

# Corridor Management Plan and Project Level In-Service Road Safety Review Guidelines

## Introduction

*These guidelines were prepared in response to the realization that, although ICBC sponsored highway corridor safety analyses were making good recommendations over the past several years, they were not meeting all of MoT's Corridor Management Plan (CMP) Safety Review needs. Principally they were not identifying all of the corridor's safety problems or developing a full range of options suitable for MoT Capital Program Development, problem identification criteria were not uniform across all corridors, the problem definition and option development phases did not allow for sufficient input from staff and stakeholders familiar with the corridors, and the option evaluation phase was based on ICBC criteria which differ from MoT criteria.*

*Past corridor safety reviews sponsored by ICBC have focussed on lower cost improvements that would typically fall into the MoT rehabilitation program "safety" category. This is usually an effective interim strategy to improve safety to tie over to capital investments; however, MoT is interested in developing and evaluating options that fall into all program categories (capital, rehabilitation, maintenance and operations).*

*To ensure that the requirements of all relevant agencies are met, it is necessary that a corridor safety review provide a complete and thorough problem identification and problem definition. This will provide the background safety analysis necessary for ICBC and/or MoT to fully understand the magnitude of the corridor safety problems, and to subsequently develop and evaluate improvement options for all problem sites as time and budget permit.*

*In some cases, ICBC safety option development has been performed in isolation of the rest of the Corridor Management Plan option development. To assist in a broader perspective, MoT should lead the option development and evaluation steps. ICBC safety recommendations can be used as input to the more comprehensive option development and evaluation undertaken by MoT in Corridor Management Plans.*

*MoT acknowledges the importance of ICBC involvement with expertise and funding, but requires a more balanced approach. A description of the recommended approach follows.*

## Overview of the CMP Safety Review Process

*Note – although these guidelines have been written from the CMP perspective they generally apply to project level analysis as well.*

A comprehensive CMP safety review involves the review and analysis of all available data and information necessary to carry out the following 4 steps.

1. Problem Identification (Where are the safety problems?)
2. Problem Definition (What are the root causes of the identified problems?)
3. Option Development (What options are reasonable?)
4. Option Evaluation (What are the costs, benefits and other impacts of each option?)

Furthermore, these steps need be investigated at each of the following 3 levels.

1. Corridor level
2. Homogeneous section level
3. Project level – collision prone locations and sections

Examples of solutions at the corridor or homogeneous section level include improved signing, continuous shoulder rumble strips, and skid resistant pavement.

In general, options should consider countermeasures involving one or more of:

1. engineering
2. enforcement
3. education

It is not anticipated that a CMP safety review will go into specifics about enforcement and education options, but it should recognize that in some cases it may be more cost-effective to address problem areas through these approaches than through a solution involving capital or rehabilitation funding.

Safety improvements will generally fall into one of the following 3 programs:

1. Capital – short term (0 to 3 yrs), medium term (4 to 10 yrs) and long term (11 to 25 yrs)
2. Rehabilitation
3. Maintenance

There are no specific safety programs for maintenance, but it is included here because it should be recognized that some improvements such as enhanced shoulder sweeping or brush clearing could improve safety.

# **CMP Safety Review Guidelines**

## ***Introduction***

The four main steps in the CMP safety review process are:

1. Comprehensive problem identification
2. Comprehensive problem definition
3. Option development – for as many problems as time and budget permit
4. Option evaluation

Steps 1 and 2 may be completed by an MOT or ICBC consultant; however, it is important that a complete and thorough list of safety problem sites be identified and defined. This will provide the background safety analysis necessary for ICBC and/or MoT to fully understand the magnitude of the corridor's safety problems, and to subsequently develop and evaluate improvement options for all problem sites as time and budget permit.

Steps 3 and 4 should be carefully managed by MOT in conjunction with the option development and evaluation of other corridor deficiencies. ICBC consultant work on steps 3 and 4, when available, is valuable input to MoT managed steps 3 and 4. The four steps are described in more detail below.

Important reference documents:

1. Canadian Guide to In-Service Road Safety Reviews, TAC, January 2004
2. Highway Safety Manual, AASHTO, 2010
3. Collision Prediction Models for BC, available on the ministry Internet
4. Collision Modification Factors for BC, available on the ministry Internet
5. CMF Clearinghouse, available on the www

## ***1.0 Comprehensive Problem Identification***

The objective of this first step is to develop a comprehensive list of specific locations (e.g. intersections) and highway segments where a safety problem exists. Problems are identified where safety performance is below acceptable thresholds or where there are other good reasons to believe that a safety problem exists. Additionally, the safety performance of homogeneous highway sections and the corridor as a whole should be investigated. A number of primary screening tools are recommended in order to develop a comprehensive list.

### ***1.1 Collision Information System (CIS) – Collision Prone Locations (CPL) Program and Collision Prone Sections (CPS) Program***

The ministry's Collision Information System (CIS) is the principle source of collision data for highway corridors. The CIS contains data for collisions that have occurred on the ministry's landmark kilometer inventory (LKI) network if they were attended by police officials and if there was a fatality, an injury, or property damage exceeded \$1000. The primary tools in the CIS for identifying safety problem sites are the Collision Prone Locations (CPL) Program and the Collision Prone Sections (CPS) Program.

- The CPL/CPS programs produce a list of locations (i.e. stop and signal controlled intersections) and a list of highway sections (minimum 1km in length) where safety performance is below a user specified threshold. Typical provincial criteria/thresholds are as follows:

Collision rate  $\geq$  critical collision rate\*

*OR*

Collision severity ratio  $\geq$  threshold collision severity ratio (typically 6.2 to 7.2)

*AND*

Collision frequency  $\geq$  threshold collision frequency (typically 3 collisions/yr)

\* The critical collision rate is a statistically adjusted provincial average collision rate which must be calculated separately for every location and section under investigation.

- These programs do not have to be run for each CMP because base provincial CPL/CPS lists have already been produced and are available for use by MoT staff and consultants retained by MoT. These provincial lists contain sites identified using the “level 1” criteria specified above as well as sites identified using a lower “level 2” criteria (frequency reduced to 1 collision/yr).
- Separate CPL/CPS lists may be created locally using different time periods and modified thresholds if too few sites are provided in the provincial lists. It is recommended that a minimum of 3 yrs and maximum of 5 yrs of collision data be used. Local criteria/thresholds that differ from base provincial criteria/thresholds should be clearly described.
- Traffic volume data in the CIS is not perfect and primarily supports system level safety analysis. Project level analysis should not rely on CIS traffic volume data. Project level traffic volume data is available on the ministry’s website at:  
<http://www.th.gov.bc.ca/trafficData/index.htm>
- Project level “problem confirmation” is recommended for each CPL/CPS identified by the CIS. As a minimum, the collision data should be reviewed to confirm reasonableness (e.g. have there been any errors in location coding or other critical data elements?) and the CIS traffic volume should be reviewed using project level traffic data. If changes are warranted then the criteria above should be re-evaluated to determine whether or not the site is collision prone.

### ***1.2 CIS Counter-Measure Based Approach to Identify other CPLs and CPSs***

The counter-measure based approach to identify CPLs and CPSs searches for sites which have an over-representation of one or more collision types. This utility of the CIS can be run for all collision types, resulting in a second list of CPLs and CPSs. A base provincial list using the counter-measure utility does not currently exist (November 2010).

### ***1.3 Using Collision Prediction Models to Identify CPLs and CPSs***

Individual collision prone sites can also be identified using Collision Prediction Models along with the Empirical Bayes refinement method as described in the ministry’s document, “Collision Prediction Models for BC”. This cannot currently be automated for a region or corridor using the CIS because CPMs have not yet been incorporated into the CIS.

#### *1.4 Homogeneous Sections Safety Performance*

In the course of developing a CMP, the corridor is often divided into several homogeneous sections. It is recommended that some simple performance measures be used to evaluate the safety performance of each section. Examples include calculating the collision density, collision rate, and collision severity index. The sections can then be ranked in descending order of performance, and the most problematic sections can be carried through to the problem definition stage. This may uncover safety problems not identified through CPL/CPS analysis.

#### *1.5 Corridor Safety Performance*

The safety performance of the entire corridor can be assessed in a similar way as the homogeneous sections to provide a broader perspective on safety performance and to support comparison with other corridors.

#### *1.6 Drive-Through Safety Review*

A drive-through safety review is a formal examination of an existing corridor in which a team of examiners drives the corridor to identify and define safety problems, and to help develop improvement options. Suggested participants include the MoT District Transportation Manager or Area Manager, the MoT Traffic Engineer, a police representative, the MoT CMP study consultant, the ICBC consultant (if applicable). While there may be difficulties in getting all the participants together, every effort should be made to do so, as there is typically much benefit from group synergy. The team can confirm that the CIS CPL/CPS list is reasonable and also identify additional sites that may be hazardous.

#### *1.7 Stakeholder Consultation Process*

Stakeholders are another useful source of information for the identification of safety problems (as well as problem definition). Stakeholders should be asked to identify specific problem sites, to comment on the causes of the problems and to provide any available reports or background information. It may be useful to review the corridor with the stakeholder using the photolog if time permits.

#### *Potential Stakeholders*

<b>Primary Stakeholders</b>	<b>Other Possible Stakeholders</b>
MoT Regions & Districts	Other emergency services (fire & ambulance)
RCMP / Police	School boards
Highway Maintenance Contractor	Trucking association
Local ICBC claims office	BC Transit
Local government staff	BC Ferries
	Railroads
	Airport Authorities
	Cycling Coalition

	MLA and local government elected officials
	Other groups – seniors, physically challenged, equestrian

### *Potential Stakeholder Questions*

Ask stakeholders to provide details of the location and the problem for any of the following which they are aware of:

- Complaints concerning road safety
- High crash locations – provide details of types of collisions, frequency and severity
- Intersections or highway segments which may be poorly designed or require improvement
- Safety problems involving pedestrians, cyclists, or wild animals
- Complaints concerning vehicle travel speeds or driver behavior
- Complaints about the lack of passing opportunities
- Concerns about severe curves, grades or other geometric features
- Road condition problems such as pavement condition, drainage, inadequate shoulders, or high drop-offs
- Safety problems involving heavy trucks, motorcycles, RVs or other vehicle types – provide details of vehicle types
- Weather or seasonal related problems such as fog, ice, rain, or frost creating safety hazards
- Highway sections with inadequate lighting

## **2.0 Comprehensive Problem Definition**

Problem definition is the process of carefully studying the previously identified safety problems to fully understand their magnitude and root causes. This step is critical, as cost effective options cannot be developed without a full understanding of the root causes of the previously identified problems. It is expected that problem definition will be completed for each safety problem that has been identified in the CMP.

Important reference documents:

1. Canadian Guide to In-Service Road Safety Reviews, TAC, January 2004
2. Highway Safety Manual, AASHTO, 2010

Sources of information include:

- the CIS collision data
- a site visit
- consultation with local stakeholders

### **2.1 Analysis of CIS Collision Data**

For each CPL/CPS, conduct a detailed analysis of the collision data from the CIS to gain a better understanding of the magnitude and causes of the safety problems. The analysis involves

comparing each CPL/CPS to 3 different comparison groups. The 3 comparison groups are the larger homogeneous segment, the entire corridor, and the province (for the same service class). Comparisons are made for a number of different performance measures that fall into 2 general categories.

The first category consists of the basic safety performance measures: collision frequency, rate, density and severity. Table 1 provides an example. The comparisons in Table 1 are designed to identify the specific safety performance measures in which the CPL/CPS is deficient, and to provide an estimate of the magnitude of the deficiency.

*Table 1 – Comparison of Basic Safety Performance Measures*

Safety Performance Measure	Collision Prone Section	Comparison Groups (trend or averages) <sup>1</sup>			Deficient
		Segment	Corridor	Provincial	
Collision Frequency (Trend) <sup>2</sup>	increasing	increasing	constant	decreasing	n-y-y
Collision Rate (coll./ MVkm)	1.7	1.2	1.0	0.8	y-y-y
Collision Density (Coll. / km / yr)	3.2	2.7	2.3	1.1	y-y-y
Collision Severity (CSI) <sup>3</sup>	5.1	5.9	6.2	5.1	n-n-n

1. Data used to calculate values for the comparison groups must be consistent with the specific CPL or CPS that is being analyzed. For example, if a collision prone location is a signalized intersection, then only signalized intersection collision data on the segment, corridor and provincially should be used.
2. Collision frequency trend is a measure of whether the collision frequency is increasing, decreasing or remaining constant over time. A minimum of 3 years of data should be used.
3.  $CSI = [100x(\#fatals) + 10x(\#injury) + \#pdo] / [\#fatals + \#injury + \#pdo]$

The second category of performance measures involves working out the “percentage of total collisions” under a variety of collision data categories, and then comparing to the segment, corridor and province. Table 2 provides an example using some of the collision data categories that are most frequently over-represented.

*Table 2 - Comparison of % of Total Collisions for Different Collision Data Categories*

Collision Data Category		Collision Prone Section	Comparison Groups (averages) <sup>1</sup>			Significant <sup>2</sup>
			Segment	Corridor	Provincial	
Temporal	August	29%	8%	11%	10%	y-y-y
	Wednesday	29%	10%	12%	13%	y-y-y
Collision Type	Rear End	33%	9%	25%	29%	y-n-n
	Intersection-Turning	24%	5%	19%	24%	y-n-n
	Off - Road	24%	47%	38%	33%	n-n-n
Location Type	At Intersection	52%	21%	28%	31%	y-y-y
	Between Intersection	33%	59%	51%	48%	n-n-n
Contributing Factors	Driver Error	71%	68%	73%	65%	n-n-n
	Undue Care	48%	24%	31%	23%	y-y-y

1. Data used to calculate values for the comparison groups must be consistent with the specific CPL or CPS that is being analyzed. For example, if a collision prone location is a signalized intersection, then only signalized intersection collision data on the segment, corridor and provincially should be used.
2. A description of the Chi-Squared Test of Statistical Significance as applied to Table 2 is provided at the end of these Guidelines.

The format presented in Table 1 and Table 2 above can also be applied to:

- CPLs and CPSs identified using the counter-measure based approach
- CPLs and CPSs identified using collision prediction models
- Sites identified by the drive-through safety review
- Sites identified by stakeholders
- Homogeneous sections

**2.2 Site Visit**

The drive-through safety review team should strive to visit each collision prone site that has been identified to try to determine what may be contributing to the problem, and to record initial ideas on option development.

Wherever possible, the reviewers should consider key factors such as lighting (daytime, sunrise/sunset, nighttime), weather (dry, wet, icy pavement; rain, fog, snow, wind) and road user profiles. Photos or videos will be useful for later reference.

Other factors to consider:

1. General Topics – landscaping, parking, temporary works, head light glare
2. Alignment and Cross Section – visibility, sight distance, design speed, overtaking, widths, shoulders

3. Intersections – location, warning, controls, layout, visibility, sight distance
4. Auxiliary Lanes and Turn Lanes – tapers, shoulders, signs, turning traffic, visibility, sight distance
5. Non-Motorized Traffic – paths, barriers and fencing, bus stops, elderly and disabled, cyclists
6. Signs and Lighting – lighting, signs, marking and delineation
7. Traffic Signals – operation, visibility, other provisions
8. Physical Objects – clear zone, crash barriers, fencing
9. Delineation – line-marking, guide posts, chevron alignment
10. Pavement – pavement defects, skid resistance, ponding, loose screenings

### ***2.3 Geometric and Operational Analysis***

A geometric analysis and an operational analysis are two more important analytical tasks that should be undertaken as part of the problem definition phase of an In-Service Road Safety Review. TAC's "Canadian Guide to In-Service Road Safety Reviews" provides good guidance on these 2 tasks, as well as traffic conflict analysis and human factor analysis which may be beneficial for certain studies.

### ***2.4 Stakeholder Consultation***

Stakeholder views on problem definition can be sought for both stakeholder identified sites and sites identified by the CIS or the project team. The information is subjective, based on local knowledge, but offers additional information that may not be available from collision data or may not be obvious to a safety analyst unfamiliar with the corridor.

### ***3.0 Option Development***

The number of problem sites for which options are developed as part of the CMP depends on the available budget. It is not expected that every CMP will address each problem site that exists on the corridor. Sites that are not addressed in the CMP should be set aside for future option development and evaluation work.

Project level option development is the process of developing road safety improvements that will address the *root causes* of collisions at a particular site. Phasing from lower cost options in the short term to higher cost options in the long term should also be considered. The development of good options depends on good problem definition (i.e. an understanding of the root causes of the problems). Similarly, option development should be considered for each homogeneous segment.

Option development must be completed by MOT (preferably with input from ICBC) in conjunction with option development for other corridor problems regarding mobility, reliability and condition. If ICBC has recommended options, they should be used as inputs to the more comprehensive option development and evaluation undertaken in the corridor management plan.

The development of improvement options should not be constrained by concerns about funding availability. The ministry is interested in the best options, not necessarily the least expensive.

For each option make a note of its effectiveness in terms of collision mitigation and the source for the information. Key information sources include “Collision Modification Factors for BC” available on the ministry’s Internet website, AASHTO’s “Highway Safety Manual”, and the CMF Clearinghouse available on the www.

#### **4.0 Option Evaluation**

Option evaluation is the process of estimating the costs, benefits and other impacts of each option to highlight the differences between options for any given problem site.

Although option development should not be limited to any particular funding program (i.e. capital, rehabilitation, maintenance), option evaluation in the CMP should generally be limited to capital improvements. Recommended rehabilitation, maintenance and other non-capital safety improvements need not be evaluated, but should be clearly summarized so that they can be used as inputs to these other programs.

Evaluation of capital improvement options should be completed by MoT (or their consultant) using the Multiple Account Evaluation (MAE) framework. Guidance on MAE, and benefit cost analysis of safety improvements can be found on the ministry’s Internet website, “Highway Planning Publications” web page.

#### **The Chi-Squared Test of Statistical Significance as Applied to Table 2 of these Guidelines**

The Chi-Squared test value is calculated using the following equation.

$$\chi^2 = \frac{(x - p n)^2}{\bar{p} n} + \frac{[(n - x) - n(1 - p)]^2}{n(1 - \bar{p})}$$

- Where:  $\chi^2$  = Chi-Squared test value  
 p = the segment, corridor or provincial average proportion for the collision data category being investigated  
 x = the frequency at the site for the category being investigated  
 n = the total number of collisions at the site

Confidence Level	Critical $\chi^2$ Value
95.0%	3.84
97.5%	5.03
99.0%	6.64
99.5%	7.88

If the calculated Chi-Squared test value  $\chi^2$  exceeds the Critical  $\chi^2$  value for a given confidence level then the collision data category under investigation is significantly over-represented at the site for that confidence level.