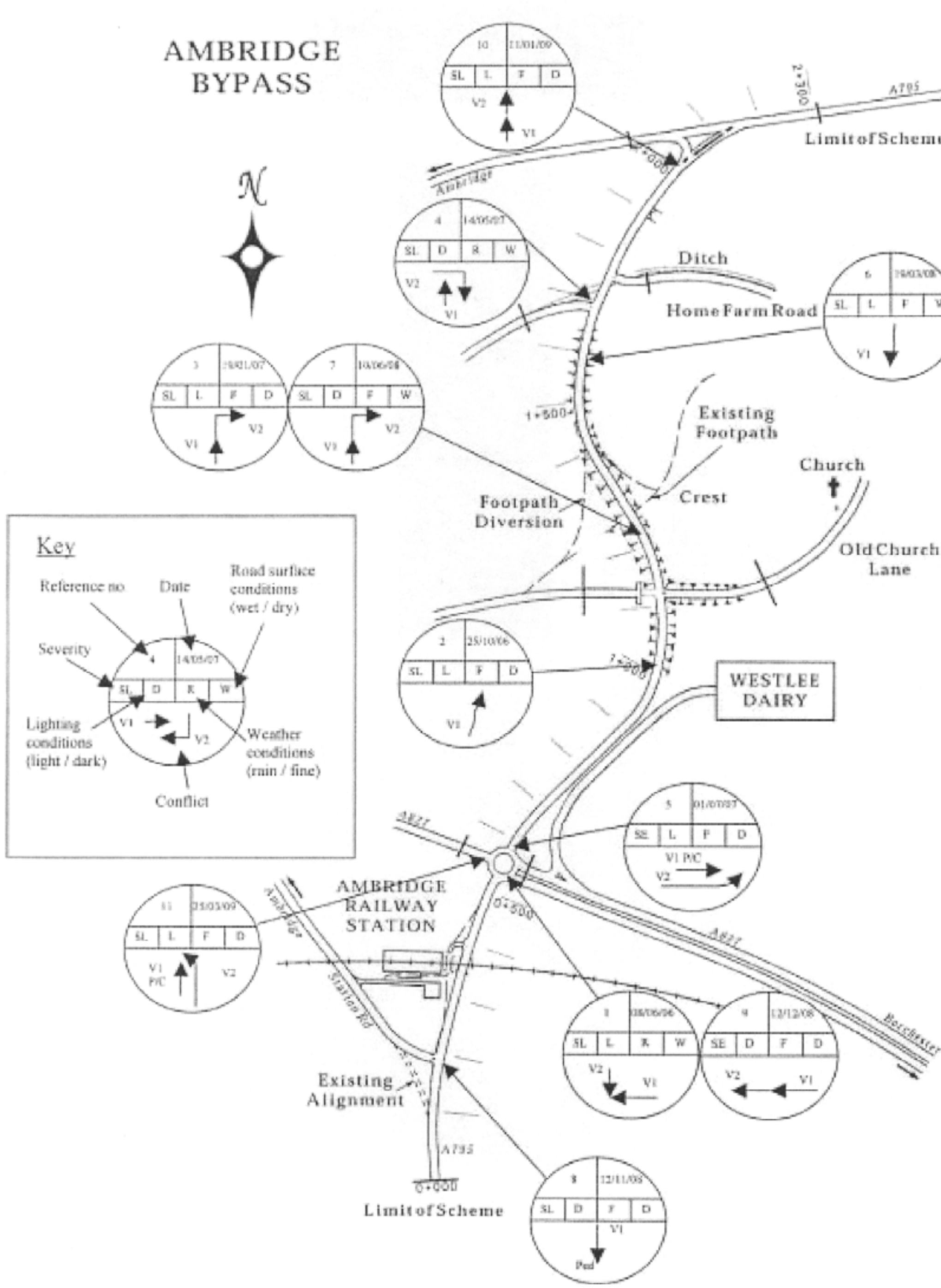
(2) A Road Safety Good Practice Guide, First Edition: Department for Transport, June 2001
(3) Monitoring Of Local Authority Safety Schemes, County Surveyors' Society & Highways Agency

APPENDICES

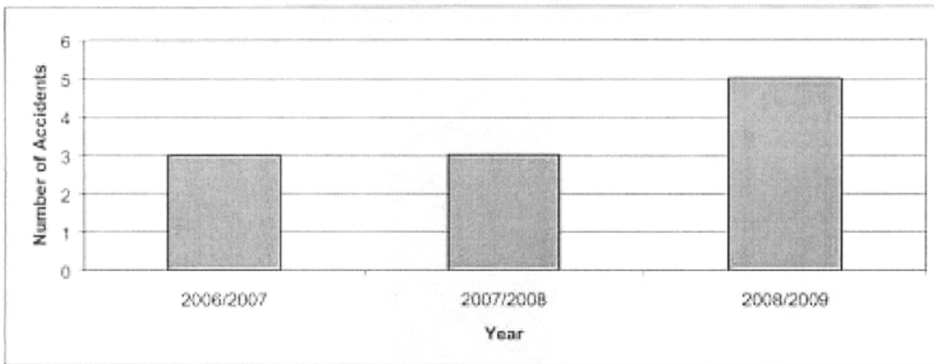
Appendix I—Accident Record 1st April 2006 to 31st March 2009

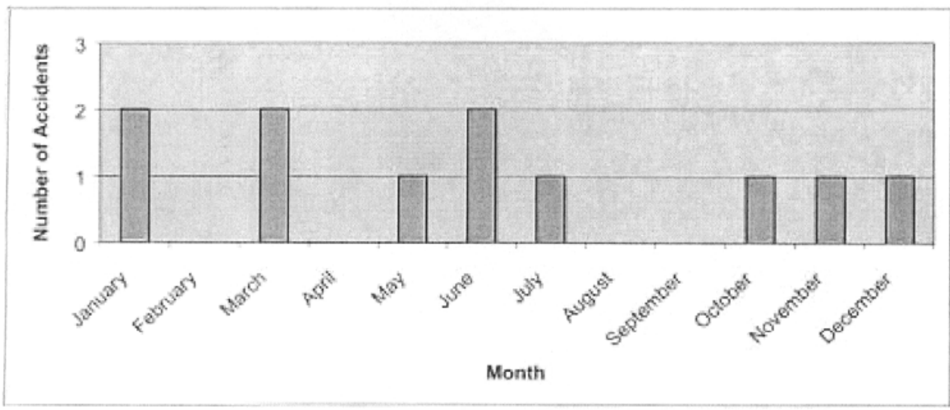
Reference:	1	2	3	4	5	6	7	8	9	10	11
Accident No.	T39195	T12495	T56395	T32196	T22396	T34596	T43196	T55296	T11297	T37897	T56797
Year	2006	2006	2007	2007	2007	2008	2008	2008	2008	2009	2009
Month	June	October	January	May	July	March	June	November	December	January	March
Date	8	25	19	14	1	19	10	12	12	11	25
Day	Thursday	Wednesday	Friday	Monday	Sunday	Wednesday	Tuesday	Wednesday	Friday	Sunday	Wednesday
Time	10:40:00	09:10:00	13:15:00	19:25:00	16:10:00	12:15:00	15:15:00	21:20:00	16:45:00	11:15:00	17:00:00
Severity	Slight	Slight	Slight	Slight	Serious	Slight	Slight	Slight	Serious	Slight	Slight
Dark/Light	Light	Light	Light	Dark	Light	Light	Light	Dark	Dark	Light	Light
Weather	Rain	Fine	Fine	Rain	Fine	Fine	Rain	Fine	Fine	Fine	Fine
Road Surface	Wet	Dry	Dry	Wet	Dry	Wet	Wet	Dry	Dry	Dry	Dry
No. Vehicles	2	1	2	2	2	1	2	1	2	2	2
Vehicle 1	Car	M/C	Car	M/C	P/C	Car	Car	Car	Car	Car	P/C
Vehicle 2	Van		Car	Car	Car		Van		Van	Car	Car
Vehicle 3											
No. Casualties	1	1	2	1	1	1	1	1	2	1	1
Casualty 1	Driver V1 Male 25	Rider V1 Male 34	Passenger V2 Female 54	Rider V1 Male 27	Rider V1 Male 54	Passenger V2 Female 65	Driver V2 Male 32	Pedestrian V1 Male 22	Driver V1 Male 23	Driver V1 Male 72	Rider V1 Female 48
Casualty 2			Driver V1 Male 43						Driver V2 Male 44		
Causation	Veh 1 failed to give way and pulled out across path of veh. 2	Rider lost control of machine on oil patch	Veh. 2 waiting to turn right into Lay-by, veh 1 skids into rear	Veh 2 turns right out from junction in path of motorcycle	V2 exits rbt to A795 across path of P/C V1 negotiating cir/cway	Veh. 1 lost control – distracted by passenger	Veh. 1 skids into rear of Veh. 2 turning right into lay-by	Ped. drunk in road hit by car	Veh 1 runs into the back of Veh 2 on approach to junction	Veh 1 runs into the back of Veh 2 on approach to junction	V2 exits rbt to A827 across path of P/C V1 negotiating cir/cway
Manoeuvre	V2 V1	V1	V2 V1	V2 V1	V1 V2	V1	V2 V1	Ped	V2 V1	V2 V1	V1 P/C V2
Location	A827/A795 Rbt	N/B approach to Old Church Lane	S/B lay-by north of Old Church Lane	A795/Home Farm Road Junction	A827/A795 Rbt	South of Home Farm Road	S/B lay-by north of Old Church Lane	South of Station Road	A827/A795 Rbt	A795 Ambridge Rd junction	A827/A795 Rbt

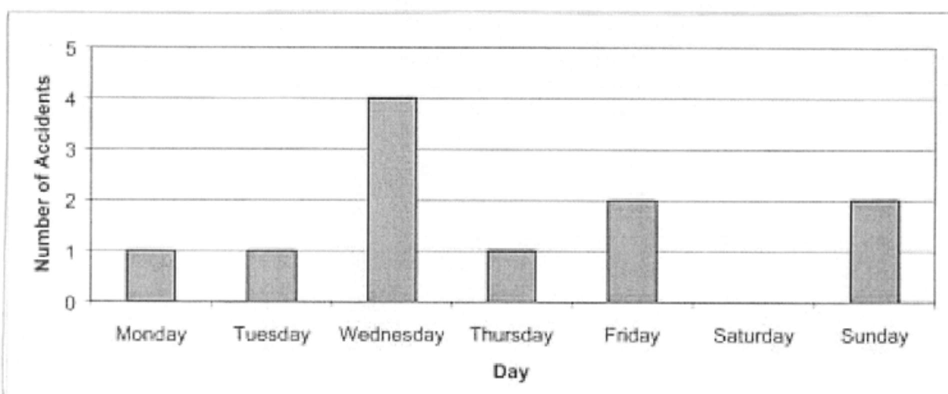
Appendix II—Accident Plot 1st April 2006 to 31st March 2009



Appendix III—Accident Frequency by Year, Month & Day of Week

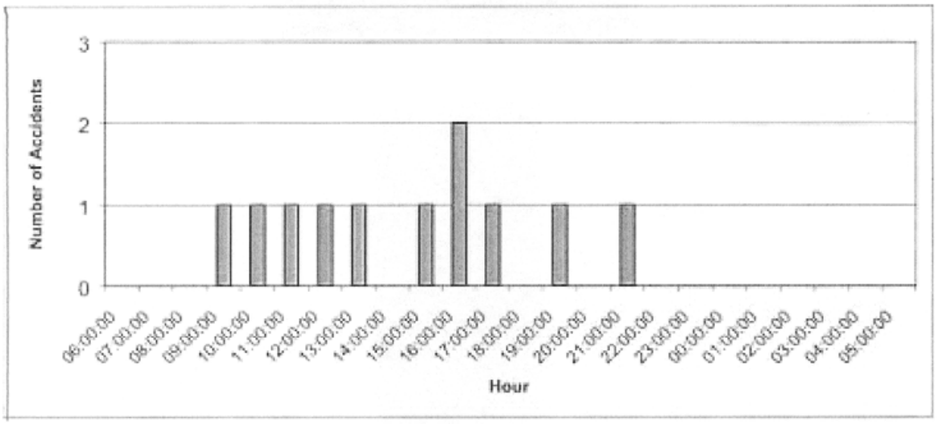


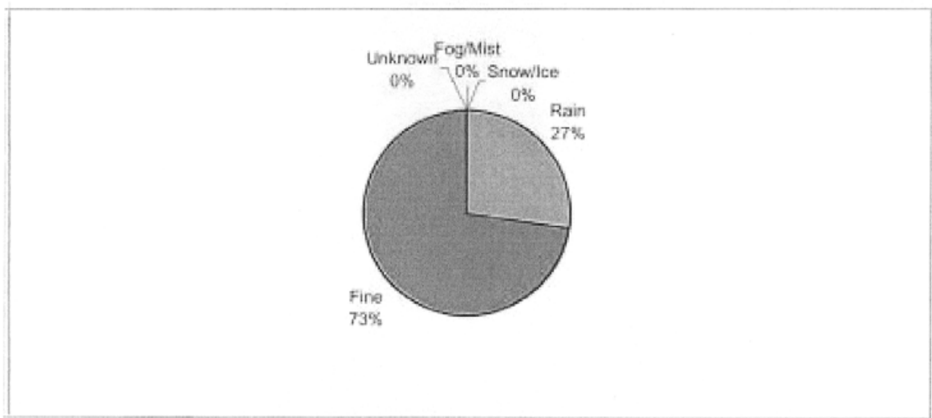


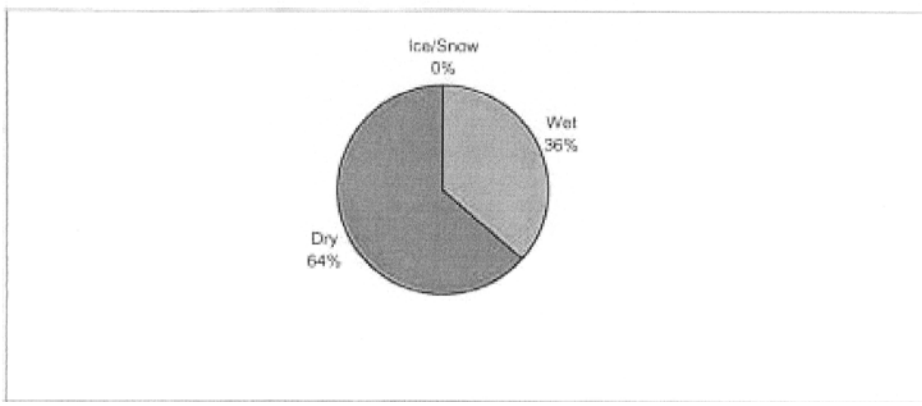


Appendix IV—Accident Frequency by Hour of the Day, Weather Conditions & Road Surface Conditions

Ambridge Bypass from 01/04/2006 to 31/03/2009

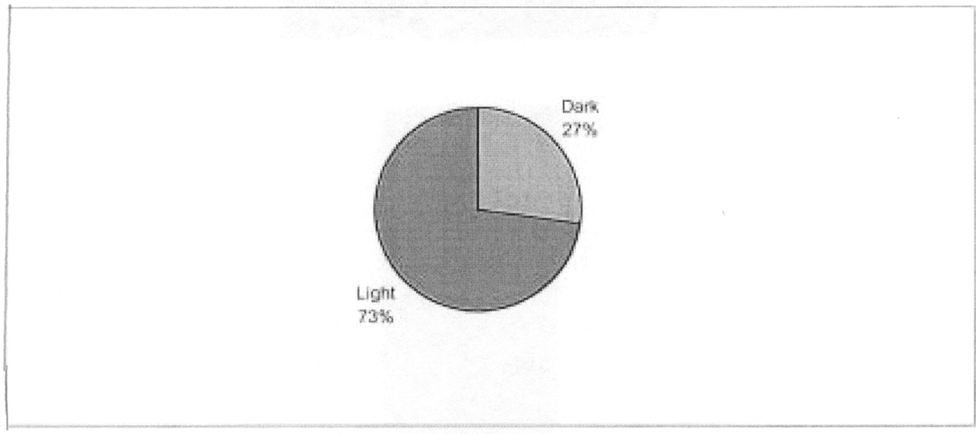






Appendix V—Accident by Light Conditions

Ambridge Bypass from 01/04/2006 to 31/03/20009



RSA TOOL KIT

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LOCAL RURAL GOVERNMENT RSAR PROCESS

Functional Local Rural Road Classifications

RSAR Form

Instructions for Local Rural Road Safety Audit Review Program

Safety Issues to LOOK FOR

Sample Report of RSAR Findings

"The key to safety is implementing
improvements for safety issues identified as urgent."

SAMPLE REPORT

County Road Safety Audit Reviews

Roadways reviewed and the recommendations resulting from the reviews are as follows (specifics on exact locations and more details are provided in the review notes):

Local/Rural Major High Speed Road

Several items were noted that could be improved if the road was ever reconstructed. However, considering the classifications of the road and the cost of improvements, many items were recommended to leave as they are. Included are parallel drainage pipe blunt ends, trees, power poles, mailbox supports, and some relatively steep side slopes.

The following items were thought to be of a relatively low cost improvement that could have positive safety benefits and should be considered for improvement within a reasonably short time frame:

Westbound:

- Relocate curve sign further upstream
- Delineate roadside where roadway narrows at horizontal curve and a relatively steep slope exists (2 locations)
- Replace non-standard speed limit signs

Eastbound:

- Replace curve sign with a curve/intersection warning sign
- Relocate mailboxes
- Relocate curve sign further upstream
- Replace curve warning advisory speed plate to be consistent with opposite direction
- Add delineation to clearly define edge of roadway cross-section
- Install a STOP sign

The following item was thought to be of such a nature that we recommend the improvement be initiated as soon as possible:

- Install delineation where roadway alignment is not consistent with the power pole alignment

The following items were considered to be of such a nature that they would have relatively high safety benefit if corrected, but are of relatively high cost for this classification of roadway. Therefore, it is recommended that they be considered for improvement if major reconstruction occurs on the roadway at or near these locations.

- Driveway approach in poor location
- Westbound view blocked by fence, restricted sight distance
- Driveway approach grades cause restricted sight distance

Local/Rural Local Road

- Numerous potential safety concerns exist on this roadway. However, due to the classification of the roadway, it is recommended that no improvements be made except to install a STOP sign.

Local/Rural Low Volume Local Road

Several items were noted that could be improved if the road was ever reconstructed at those specific locations. However, considering the classification of the road and the cost of improvements, many items were recommended to leave as they are. Included are relatively steep slopes and ditches, vertical and horizontal alignment creating sight restrictions, no notification of road ending, and power poles.

The following item was thought to be a relatively low cost improvement that could have positive safety benefits and should be considered for improvement within a reasonably short time frame:

- Pull ditches and remove large rocks

The following four audit reports are examples of how audits will vary with different audit teams. The first two audit reports are for the same facility, but performed by two different audit teams; the last two are for another facility, again performed by two different audit teams.

Road Safety Audit Report on the Preliminary Design of the County Road (State Route 51) and Slade Street Intersection Improvements

August 27, 2002

Project Description

The signalized intersection of Route 51 (County Road) and Slade Street is currently a high crash location with over 50 crashes in the latest three (3) year crash history. In addition, this intersection operates at failing levels of service during peak times of the day. The existing speed limits vary from 35 MPH on Slade Street to 40 MPH on County Road.

Adjacent land use in the area is primarily commercial in nature with a residential neighborhood located in the northeast quadrant of the intersection.

Numerous full movement entrances in the vicinity of the intersection exacerbate the existing over-capacity conditions and contribute to the high crash location status.

The alternatives presented include primarily the addition of a travel lane on each of the approaches with reconstruction to provide for the receiving lanes. In addition, raised bituminous islands with sloped granite curbing will be constructed to reduce the existing number of turning movements at adjacent entrances and residential streets.

Purpose of Audit

Conduct a review of the preliminary design with emphasis on vehicle and intersection safety. Visit the project site and make suggestions to enhance the safety of the intersection

Audit Team

Members of the audit team are as follows:

Division 3 Traffic Engineer; Designer, Urban and Arterial Program; Division 6 Traffic Engineer; Safety Engineer, FHWA; and Resident Inspector, Regional Program, Division 7.

Data and Information Used

We reviewed the following data and information during the conduct of this audit.

- Preliminary plan
- Typical sections
- Profiles
- Crash data
- State Access Management Rules
- Manual on Traffic Control Devices (MUTCD)
- State Highway Design Guide

General Findings

- The existing intersections operate at low levels of service with turning movements into/out of the driveways/entrances/streets in the immediate vicinity.
- Vehicles use shoulders inappropriately.
- Existing insufficient truck turning radii.

SPECIFIC FINDINGS

County Road Westbound Approach

- Receiving lanes on the east leg of the intersection appear to be short prior to the lane drop. The concern is that the contributing westbound through or southbound dual left turn lanes will not be fully utilized. Extend the two eastbound receiving lanes to station 1+420 before starting lane drop. Ideally, the two-lane section should be extended to the intersection of County Road and the Exit 7A connector road.

- The westbound approach right and through lanes need to be extended to Station 1+420. The lane transition length appears to be the same as the lane drop transition; this should be one half the lane drop distance.

- Consider a frontage road to connect Cottonwood Street with Elm Street. This configuration will reduce the number accesses onto County Road.

County Road Eastbound Approach

- The proposed median opening on Route 51 at Station 1+100 to 1+120 should be closed and the access to the CMP substation be restricted to right in and right out only.

Slade Street Northbound Approach

- Narrow the proposed median opening on Slade Street at approximately Station 5+320 Lt to 5+340 Lt to allow passenger cars only. The shared entrance narrowed to 30-foot wide and signed to prohibit truck traffic and direct them to Lance Drive.

Intersection Signal

- The phasing of the intersection indicates the southbound (SB) dual left turns will operate concurrently with the northbound (NB) left-turn lane. There does not appear to be sufficient room within the intersection for this to occur.

Speed Limit

The speed zones on County Road and Slade Street should be reviewed. A speed reduction may reduce the number of crashes

Conclusions

In our judgment, consideration of the findings should improve the overall safety of the signalized intersection of Route 51 (County Road) and Slade Street in Layton. We also suggest that a subsequent road safety audit take place after final design plans have been completed.

Although we still have concerns with the Elm Street and County Road intersection, there does not seem to be a feasible solution that would not significantly alter the scope of the project while allowing for safe and efficient traffic flow at this location.

Respectfully submitted,

Team Leader

Road Safety Audit Report on the Preliminary Design of the Intersection Improvement at Route 51 and Slade Street in the Town of Layton

Project Description

The Route 51 and Slade Street intersection is a suburban intersection surrounded by commercial and residential land use. The intersection is in a major commuter route from the surrounding communities to the Turnpike/Interstate as well as the mall area. It is believed that capacity issues are the driving forces behind this improvement.

The existing intersection is classified a high crash location by the state Department of Transportation, with 50 accidents in the years 1999–2001.

We have reviewed the preliminary plan, which includes widening of the intersection to separate turning movements and provide dedicated left-turn lanes as well as additional thru lanes at the intersection.

Audit Team Members

The following members comprise the audit team:

- Division 2 Traffic Engineer
- Division Engineer, Division 4
- Division 7 Traffic Engineer
- DOT Traffic
- Division 7 Regional Program
- Assistant Engineer, Division 6

Data and Documentation

We have reviewed the following data and documentation during the conduct of this audit:

- Preliminary Plan titled Layton, Project No. 1452, Produced by Smith Consulting Engineers, Dated PDR August 9, 2002.
- Crash data produced by state DOT.

Assumptions

We have based our audit on the following assumptions:

- The existing highway is built to design standards at the time of construction.
- The plans for the proposed intersection improvements are according to current design standards.
- Utilities will be moved outside of the clear zone.
- Pedestrian and bicycle traffic has been considered.
- Turning movements and capacity issues have been considered.
- All traffic signals and signage will be according to the MUTCD.

Site Visit

We visited the site on August 29, 2002, from approximately 8 AM to 10 AM to review field conditions and traffic flows. The weather at the time of the visit was partly cloudy. The intersection was viewed from all quadrants during the site visit. The existing intersection is located in a mix of residential and commercial land uses. There are a few entrances located within the project limits, which should be considered for access management. Pedestrian and bicycle use was non-existent during our visit. Drainage did not appear to be an issue at this time, but storage for winter snow appeared to be limited due to the narrow shoulders in the intersection.

Findings

The group identified the following issues as potential safety problems:

- The left turns on both legs of Slade Street are allowed to run at the same time, under the proposed signal phasing. There does not appear to be enough room in the intersection for these movements to be made at the same time without conflict. Increasing the space in the intersection for these opposing left-turning movements is one possible solution. The other solution would be to not allow the left turns to run concurrently.
- Left-turning trucks from County Road onto Slade Street need additional room to make the turn due to the acute angle involved. This occurs on both legs of the County Road. Additional room should be given for these truck movements.
- Access management should be strongly considered around Wren's Auto Repair and the local side streets (Cottonwood and Elm Streets). We feel that consideration should be given to combining Cottonwood and Elm Streets at Elm Street and eliminating the present Cottonwood Street entrance onto Route 51. The connection should be located as far from Route 51 as possible to provide the maximum comer clearance. The Wren's Auto Repair lot should only have access off from Cottonwood Street. We also feel that the little house behind Wren's Auto Repair on Slade Street should be purchased so that the present entrance can be eliminated.
- Is the proposed left-turn pocket long enough for expected traffic? We feel that a refuge may be appropriate for left-turning vehicles into and out of Elm Street. Left-turning traffic would only have to cross half of the roadway at a time if a refuge was provided.
- No lighting was shown on the plans. We recommend that additional overhead lighting should be installed at the intersection.
- There are numerous trees around the intersection that inhibit sight distance. These trees should be removed and any new plantings should be small enough or located such that sight distance is not impaired.
- The No Parking ordinance should be maintained in the area around the intersection after construction.
- All utilities should be moved outside of the clear zone.
- The island on Slade Street at Station 5+200 does not appear to be wide enough on the plans. This island needs to be wide enough to accommodate keep right signs.
- The tapers entering into the intersections do not appear to be long enough for the proposed transition zones. These transition zones should be lengthened to meet existing standards.
- The group feels that the entrance at 5+330 right on Slade Street should be moved across from the drive at 5+370 left. This would eliminate some turning conflicts at the two locations. It would also eliminate the median cut at this location.

Conclusions

In our judgment, considerations of the findings should improve the overall safety of the intersection improvement at the intersection of Route 51 and Slade Street in Layton. We also feel that a subsequent Road Safety Audit should be conducted later on in the design phase to provide additional feedback on any design changes that are made.

ROAD SAFETY AUDIT REPORT

for the design of the

Route 197 Project in Stanford

August 29, 2002

Project Description

The proposed project is on State Route 197 from the intersection of Castle Road to the state DOT compact urban line, approximately 1.2 miles from the intersection heading toward Douglas. The project also involves several intersections beyond Castle Road. This includes Maple Drive, Hill Road, and Stanford Road/Clay Drive (a 4-way signalized intersection).

This particular area has experienced residential/commercial growth and will continue to experience more growth in the future. From the increase in traffic volume, geometries have become a concern for safety. This road has a variety of vertical curve elements that need addressing. In combination with the geometries, driver inattention has contributed to the largest population of crashes for the current speeds in this corridor. To address some of the crashes and pedestrian uses, 12-foot lanes are being proposed with 6-foot shoulders. In conjunction with these modifications, sidewalks with an esplanade are being implemented to accommodate the expanding bedroom community here.

Purpose of Audit

The purpose of the audit is to review preliminary plans for safety issues. A field review was also conducted. The field review and plan review will be combined for recommendations and proposed changes to plans and/or specifications for the purpose of improving safety on this project.

Audit Team

Members of the Audit Team are as follows:

Safety and Traffic Engineer, FHWA; Designer, Urban and Arterial Program; Major Project Studies, Bureau of Planning; Traffic Engineer, Bureau of Planning; Assistant Engineer, Bureau of Planning; Resident Inspector, Regional Program, Division 7; and Project Administrator, Urban and Arterial Program.

Data and Information Used

We reviewed, or used information from, the following sources while conducting this audit:

- Preliminary plan
- Crash data
- Cover letter from Designer that included additional project information
- State Access Management Rules
- Manual on Uniform Traffic Control Devices (MUTCD)
- State Highway Design Guide

General Findings

There are currently inadequate shoulders throughout the length of this project. The lack of shoulders appears to contribute to many of the crashes along this section.

Sight distance is a problem throughout this project. Unimproved horizontal and vertical alignment in conjunction with the numerous residential and light commercial properties creates safety concerns throughout the length of the project.

The intersection just before the southern project terminus (Castle Road Intersection) is a relatively high-volume intersection that is likely to see significant increases in volume due to development of adjacent property for high-use commercial purposes. This intersection also has a fairly high accident cluster over the past 3 years. As such, this intersection was included in our review.

The project also includes another signalized four-way intersection at Stanford Road. This intersection involves many traffic movements and will require realignment, increased turning radii, and construction of exclusive left-turn lanes in all directions.

Specific Findings

Review stopping and intersection sight distances throughout the project. For example, the Credit Union area between 0+420 to 0+580 and all other intersections.

School bus was observed making a wide turn onto Maple Street. Please review all turning radii at intersections.

Crash data indicate a problem in the Credit Union area. Consider adding turning lanes if warranted.

Consider adding a protected left-turn phase at both intersections if warranted.

Consider exclusive left-turn lanes at Castle Road if warranted, while R/W is more readily available.

Consider pedestrian signals at all signalized intersections.

Improve "landing area" at Hill Street as much as possible. Verify guardrail length of need and all end treatments throughout project. Use guardrail along sidewalk even if outside designated clear zone (as opposed to chain-link fence), because of the severe slopes.

Coordinate design effort with Bridge Design to ensure adequate treatment of structure at north terminus of project.

Eradicate poison ivy before construction.

The proposed design will severely impact homes in the northeast and southwest corners of the intersection at Stanford Road/Clay Drive; consider realigning the intersection (Clay Drive) southerly (20 m) to improve traffic operations. By taking one property this will eliminate sever impacts to both residences.

Conclusions

The Review Team strongly recommends consideration of all recommendations in this report. This is an unimproved roadway that has high traffic volumes and currently connects two improved sections of roadway that appear to meet all current standards. The proposed design will significantly improve safety in the vicinity with the construction of the 12-foot travel lanes along with 6-ft shoulders. The inclusion of a 5 ft sidewalk from Castle Road to Stanford Road on the west side of the roadway (including a 4 ft esplanade) and a 5 ft sidewalk on the east side between Hill Road and Stanford Road will also significantly increase safety along this stretch of roadway. To further improve safety in this area, we have made several recommendations that relate to further improving the sight distance along the project. In addition, we recommend that a complete guardrail review be completed to ensure that adequate protection is provided in areas where the slopes are not traversable and hazards are present. Other recommendations relate specifically to the intersections at Castle Road and Stanford Road.

State Department of Transportation

Road Safety Audit
Route 197 Stanford
Preliminary Plan Review

Tuesday, August 27, 2002

Project Description

Route 197 is currently a two-lane rural/suburban minor arterial highway extending one mile north of the intersection with the Castle Road. The existing speed limit on Route 197 is 35 miles per hour. Adjacent land uses include residential and commercial. Intersections along the corridor include:

- Castle Road/Route 197
- Maple Street/Route 197
- Hill Street/Route 197
- Stanford and Clay Road/Route 197

There are numerous driveway accesses and wide driveways on this section.
We have reviewed a preliminary proposal to use a two-lane curb and gutter section with additional left- and right-turn lanes at intersections. The proposed typical section is assumed to include 5-foot sidewalks on the east and west side of the road north of the Clay and Stanford Roads, with a 4-foot grass esplanade separating the shoulder and sidewalk on the west side.

Audit Team Members

The following members comprise the audit team:

- Division 1 Traffic Engineer
- Division 2 Traffic Engineer
- Assistant Project Manager
- Transportation Analysis
- FHWA
- Urban and Arterial Designer

Data and Documentation

We have reviewed the following data and documentation while conducting this audit:

- Preliminary alignment plans and profile entitled Improvements to Route 197 Stanford by Smith Engineering.
- Crash data for 1999–2001 produced by state DOT for this section of road.
- Letter re: Route 197 Stanford, Plans for Safety Training Course.

Needs

The following data will be needed to adequately address safety:

- Design AADTs, including truck counts;
- Present timing and phase layout of existing signals;
- Turning movements at intersections;
- Design speed;
- Typical cross sections;
- Maintenance concerns could possibly be addressed by including a maintenance person on the Road Safety Audit teams; and

- Law enforcement input should be encouraged.

Assumptions

We have based our audit on the following assumptions:

- The plans for the proposed section are according to current design standards.
- Some entrances and driveways on Route 197 will be eliminated.
- Intersections presently signalized will remain signalized.
- Curbing will be used at the sidewalks and esplanade.
- Utilities will be moved outside the clear zone or underground.
- Pedestrian and bike traffic have been considered.
- Parking will be regulated.
- Center lanes are typically left-turn lanes and far right lanes are right-turn lanes when shown on the plan.

Site Visit

We visited the site on August 27, 2002, from approximately 1:30 PM to 4 PM to evaluate the proposed plans in relation to present use of the current roadway. The weather was mostly sunny.

The existing roadway appears to have drainage deficiencies with excessive rutting along sections with the greater grades. This area is a mix of commercial and residential uses. This area transitions from rural to recently completed urban development. Trucks were observed to account for a significant portion of the traffic volume. Pedestrians and bicyclists are assumed to be significant here as well, although very little was observed during our review. The 85th percentile speeds appeared to be between 40 and 45 miles per hour.

We walked the entire proposed project while reviewing the proposed plans. We then compared and contrasted our observations with those we anticipated before compiling this report.

We were not able to visit the site after dark or under differing weather conditions, which may reveal additional safety needs beyond those outlined below. Safety needs determined because of these different conditions should be considered in the design of this project and may normally require additional visits to the sites during road safety audits.

Findings

Our findings and observations are identified below. These findings are the consensus of the team.

Overall Concerns

- Queue lengths of proposed left-turn and right-turn lanes should be designed to be adequate for design AADTs and turning movements.
- Sidewalk south of this project near Red Creek is on the east side of Route 197. Sidewalk should be extended from this project to that area. Presently, no sidewalk is shown on the east side of the proposed plan from Hill Street south. Schools are on the east side of this route. These factors should be considered in determining whether the sidewalk should be on the east, west, or both sides throughout and along the project.
- All utilities should be moved outside the proposed clear zone. Numerous utility poles and fire hydrants were observed inside the proposed clear zone.
- Sight distance concerns were observed at numerous accesses and intersections near the vertical curve crests.
- The speed limit sign at 0+240± right is a 35 mile per hour sign, not 25 miles per hour as shown on the plan.
- Slope stability needs to be considered at a number of locations including:
  - 0+240± right
  - 1+540± right
  - 0+740± left.
- Guardrail end treatments should reflect current standards.
- Proposed locations of guardrails should be considered when evaluating sight distances. Remember to consider the location of the guardrail in relation to the proposed edge of shoulder as it will be built.

- Numerous drainage deficiencies were observed and need to be addressed.
- Excessive rutting was observed at numerous locations including:
  - 0+700 southbound lane
  - 0+890 southbound lane.
- Left-turn tracking was observed beyond the existing pavement at a number of locations including:
  - 0+450
  - 1+740 –1+780
  - 1+400
  - commercial establishments, in general.
- Entrances should be offset directly across from each other as much as possible.
- Phases and timing of signals should be re-evaluated in relation to lane and shoulder modifications (including sidewalk and crosswalk needs).

Specific Concerns

- The existing entrance at 0+120 should be considered for elimination, since it appears this parcel may be able to enter on to the Leighton Road, with lower expected volumes and level of service needs.
- Sight distance at 0+200, right, access may not meet design speed criteria.
- Maple Street should be re-oriented at the intersection with Route 197 to intersect at a 90º angle.
- The entrance at 0+280 left should be considered for modification to allow entrance on to Maple Street or more significantly entering on to Route 197 at a right angle.
- Sight distance at 0+380, left, access may not meet design speed criteria and should be considered for elimination. Excavation of the bank to the north needs to be evaluated in relation to sight distance needs at this entrance if it is not eliminated.
- The entrance at 0+450± right should be considered for placement opposite the entrance at 0+430± left.
- The entrance at 0+500± right should be considered for placement opposite the entrance at 0+480± left or being shared with the Credit Union entrance.
- Sight distance at 0+570, left, access may not meet design speed criteria and modifications to vertical profile of the road or movement of the entrance location should be considered to meet the criteria.
- Entrances at 0+620 and 0+640 left appear to have tracked in to each other and will need some means of positive separation to maintain access management in the future.
- Sight distance at 0+620, right, access may not meet design speed criteria. Excavation of the bank to the north and/or movement of the entrance needs to be evaluated in relation to sight distance needs here.
- Evidence of spinning tires was observed at a number of entrances including 0+780±right. Level landings of these entrances at the road should be provided.
- Sight distance at 0+780, right, access may not meet design speed criteria.
- Sight distance at 0+850, right, access may not meet design speed criteria. Excavation of the bank to the north and/or movement of the entrance needs to be evaluated in relation to sight distance needs here.
- Sight distance at 0+920, right, access may not meet design speed criteria. Excavation of the bank to the south and/or vegetation interferences need to be evaluated in relation to sight distance needs here.
- Sight distance at 0+930, left, access may not meet design speed criteria and modifications to vertical profile of the road and/or elimination of vegetation interferences should be considered to meet the criteria.
- Hill Street is presently closed. The grade on the approach and the width of the opening is excessive and a utility pole, creating the need for an island in the middle of the opening, is undesirable. Sight distances may not meet design speed criteria. Keeping the road closed should be considered. If not kept closed, the grade should be reduced and approach profile raised, width of the opening reduced, and the island and utility pole eliminated at the present approach.
- The entrance at 1+140 right should be considered for elimination.
- Drives and parking from1+140 to 1+200 left should be designed to eliminate vehicles backing in to the roadway.
- The angle of intersection at the Stanford Road and Route 197 intersection creates vehicle tracking and sight distance problems. The stop line is presently located a considerable distance back from the intersection. Modification of this approach should be considered to eliminate these problems. The most significant tracking problem was observed for vehicles turning left off the Stanford Road on to Route 197.
- Sight distance at 1+330, left, access may not meet design speed criteria and elimination of such should be considered.

- Sight distance at 1+360, left, access may not meet design speed criteria. Excavation of the bank to the north and/or movement of the entrance needs to be evaluated in relation to sight distance needs here. A level landing of the entrance should be provided at the road.
- Parking needs at 1+410 right exceeded parking available off the road. Three cars were parked along the shoulder of the road when we passed by. This will create traffic flow problems along the project if parking is allowed along the shoulders.
- Entrance at 1+610 right allows for vehicles to enter road at excessive speeds. This should be configured to constrict their entrance to be more perpendicular to the road.

Conclusions

In our judgment, consideration of the findings should improve the overall safety of the Route 197 corridor in Stanford. We also suggest that a subsequent road safety audit take place after the preliminary plans have been completed.

Signed by:

______________________________Division 1 Traffic Engineer

______________________________Division 2 Traffic Engineer

______________________________ Assistant Project Manager

______________________________Transportation Analysis

______________________________FHWA

______________________________Urban and Arterial Designer

APPENDIX D

Audit Checklists

FHWA Study Tour for ROAD SAFETY AUDITS

Part 2

October 1997

Prepared by the Scanning Team:

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and by
American Trade Initiatives, Inc.

Prepared for:
Federal Highway Administration
U.S. Department of Transportation
October 1997

3.1 Sample Checklists from Transit New Zealand: MASTER and STAGE 1

Excerpts are reprinted with permission from Transit and Transfund New Zealand.

M

MASTER CHECK LIST - ALL STAGES

STAGE 1-FEASIBILITY (AF@)	STATE 2-PROJECT ASSESSMENT (AP@)	STAGE 3-FINAL DEIGN (AD@)	STAGE 4-PREOPENING (AO@)
F1a General Topics: 1. Scope of Project, function, traffic mix 2. Type and degree of Access to Property and Developments 3. Significant adjacent Developments 4. Influence of staging 5. Future widening &/or Realignments 6. Wider network effects	P1a. General Topics: 1. Changes since Stage 1 2. Drainage 3. Climatic Conditions 4. Landscaping 5. Services 5. Access to Property and Development 7. Emergency vehicles and Access 8. Future widening &/or Realignments 9. Staging of scheme 10. Staging of works 11 Significant adjacent Developments 12. Stability of cut & fill—surface effects	D1a General Topics: 1. Changes since Stage 2 2. Drainage 3. Climatic Conditions 4. Landscaping 5. Services. 6. Access to Property and Development 7. Emergency vehicles and Access 8. Future widening &/or Realignments 9. Staging of scheme 10. Staging of works 11. Significant adjacent Developments 12. Batter stability—surface effects	O1a. General Topics: 1. Changes since Stage 3 & Transition of Design 2. Drainage 3. Climatic Conditions 4. Landscaping 5. Services 6. Access to Property 7. Emergency vehicles & Access 11. Significant adjacent Developments 12. Batter Treatment 17. Shoulders & edge delin. 20. Signs and markings 21. Surface, skid resistance 22. Contrast with markings 23. Installed hazards 24. Natural features
F1b Design Approach 7. Route Choice 8. Impact of continuity with existing network 9. Broad design standard 10. Design speed 11. Design Volume, traffic characteristic	P1b Design Approach 13. Geometry of horizontal and Vertical Alignment 14. Typical Cross Sections 15. Effect of Cross Sectional Variation 16.Roadway Layout 17. Shoulders and edge treatment 18. Effect of Departure from Standards & guidelines	D1b Design Approach 13 Geometry of horizontal and Vertical Alignment 14. Typical Cross Sections 15. Effect of Cross Sectional Variation 16. Roadway Layout 17. Shoulders, edge treatment 18. Effect of Departure from Standards & guidelines 19. Visibility, sight distances 20. Signs and markings	
F2 Intersections 1. Number and Type of Intersections	P2 Local Alignment 1. Visibility 2. Layout, including appropriateness of type 3. Readability by drivers	D2 Local Alignment 1. Visibility 2. New/Existing Road Interface 3. Readability by drivers 4. Detailed Geometric Design 5. Treatment—bridges & culverts	O2. Local Alignment 1. Visibility, sight distances 2. New/Existing Road Interface 3. Readability by drivers 5. Treatment at Bridges and Culverts
F3. Environmental Constraints 1. Safety Aspects, including weather, natural features	P3. Intersections 1. Visibility 2. Layout, including appropriateness of type 3. Readability by drivers	D3. Intersections 1. Visibility 2. New/Existing Road Interface 3. Readability by drivers 4. Detailed Geometric Design 5. Traffic signals 6. Roundabouts, islands 7. Other intersections	O3. Intersections 1. Visibility 3. Readability by drivers 5. Traffic Signals 6. Roundabouts, islands
F4. Any Matter not covered above 1. Safety aspects not already dealt with	P4. Non-Vehicular provision 1. Adjacent Land 2. Pedestrians 3. Cyclists 4. Equestrians/stock	P4. Non-Vehicular provision 1. Adjacent Land 2. Pedestrians 3. Cyclists 4. Equestrians/stock	O4. Non-vehicular provision 1. Adjacent Land 2. Pedestrians, incl. refuges 3. Cyclists 4. Equestrians/stock

	P5 (6). Signs and Lighting 1. Lighting 2. Signs 3. Markers, edge delineation	D5. Signs and Lighting 1. Lighting 2. Signs 3. Markers, edge delineation	O5. Signs and Lighting 1. Lighting 2. Signs, visibility & position 3. Markers, edge delineation
		D6. Physical Objects (poles, barriers, etc.) 1. Median barriers 2. Poles & other obstructions 3. Guardrailing 4. Bridge & culvert parapets	O6. Physical Objects (poles, barriers, etc.) 1. Median Barriers 2. Poles & other obstructions 3. Guardrailing
Note: This stage is the only checklist not to conform with the standard sequential numbering and topic descriptions. All subsequent safety audit checklists have a standard format and text	P7. Construction and Operation 1. Buildability 2. Operation 3. Traffic Management 4. Network Management 5. By-law requirements	D7. Construction and Operation 1. Buildability 2. Operation 3. Traffic Management 4. Network Management 5. Temporary traffic control/ management	O7. Construction and Operation 2. Operation 3. Traffic Management in pract 6. Temporary Traffic Control/Management, change to permanent
The narrow columns are for the use of Safety Auditors in any way they see fit.	P8. Any other matter 1. Safety aspects not already covered	D8. Any other matter 1. Safety aspects not already covered	O8. Any other matter 1. Safety aspects not already covered

F

STAGE 1 - FEASIBILITY (AF@)

REFERENCE	TOPIC	NO.	ITEM
F1a	General Topics: Broad issues to be addressed	1 2 3 4 5 6	Scope of Project, function, traffic mix Type and degree of Access to Property and Developments Significant adjacent Developments Influence of staging Future widening &/or Realignments Wider Network effect
F1b	General Topics: Design approach	7 8 9 10 11	Route Choice Impact of continuity with existing network Broad design standard aimed at Design speed Design Volume, traffic characteristics
F2	Intersections	1	Number and Type of Intersections
F3	Environmental	1	Safety Aspects, including weather, natural constraints features
F4	Any Matter not covered above	1	Safety aspects not already dealt with

Note: This is the only checklist not to conform with the standard sequential numbering and topic descriptions.
All subsequent safety audit checklists have standard format and text.

F1a

STAGE 1 - FEASIBILITY (AF@)

Check list F1a: General Topics: Broad Issues to be Addressed

ITEM	ISSUES TO BE CONSIDERED	CHECK
1 Scope of Project Function Traffic Mix	A broad appreciation of the scope of the project will assist in addressing topics further on in this check list. What is the general type of project for which the design has been carried e.g: Motorway or major arterial, or simply a minor improvement? Is the road intended to carry high speed traffic or possibly serve local access needs only? What kind of traffic is to be carried, ranging from high speed mixed traffic (i.e. including a significant number of heavy goods vehicles) or for more general use including for instance, cycles and significant pedestrian foot traffic?	
2 Type and degree of accessed property and developments	Check the general layout of the scheme, including (a) Questions of visibility and speed, related to the number and type of intersections and accesses to property alongside. (b) Check the width of the right of way, or the detailed design within that width, as affected by access requirements.	
3 Significant adjacent developments	Check major generators of traffic, including housing or shopping centres, that may have a significant influence on the form of the design. Check for distance of accesses from intersections and visibility of and from accesses to significant traffic generators.	
4 Influence of staging	Check the design against staging requirements. Will this scheme be one stage of several? Will future schemes be either linear extensions of the scheme, or will possible redundancies be caused by widening?	
5 Future widening and/or realignments	What is the likelihood of (a) Future widening? (b) The addition of a complete second carriageway? (c) Later realignments? (d) Introductions of major geometric changes at intersections?	
6 Wider network effects	Are there any harmful or beneficial safety aspects within the proposed project or on the surrounding network?	

F1b

STAGE 1 - FEASIBILITY (AF@)

ITEM	ISSUES TO BE CONSIDERED	CHECK
7 Route Choice	Consider the broad concept involved in the choice of a route or alignment Does the route follow existing roads or is it a "Green fields Project" and what are the effects of this? Does the scheme fit in with the physical constraints of the landscape and major network considerations?	
8 Impact of continuity with the existing network	Check for potential problems where the proposed roading scheme blends with or adjoins the existing network.	
9 Broad design standard aimed at	Check that the appropriate design standards have been used having regard to the scope of the project, its function in relation to the traffic mix.	
10 The design speed	Check the design speed for horizontal and vertical alignment, visibility, merging, weaving, and decelerating or accelerating traffic at controlled intersections. Check the effects of sudden changes in the speed regime or posted speed limit. Check the appropriateness of both the design speed and designated speed limit, if any, on the proposed roading project.	
11 Design volume traffic characteristics	Check the appropriateness of the design for the volume and traffic characteristics (including the effects of unusual proportions of heavy vehicles, cyclists and pedestrians, or side friction effects). Check the possible effects of unforeseen or large increases in traffic volume or changes in the traffic characteristics.	

F2,3

STAGE 1 - FEASIBILITY (AF@)

ITEM	ISSUES TO BE CONSIDERED	CHECK
1 Number and type of intersections	Check the appropriateness of intersections with respect to the broad concept of the project, its function and traffic mix and also the need to serve intersecting roads appropriately to their function. Check the number and type of intersections, including the relationship both of spacing and type of one intersection with another. Are there any traffic or safety aspects of the scheme or of the traffic in the area which would favour or disfavour any particular layout? Are there any physical or visibility constraints which would influence the choice or spacing of intersections? Are all of the proposed intersections necessary or essential, or can the surrounding network be modified beneficially? Does the vertical, geometry or horizontal alignment have any influence on the style or spacing of inter-sections?	

Check List F3 - Environmental Constraints

ITEM	ISSUES TO BE CONSIDERED	CHECK
1 Safety aspects, including weather and natural features	Check the surrounding terrain for physical or vegetation defects which could affect the safety of the scheme—for instance, heavy planting or forestry, deep cuttings, physical features such as steep or rocky bluffs which constrain design. Check the scheme for the effects of wind. Check for the effects of mist or ice. Do the gradients, curves and general design approach fit in with the likely weather or environmental aspects of the terrain?	

F4

STAGE 1 - FEASIBILITY (AF@)

Check List F4: Any Matter Not Covered Above

ITEM	ISSUES TO BE CONSIDERED	CHECK
1 Safety aspects not already dealt with	Check any aspects which do not readily fall into any of the above categories. e.g.: (a) The absence of electric power limiting the form of warning notices, (b) Flooding, (c) Moving stock, (d) The country may be unstable, (e) Low flying aircraft or advertising could be distracting to drivers. (f) Laybys or parking may be needed (e.g. for tourist routes, picnic or rest areas). (g) The potential of the route to attract roadside stalls, (h) Special events creating unusual or hazardous conditions, (i) Any other matter which may have a bearing on safety.	

3.2 Sample Checklist from Roads and Traffic Authority: STAGE 2

Excerpts are reprinted with permission from the Roads and Traffic Authority of New South Wales.

	N/A	YES	NO	COMMENTS

STAGE 2: DRAFT DESIGN

At this stage, issues like intersection or interchange layout and the chosen design standards are addressed. Where land acquisition is required, the draft design stage audit is undertaken before title boundaries are finalized.

It should be noted that the auditor may not be able to answer some questions at this point. Where the question cannot be given a >Yes' due to lack of detail at this stage, it should be answered >No= with the comment simply indicating that the auditor cannot determine that issue at this stage.

2.1 GENERAL TOPICS

1 Changes Since Stage 1 (Feasibility)

1A Do the conditions for which the route was originally designed still apply? (i.e., there have not been significant changes to the surrounding network or area to be served or traffic mix.)
1B Has the project design remained unchanged, in principle, since a Stage 1 audit (if any) was carried out?

2 Drainage

2A Will the new road drain adequately?
2B Has the possibility of surface flooding been adequately addressed, including overflow from surrounding or intersecting drains and water courses?

3 Climatic Conditions

3A Has consideration been given to weather records or local experience which may indicate a particular problem? (eg., snow, ice, wind, fog).

4 Landscaping

4A Has safety been adequately considered in the landscaping design or planting? (eg. Will road traffic see pedestrians and vice versa; etc).
4B Has safety been adequately considered for when vegetation is mature or growth is seasonal (eg. through loss of visibility, obscuring signs, shading or light effects, leaves, flowers or seeds dropping onto the highway)?
4C Has the use of "frangible" vegetation been considered?

5 Services

5A Does the design adequately deal with buried and overhead services (especially in regard to overhead clearances)?
5B Has the location of fixed objects or furniture associated with services been checked, including the position of poles?

6 Access to Property and Developments

6A Can all accesses be used safely? (entry and exit/merging).
6B Is the design free of any down-stream or upstream effects from accesses, particularly near intersections?
6C Have rest areas and truck parking accesses been checked for adequate sight distances, etc.?

7 Emergency Vehicles and Access

7A Has provision been made for safe access and movements by emergency vehicles?
7B Does the positioning of medians and vehicle barriers allow emergency vehicles to stop & turn without unnecessarily disrupting traffic?

	N/A	YES	NO	COMMENTS
8 Future Widening and/or Realignment 8A If the scheme is only a stag towards a wider or dual carriageway: - is the design adequate to impart this message to drivers? - is the signing adequate to impart this message to drivers? 8B Is the transition from single to dual carriageway handled safely? 8C Is the transition from dual carriageway to single carriageway handled safely? (this is especially important in transition from freeway to 2 lane-2 way highway.) **9 Staging the Scheme** If the scheme is to be staged or constructed at different times: 9A Are the construction plans and program arranged to ensure maximum safety? 9B Do they include specific safety measures for any temporary arrangements? (e.g. signing; adequate transitional geometry; etc.). **10 Staging of the Works** 10A If the construction is to be split into several contracts, have each of these been arranged for maximum safety? **11 Adjacent Developments** 11A Does the design handle accesses to major adjacent generators of traffic and developments safely? 11B Is the driver's perception of the road ahead free of adverse effects of lighting and/or traffic signals on adjacent roads? **12 Stability of Cut and Fill** 12A Has a satisfactory report on the geological stability of the country through which the road is to be constructed (and resulting cut and fill) been completed? **13 Maintenance** 13A Can maintenance vehicles be safely located? **2.2 DESIGN ISSUES (GENERAL)** **1 Geometry of Horizontal and Vertical Alignment** 1A Does the horizontal and vertical design combination of the road provide a suitable alignment for drivers? 1B Do the combinations of horizontal and vertical design elements conform to design practice? (ie. there shouldn't be undesirable combinations of horizontal and vertical design) 1C Is the design free of cues that would cause a driver to misread the road characteristics? (eg. visual illusions, subliminal delineation such as lines of trees, poles, etc.) 1D Does the alignment selected ensure speed consistency? 1E Are overtaking/climbing criteria met? **2 Typical Cross Sections** 2A Are the lane widths, shoulders, medians and other cross section features in accordance with standard design and adequate for the function of the road? 2B Is the width of traffic lanes and carriageway suitable in relation to: - alignment? - traffic? - vehicle dimensions? - speed environment? - combinations of speed and traffic volume?				

	N/A	YES	NO	COMMENTS
3 The Effect of Cross Sectional Variation 3A Is the design free of variations in cross section design that may have an adverse affect on road safety? 3B Are cross falls safe? (particularly where sections of existing highway have been utilised or there have been compromises to accommodate accesses, etc.) 3C Are cross falls safe where compromises have been made such as narrowing at bridge approaches or to avoid physical features? **4 Roadway layout** 4A Are all traffic management features (in addition to horizontal and vertical alignment and cross section) designed so as to avoid creating unsafe conditions? 4B Is the layout of road markings and reflective media (both on the road and on the surrounds) able to deal satisfactorily with changes in alignment? (particularly where the alignment may be substandard.) **5 Design Standards** 5A Has the design speed been selected in keeping with the terrain and importance of the road? 5B Is the design speed commensurate with the intended speed limit? **6 Shoulders and Edge Treatment** 6A Are the following safety aspects of shoulder provision satisfactory: - provision of sealed or unsealed shoulders? - width and treatment on embankments? - cross fall of shoulders? 6B Are the shoulders likely to be safe if used by slow moving vehicles or cyclists? 6C Have the safety aspects of rest areas and truck parking areas been checked in regard to shoulders? **7 Effect of Departures from Standards or Guidelines** 7A Are there any approved departures from standards which affect safety? 7B Have all hitherto undetected departures from standards been brought to the attention of the designer? **2.3 ALIGNMENT DETAILS** **1 Visibility; Sight Distance** 1A Are horizontal and vertical alignments consistent with the visibility requirements? 1B Will the design be free of sight line obstructions due to: - Safety fences? - Boundary fences? - Street furniture? - Parking facilities? - Signs? - Landscaping? - Bridge abutments? - parked vehicles in laybys? - parked or queued traffic? 1C Are railway crossings, bridges and other hazards all conspicuous? 1D Is the design free of any other local features which may affect visibility? **2 New/Existing Road Interface** 2A Have implications for safety at the interface been considered? (Include the accident rate and severity on the adjacent network, and the effect of sudden changes in the speed regime, or access, or side friction characteristics.) 2B Does the interface occur well away from any hazard? (eg. a crest, bend or where poor visibility/ distractions may occur.) 2C Is the change affected safely at any location where carriageway standards differ?				

	N/A	YES	NO	COMMENTS
2D Are transitions where the road environment changes safe? (eg. urban to rural; restricted to unrestricted; lit to unlit.) 2E Has the need for advance warning been considered? **3 >Readability= for the alignment by drivers** 3A Will the general layout, function and broad features be recognised by drivers in sufficient time? 3B Are the approach speeds and general likely positions of vehicles as they track through the scheme satisfactory? **2.4 INTERSECTIONS** **1 Visibility to and visibility at intersections** 1A Are horizontal and vertical alignments at the intersection or on the approaches to the intersection consistent with the visibility requirements? 1B Will drivers be aware of the presence of the intersection? 1C Will the design be free of sight line obstructions due to: - Safety fences? - Boundary fences? - Street furniture? - Parking facilities? - Signs? - Landscaping? - Bridge abutments? 1D Are railway crossings, bridges and other hazards all conspicuous? 1E Will the design be free of any local features which adversely affect visibility? 1F Will sight lines be unobstructed by permanent or temporary features such as parked vehicles in laybys, or by parked or queued traffic generally? **2 Layout, including the appropriateness of type** 2A Is the type of intersection selected (cross roads, T, roundabout, signalised, etc) appropriate for the function of the two roads? 2B Are the proposed controls (Stop, Give Way, Signals, etc.) appropriate for the particular intersection being considered? 2C Are junction sizes appropriate for all vehicle movements? 2D Are the intersections free of any unusual features which could affect road safety? 2E Are the lane widths and swept paths adequate for all vehicles? 2F Is the design free of any upstream or downstream geometric features which could affect safety? (eg. merging of lanes.) 2G Have public transport facilities been catered for? 2H Are the approach speeds commensurate with the intersection design? 2I Where a roundabout is proposed: - have pedal cycle movements been considered? - have pedestrian movements been considered? - are details regarding the circulating carriageway sufficient? **3 Readability by Drivers** 3A Will the general layout, function and broad features be perceived by drivers adequately? 3B Are the approach speeds and general likely positions of vehicles as they track through the scheme satisfactory? 3C Is the design free of sunrise or sunset problems which may create a hazard for motorists?				

3.3 Sample Checklist from Austroads: STAGE 4

Excerpts are reprinted from Road Safety Audit, Austroads, 1994.

ITEM	ITEMS TO BE CONSIDERED	CHECK	COMMENTS
1	Carry out a general check -- particularly for matters changed at previous audits.		
Changes since Stage 3 and translation of design into practice	Check the translation of the design into its physical form and any changes that could affect safety.		
2 Drainage	Check drainage of road and surrounds is adequate.		
3 Climatic conditions	Check effectiveness of any facilities put in place to counter climatic conditions.		
4 Landscaping	Check that planting and species selection is appropriate from safety point of view.		
5 Services	Check that boxes, pillars, posts and lighting columns are located in safe positions. Are they of appropriate materials or design?		
6 Access to property and developments	Check that accesses are safe for intended use. Check on adequacy of design, location and visibility in particular.		
7 Emergency vehicles and access	Check that provision for emergency vehicle access and stopping is safe.		
8 Significant adjacent developments	Check effectiveness of screening of adjacent developments and other special features.		
9 Batter treatment	Check that batter treatment will prevent or limit debris falling on to the carriageway.		
10 Shoulders and edge delineation	Check that all delineators and pavement markings are correctly in place.		
11 Signs and Markings	Check that all signs and pavement markings are correctly in place. Check that the appropriate sign has been used (especially Chevron Alignment Markers). Check that they will remain visible at all times. Check that old delineation (signs, markings) have been removed and are not liable to confuse.		
12 Surface treatment, skid resistance	Check all joints in surfacing for excessive bleeding or low skid resistance. Check all trafficked areas for similar problems, including loose stones.		
13 Contrast with markings	Check that the road markings as installed have sufficient contrast with the surfacing and are clear of debris.		
14 Roadside hazards	Check that no roadside hazard has been installed or overlooked.		
15 Natural features	Check that no natural feature (e.g., a bank rock or major tree) creates danger by its presence or loss of visibility.		

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Visibility, sight distances	Check that sight lines are not obstructed.		
2 New/existing road interface	Check the need for additional signs and/or markings.		
3 Readabilty by drivers	Check that the form and function of the road and its traffic management are easily recognized under likely operating conditions (e.g. under heavy traffic or poor visibility conditions). Check transition between old and new alignment, that the road is >readable= and does not create uncertainty at the point of transition.		
4 Treatment at bridges and culverts	Check that all markings and signs are in place and readable.		

ITEM	ISSUES TO BE CONSIDERED	CHECK	COMMENTS
1 Visibility of intersection	Are drivers aware of the presence of the intersection (especially if facing a Stop/Give Way sign)?		
2 Visibility at intersection	Check that all visibility splays or parts of the right of way required for visibility are clear for cars, trucks and vehicles with restricted visibility (e.g. vans, cars towing caravans).		
3 Readability by drivers	Check by driving each approach that the form and function of the intersection is clear to all drivers. Check that the stop/give way line is clear, and that the driver is given sufficient cues to stop before protruding into conflicting traffic.		
4 Traffic signals	Check alignment and general correctness of installation and that all aspects are visible from each approach lane at the appropriate distances. Check the safe operation of signals and associated equipment for all road users. Check markings for right turning vehicles.		
5 Roundabouts and approach islands	Check that the roundabout or island is fully visible and recognisable from all approaches and that signs, markings and lighting are correctly in place.		

ANNEX A: STAGE 1 CHECKLISTS—COMPLETION OF PRELIMINARY DESIGN

List A1 – General

Item	Possible Issues
• Departures from Standards	What are the road safety implications of any approved Departures from Standards or Relaxations?
• Cross-sections	How safely do the cross-sections accommodate drainage, ducting, signing, fencing, lighting and pedestrian and cycle routes?
• Cross-sectional Variation	What are the road safety implications if the standard of the proposed scheme differs from adjacent lengths?
• Drainage	Will the new road drain adequately?
• Landscaping	Could areas of landscaping conflict with sight lines (including during windy conditions)?
• Public Utilities/Services Apparatus	Have the road safety implications been considered?
• Lay-bys	Has adequate provision been made for vehicles to stop off the carriageway including picnic areas? How will parked vehicles affect sight lines?
• Access Can all accesses be used safely?	Can multiple accesses be linked into one service road? Are there any conflicts between turning and parked vehicles?
• Emergency Vehicles	Has provision been made for safe access by emergency vehicles?
• Future Widening	Where a single carriageway scheme is to form part of future dual carriageway, is it clear to road users that the road is for two-way traffic?
• Adjacent Development	Does adjacent development cause interference/confusion e.g. lighting or traffic signals on adjacent road may affect a road user's perception of the road ahead?
• Basic Design Principles	Are the overall design principles appropriate for the predicted level of use for all road users?

List A-2 Local Alignment

Item	Possible Issues
• Visibility	Are horizontal and vertical alignments consistent with required visibility? Will sight lines be obstructed by permanent and temporary features e.g. bridge abutments and parked vehicles?
• New/Existing Road Interface	Will the proposed scheme be consistent with standards on adjacent lengths of road and if not, is this made obvious to the road user? Does interface occur near any hazard, i.e. crest, bend after steep gradient?
• Vertical Alignment	Are climbing lanes to be provided?

List A3-Junctions

Item	Possible Issues
• Layout	Is provision for right turning vehicles required?
	Are acceleration/deceleration lanes required?
	Are splitter islands required on minor arms to assist pedestrians or formalise road users movements to/from the junction?
	Are there any unusual features that affect road safety?
	Are widths and swept paths adequate for all road users? Will large vehicles overrun pedestrian or cycle facilities?
	Are there any conflicts between turning and parked vehicles?
	Are any junctions sited on a crest?
• Visibility	Are sight lines adequate on and through junction ap proaches and from the minor arm?
	Are visibility splays adequate and clear of obstructions such as street furniture and landscaping?

List A4 – Non Motorised User Provision

Item	Possible Issues
• Adjacent Land	Will the scheme have an adverse effect on safe use of adjacent land?
• Pedestrian /Cyclists	Have pedestrian and cycle routes been provided where required?
	Do shared facilities take account of the needs of all user groups?
	Can verge strip dividing footways and carriageways be provided?
	Where footpaths have been diverted, will the new alignment permit the same users free access?
	Are footbridges/subways sited to attract maximum use?
	Is specific provision required for special and vulnerable groups i.e. the young, elderly, mobility and visually impaired?
	Are tactile paving, flush kerbs and guard railing proposed? Is it specified correctly and in the best location?
	Have needs been considered, especially at junctions?
	Are these routes clear of obstructions such as signposts, lamp columns etc?
• Equestrians	Have needs been considered?
	Does the scheme involve the diversion of bridleways?

List A5 – Road Signs, Carriageway Markings And Lighting

Item	Possible Issues
• Lighting	Is scheme to be lit?
	Has lighting been considered at new junctions and where adjoining existing roads?
	Are lighting columns located in the best positions e.g. behind safety fences?
• Signs	Are sign gantries needed?
• Poles/Columns	Will poles/columns be appropriately located and protected?
• Road Markings	Are any road markings proposed at this stage appropriate?

ANNEX B: STAGE 2 CHECKLISTS—COMPLETION OF DETAILED DESIGN

The Audit Team should satisfy itself that all issues raised at Stage 1 have been resolved. Items may require further consideration where significant design changes have occurred.

If a Highway Improvement Scheme has not been subject to a Stage 1 Audit, the items listed in Lists A1 to A5 should be considered together with the items listed below.

List B1: General

Item	Possible Issues
• Departures from Standards	Consider road safety aspects of any Departures granted since Stage 1.
• Drainage	Do drainage facilities (e.g. gully spacing, flat spots, crossfall, ditches) appear to be adequate? Do features such as gullies obstruct cycle routes, footpaths or equestrian routes?
	Do the locations of features such as manhole covers give concern for motorcycle/cyclist stability?
• Climatic Conditions	Is there a need for specific provision to mitigate effects of fog, wind, sun glare, snow, and icing?
• Landscaping	Could planting (new or when mature) encroach onto carriageway or obscure signs or sight lines (including during windy conditions)?
	Could mounding obscure signs or visibility?
	Could trees (new or when mature) be a hazard to a vehicle leaving the carriageway?
	Could planting affect lighting or shed leaves on to the carriageway?
	Can maintenance vehicles stop clear of traffic lanes?
• Public Utilities/Services Apparatus	Can maintenance vehicles stop clear of traffic lanes? If so, could they obscure signs or sight lines?
	Are boxes, pillars, posts and cabinets located in safe positions? Do they interfere with visibility?
	Has sufficient clearance of overhead cables been provided?
	Have any special accesses/parking areas been provided and are they safe?
• Lay-bys	Have lay-bys been positioned safely?
	Could parked vehicles obscure sight lines?
	Are lay-bys adequately signed?
	Are picnic areas properly segregated from vehicular traffic?
• Access	Is the visibility to/from access adequate?
	Are the accesses of adequate length to ensure all vehicles clear the main carriageway?
	Do all accesses appear safe for their intended use?
• Skid Resistance	Are there locations where a high skid resistance surfacing (such as on approaches to junctions and crossings) would be beneficial?
	Do surface changes occur at locations where they could adversely affect motorcycle stability?
• Agriculture	Have the needs of agricultural vehicles and plant been taken into consideration (e.g. room to stop between carriageway and gate, facilities for turning on dual carriageways)? Are such facilities safe to use and are they adequately signed?
• Fences and Road Restraint Systems	Is there a need for road restraint systems to protect road users from signs, gantries, abutments, steep embankments or water hazards?
	Do the restraint systems provided give adequate protection?
	Are the restraint systems long enough?

• Adjacent Developments and Roads	Has screening been provided to avoid headlamp glare between opposing carriageways, or any distraction to road users? Are there any safety issues relating to the provision of environmental barriers or screens?

List B2: Local Alignment

Item	Possible Issues
• Visibility	Obstruction of sight lines by: i. safety fences ii. boundary fences iii. street furniture iv. parking facilities v. signs vi. landscaping vii. structures viii. environmental barriers ix. crests x. features such as buildings, plant or materials outside the highway boundary Is the forward visibility of at-grade crossings sufficient to ensure they are conspicuous?
• New/Existing Road Interface	Where a new road scheme joins an existing road, or where an on-line improvement is to be constructed, will the transition give rise to potential hazards? Where road environment changes (e.g. urban to rural, restricted to unrestricted) is the transition made obvious by signing and carriageway markings?

List B3: Junctions

Item	Possible Issues
• Layout	Are the junctions and accesses adequate for all vehicular movements? Are there any unusual features, which may have an adverse effect on road safety? Have guard rails/safety fences been provided where appropriate? Do any roadside features (e.g. guard rails, safety fences, signs and traffic signals) intrude into drivers' line of sight? Are splitter islands and bollards required on minor arms to assist pedestrians or formalise road users' movements to/from the junction? Are parking or stopping zones for buses, taxis and public utilities vehicles situated within the junction area? Are they located outside visibility splays?
• Visibility	Are the sight lines adequate at and through the junctions and from minor roads? Are visibility splays clear of obstruction?
• Signing	Is the junction signing adequate and easily understood? Have the appropriate warning signs been provided? Are signs appropriately located and of the appropriate size for approach speeds? Are sign posts protected by safety barriers where appropriate?
• Road Markings	Do the carriageway markings clearly define routes and priorities?

	Are the dimensions of the markings appropriate for the speed limit of the road? Have old road markings and road studs been adequately removed?
• T, X, Y-Junctions	Have ghost islands and refuges been provided where required? Do junctions have adequate stacking space for turning movements? Can staggered crossroads accommodate all vehicle types and movements?
• All Roundabouts	Are the deflection angles of approach roads adequate for the likely approach speed? Are splitter islands necessary? Is visibility on approach adequate to ensure drivers can perceive the correct path through the junction? Is there a need for chevron signs? Are dedicated approach lanes required? If provided, will the road markings and signs be clear to all users?
• Mini Roundabouts	Are the approach speeds for each arm likely to be appropriate for a mini roundabout? Is the centre island visible from all approaches?
• Traffic Signals	Will speed discrimination equipment be required? Is the advance signing adequate? Are signals clearly visible in relation to the likely approach speeds? Is “see through” likely to be a problem? Would lantern filters assist? Is the visibility of signals likely to be affected by sunrise/sunset? Would high intensity signals and/or backing boards improve visibility? Would high-level signal units be of value? Are the markings for right turning vehicles adequate? Is there a need for box junction markings? Is the phasing appropriate? Will pedestrian/cyclist phases be needed? Does the number of exit lanes equal the number of approach lanes, if not is the taper length adequate? Is the required junction intervisibility provided?

List B4: Non Motorised User Provision

Item	**Possible Issues**
• Adjacent Land	Are accesses to and from adjacent land/properties safe to use? Has adjacent land been suitably fenced?
• Pedestrians	Are facilities required for NMUs at: a) junctions; b) pelican/zebra crossings; c) refuges; d) other locations? Are crossing facilities placed and designed to attract maximum use? Are guardrails/fencing present/required to deter pedestrians from crossing the road at unsafe locations? For each type of crossing (bridges, subways, at grade) have the following been fully considered? a) visibility both by and of pedestrians; b) use by mobility and visually impaired; c) use by elderly; d) use by children/schools; e) need for guardrails in verges/central reserve;

	f) signs; g) width and gradient; h) surfacing; i) provision of dropped kerbs; j) avoidance of channels and gullies; k) need for deterrent kerbing; i) need for lighting.
• Cyclists	Have the needs of cyclists been considered especially at junctions and roundabouts? Are cycle lanes or segregated cycle tracks required? Does the signing make clear the intended use of such facilities? Are cycle crossings adequately signed? Do guardrails need to be provided to make cyclists slow down or dismount at junctions/crossings? Has lighting been provided on cycle routes?
• Equestrians	Should bridleways or shared facilities be provided? Does the signing make clear the intended use of such paths and is sufficient local signing provided to attract users? Have suitable parapets/rails been provided where necessary?
• ADS and Local Traffic Signs	Do destinations shown accord with signing policy? Are signs easy to understand? Are the signs located behind safety fencing and out of the way of pedestrians and cyclists? Is there a need for overhead signs? Where overhead signs are necessary is there sufficient headroom to enable designated NMU usage? Do signs need reflectorisations where road is unlit and is facing material appropriate for location?
• Variable Message Signs	Are the legends relevant and easily understood? Are signs located behind safety fencing?
• Lighting	Has lighting been considered at new junctions and where adjoining existing roads? Is there a need for lighting, including lighting of signs and bollards? Are lighting columns located in the best positions e.g. behind safety fences and not obstructing NMU routes?
• Road Markings	Are road markings appropriate to location? a) Centre lines; b) Edge lines; c) Hatching; d) Studs; e) Text/Destinations; f) Approved and/or conform to the regulations.
• Poles and Columns	Are poles and columns protected by safety fencing where appropriate?

ANNEX C: STAGE 3 CHECKLISTS—COMPLETION OF CONSTRUCTION

The Audit Team should consider whether the design has been properly translated into the scheme as constructed and that no inherent road safety defect has been incorporated into the works.

Particular attention should be paid to design changes, which have occurred during construction.

List C1: General

Item	Possible Issues
• Departures from Standards	Are there any adverse road safety implications of any departures granted since Stage 2?
• Drainage	Does drainage of roads, cycle routes and footpaths appear adequate? Do drainage features such as gullies obstruct footpaths, cycle routes or equestrian routes?
• Climatic Conditions	Are any extraordinary measures required?
• Landscaping	Could planting obscure signs or sight lines (including during periods of windy weather)? Does mounding obscure signs or visibility?
• Public Utilities	Have boxes, pillars, posts and cabinets been located so that they don't obscure visibility?
• Access	Is the visibility to/from access adequate? Are the accesses of adequate length to ensure all vehicles clear the main carriageway?
• Skid Resistance	Do any joints in the surfacing appear to have excessive bleeding or low skid resistance? Do surface changes occur at locations where they could adversely affect motorcycle stability?
• Fences and Road Restraint Systems	Is the restraint system adequate? In the case of wooden post and rail boundary fences, are the rails placed on the non-traffic side of the posts?
• Adjacent Development	Have environmental barriers been provided and do they create a hazard?
• Bridge Parapets	Is the projection of any attachment excessive?
• Network management	Have appropriate signs and/or markings been installed in respect of Traffic Regulation Orders?

List C2: Local Alignment

Item	Possible Issues
• Visibility	Are the sight lines clear of obstruction?
• New/Existing Road Interface	Is there a need for additional signs and/or road markings?

List C3: Junctions

Item	Possible Issues
• Visibility	Are all visibility splays clear of obstructions?
• Road Markings	Do the carriageway markings clearly define routes and priorities? Have all superseded road markings and studs been removed adequately?

• Roundabouts	Can the junction be seen from appropriate distances and is the signing adequate?
• Traffic Signals	Can the signals be seen from appropriate distances? Can drivers see signals for opposing traffic? For the operation of signals: Do phases correspond to the design? Do pedestrian phases give adequate crossing time?
• T, X and Y junctions	Are priorities clearly defined? Is signing adequate?

List C4: Non Motorised User Provision

Item	Possible Issues
• Adjacent Land	Has suitable fencing been provided?
• Pedestrians	Are the following adequate for each type of crossing (bridges, subways, at grade)? a) visibility; b) signs; c) surfacing; d) other guardrails; e) drop kerbing or flush surfaces; f) tactile paving.
• Cyclists	Do the following provide sufficient levels of road safety for cyclists on, or crossing the road? a) visibility; b) signs; c) guardrails; d) drop kerbing or flush surfaces; e) surfacing; f) tactile paving.
• Equestrians	Do the following provide sufficient levels of road safety for equestrians? a) visibility; b) signs; c) guardrails.

List C5: Road Signs, Carriageway Markings And Lighting

Item	Possible Issues
• Signs	Are the visibility, locations and legibility of all signs (during daylight and darkness) adequate? Are signposts protected from vehicle impact? Will signposts impede the safe and convenient passage of pedestrians and cyclists? Have additional warning signs been provided where necessary?
• Variable Message Signs	Can VMS be read and easily understood at distances appropriate for vehicle speeds? Are they adequately protected from vehicle impact?
• Lighting	Does the street lighting provide adequate illumination of roadside features, road markings and non-vehicular users to drivers? Is the level of illumination adequate for the road safety of non-motor vehicle users?
• Carriageway Markings	Are all road markings/studs clear and appropriate for their location? Have all superseded road markings and studs been removed adequately?

Preliminary Design

General Topics

Item	Issues to be Considered	Check	Comments
1 Changes since Stage 1	Check for any major changes in principle since the Stage 1 Audit was carried out. Check that the conditions for which the project was originally designed still apply, i.e., there have not been significant changes to the surrounding network or area to be served, or traffic mix.		
2 Drainage	Will the new road drain adequately? Is there a possibility of surface flooding or overflowing from surrounding or intersected drains and water courses?		
3 Climatic conditions	Do weather records or local experience indicate a problem (e.g., snow, ice, wind, fog)?		
4 Landscaping	Is the landscaping design or planting likely to lead to a lowering of safety with mature or seasonal growth? (i.e.through loss of visibility, obscuring signs, shading or light effects, leaves, flowers, or seeds dropping on the highway) ? Is "frangible" vegetation appropriate? Consider pedestrian visibility in particular.		
5 Services	Does the design adequately deal with buried and overhead services? At this stage the location of fixed objects or furniture associated with services should be checked, including the position of poles.		
6 Access to property and developments	Can all accesses be used safely? Are there any downstream/upstream effects from development accesses, particularly near intersections? Check rest area accesses.		
7 Emergency vehicles and access	Has provision been made for safe access by emergency vehicles and vehicles? Check the design of medians and barriers, and the ability of emergency vehicles to stop without necessarily disrupting traffic.		
8 Future widening and/or realignments	If the project is only a stage towards a wider or divided roadway, is the signing and design adequate to impart this message to drivers? Is the transition from two way to divided roadway handled safely?		
9 Staging of the project	If the scheme is to be staged or constructed at different times, are the construction plans and program arranged to ensure maximum safety and do they include specific safety measures, signing, and adequate transitional geometry for any temporary arrangements?		
10 Staging of the works	If the construction of this project is to be staged or split into several contracts check that these are arranged for maximum safety.		
11 Significant adjacent developments	Check that the design handles accesses to major adjacent generators of traffic and parking and developments safely. Check that lighting or traffic signals on an adjacent road do not affect the drivers' perception of the road ahead.		
12 Stability of cut and fill	Check that the geological conditions in the country through which the road is to be constructed do not pose a significant threat to safety of vehicle occupants.		
13 Maintenance	Check if maintenance vehicles can be safely located.		

Design Issues

Item	Issues to be Considered	Check	Comments
1 Geometry of horizontal and vertical alignment	Do the horizontal and vertical design of the project fit together comfortably? Check the design for adequacy with regard to the function of the road. Check the possibility of drivers not being able to read the road characteristics due to visual illusions, subliminal delineation, etc., (e.g., line of trees, line of poles, etc).		

2 Typical crosssections	Are the lane widths, shoulders, medians and other cross section features in accordance with standard design or adequate for the function of the road?		
3 Effect of crosssectional variation	Check that there are no undesirable variations in cross section design. Check cross slopes which could affect safety, particularly where sections of existing highway have been utilised, or where there have been compromises to accommodate accesses, etc. Check where compromises have been made such as narrowing at bridge approaches or to avoid physical features.		
4 Roadway layout	Check that total traffic management features in addition to horizontal and vertical alignment and cross section) are not likely to create unsafe conditions. Check the layout of road markings and reflective media both on the road and on the surrounds to deal with changes in alignment, particularly where these are substandard.		
5 Design standards	Check the appropriateness of the design speed and speed limit. What design and check vehicles are used?		
6 Shoulders and edge treatment	Check the safety aspects of shoulder provision, including the provision of sealed shoulders, the width and treatment on embankments and cross slope of shoulders. Are the shoulders likely to be used by slow moving vehicles or cyclists? Check safety aspects of rest areas.		
7 The effect of departures from standards or guidelines	Are there any approved departures from standards or guidelines which affect safety? Are there any hitherto undetected departures from standards which should be brought to the attention of the designer?		

Alignment Details

Item	Issues to be Considered	Check	Comments
1 Visibility, sight distance	Are horizontal and vertical alignments consistent with the required visibility requirements? Check that sight lines are not obstructed by: (a) Fences and crash barriers (b) Boundary fences (c) Street furniture (d) Parking facilities (e) Signs (f) Landscaping (g) Bridge abutments. Inappropriate consideration of horizontal and vertical alignment (e.g. horizontal curve just over a crest vertical curve). Check that railway crossings, bridges and other hazards are conspicuous. Are there any other local features which affect visibility? Will sight lines be obstructed by temporary features such as parked vehicles in turn outs, or by parked or queued traffic generally?		
2 New/existing road interface	Have implications for safety at the interface been considered? Are there sudden changes in the speed profile or access or lateral acceleration characteristics? Does the interface occur near any hazard, i.e., at a crest or bend or where poor visibility or distractions occur? Check that the change is affected safely where roadway standards differ. Check transition is safe where road environment changes, for example, urban to rural, fast to slow, lit to unlit. Check the need for advance warning.		
3 Readability by drivers	Will the general layout, function and broad features be recognized by drivers in adequate time? Check the approach speed and general likely position of vehicles as they track through the project.		

Intersections

Item	Issues to be Considered	Check	Comments
1 Visibility to and visibility at intersection	Are horizontal and vertical alignments consistent with the required visibility requirements? Will drivers be aware of the presence of the intersection (especially if facing a Stop/Yield sign)? Check that sight lines are not obstructed by: (a) Fences and crash barriers (b) Boundary fences (c) Street furniture (d) Parking facilities (e) Signs (f) Landscaping (g) Bridge abutments. Check that railway crossings, bridges and other hazards are conspicuous. Are there any local features which require affect visibility? Will sight lines be obstructed by permanent or temporary features such as parked vehicles in turn outs, or by parked or queued traffic generally?		
2 Layout, including appropriateness	Is the type of intersection selected (crossroad, T, roundabout, signalized, etc.) appropriate for the function of the two roads? Are the proposed controls (Stop, Yield, signals, etc.) appropriate for the particular intersection being considered? Are junction sizes appropriate for all vehicle movements? Are there any unusual features which could affect road safety (e.g., cyclists, heavy truck movements, public transport operations, etc.)? Are the lane widths and swept paths adequate for all vehicles? Are there any upstream or downstream geometric features which could affect safety, e.g., merging of lanes?		
3 Readability by drivers	Will the general type, function, priority rules and broad features be recognized by drivers in adequate time. Check the approach speed and general likely position of vehicles as they track through the project.		

Special Road Users

Item	Issues to be Considered	Check	Comments
1 Adjacent land	Will adjacent activity and intensity of land use have an adverse safety effect on the project? Are special measures needed?		
2 Pedestrians	Have pedestrian needs been If footpaths are not specifically provided, is the road layout safe for use by pedestrians, particularly at blind corners or on bridges? Are pedestrian subways or footbridges sited to provide maximum use? Is the avoidance of footbridges or subways possible by crossing the road at grade? Has specific provision been made for pedestrian crossings, school crossings or pedestrian signals? Are these sited to provide maximum use? Are pedestrian refuges/curb extensions needed? Is specific provision required for special groups, e.g., the young, elderly, sick, disabled, deaf, or blind?		
3 Cyclists	Have the needs of cyclists been considered, especially at intersections? Is a bicycle lane needed? Are any bikeways separate from the main roadway, of standard or adequate design? Is there a need for shared pedestrian/cycle facilities? Where bikeways terminate at intersections or adjacent to the roadway, has the transition treatment been handled safely? Are there any needs for special bicycle facilities (e.g., bicycle signals) if not already provided?		

4 Equestrians and stock	Have the needs of equestrians been considered, including the use of verges or shoulders and rules regarding the use of the roadway? Can underpass facilities be used by equestrians/stock?		
5 Freight	Have the needs of truck drivers been considered, including turning radii and lane widths?		
6 Public Transport	Have the needs of public transport users been considered? Are bus stops positioned for safety?		
7 Road maintenance vehicles	Road maintenance vehicles Has provision been made for road maintenance vehicles to safely be used at this site?		

Signs and Lighting

Item	Issues to be Considered	Check	Comments
1 Lighting	Is this project to be lit? Are there difficulties of illuminating sections of the road caused by trees or overpasses, for example? Has the question of siting of lighting poles been considered as part of the general concept of the project? Are frangible or slip-base poles to be provided? Are any special needs created by ambient lighting? Are there any aspects of the provision of lighting poles which would require consideration from the safety point of view in their being struck by vehicles?		
2 Signs	Are sign structures needed? Are signs located at points to allow adequate readability? Are signs located to limit visibility from accesses and intersecting roads? Are signs appropriate to the drivers needs (i.e., destination signs, advisory speed signs, etc)? Have the safety aspects of signs been considered as part of the general concept? Are there any aspects of the provision of sign posts which would require consideration from the safety point of view in their being struck by vehicles?		
3 Marking and delineation	Check that the appropriate standard of delineation and marking has been adopted.		

Construction and Operation

Item	Issues to be Considered	Check	Comments
1 Buildability	Are there any features which could inhibit safe construction (e.g., through traffic, construction vehicles.)?		
2 Operation	Is adequate safe access to the works available?		
3 Traffic management	Are there any factors requiring specific road safety provision, including maintenance?		
4 Network management	Are there any traffic management features which management would require special attention during construction or during the transition from construction to full operation?		

Other Issues

Item	Issues to be Considered	Check	Comments
1 Safety aspects not already covered	This could include unusual events, special effects of land uses alongside, including stock being driven onto or along the road. The ability of the road to take overweight or over-dimension vehicles or other large vehicles - trucks - buses - emergency vehicles - utility/road maintenance vehicles.		

	The ability to close the road for special events in a safe manner. The special requirements of scenic or tourist routes. The provision of rest areas with safe access and egress. Safety auditors are to check for any issue or item not already covered.		

Detailed Design

General Topics

Item	Issues to be Considered	Check	Comments
1 Changes since Stage 2	Check for any major changes in principle since the Stage 2 Audit was carried out. Check that the conditions for which the project was originally designed still apply, i.e., there have not been significant changes to the surrounding network or area to be served, or traffic mix.		
2 Drainage	Will the new road drain adequately? Is there a possibility of surface flooding or overflowing from surrounding or intersected drains and water courses? Is pit spacing adequate to limit flooding?		
3 Climatic conditions	Do weather records or local experience indicate a problem (e.g., snow, ice, wind, fog)?		
4 Landscaping	Check the landscape design or planting species for a lowering of safety. Is it likely to lead to a lower safety with mature or seasonal growth (e.g. through loss of visibility, obscuring signs, shading or light effects, leaves, flowers or seeds dropping on to the highway)? Is frangible vegetation appropriate? Consider pedestrian visibility in particular.		
5 Services	Does the design adequately deal with buried and overhead services? Check the location of fixed objects or furniture associated with services, including for loss of visibility and check the position of lighting and other poles for accuracy. Check the clearance to overhead wires.		
6 Access to property and developments	Can all accesses be used safely? Are there any downstream or upstream effects from accesses, particularly near intersections?		
7 Emergency vehicles and access	Has provision been made for safe access by emergency vehicles? Check the design of medians and vehicle barriers, and the ability of emergency vehicles to stop without necessarily disrupting traffic.		
8 Future widening and/or realignments	If the project is only a stage towards a wider or divided roadway, is the signing and design adequate to impart this message to drivers? Is the transition from two way to divided roadway handled safely?		
9 Staging of the project	If the project is to be staged or constructed at different times, are the construction plans and program arranged to ensure maximum safety and do they include specific safety measures, signing, also adequate transitional geometry for any temporary arrangements?		
10 Staging of the works	If the construction of this project is to be staged or split into several contracts check that these are arranged for maximum safety.		
11 Significant adjacent developments	Check that the design handles accesses to major adjacent generators of traffic and developments safely. Check the need for screening against glare from lighting of adjacent developments. Check that lighting or traffic signals on an adjacent road do not affect the drivers' perception of the road ahead.		
12 Stability of cut and fill	Do the geological conditions in the country through which the road is to be built pose significant threats to the safety of vehicle occupants? Check batters for stability, potential for loose material.		

13 Skid resistance	Check the need for high level skid surface on grades or where braking or good road adhesion is essential.		
14 Maintenance	Check that maintenance vehicles can be safely located.		

Design Issues

Item	Issues to be Considered	Check	Comments
1 Geometry of horizontal and vertical alignment	Check that the horizontal and vertical design of the project fit together comfortably. Check the design for adequacy having regard to the function of the road. Check the possibility of drivers not being able to read the road characteristics, i.e., visual illusions, subliminal delineation, etc.		
2 Typical cross sections	Are the lane widths, shoulders, medians and other cross section features in accordance with standard design or adequate for the function of the road?		
3 Effect of cross-sectional variation	Check that there are no variations in cross section design which could affect safety, particularly where sections of existing highway have been utilized, or there have been compromises to accommodate accesses, etc. Check where compromises have been made, e.g., at bridges or to avoid physical features.		
4 Roadway layout	Check that total traffic management features (i.e., in addition to questions of horizontal and vertical alignment and cross section) are not likely to create unsafe conditions. This includes the installation of signs and markings both on the road and nearby to deal with changes in alignment, particularly where these are substandard.		
5 Shoulders and edge treatment	Check the safety aspects of shoulder provision, if any, including seal shoulders, the width and treatment on embankments and cross slopes of shoulders. Are the shoulders likely to be used by slow moving vehicles or cyclists?		
6 The effect of departures from standards or guidelines	Are there any approved departures from standards or guidelines which affect safety? Are there any hitherto undetected departures from standards which should be brought to the attention of the designer?		
7 Visibility, sight distance	Are horizontal and vertical alignments consistent with the required visibility requirements? Confirm that the standard adopted for provision of visibility in the design is appropriate for the ruling or 85th percentile speed and for any unusual traffic mix. Check that sight lines are not obstructed by: (a) Safety fences and barriers (b) Boundary fences (c) Street furniture (d) Parking facilities (e) Signs (f) Landscaping (g) Bridge abutments. Check that railway crossings, bridges and other hazards are conspicuous. Will sight lines be obstructed by temporary features such as parked vehicles in turn outs, or by parked or queued traffic generally?		
8 Signs and markings	Has the design approach taken into account the provision of signs and road markings? Are they adequately detailed so as to promote good traffic management and safety?		

Alignment Details

Item	Issues to be Considered	Check	Comments
1 Visibility, sight distance	Are horizontal and vertical alignments consistent with the required visibility requirements? Confirm that the standard adopted for provision of visibility in the design is appropriate for the ruling or 85th percentile speed and for any nusual traffic mix. Check sight lines are not obstructed by: (a) Safety fences and barriers (b) Boundary fences (c) Street furniture (d) Parking facilities (e) Signs (f) Landscaping (g) Bridge abutments. Check that railway crossings, bridges and other hazards are conspicuous. Will sight lines be obstructed by temporary features such as parked vehicles in turn outs, or by parked or queued traffic generally?		
2 New/existing road interface	Have implications for safety at the interface been considered? Include the accident rate and severity on the adjacent network, and the effect of sudden changes in the speed profile or access and side friction characteristics. Does the interface occur near any hazard, i.e., at a crest or bend or where poor visibility or distractions occur? Check that the change is affected safely where roadway standards differ. Check transition is safe where road environment changes, for example, urban to rural, fast to slow, lit to unlit. Check the need for advance warning.		
3 Readability by drivers	Will the general layout, function and broad features be recognized by drivers in adequate time for safety not to be impaired? If new work is of higher geometric standard —is there clear and unambiguous advance warning or reduction in standard? Is there need for a transition zone between higher standard of new road and lower standard of old road (especially perception of horizontal curvature, which is the primary determinant out of desired speed). Check the approach speed and general likely position of vehicles as they track through the project.		
4 Detail of geometric design	Check that the design standards are appropriate for all the new requirements of the proposed project. Check for consistency of general standards and guidelines such as lane widths and cross slopes.		
5 Treatment of bridges and culverts	Check that the geometric transition from the standard cross section to that on the bridge is handled so as to promote safety.		

Intersections

Item	Issues to be Considered	Check	Comments
1 Visibility to and visibility at intersection	Are horizontal and vertical alignments consistent with the required visibility requirements? Will drivers be aware of the presence of the intersection (especially if facing a Stop/Yield sign)? Confirm that the standard adopted for provision of visibility in the design is appropriate for the ruling or 85th percentile speed and for any unusual traffic mix. Check that sight lines are not obstructed by: (a) Safety fences and barriers (b) Boundary fences (c) Street furniture (d) Parking facilities (e) Signs (f) Landscaping (g) Bridge abutments. Check that railway crossings, bridges and other hazards are conspicuous. Will sight lines be obstructed by permanent or temporary features such as parked vehicles in turn outs, or by parked or queued traffic generally?		
2 Layout	Check junctions and accesses are adequate for all vehicle movements. Check turning paths to establish that the layout caters for the design vehicles and other road users. Checks safety of any unusual features. Check if heavy truck movements or curvature of the roadway may suggest that the opposing left turn lanes be offset to gain sight distance. Check need for crash attenuators or pedestrian fences. Check need for channelization islands and signs. Check features for visibility intrusion e.g., crash attenuators, pedestrian fences, signs, and traffic signals. Check safety where vehicles (including buses and taxis) may park or service premises within the intersection area.		
3 Readability by drivers	Will the general type, function, priority rules and broad features be recognized by drivers in adequate time. Check the approach speed and general likely position of vehicles as they track through the project. Is there anything misleading?		
4 Detail of geometric design	Check the layout adopted for traffic safety, compliance with standards or reason for variation, swept paths, ability to handle unusual traffic mixes or circumstances safely. Check that receiving lanes are 12 ft. (3.6m) wide with a 4 ft. (1.2m) outside shoulder, minimum. Check that roadways meet at angles of 90 degrees, and no less than 75 degrees. Check the correctness of the design approach speed and general likely position of vehicles.		
5 Traffic signals	Check visibility of signal head. Can drivers be confused by seeing other signal aspects within the intersection or elsewhere? Check need for high intensity signals, strobes, and/or backplates if likely to be affected by sunrise/sunset. Check if separate signal heads are used to control movements in each lane. Check to see that the protected left turn phase is leading, not trailing. Check markings for left and right turn vehicles. Determine if protected-only phases can be used without an unacceptable reduction in level of service. Check if right-turn-on-red has been prohibited at skewed intersections if angle is less than 75 degrees or greater than 105 degrees. Check if street name signs are included. Check if overhead lane control signs are appropriate. Check need for pedestrian phases and/or protected turning movements.		
6	Check that deflection angles of approach roads are adequate.		

Roundabouts and approach islands	Check need for splitter islands. Check that center island is prominent. Check need for hazard markers and markings and that they are correctly located. Check need for dedicated lanes. Check that speeds are not likely to be greater than 50 km/h (or lower in local street). Check that speeds are not likely to be greater than 50 km/h (or lower in local street). Check pole location on central island and nearby curbs.		
7 Other intersections	Check the need for curbed or painted islands and refuges. Check intersection has adequate storage space for turning movements. Check that staggered cross roads can accommodate all vehicle types and movements.		

Special Road Users

Item	Issues to be Considered	Check	Comments
1 Adjacent land	Check that access to and from adjacent land/properties is safe. Consider the special needs of agriculture, movements of stock.		
2 Pedestrians	Check that fencing is adequate on freeways. Check need to deter pedestrians from crossing road at unsafe locations. Check if raised channelization is used in low speed areas. Check provision for pedestrians to cross safely at: (a) Intersections (b) Signalized and pedestrian crossings (c) Refuges (d) Curb extensions (e) Other locations. Check the following for each crossing (bridges, subways, at grade) as necessary: (a) Visibility (b) Use by disabled (c) Use by elderly (d) Use by children/schools (e) Need for pedestrian fencing on reservations and medians (f) Signs (g) Width and gradient (h) Surfacing (j) Avoidance of channels and gullies (k) Need for deterrent curbing (I) Need for lighting (m) Sited to provide maximum use (n) Can their use be avoided by crossing at grade or elsewhere?		
3 Cyclists	Check needs of cyclists have been considered: (a) At intersections (particularly roundabouts) (b) On roads having speed in excess of 50 km/h (c) Bicycle routes and crossings. Check shared bikeway/footway facilities including subways and bridges are safe and adequately signed.		
4 Equestrians and stock	Check needs have been considered and adequately signed and catered for.		
5 Freight	Check needs have been considered and adequately signed and catered for.		
6 Public Transport	Check that needs have been considered and adequatelysigned and catered for.		
7 Road maintenance vehicles	Check that needs have been considered and adequatelysigned and catered for, i.e., crossovers, radii, sight distance concerns, etc.		

Signs and Lighting

Item	Issues to be Considered	Check	Comments
1 Lighting	Is this project to be lit? Are there difficulties of illuminating sections of the road caused by trees or over bridges, for example? Has the question of siting of lighting poles been considered as part of the general concept of the scheme? Are frangible or slip-base poles to be provided? Are any special needs created by ambient lighting? Are there any aspects of the provision of lighting poles which would require consideration from the safety point of view in their being struck by vehicles (e.g., traffic islands)?		
2 Signs	Are sign structures needed? Are signs located at points to allow adequate readability? Are signs located to limit visibility from accesses and intersecting roads? Are signs appropriate to the drivers needs, i.e., destination signs, advisory speed signs, etc.? Have the safety aspects of signs been considered as part of the general concept? Are there any aspects of the provision of sign posts which would require consideration from the safety point of view in their being struck by vehicles?		
3 Marking and delineation	Check that the appropriate standard of delineation and marking has been adopted.		

Physical Objects

Item	Issues to be Considered	Check	Comments
1 Median barriers	Are median barriers necessary and have they been properly detailed? Are there any design features such as end conditions which require special attention?		
2 Poles and other obstructions	Are there any poles located adjacent to moving traffic which could be sited elsewhere, (i.e., atthe property boundary)? Have frangible or breakaway poles been detailed? Is the unprotected median width adequate to accommodate lighting poles? Check the position of traffic signal controllers and other service apparatus. Are there any other obstructions which are likely to create a safety hazard and can they be mitigated or relocated?		
3 Crash attenuators and guide rail	Is a crash attenuator provided where necessary and is it properly detailed? Are there any features about the design or presence of the crash attenuator which could create danger to any road user, including pedestrians? Are the end conditions of the crash attenuator likely to create a safety problem? Do any guide rail installations restrict sight distance? Is the guide rail designed according to standards: - end treatments - NCHRP 350 requirements - driveway treatments - intersecting road treatments - anchorages - post spacings - block outs - post depths - rail overlaps - minimum unobstructive distances		
4 Bridges and culverts	Check bridge barrier and culvert end walls for: (a) Visibility (b) Ease of recognition (c) Proximity to moving traffic (d) Possibility of causing injury or damage (e) Collapsible or frangible ends		

	(f) The need to be able to see through bridge guard railing for safety purposes (g) Signs and markings (h) Connection of bridge railing to bridge posts (i) Connection of approach barriers to bridge (j) End post transition of stiffness between approach barrier and bridge end post.		

Construction and Operation

Item	Issues to be Considered	Check	Comments
1 Constructability	Check that traffic management provisions are adequate during construction period. Check that site access routes are safe. Check need for construction safety zones, including overhead work. Check need for restrictions on any road. Check that law enforcement and other emergency services have been consulted.		
2 Operation	Check access to structures and road furniture is safe. Check that the road or utilities in the road reserve can be maintained safely. Both road users and maintenance personnel should be considered.		
3 Traffic management	Check that the traffic management of the construction site has been adequately spelled out from the safety point of view, and that the transition from the existing arrangements to the construction site and from the construction site to the final layout can be effected safely, and has been adequately detailed.		
4 Network management	Check that all parking and clearway matters affecting road safety have been considered.		
5 Temporary traffic control and management	Check that the arrangements for temporary traffic control or management, including possible signals, temporary diversions including signing and lighting of the site have been adequately detailed from the safety point of view.		

Other Issues

Item	Issues to be Considered	Check	Comments
1 Safety aspects not already covered	Safety auditors are to check for any issue or item not already covered. This could include: (a) Unusual events (b) Special effects on land uses alongside (c) Stock being driven onto or along the road (d) The ability of the road to take overweight or over-dimension vehicles or other large vehicles - trucks - buses - emergency vehicles - utility/road maintenance vehicles. (e) The ability to close the road for special events in a safe manner. (f) The special requirements of scenic or tourist routes. (g) Signals not at intersections.		

	Yes	No	N/A	Comments
ROAD SAFETY AUDIT—GENERAL ISSUES (1 OF 2)				
<u>INTERSECTIONS</u>				
Are intersections free of sight restrictions that could result in safety problems?				
Are intersections free of abrupt changes in elevation or surface condition?				
Are advance warning signs installed when intersection traffic control cannot be seen a safe distance ahead of the intersection?				
<u>SIGNING AND DELINEATION</u>				
Signing				
Is the road free of locations where signing is needed to improve safety?				
Are the regulatory, warning, and directory signs in place conspicuous?				
Is the road free of unnecessary signing that may cause safety problems?				
Are signs effective for likely conditions?				
Can signs be read at a safe distance?				
Is the road free of signing that impairs safe sight distances?				
Delineation				
Is the road free of locations with improper or unsuitable delineation (post delineators, chevrons, object markers)?				

	Yes	No	N/A	Comments
ROAD SAFETY AUDIT—GENERAL ISSUES (2 OF 2)				
ROADSIDE FEATURES / PHYSICAL OBJECTS				
Are clear zones free of hazardous, non-traversable side slopes with no safety barriers?				
Are the clear zones free of nonconforming and/or dangerous obstruction that are not properly attenuated?				
SPECIAL ROAD USERS				
Are travel paths and crossing points for pedestrians and cyclists properly signed and/or marked?				
Are bus stops safely located with adequate clearance and visibility from the traffic lane?				
Is appropriate advance signing provided for bus stops and refuse areas?				
RAILROAD CROSSINGS				
Are railroad crossing (cross bucks) signs used on each approach at railroad crossings?				
Are railroad crossings free of vegetation and other obstructions that have the potential to restrict sight distance?				
Are roadway approach grades to railroad crossings flat enough to prevent vehicle snagging?				
CONSISTENCY				
Is the road section free of inconsistencies that could result in safety problems?				

	Yes	No	N/A	Comments
ROAD SAFETY AUDIT—PAVED ROAD ISSUES (1 OF 1)				
PAVEMENT MARKINGS				
Is the road free of locations with pavement marking safety deficiencies?				
Is the road free of pavement markings that are not effective for likely conditions?				
Is the road free of old pavement markings that affect the safety of the roadway?				
PAVEMENT CONDITION				
Is the pavement free of defects that could result in safety problems (e.g., loss of steering control)?				
Are changes in surface type (e.g., pavement ends) free of drop-offs/poor transitions?				
Is the pavement free of locations that appear to have inadequate skid resistance that could result in safety problems, particularly on curves, steep grades, and approaches to intersections?				
Is the pavement free of areas where ponding or sheet flow of water occurs resulting in safety problems?				
Is the pavement free of loose aggregate/gravel that may cause safety problems?				

	Yes	No	N/A	Comments
ROAD SAFETY AUDIT—UNPAVED ROAD ISSUES (1 OF 1) **ROADWAY SURFACE** Is the road surface free of defects that could result in safety problems (e.g., loss of steering control)? Is the road surface free of areas where ponding or sheet flow of water occurs resulting in safety problems? Is the road surface free of loose gravel/fines that may cause safety problems (control, visibility, etc.)? Are changes in surface type (e.g., pavement ends) free of drop-offs/poor transitions?				

Road Safety Audits and Road Safety Audit Reviews

Road safety audits (RSAs), adaptable to local needs and conditions, are a powerful tool for state and local agencies to enhance the state of safety practices in their jurisdictions. With fewer new projects being constructed, the focus of RSAs is shifting to use by local agencies on existing roadways. For an existing road, the RSA is called a road safety audit review (RSAR).

What is an RSA? Simply put, an RSA is an examination of a future or existing roadway in which an independent, qualified audit team reports on safety issues. The step-by-step procedure of an RSA can be performed during any or all stages of a project, including planning, preliminary design, detailed design, construction, pre-opening, and on existing roads.

RSAs are a proactive approach to improving transportation safety. Agencies in the United States are just beginning to focus on RSAs. Considering the unacceptable number of motor vehicle crashes that occur each year, the potential savings—in lives, serious injuries, and property damage—is incalculable.

Although concerns have been raised that the use of RSAs would increase an agency's liability, in fact, just the opposite should be true. Implementing a plan to reduce the crash potential and improve the safety performance of a roadway using a proactive approach to safety can be used in defense of tort liability. Identifying and documenting safety issues on an existing roadway is not an admission of guilt. Rather, it is the first step in a process designed to improve safety. Proper documentation, communication, and logical prioritization of an agency's plan to address safety issues would be difficult to fault.

An RSAR program need not be disruptive to an agency's ongoing operations; it can be implemented in small stages as time and resources allow. Classifying the roads in your jurisdiction and tailoring the RSAR to fit your needs is a practical approach to improving road safety that can be implemented in spite of limited resources and the ongoing need to focus on maintenance and operations. Consider using the expertise of personnel from neighboring counties to lend more eyes and fresh viewpoints in assessing the safety of your roadways. Seek additional and special funding from 402 safety funds using the results of the audit.

Determine the value of an RSAR by (1) having a roadway section audited using a team of three or four road supervisors and engineers from adjacent counties, and/or (2) auditing a major project being designed to improve one of your roads. The value of the RSA/RSAR process as an important component of any agency's safety strategy will become evident.

Planning for an RSAR Program

I. Classify your roadway system functionally.
   a. Identify several sections of roadways in each functional classification for an RSAR trial.
II. Begin a trial RSAR program.
   a. Solicit reviews from team of adjacent local county engineers and road supervisors (three or four).
   b. Provide the RSAR for one another's selected roadways. (Use the attached RSAR Tool Kit.)
III. Prepare a brief statement of your findings.
   a. Briefly summarize the safety issues.
   b. Prioritize the issues identified.
   c. Recommend actions to be taken.
   d. Provide an overall evaluation of the road section.
   e. Discuss the findings with each county.
IV. Seek special funding as needed.
   a. Consider applying for 402 safety funds.
V. Implement and evaluate the RSAR program.
   a. Implement improvements.
   b. Evaluate the RSAR concept.
   c. Evaluate the effectiveness of the improvements.
VI. Make the decision on beginning an RSAR trial program.
   a. Begin an RSAR program by developing a four- or five-year plan to look at all roadways.
   b. Consider auditing the design of a major project from a safety viewpoint for all road users.
VII. Promote the proactive RSA/RSAR program.

RSA TOOL KIT

Developed by Eugene M. Wilson, Ph.D., PE, PTOE

Safety Issues to LOOK FOR:

Roadside Features

1. Are clear zones free of hazards and non-traversable side slopes without safety barriers?
2. Are the clear zones free of nonconforming and/or dangerous obstructions that are not properly shielded?

Road Surface—Pavement Condition

3. Is the pavement free of defects that could result in safety problems (e.g., loss of steering control)?
4. Are changes in surface type (e.g., pavement ends or begins) free of poor transitions?
5. Is the pavement free of locations that appear to have inadequate skid resistance that could result in safety problems, particularly on curves, steep grades, and approaches to intersections?
6. Is the pavement free of areas where ponding or sheet flow of water may occur resulting in safety problems?
7. Is the pavement free of loose aggregate/gravel that may cause safety problems?

Road Surface—Pavement Markings

8. Is the road free of locations with pavement marking safety deficiencies?
9. Is the road free of pavement markings that are not effective for the conditions present?
10. Is the road free of old pavement markings that affect the safety of the roadway?

Road Surface—Unpaved Roads

11. Is the road surface free of defects that could result in safety problems (e.g., loss of steering control)?
12. Is the road surface free of areas where ponding or sheet flow of water may occur resulting in safety problems?
13. Is the road surface free of loose gravel or fines that may cause safety problems (control, visibility, etc.)?
14. Are changes in surface type (e.g., pavement ends or begins) free of drop-offs or poor transitions?

Signing and Delineation

15. Is the road free of locations where signing is needed to improve safety?
16. Are existing regulatory, warning, and directory signs conspicuous?
17. Is the road free of locations with improper signing that may cause safety problems?
18. Is the road free of unnecessary signing that may cause safety problems?
19. Are signs effective for existing conditions?
20. Can signs be read at a safe distance?
21. Is the road free of signing that impairs safe sight distances?
22. Is the road free of locations with improper or unsuitable delineation (post delineators, chevrons, and object markers)?

Intersections and Approaches

23. Are intersections free of sight restrictions that could result in safety problems?
24. Are intersections free of abrupt changes in elevation or surface condition?
25. Are advance warning signs installed when intersection traffic control cannot be seen a safe distance ahead of the intersection?

Special Road Users, Railroad Crossings, Consistency

26. Are travel paths and crossing points for pedestrians and cyclists properly signed and/or marked?
27. Are bus stops and mail boxes safely located with adequate clearance and visibility from the traffic lane?
28. Is appropriate advance signing provided for bus stops and refuge areas?
29. Are railroad crossing (cross bucks) signs used on each approach at railroad crossings?
30. Are railroad advance warning signs used at railroad crossing approaches?
31. Are railroad crossings free of vegetation and other obstructions that have the potential to restrict sight distance?
32. Are roadway approach grades to railroad crossings flat enough to prevent vehicle snagging?
33. Is the road section free of inconsistencies that could result in safety problems?

APPENDIX E

South Carolina DOT Road Safety Audit Program

SCDOT
SAFETY AUDIT

Administrative Procedures

August 2002

Road Safety Audit Roles/Responsibilities

Road Safety Audit Team Selection Process

Road Safety Audit Project Selection Process

Road Safety Audit Project Procedures

Road Safety Audit Reporting Procedures

Follow-up on Results of Audit

SCDOT ROAD SAFETY AUDIT PROGRAM

Administrative Procedures
August, 2002

ROAD SAFETY AUDIT (RSA) ROLES/RESPONSIBILITIES

Program Coordination

The SCDOT RSA Program will be coordinated by the SCDOT Safety Office. The Director of Safety is responsible for oversight and management of the program.

Road Safety Audit Program Advisory Committee

An RSA Program Advisory Committee has been established to provide guidance and advice in the implementation of the RSA Program. The RSA Program Advisory Committee's role in the program is as follows:

- Participate in quarterly or semi-annual (as appropriate) meetings.
- Review program procedures and make recommendations to enhance operations.
- Review and approve annual projects selected for audit.
- Review and approve an annual report to be submitted to Executive Management, detailing progress, cost, cost savings, and benefits realized by the program.

The RSA Program Advisory Committee is chaired by the Director of Safety. Committee members include:

- Deputy State Highway Engineer
- Director of Construction
- Director of Maintenance
- Director of Pre-Construction
- Director of Traffic Engineering
- Director of Planning
- District Engineering Administrators (2–3 selected annually).

RSA Program Coordinator

The Director of Safety will assign a staff member to serve as the RSA Program Coordinator (PC). The RSA PC is responsible for day-to-day operations and the full implementation of the program. Responsibilities include but are not limited to the following areas:

- Develops, monitors, and updates policies and procedures for the RSA Program.
- Solicits and assembles an annual list of proposed projects for consideration for audit.
- Assembles RSA personnel on a bi-annual basis.
- Develops and prepares a final annual list of projects selected for audit.
- Schedules and coordinates RSA Program Advisory Committee meetings.
- Coordinates bi-annual RSA personnel training through seminars/workshops.
- Obtains project information from Pre-Construction Program Manager (PM) and/or District Engineering Administrator (DEA).
- Makes RSA team assignments based on project specifics in coordination with Engineering Directors and DEAs.
- Coordinates team meetings for each stage of the project.
- Oversees and monitors the implementation of RSA stages for all audits conducted.
- Monitors communication between RSA teams and the PM and/or DEA.

- Serves as a mediator for conflict resolution.
- Provides the RSA team with the DEA's response to audit.
- Briefs the RSA Program Advisory Committee on the annual progress of audits.
- Maintains all original correspondence, audit reports, budget, and logistics associated with all audits.
- Monitors funding allocated to RSA projects.
- Develops RSA Program annual budget.
- Compiles evaluation data as appropriate for roads/projects for which audits were conducted.

RSA Team

An RSA Team will be established for each project selected for audit. A different team may be established for the various phases of the audit, depending upon the amount of time between phases and the availability of team members. The RSA PC will select team members based upon their expertise as related to the project selected for audit. The RSA PC will contact the appropriate Engineering Director/DEA to verify the availability of the selected individual for service on a team. Once the Engineering Director/DEA has given approval for the individual to serve on the team, the person selected will be notified accordingly.

RSA Team members will be nominated for service bi-annually by the Engineering Directors and DEAs. Team members will serve a two-year term and will receive training in the RSA concept and procedures prior to service. Each RSA Team is responsible for the following:

- Completing RSA training prior to participating in an audit.
- Electing a Team Leader at the beginning of each audit.
- Using their expertise to identify concerns relative to proposed project.
- Preparing audit reports for each audit stage completed.
- Providing documentation to the RSA PC regarding expenditures and time allocated to a specific audit.

District Engineering Administrator

The DEAs will serve as the central point of contact for projects selected for audit within their districts. The DEA's role in the RSA Program is as follows:

- Provide necessary information on the project as requested by the RSA PC.
- Present the project to the audit team.
- Be available for questions during an audit.
- Review RSA report recommendations.
- Determine action(s) to be taken.
- Investigate alternate solutions to address the identified concerns.
- Respond to concerns outlined in the RSA report.
- Respond to the RSA report and forward a written response to the RSA PC.
- Seek funding and implement solutions.

In fulfilling these responsibilities, the DEA may appoint/assign staff as appropriate to assemble the information needed.

Pre-Construction Program Manager

The PM's role in the RSA Program is as follows:

- Provide necessary information on projects as requested by the RSA PC.
- Present project (Stages 1 and 2) to audit team.
- Be available for questions during audit.

ROAD SAFETY AUDIT TEAM SELECTION PROCESS

- The RSA PC will assemble RSA teams based on assigned projects. Teams will include a minimum of four members and often additional members from the following areas:

  - Preconstruction
  - Construction (includes CRM representative)
  - Planning
  - Traffic engineering
  - Maintenance
  - District offices
  - Non-SCDOT personnel (police/fire/EMS/community organizations—pedestrian, bicyclist, transit, etc./local traffic engineers)
  - Safety
  - Risk management

- The RSA PC will submit a memorandum to the DEA or Engineering Director advising which project team members in their division are being requested to serve on a team. Once approval is granted, the RSA PC will contact the individual selected.

- The RSA PC will schedule a meeting with each team independently. At the meeting, the teams will select a Team Leader for each project.

- The RSA PC will open the meeting, introducing the team members and then the Pre-Construction PM and/or the DEA (or his assigned staff person) who will present the audit projects. Following the introductions and project presentation, the team will be required to accomplish the following:

  - Select a Team Leader.

  - Establish a Project Completion Schedule.

    - Schedule a meeting with project PM,
    - Conduct the audit and draft a report, and
    - Establish final submittal date of report.

  - Assign Project Responsibilities (if applicable).

- RSA Team members will serve a two-year term. Department Directors and DEAs will have the opportunity to assign individuals to assist in the RSA Program on a bi-annual cycle.

- RSA Training Workshops will be conducted every two years for new team members. The RSA PC will conduct the workshops.

ROAD SAFETY AUDIT PROJECT SELECTION PROCESS

- During the first week of May of each year, the RSA PC will request from various SCDOT Directors/DEAs/Deputy State Highway Engineer a list of five potential projects to be evaluated through the RSA program for the upcoming fiscal year (July 1–June 30). Proposed projects will be submitted to the RSA PC within two weeks of the request. The following individuals will be asked to submit potential projects:

  - Director of Preconstruction
  - Director of Construction
  - Director of Planning
  - Director of Traffic Engineering
  - Director of Maintenance

- District Engineering Administrators
- Director of Safety
- Deputy State Highway Engineer.

- The RSA PC will compile a summary of the potential projects by category: (1) new infrastructure projects, (2) projects under construction, and (3) existing infrastructure with high crash frequencies. The listing will denote if a road/project has been proposed by more than one office.

- The RSA PC will review the project summary and compile a proposed list of projects selected for audit for the upcoming fiscal year. The number of projects included for audit may vary annually and will be based on the availability of budget funds and the estimated amount of time needed to conduct audits on the projects selected.

- Upon completion of the "Proposed Projects Selected for Audit" list, the RSA PC will schedule a meeting of the RSA Program Advisory Committee for mid-June. The RSA PC will forward the "Proposed Projects Selected for Audit" list to members of the RSA Program Advisory Committee for their review in advance of the meeting.

- The RSA PC shall serve as staff/resource personnel for the Advisory Committee.

- The RSA PC will make all necessary arrangements for the annual RSA Advisory Committee meeting, as well as prepare all necessary materials.

- The RSA Advisory Committee will meet on the scheduled day to discuss and select the RSA projects for the upcoming fiscal year. Projects will be chosen as follows:

  - 2-New Infrastructure Projects
  - 5-Projects Under Construction
  - 3-Existing Infrastructure.

- The RSA Advisory Committee will review RSA operational procedures and discuss any recommended changes.

- The RSA PC will provide the Committee with an annual report summarizing the results of audits conducted during the previous fiscal year.

- The RSA PC will prepare meeting minutes from the annual meeting and distribute them to all Committee and RSA Team members.

ROAD SAFETY AUDIT PROJECT PROCEDURES

Projects will be evaluated using the established RSA stages.

Future Roads

- RSA Stage 1—Planning
  The RSA team will complete at a minimum the following:

  - Review basic project scope,
  - Review proposed layouts for alternative routes,
  - Evaluate intersection access and surrounding topography,
  - Examine project impact to surrounding roadway system, and
  - Evaluate type of access/access management.

- RSA Stage 2—Preliminary Design
  The RSA team will evaluate at a minimum the following categories:

- Alignment alternatives,
- Interchange type and layout,
- Intersection design,
- Sight distances,
- Lane and shoulder widths,
- Provisions for non-motorized vehicles, and
- Superelevation.

- Once a project is under construction, the Team will follow guidelines for RSA stages listed under "Roads Under Construction."

Roads Under Construction

- RSA Stage 3—Final Design
  The RSA team will evaluate at a minimum the following:

  - Final geometric design,
  - Signing and pavement marking plan,
  - Lighting,
  - Landscaping,
  - Provisions for special users, and
  - Drainage, guardrail, and other roadside obstacles.

- RSA Stage 4—Pre-Opening
  The RSA team will review the road after most construction is complete. The main focus is to find overlooked physical obstructions and weather-related concerns missed in prior audit stages.

- Once the project is complete, the Team will follow guidelines for the RSA stage listed under "Existing Roadways."

Existing Roadways

- RSA Stage 5—Operations Review
  This stage allows the audit team a final look at how well the road operates and to identify safety concerns while observing actual traffic and traveling the route.

ROAD SAFETY AUDIT REPORTING PROCEDURES

The following steps will be completed for each RSA stage:

- The RSA team meets with the Pre-Construction PM or DEA (or the staff person to whom he has assigned the project) to discuss the project and receive background materials.

- The RSA team conducts a RSA audit based on established RSA procedures.

- Upon completion of each RSA stage, the Team will discuss their observations, develop recommendations, prioritize recommendations, and establish a consensus on which concerns and recommendations should be included in the RSA report. The Team Leader will prepare a report outlining the stage's findings and recommendations. The report will be submitted to the DEA in charge of the project, RSA Team members, and the RSA (PC).

- The DEA has up to 45 days to reply to the RSA report. The RSA Team will determine the amount of time for reply, based on the complexity of the recommendations made. The time for response may vary from 15 to 45 days. Extensions may be requested as needed. The reply should address each of the issues listed. The DEA has the option of incorporating the recommendations; however, the recommendations are not mandatory. If the DEA does not use a recommendation, he must state a reason.

- In assembling information for response to the audit recommendations, the DEA (or the staff person assigned) should contact at a minimum the Pre-Construction Program Manager; Traffic Engineering; Environmental; Right-of-Way; and other units that may have pertinent information or be impacted by the recommendation. Information these groups provide will assist the DEA in making a determination as to whether the recommendation can be implemented.

- The DEA forwards his response to the RSA PC.

- The RSA PC will forward to the RSA Team the DEA's response.

- The RSA PC is responsible for maintaining all original correspondence, reports, etc.

- Team members will provide copies of their time sheets and expense reports to the RSA PC to be used as documentation of total expenditures. This documentation will be filed by audit.

- The RSA PC will be required to review the expenditure/time documents and verify validity. If there are any discrepancies, the RSA PC will request an explanation (via email or written memorandum) from the team member.

Abbreviations used without definition in TRB Publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation