Ministry
of
Transportation

Ontario

PRIORITIZED CONTRACT CONTENT GUIDELINES

EDITION 2.1

MARCH 1997

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ISBN 0-7778-6385-5

To all users of this publication:

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Prioritized Contract Content Guidelines

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INTRODUCTION

Prioritized Contract Content

The objective of the Prioritized Contract Content (PCC) initiative is to improve the cost-effectiveness of projects due to the need to optimize/reduce capital budgets now and in the future.

The PCC initiative is the reconsideration of which components are included in upcoming projects in order to redirect the ministry's scarce resources towards the province's most pressing needs. The guidelines do not replace the ministry's documented design standards, but rather introduces a prioritization mechanism. Significant emphasis has been placed on the use of benefit/cost analysis.

The traditional approach, from project initiation to contract preparation, has been to review a particular geographic section of highway and to remedy deficient elements within the defined project limits. The inherent assumption has been that a contract should include all work necessary to bring all elements of a section of roadway up to current accepted standards.

The PCC approach recognizes that for some highways it may not be cost-effective to include all improvements and upgrades solely to bring a roadway section to current ministry standards. Being in a particular vicinity or looking at a particular geographic area does not necessarily constitute a mandatory reason to restore or to repair. Other grounds for action, for example, collision propensity, structural integrity and financial ability, impact on decisions to do work. As a result, remedial action needs to be prioritized not only by the geographic location of contracts but by the deficient elements themselves.

The *PCC Guidelines*

The *PCC Guidelines* is a living document. It is expected that as experience is gained with prioritization on projects, constant improvements and updates will be made to the document, and through project use (i.e. user feedback), additional benefit quantification methods will be developed for more contract components.

Application of PCC

The *PCC Guidelines* should be introduced into the design process as early as possible, preferably as part of the first stage of detail design, so as to minimize the amount of time expended on items that are going to be deferred from a contract. PCC may be introduced earlier if situations warrant. Caution should be exercised, as the premature application of the Guidelines may result in contract elements being deferred prior to their identification. Designers are still responsible to evaluate each project for elements that would bring the roadway up to standard as directed in ministry manuals and directives. Any component that is removed from a contract, as part of the PCC process, should be recorded and retained for future prioritization and programming.

In carrying out a PCC review, a standard format is encouraged for both documenting the project and recording deferrals for future prioritization and programming. A standard recording format has been included in Appendix F.

Candidate Projects for PCC

The *PCC Guidelines* should be applied to all projects except:

- Construction of a new facility, or major expansion to an existing facility. For new construction or "green field" projects, all MTO standards are assumed to be cost-effective. It should be noted that on rehabilitation projects, the incremental cost of upgrading all deficient elements to standard is often large relative to the project cost. In addition, partial upgrades have the potential to make problems worse. However, for new construction, where the entire highway is often on newly acquired right-of-way, the added cost of constructing to the current standard is comparatively low. Therefore, achieving current standards can be much more costly for rehabilitation projects than for new projects, and therefore requires careful analysis of the benefits versus the costs.

Contract Components

A number of contract components are included in the *PCC Guidelines*. The components have been categorized into eight project activities, each representing a section of the Guidelines. Refer to Figure 1 - Project Activity Sections/Contract Components.

All contract components were originally developed using a common set of criteria for consideration These consisted of volume, % commercial, design speed, collision history, policy and warrants, life cycle analysis, benefit/cost analysis, functional requirements, environmental considerations and special considerations. Project Activity #5 and #6 remain structured using the criteria as the basis for their formats. However, due to the interrelationships of the criteria on the contract components, the other project activity sections have been restructured in a more concise format and are no longer documented by criteria.

Present Worth and Benefit / Cost Analysis

The PCC process suggests the use of Present Worth Analysis and Benefit / Cost Analysis for several contract components. For some contract components specific quantifiable relationships are provided For other components, suggestions as to types of considerations, are provided, and the user of the Guidelines should decide on the appropriate level of analysis required (often based on project or site specific issues or conditions). It should be noted that for all PCC analyses, the ministry has established a target B/C ratio of 2.0.

Because the conclusions of a benefit / costs analysis can be very sensitive to various inputs such as discount rates, collision costs, value of time, and other assumptions, these inputs have been defined for use in the PCC analysis. Consistent use of these inputs will create a more level playing field when deciding where to direct the ministry's limited financial resources. **While inputs are provided in the benefit/cost worksheet examples, a thorough understanding of "Introduction to Present Worth & B/C Analysis" provided in Appendix C is an absolute prerequisite for use of these Guidelines.**

FIGURE 1 - Project Activity Sections/Contract Components

Project Activity	Contract Component
1. Pavement	Pavement
2. Geometrics	**Alignment**
	Horizontal
	Vertical
	Cross Section
	Crossfall
	Lane Width
	Shoulder Restoration/ Width
	Pavement Widening on Curves
	Paved Shoulders
3. Roadside	Fencing
	Landscaping
	Clear Zone
	Hazard Rock
4. Drainage	Cross Culverts
	Other Culverts
	Curb and Gutter
5. Structures	Replace Structure
	Widening Structures
	Strengthening Structures
	Replace/Rehabilitate Components
	Barrier Wall/Railings
	Expansion Joints
	Deck Rehabilitation
	Structure Coating

Project Activity	Contract Component
6. Safety	Traffic Signals
	Pavement Markings
	Roadside Signs
	Overhead Signs
	Illumination
	Guiderail Systems
	Replacing Single Cable Guiderail
	Upgrading Guiderail
	Median Barriers- New
	Median Barriers- Upgrade
7. Facilities	Commuter Parking Facilities
	Highway Service Centres
	Rest Areas
	Park and Picnic Areas
	Truck Inspection Stations
	Patrol Yards and Buildings
	Bike Paths and Shoulder Bikeways
	Pedestrian Facilities
	Snowmobile Crossings
8. Operational Improvements	Truck Climbing Lanes
	Passing Lanes
	Intersections
	Construction Traffic Management
	Auxiliary Lanes
	Reserved Bus Lanes
	HOV Facilities
	Bus Bays

Collision Reductions

For various contract components, the benefits of remedying a deficiency can be quantified through a reduction in collision potential. It must be remembered that many factors affect collisions, including geometric features, pavement condition, weather, traffic flow, driver operating characteristics, vehicle operational characteristics, etc. It is very difficult to ascertain collision reductions which could result from a single contract component, especially given that most collisions result from a series of interacting factors.

The specific benefit/cost relationships introduced in these guidelines are based on research from various sources which have attempted to isolate collisions related only to a given contract component.

Methods for determining benchmark collision rates, collision severity rates and resulting costs are introduced in Appendix E.

USING THE GUIDELINES

When using the Guidelines, the following rules should be followed:

- Decisions for inclusion to be based on consideration of all relevant criteria;
- Contract components which will result in improvements at little or no cost should be retained; (e.g. crossfall correction as a result of pavement reconstruction)
- Items paid by others to be retained;
- All contract components removed from contracts to be recorded;
- Retained contract components to be constructed in accordance with current standards;
- Deferral, deletion and lower cost options should always be considered for any proposed contract component;
- All contract components to be considered in the context of the other work retained;
- Benefit/cost, life cycle and risk analysis should be verified over a reasonable range of parameters;
- Some options are listed in the guidelines for several components, however any other additional options should be considered as well;
- Existing conditions that are unsafe and/or non-standard should be considered carefully. Items included or excluded should not result in less safe conditions (as compared to the existing) as a result of the Prioritized Contract Content process;
- Work necessitated by other work (to remain) in the contract should be retained;
- Criteria should be evaluated as they affect the actual site, or segment of road relevant to the contract component;
- A consistent approach should be maintained with respect to the application of PCC to improvements within a contract.

GLOSSARY OF TERMS

Volume(AADT/SADT),% Commercial, Design Speed

The definition of these terms may vary, depending on the application. Refer to the appropriate Ministry reference (e.g. Geometric Design Standards, Roadside Safety Manual, etc.) for the definition specific to the component under consideration.

Life Cycle Cost Analysis

A calculation of the long term cost of an improvement or option, using present worth or other accepted financial analysis techniques.

Benefit/Cost Analysis

Comparison of the present worth of the cost of an improvement or option, compared to present worth of its identifiable and quantifiable benefits; usually expressed in life cycle costs. Analysis should recognize the incremental difference in benefits vs. costs between different options.

Special Considerations

Legislated requirements, irrevocable commitments, terms of legal agreements, property settlements, cost sharing by others, or other non-engineering special considerations.

Accident or Collision

For the purpose of this document the terms accident or collision are interchangeable.

Functional Requirements

The effectiveness of the existing condition or element being considered for improvement, or replacement. Can be expressed in terms of:

Structural Adequacy: Current, or resulting deficiency of a bridge or roadway;

Hydraulic Adequacy: Existing or resulting hydraulic deficiency related to the component;

Functional Adequacy: The acceptability of the performance of the existing situation, component or roadway under consideration compared with the improvement expected from the construction of the improvement. Adequacy may be related to safety, level of service or other considerations.

Environmental Considerations

Requirements to address environmental needs or deficiencies.

KHGSPM

King's Highway Guide Sign Policy Manual

MUTCD

Manual of Uniform Traffic Control Devices (Ontario)

GDM

Geometric Design Standards for Ontario Highways

RSM

Roadside Safety Manual

[P/(A or F), 6%, growth, n]

Present worth analysis factor. Reference Appendix C for a more thorough description.

Project Activity #1: PAVEMENT

1.0 INTRODUCTION

The guidelines contained in Project Activity #1 are not specifically categorized as being applicable to Provincial Level Highways or to Regional/Area Level Highways, per Ontario's Highway Network Classification System, and as a result apply equally to both.

The pavement design for any project must be based on proper field investigation including soils borings, and coring, as well as a review of the history of the pavement or pavements in the area, etc. The design must be suitable to address the traffic, environment, existing conditions, drainage needs and geometrics of the highway as well as provide a reasonable service life of 10 to 15 years.

The ultimate design is chosen using proper pavement design techniques, life cycle costing and risk analysis of a variety of possible designs. While the above is a brief outline of how a pavement design is determined, it is important to note that changes to the design in any manner cannot be made without affecting the overall quality of the pavement (including safety and ride) and the service life.

1.1 ALTERNATIVES

The first step of the PCC pavement review process is to develop a series of alternatives, not only with respect to pavement structure, but also from an implementation perspective. These alternatives should be based on sound engineering judgement and established pavement design principles. Typical types of alternatives may include:

Holding Strategy

Alternatives should address the situation of the standard rehabilitation strategy being delayed by two to three years. Such an alternative should examine the potential that some type of interim holding strategy could preserve the pavement condition at a level; so that the standard rehabilitation strategy may still be implemented after the delay. For example, if the standard rehabilitation strategy is one lift resurfacing in 1999, the holding strategy may consist of 10% patching in 1998 and one lift resurfacing in 2001. The delay would result in the added cost of patching. Any holding strategy, or preservation management strategy, must be discussed between the District and Regional Geotechnical Section.

Deferral Strategy

Consideration should also be given to alternatives that address the situation of the standard rehabilitation strategy being deferred for a greater period of time, possibly three or more years. Such an alternative would have to examine whether the pavement is likely to deteriorate to a point where the standard rehabilitation strategy would now be inadequate and as a result, more work than either the standard rehabilitation strategy or the holding strategy would be required in order to restore the pavement to an acceptable standard. For example, a two-lift resurfacing in 2000 may be required instead of the standard rehabilitation strategy of one lift resurfacing in 1997, at the added cost of one more lift of asphalt.

Staged Construction

As part of the alternative development process, consideration should be given to using pavement that is designed to be constructed in two stages. The initial design would provide adequate structural strength to carry the accumulated traffic over a short service life of approximately 4 to 7 years. The pavement structure would then be increased to carry the remaining accumulated traffic to accommodate the normal expected life of 10 to 15 years. Although such a strategy will result in lower initial costs there are some disadvantages such as greater disruption to the public, a risk that money will not be available for the second stage, and that increased work will be required in the second stage ie: milling/tack coating because of wearing of the initial surface course.

Alternative Bids

Alternative construction methodologies/designs should be considered when the alternatives have similar life cycle costs for rehabilitation and maintenance strategies, and similar initial service lives.

POLICY: Any deviations from ministry pavement design policy must be approved by the Pavement Advisory Committee.

1.2 LIFE CYCLE COST ANALYSIS

The second step of the PCC pavement review process is the analysis and selection of the preferred alternative. Life cycle costs and sound engineering judgement should be used to selected the alternative that is optimal with respect to benefits, timing, and selection of the treatment. This is achieved by evaluating alternatives against each other and against available resources. The appropriate life cycle costing procedure is detailed in the Pavement Design and Rehabilitation Manual.

Project Activity #2: ROADWAY GEOMETRICS

2.0 INTRODUCTION

The societal cost of collisions (which is used as the quantifiable benefit of improved geometrics in this section) is not a product of the highway's network significance, but a product of the frequency and severity of the collisions avoided. For this reason, Project Activity #2 guidelines will not be categorized into either Provincial Level Highways or Regional/Area Level Highways.

The consideration of the geometrics components of a contract is a four step process:

1. Develop/derive typical collision information for a facility of this type (e.g. Provincial or MTO Regional);
2. Consider alignment/design speed related components;
3. Consider cross-sectional components;
4. Review total benefits generated by collision reduction.

More so than other Project Activities, the roadway geometrics section has a hierarchy of order to the contract components. The contract components have been divided into two categories; alignment and cross-section. Contract components are organized as follows:

Alignment	**Cross-Section**
Horizontal	Crossfall
Vertical	Lane Width
	Shoulder Restoration / Width
	Pavement Widening on Curves
	Paved Shoulders: Partial or Full

The alignment components are to be completed first. This is because the contract components included in the alignment category are directly related to design speed. It is possible that for projects where an overall increase in design speed is proposed, the results of the application of the PCC Guidelines could be the deferral of an alignment component. This would necessitate a change, or addendum, to the Design Criteria which in turn may affect subsequent contract component analyses.

The following sections outline the process and the tools necessary to complete steps 1 through 4.

2.1 STEP 1: COLLISION RATES

In order to understand the potential benefits of improving deficient geometrics, one must first evaluate the normal collision rates and collision severity rates on a facility of the type being considered. However, for certain contract components (e.g. horizontal alignment, lane width, and shoulder width), theoretical collision rate reductions are built into the B/C equation and do not require separate evaluation. In cases where actual collision rates are used, they provide a better understanding of the potential savings based on the reduction of existing collision rates. A method for developing collision rates and vehicle collision costs is provided in Appendix E.

2.2 STEP 2: ALIGNMENT COMPONENTS

Current standards and practices generally emphasize lane and shoulder width improvements over alignment improvements. As traffic volumes increase, reconstruction of horizontal curves (flattening) may be more cost-effective than lane and shoulder widening, while also reducing operation costs and travel time.

2.2.1 HORIZONTAL ALIGNMENT *(Including Superelevation)*

The purpose of this section is to outline the process and tools necessary to consider the most cost-effective solutions to horizontal alignment deficiencies.

There is no need to further consider horizontal alignment if:

- All the horizontal curves within the study limits provide for a design speed that is greater than or equal to the design speed as stated in the Design Criteria;

If a granular grade is to be produced, then the superelevation is to be corrected as to the design standards outlined in the GDM. If a granular grade is not to be produced and the superelevation is deficient for the posted speed, then the superelevation will be improved to the rate necessary to meet the design standards. Numerous major studies have shown that it is always cost-effective to improve deficient superelevation to design standards. Because of this, there are no available quantifiable relationships between superelevation and collision reduction (a benefit/cost calculation is not required). In particular, references number 2, 9, 10 and 12 in Appendix A all recommend superelevation improvements as a necessary component of rehabilitation projects.

The design speed should be calculated for every curve identified as deficient, based on the superelevation and the radius of the curve. If the calculated speed is greater than the posted speed but less than the design speed, this deficiency will be noted on a deferral list and the curve will remain as is.

If the calculated speed is less than the posted speed, then two options, other than superelevation, exist:

- Flatten curve, or;
- Post an advisory speed limit

Research has shown that there is a potential reduction in collisions associated with the flattening of a horizontal curve. This reduction produces a benefit that can be valued and compared to the construction/property cost of the flattening. If the B/C ratio is equal to or greater than 2.0, then it is recommended that the curve be flattened. If the B/C ratio is less than 2.0, an advisory speed sign should be posted. The Regional Traffic Section should be consulted prior to posting any advisory speed limit.

For site-specific design, the following example outlines a relationship that provides a helpful estimate of the collision reduction that may be possible by flattening a curve. It must be used judiciously along with other pertinent information such as traffic characteristics, adjacent highway alignment, shoulder and roadside characteristics, and prior collision experience.

[The example outlines one possible technique, based upon a study entitled "Cost-Effective Geometric Improvements for Safety Upgrading of Horizontal Curves" (Reference 6, Appendix A), for completing a benefit/cost calculation. Users of this guide are encouraged to research further relationships between curve flattening and collision reduction as local conditions require.]

This information sheet will aid in the calculation of the benefits of improving the horizontal alignment of a curve. This is to be used as a guide only, as existing conditions, local needs and collision history should always be considered. The major benefit of curve flattening is a reduction in collision potential. An example of this analysis is included at the end of the section.

1. Collision Reduction

$$A_n = [0.00188(L_n) + \frac{47.66}{R_n} - 0.0234S]0.9296^W V$$

$$A_o = [0.00188(L_n + \Delta L) + \frac{47.66}{R_0} - 0.0234S]0.9296^W V$$

where:

- A_n = total number of collisions on the new curve in a 5-year period
- A_o = total number of collisions on the old curve in a 5-year period
- V = volume of vehicles (million vehicles in a 5-year period passing through the curve, both directions)
- R_n = new curve radius (m)
- R_o = old curve radius (m)
- S = presence of spiral transitions on both ends of the curve, where S=0 if no spiral exists, and S=1 if spirals do exist
- W = width of the roadway on the curve (m)
- L_n = length of the new curve (m)
- ΔL = amount by which the highway alignment is shortened due to flattening (m)
  = $2 (R_n - R_o) \tan (I/2)$,
  where I = central angle of new curve in degrees = $57.296 (L_n/R_n)$

$$\Delta A = A_n - A_o$$

where:

- ΔA = reduction in collisions due to curve flattening per 5 years

2. Benefit - Cost Analysis

Potential Annual Collision Cost Savings = (ΔA) (VCC)/5

where:

VCC = Vehicle Collision Cost ($) *(Reference Appendix E)*

Benefits	=	Net present worth of above cost savings each year for the service life of the facility at 6%. If AADT is projected to increase during the service life, then the net present worth is adjusted to account for that. *(Benefits valued at 100% - Reference Appendix C)*
Costs	=	Estimated construction costs discounted over the service life of the facility *(Deferral selected as the base case - Reference Appendix C).*
B/C	=	Benefits / Costs

3. Example

A curve on a 2 lane undivided King's Highway (Design Speed = 90 km/h) has a radius of 280 m. Determine whether it is cost-effective to flatten the curve to standard now, or to defer the project one service life.

Given:

Curve Radius = 280 m

Design Speed = 90 km/h (minimum radius = 340 m)

Roadway width = 8.5 m

AADT = 6,000

Service life = 10 years

Traffic growth rate = 0%

Length of the curve = 500 m

Length of the proposed curve = 610 m

Estimated Construction Cost = $300,000

VCC = $23,500 *(VCC for Highways - Reference Appendix E)*

Calculations:

$$V=\frac{(AADT)(365)(5)}{1,000,000}=10.95$$ million vehicles/5-year period

$$\Delta L=2(340-280)\tan[\frac{57.296\times610}{2\times340}]=150.0m$$

$$Ao=[0.00188(610+150)+\frac{47.66}{280}-0.0234(1)]0.9296^{8.5}(10.95)=9.276$$ collisions/5-year period

$$A_n=[0.00188(610)+\frac{47.66}{340}-0.0234(1)]0.9296^{8.5}(10.95)=7.439$$ collisions/5-year period

$$\Delta A=\frac{9.276-7.439}{5}=0.367$$ collisions reduced/year

Potential collision savings $=\Delta A(VCC)$

$= 0.367(\$23,500)$

$= \$8,625/\text{year}$

Benefits = *$8,625/y*

Note: The 'Deferral' alternative was selected as the base case (Reference Appendix C). As a result the benefits are equal to:

Benefits	=	*Benefits to Construct - Benefits to Defer*
	=	*$8,625/y - $0/y*
	=	*$8,625/y*

Benefits(PW)	=	$8,625 (P/A, 6%, 0% growth, 10 years)
	=	$8,625 (7.36) *(Reference Appendix C, Table C1)*
	=	$63,480

Note: The 'Deferral' alternative was selected as the base case (Reference Appendix C). As a result the costs of construction are equal to:

Costs(PW)	=	Costs to Construct - Costs to Defer
	=	$300,000 - $300,000(in 10 years)
	=	$300,000 - $300,000(P/F, 6%, 10 years)
	=	$300,000 - $300,000(0.5584) *(Reference Appendix C, Table C2)*
	=	$132,480

B/C	=	$63,480 / $132,480
	=	0.48

Since the B/C ratio is less than 2.0, deferral of curve flattening is recommended.

2.2.2 VERTICAL ALIGNMENT

The purpose of this section is to outline the process necessary to consider the most cost-effective solutions to vertical alignment deficiencies.

There is no need to further consider vertical alignment if:

- All of the vertical curves within the study limits provide a design speed that is greater than or equal to the design speed as stated in the Design Criteria, or;

Generally, revisions to deficient vertical alignment will be deferred to a later date. However, the following situations should be noted:

A sag vertical curve is designed for nighttime headlight stopping sight distance. If the sag that is being considered is illuminated or will be illuminated under the current contract, and no other site specific issues are involved, the vertical curve revision should be deferred. It should be noted that illumination may be deferred from this contract under Project Activity #6.5. If this is the case, then this section must be revisited.

If the K value of a sag (non-illuminated) or a crest is between the posted speed and the design speed, the curve should not be corrected, but added to the deferral list. If the K value of the curve is less than the posted speed, engineering judgement must be exercised giving special consideration to the collision history, results of the PDR, driver comfort and other relevant factors. Generally, revisions to deficient vertical alignment will be deferred to a later date.

There is no dependable relationship between a given change in K value and the associated quantifiable reduction in number of collisions. For this reason, decisions on vertical alignment improvements must be made based on site specific factors. (A generalized benefit/cost calculation is not available for deficient vertical alignment.)

If the correction of a substandard vertical curve is deferred, designers should examine the nature of potential hazards hidden by a crest vertical curve and consider other options such as removing these hazards or providing advisory signs. In the case of hidden intersections, site specific investigations of collision histories, operating speeds etc. should be undertaken. Consideration should also be given to restricting future hazards from being constructed (i.e. new entrances).

2.3 STEP 3: CROSS-SECTION COMPONENTS

Road cross-sectional elements consist of lanes, shoulders, and sideslope areas. The sideslope areas are discussed in Project Activity #3: Roadside, specifically under Sections **3.4 Clear Zone** and **3.5 Hazard Rock.** In this section crossfall, lane widths and shoulder restoration/widths are discussed.

Wide lanes and shoulders provide motorists increased opportunities for safe recovery in run off the road incidents, and increased lateral distance between overtaking and meeting vehicles. These occurrences typically show up as single-vehicle collisions, sideswipes and head-on collisions, respectively.

Research carried out in the United States has produced quantifiable relationships between cross-section features and collision rates for two-lane rural highways. In any collision analysis it is very difficult to isolate the effect of a specific geometric feature from other operational characteristics. As a result, validation of a specific quantity in reduction is difficult. However, the relationships do represent a reasonable, most likely safety effect of the roadway improvement. They are used in this section to estimate the collision reduction that could result from incremental lane and shoulder improvements.

The research indicates that the greatest gains in collision reduction are achieved through a combination of lane and shoulder widening. The benefit/cost analysis equation introduced later in this section allows for a combination of lane and shoulder widening.

2.3.1 CROSSFALL

Crossfall should be constructed to the standards outlined in the GDM if the pavement strategy recommends the production of a granular grade (i.e. pulverizing).

The function of crossfall is to provide surface drainage. Drainage problems can have serious safety implications due to ponding and icing. Therefore, when resurfacing on a contract where granular grade is NOT produced, crossfall should be corrected to GDM standards if there is:

- observed or reported incidences of ponding;
- reported collisions directly attributed to ponding, or;
- evidence of pavement deterioration caused by standing water (alligator cracks).

2.3.2 LANE WIDTHS

For new construction, lane widths are set as per the GDM and, therefore, will be between 3.5 metres and 3.75 metres.

In a rehabilitation project if the existing lane widths are between 3.5 metres and 3.75 metres they should not be widened unless special site specific conditions apply (e.g. agreement for wider lanes due to bus routes, bicycle lanes, etc.) For a rehabilitation project of a two lane highway the existing lane width may be less than 3.5 metres. If the existing lane widths are less than 3.5 metres a benefit/cost analysis should be carried out. The analysis may or may not include shoulder work. For example:

> *The widening of lane width can result in substantial collision reduction. Studies indicate that a widening from 3.00 metres to 3.30 metres could result in a 12 % reduction in lane width related collisions. Typically, the cost-effectiveness of lane and shoulder widening will diminish as widths approach those mandated in the GDM.*

When considering a benefit/cost analysis, the following pages provide an estimate of the potential reduction in collisions that may result from lane or shoulder widening, but it must be used judiciously along with other pertinent information such as traffic characteristics, highway alignment, roadside characteristics and prior collision history.

The study entitled "Safety Effects of Cross-Section Design for Two-Lane Roads" (Reference 4, Appendix A), was conducted in 1987. The purpose of this study was to quantify the benefits and costs resulting from lane widening, shoulder widening, shoulder surfacing, sideslope flattening and roadside improvements. Over 8,000 km of two-lane roads from seven states were analyzed. A collisions prediction model was developed. The following pages outline one possible technique, based on the above study, for completing a benefit/cost calculation.

Refer to the calculation sheets on the following pages for the benefit/cost analysis which can be applied for lane widening on **two-lane rural highways**.

2.3.3 SHOULDER RESTORATIONS

Areas that require high maintenance (i.e. extensive shoulder drop-off), should be corrected as part of the rehabilitation.

If shoulder widths are as per the GDM, no widening should be considered.

If shoulder widths are less than specified in the GDM, a benefit/cost analysis should be carried out. The widening of shoulders can result in substantial collision reduction. For example, a widening of shoulder widths from 1.0 metres to 1.75 metres could result in a 20 percent reduction in shoulder width related collisions. Consideration should also be given to the use of stabilized shoulders (i.e partially paved, tar seal etc.) as they exhibit lower collision rates than non-stabilized shoulders (Reference 31, Appendix A).

When considering a benefit/cost analysis, the following pages provide a helpful estimate of the potential reduction in collisions that may result from lane or shoulder widening, but it must be used judiciously along with other pertinent information such as traffic characteristics, highway alignment, roadside characteristics and prior collision experience.

The study summarized on the following pages titled "Safety Effects of Cross-Section Design for Two-Lane Roads" (Reference 4, Appendix A), was conducted in 1987. The purpose of this study was to quantify the benefits and costs resulting from lane widening, shoulder widening, shoulder surfacing, sideslope flattening and roadside improvements. Over 8,000 km of two-lane roads from seven States were analysed. A collisions prediction model was developed. The following pages outline one possible technique, based on the above study, for completing a benefit/cost calculation.

Refer to the calculation sheets of the following pages for the benefit/cost analysis which can be applied to shoulder widening on **two lane rural highways.**

2.3.4 PAVEMENT WIDENING ON CURVES

If the pavement strategy produces a granular base, then widening should be provided as per the GDM.

If the pavement strategy does not require a granular base, then site specific information, most notably collision history known to have resulted from narrow pavement on curves, should be considered. Special consideration should also be given to providing curve widening on highways with a substantial volume of large trucks.

A quantifiable relationship does not exist for potential collision reductions based on pavement widening through curves.

2.3.5 PAVED SHOULDERS

Fully Paved Shoulders

Fully paved shoulders should be handled as per the GDM.

It should be noted that research conducted in the United States indicates that paving a shoulder would result in a minimal reduction of collisions related to shoulder conditions for a two lane rural highway. Therefore, it is anticipated that site specific shoulder pavings would be based on special considerations such as shoulder bikeways or high pedestrian volumes, etc.

Partially Paved Shoulders

In consideration of partially paved shoulders, an MTO study entitled "Summary of Deliberations of Paved Shoulder Working Group - June 15, 1992" (Reference 31, Appendix A), concluded that they were cost-effective (with a B/C ratio of 1.0) for highways with AADT's in the range of 4000. Adjusting the study's recommendations to reflect the requirements of the PCC benefit/cost methodology yields the following relationship:

B/C = 1.0* with AADT = 1000

B/C = 2.0 with AADT = 2000

It should be noted that these volume thresholds apply only to the construction of partially paved shoulders where none have existed before. Construction projects that result in the removal of partially paved shoulders on existing highways should include a provision for their immediate reinstatement.

Copies of the above mentioned study are available from the Highway Planning and Design Development Section, Surveys and Design Office, Transportation Engineering Branch.

* - The B/C assumptions are slightly different between the 1992 study and the PCC Guidelines. The 1992 study used lower vehicle collision costs (approximately half those recommended by PCC), as well as using the full capital construction costs, rather than the deferred costs (resulting in approximately twice the costs recommended by PCC).

This information sheet will aid in the calculation of the benefits of cross-section improvements (e.g. lane width, shoulder width, etc.). These techniques are to be used as a guide only, as existing conditions, local needs and past safety records should always be considered. The major benefits of a cross-section improvement is a reduction in collision potential. An example of the use of this analysis is included at the end of the section.

1. Collision Reduction

$$A = 0.00119\,(AADT)^{0.8824}\,(0.6542)^{W}\,(0.7585)^{PA}\,(0.7926)^{UP}\,(1.2365)^{H}\,(0.8822)^{TER1}\,(1.3221)^{TER2}$$

where:

A	= number of related collisions per year/km
AADT	= annual average daily traffic
W	= lane width (m)
PA	= average paved shoulder width (m)
UP	= average unpaved shoulder width (m)
H	= roadside hazard rating (number from 1 to 7 as defined below)
TER1	= terrain, 1 if flat, 0 otherwise
TER2	= terrain, 1 if mountainous, 0 otherwise

Roadside Hazard Ratings

1. Extensive open space (greater than 15.0 metres clear) on either side of the roadway - Flat side slopes;

3. Good open space (approx. 10 metres) on either side of the roadway - normal side slopes;

5. Normal rural roadway with normal clear zone requirements;

7. Very tight (less than 3.0 metres to obstructions) - either steep side slopes or tight rock-cuts.

Engineering judgement must be used in selecting a rating for the project. If the project varies in rating, an average may be used.

$$\Delta A = A_o - A_n$$

where:

ΔA	= collisions reduction /yr
A_o	= collisions /yr before improvement
A_n	= collisions /yr after improvement

2. Benefit - Cost Analysis

Potential Collision Cost Savings = (ΔA) (VCC)

where:

VCC	=	Vehicle Collision Cost ($) *(Reference Appendix E)*
Benefits	=	Net present worth of above cost savings each year for the service life of the facility at 6%. If AADT is projected to increase during the service life, then the net present worth is adjusted to account for that. *(Benefits valued at 100% - Reference Appendix C)*
Costs	=	Estimated construction costs discounted over the service life of the facility *(Deferral selected as the base case - Reference Appendix C)*
B/C	=	Benefits / Costs

3. Example

Problem:

A flat 5 km stretch of a 2 lane King's Highway has lane widths of 3.00 m and unpaved shoulders of 2.5 m on each side. Is it cost-effective to proceed with widening to 3.75 m lanes now, or to defer one service life?

Given:

2 lane King's Highway

Lane width = 3.0 m (To be widened to 3.75 metres)

Paved shoulder width = 0 m

Unpaved shoulder width = 2.5 m per side

AADT = 4,000

Service Life = 15 years

Median roadside hazard rating = 3

Flat Terrain

Traffic growth = 0%

Estimated Construction Cost = $150,000

VCC = $23,500 *(VCC for Highways - Reference Appendix E)*

Calculations:

Ao $= 0.00119\,(4000)^{0.8824}\,(0.6542)^{3}\,(0.7585)^{0}\,(0.7926)^{2.5}\,(1.2365)^{3}\,(0.8822)^{1}\,(1.3221)^{0}$

= 0.466 collisions per year/km

An $= 0.00119\,(4000)^{0.8824}\,(0.6542)^{3.75}\,(0.7585)^{0}\,(0.7926)^{2.5}\,(1.2365)^{3}\,(0.8822)^{1}\,(1.3221)^{0}$

= 0.339 collisions per year/km

ΔA = (0.466 - 0.339) = 0.127 collisions reduced per year per kilometre

Potential collision cost savings for a 5 kilometre stretch = ΔA(VCC)(5 km)

= 0.127 ($23,500)(5)

= $14,922 /year or

Benefits = $15,000/y

Note: The 'Deferral' alternative was selected as the base case (Reference Appendix C). As a result the benefits are equal to:

Benefits = *Benefits to Construct - Benefits to Defer*

= *$15,000/y - $0/y*

= *$15,000/y*

Benefits(PW) = $15,000 (P/A, 6%, 0% growth, 15 years)

= $15,000(9.712) *(Reference Appendix C, Table C1)*

= $145,680

Note: The 'Deferral' alternative was selected as the base case (Reference Appendix C). As a result the costs of construction are equal to:

Costs(PW) = Costs to Construct - Costs to Defer

= $150,000 - $150,000(in 15 years)

= $150,000 - $150,000(P/F, 6%, 15 years)

= $150,000 - $150,000(0.41727) *(Reference Appendix C, Table C2)*

= $87,410

B/C = $145,680 / $87,410

= 1.67

Since the benefit/cost ratio is less than 2.0, it is recommended that widening lanes be deferred one service life.

2.4 STEP 4: TOTAL COLLISION BENEFITS

In the preceding sections of Project Activity #2, collision benefits have been calculated for a number of different contract components. In cases of highway improvements involving related collisions, it is possible that the benefits of these improvements may have been double counted. For example:

Consider a segment of highway where the benefits associated with curve flattening, and lane and shoulder widening, have been calculated individually. An artificially high reduction in collisions from these two improvements would occur if the benefits were simply summed. Care must be taken that both improvements are not credited with eliminating the same collision.

One method to model the effects of combined collision benefits of simultaneous overlapping highway improvements was proposed in the study entitled "Safety Effects of Cross-Section Design for Two-Lane Highways" (Reference 4, Appendix A). This study proposed that the percentage reduction in collisions associated with each improvement be combined as follows:

$$R_{TOTAL} = 1 - (1 - R_1)(1 - R_2)(1 - R_3)..........(1 - R_n)$$

Where:

R_{TOTAL} = total percentage reduction in related collision.

R_1 = percentage reduction in related collisions associated with improvement 1.

R_2 = percentage reduction in related collisions associated with improvement 2.

R_3 = percentage reduction in related collisions associated with improvement 3.

R_n = percentage reduction in related collisions associated with improvement n.

For example, if curve flattening is expected to reduce related collisions by 42%, and lane and shoulder widening are expected to reduce collisions by 34%, then the combined effects of these two improvements (if they overlapped) would be:

$$R_{TOTAL} = 1 - (1 - 0.42)(1 - 0.34)$$
$$= 1 - (0.3828)$$
$$= 0.6172 \text{ or } 62\%$$

Users should be aware of the risk of overlapping simultaneous improvements.

Project Activity #3: ROADSIDE

3.0 INTRODUCTION

The guidelines contained in Project Activity #3 are not categorized as being applicable to either Provincial Level Highways or Regional/Area Level Highways and as a result, apply equally to both.

3.1 FENCING

In general, fencing should only be upgraded, or repaired where it no longer serves its intended function. Existing fence installations, within the clear zone, that pose a hazard to errant vehicles should be eliminated if possible, or replaced with safer options. For example, chainlink fences with a steel top rail should be removed, or modified through the replacement of the steel top rail with a safer tensioned cable design.

For new installations, consideration should be given to eliminating fencing placed solely to delineate the right-of-way. Factors such as traffic volumes, sight-distances, and pedestrian accessibility should be closely examined prior to deferring any new fence installation.

3.2 LANDSCAPING

In general, landscaping should no longer be carried out. Situations that warrant special review are as follows:

Environmental Needs

Landscaping should be carried out where required to fulfill natural environment needs. Specifically, erosion protection and stormwater quality schemes. It should be noted that seeding of exposed earth is considered an erosion protection scheme and should not be deferred.

Environmental Assessments/Commitments to Others

Landscaping that is required to fulfill the requirements of an approved Environmental Assessment should not be deferred. Other commitments, such as those made in property agreements, or of the political variety, should not be deferred, but should be first reaffirmed between the Region and the applicable Head Office Unit.

Special Considerations

Landscaping should be carried out if it directly impacts highway operations. Specifically, landscaping schemes aimed at reducing headlight glare, or snow drifting, or is required for positive guidance (i.e. a tangential road on a highway curve) etc. should not be deferred.

3.3 NOISE BARRIERS

The specifications for noise barriers remains unchanged, except that priority should be given to locations that meet the following criteria:

- Barriers for which commitment has been made in an individual Environmental Assessment for a new highway.
- Barriers for which a commitment has been made in an ESR and would require an addendum to the ESR and could risk a potential "bump up". The tolerance of this risk must be determined for each circumstance.

Special consideration should be given to commitments by the current government for retrofit of existing noise barriers.

3.4 CLEAR ZONE (Side Slope, Hazard Removal/Protection)

Introduction

In general, the policies as outlined in the Roadside Safety Manual remain unchanged. While the Roadside Safety Manual provides an excellent explanation of clear zone concepts and ministry policies, it provides limited discussion concerning a methodology for quantifying the magnitude of the risks associated with a hazard. Such quantifications are required to support the prioritization process, and as a result, the following procedure has been developed to evaluate typical clear zone encroachments. Atypical situations, such as high voltage transmission towers, will require more robust analyses.

Clear Zone Hazard Prioritization Process

1. Determine Benefits - potential annual collision cost savings.
2. Determine Disbenefits - potential increases/decreases in maintenance/repair costs.
3. Determine Costs - agency costs (capital).
4. Determine Benefit/Cost Ratio - apply PCC benefit/cost methodology.

Procedural Notes for the Calculation of Collision Cost Savings and Repair Costs

While a hazard may not have been struck in the past, the potential always exists. As a result, collision cost savings cannot be based solely on past experience, but must consider the potential for a hazard to be struck in the future. In order to calculate potential annual collision cost savings and repair costs associated with a roadside hazard, it is necessary to obtain/calculate the following:

1. Encroachment

The Transportation Association of Canada (TAC) has published the Manual of Geometric Design Standards for Canadian Roads (1986) which provides typical encroachment rates for a variety of highway classifications. Caution should be exercised when using these rates as they were derived from a limited set of data. They are reflective of level, tangent sections of road, though adjustment factors can used to account for grade and horizontal curvature as provided below. It should be noted that when using these adjustment factors that **Weighted Encroachment Rate = Theoretical Encroachment Rate x Horizontal Adjustment Factors x Vertical Adjustment Factors**. As this TAC manual is presently under revision, and therefore may be difficult to obtain, the following tables have been summarized and are included in the Guidelines:

Table 3.1 Theoretical Encroachment Rate
Table 3.2 Horizontal Adjustment Factors
Table 3.3 Vertical Adjustment Factors

TABLE 3.1 - Theoretical Encroachment Rates

Facility Type # Lanes	Operational Environment	Typical Encroachment Rate
Freeway (divided)		
4 lanes	rural/urban	0.00031
6 lanes	rural	0.00031
6 lanes	urban	0.00012
Highways (undivided)		
2 lanes	rural/urban	0.00045
4 lanes	rural/urban	0.00032

TABLE 3.2 - Horizontal Adjustment Factors

Horizontal curvature, as related to design speed:	
Tangent or flat curve	1.00
Intermediate curve	1.05
Inside Curve:	
*Min. or near min., or isolated intermediate curve	1.10
Isolated min. or near min. curve, or curves with radius = 170m max.	1.15
Outside Curve:	
*Min. or near min., or isolated intermediate curve	1.20
Isolated min. or near min. curve, or curves with radius = 170m max.	1.25
* *Minimum radii curves are those calculated by the usual design process to satisfy the requirements of speed, maximum superelevation, and road surface friction. Intermediate curves are defined as those whose radius is twice that of the minimum.*	

TABLE 3.3 - Vertical Adjustment Factors

Downgrade or profile conditions:	
2% or less	1.00
3%	1.05
4% or moderate* crest vertical curvature in comb. with horizontal curve	1.10
5%	1.15
6% or extreme* crest vertical curvature in comb. with horizontal curve	1.20
7% or more	1.25
* *Moderate vertical crest is one which satisfies the sight distance criteria for the design speed. An extreme crest is one which provides only half the required sight distances.*	

2. *Collision Frequency*

The American Association of State Highway and Transportation Officials (AASHTO) has published a *Roadside Design Guide (1996)* which provides a detailed explanation, including examples, for calculating collision frequency.

TAC has also produced a simplified method for calculating collision frequency. This method was used in the development of the tables included in Project Activity #6: Safety. The TAC method has been used in the benefit/cost worksheets included at the end of this project activity section.

3. *Severity Index/Collision Cost*

AASHTO has developed a comprehensive severity index system, representative of a wide variety of typical roadside hazards. The most recent version of these indices is included in the *Roadside Design Guide (1996).*

Once a severity index has been selected to represent a hazard, it is then necessary to assign a cost. As the *Roadside Design Guide (1996)* was developed for US applications, the following replacement table outlines the cost relationship for use in Ontario. These costs are of the same order of magnitude as those specified in MTO's Roadside Safety Manual.

TABLE 3.4 Resulting Severity Index - Cost Relationship

Severity Index (SI)	Cost ($)
0.0	0
0.5	547
1.0	1,504
2.0	3,429
3.0	15,088
4.0	40,304
5.0	93,554
6.0	197,483
7.0	318,446
8.0	486,959
9.0	688,516
10.0	875,000

With the collision cost and frequency calculated, it is possible to determine potential annual collision costs. Potential collision repair cost increases/decreases can also be calculated using the collision frequency calculation. These values can then serve as inputs to a benefit/cost analysis.

Since the number of clear zone encroachments is a function of volume, potential annual collision cost savings are, therefore, a function of projected future volumes. As part of the actual benefit/cost life cycle analysis, traffic growth rates should be applied to calculated potential annual collision cost savings, and for that matter potential annual collision repair costs increases/decreases, so as to more accurately represent the highway segment under consideration.

3.5 HAZARD ROCK

Rock debris, such as small boulders and stones that naturally separate from a rock face as a result of the weathering process, and fall onto an adjacent highway, are termed hazard rock. While these events are unpredictable, they do present a very real safety hazard to highway users.

A thorough review of the collision history and road maintenance records should be undertaken in an attempt to quantify the magnitude of the problem. Such an analysis should be undertaken on a site specific basis and should also include a review of sight and stopping distances. This information should be reviewed in conjunction with the regional geotechnical section in an attempt to gauge the potential for future events.

While no benefit/cost relationships exist to predict the potential for hazard rock generation and the severity of possible resulting collisions, steps should be taken to quantify the risk as part of the PCC process. Appropriate treatments should be evaluated in terms of cost-effectiveness.

It should be noted that rock outcrops, or longitudinal rock faces, that pose a hazard to errant vehicles are considered a clear zone hazard and should be evaluated in accordance with section 3.4.

This information sheet will aid in the calculation of the benefits of various roadside improvements within the clear zone (as defined in MTO's Roadside Safety Manual). These techniques are to be used as a guide only as existing conditions, local needs and collision history should always be considered. The major benefit of roadside improvements is a reduction in collision potential and/or the reduction in collision severity. An example of the use of this analysis is included at the end of the section.

1. Collision Frequency

The following is the TAC formula for calculating the collision frequency (with a given roadside hazard) in collisions per year. This will be used to compare alternatives.

$$Cf = (Ef/2000)\,[(L + 19.2)\,P[Y \geq A] + 5.14\sum P[Y \geq (A + 1.8 + (2J-1)/2)]]$$

where:

- Cf = collision frequency (collisions/year)
- Ef = number of encroachments per year /km/direction = (Encroachment rate) (Directional Split) (AADT)
- L = horizontal length of the roadside obstacle (m)
- W = width of obstacle (m)
- A = lateral distance of roadside obstacle to edge of pavement (m)
- Y = lateral displacement of the encroaching vehicle from the edge of pavement (m)
- $P[Y \geq ..]$ = probability of a vehicle lateral displacement greater than some value (see notes)
- J = the number of 1 metre wide obstacle-width increments (the number of J units is equal to W rounded to the nearest whole number)
- $\sum$ = mathematical summation with summation index range from J=1 to J=W (in 1m steps)

Notes:

- With respect to the calculation of $P[Y>...]$, refer to Figure 1.2.3 "Depth of Penetration from Edge of Pavement for Errant Vehicles", MTO Roadside Safety Manual, p. 0102-9.
- Values for Cf should be calculated for both directions

2.0 Benefit/Cost Analysis

When considering a roadside hazard within the clear zone there are usually four alternatives: (a) do nothing (i.e. deferral of upgrade); (b) upgrade the hazard to make it forgiving (e.g. break-away pole); c) relocate the hazard out of the clear zone; and (d) provide protection for the hazard. The benefits of these alternatives should be calculated and compared to their respective implementation costs.

In general, the following should be calculated for each alternative:

1. Cf_n = Collision frequency of hazard n

where:

$$Cf_n = (Ef/2000)\,[(L_n+19.2)\,P[Y \geq A_n] + 5.14\sum P[Y \geq (A_n + 1.8 + (2J-1)/2)]]$$

2. CC_n = Annual collision cost of hazard n

where:

$$CC_n = (Cf_n)\,(HC_n)$$

where:

HC_n = Collision cost per occurrence, determined from AASHTO Severity Index (Reference *AASHTO Roadside Design Guide-1996*) and Cost Relationships (Table 3.4)

Benefits = Potential collision cost savings

Note: *Potential maintenance cost savings could be included in the analysis if applicable.*

Cost = Estimated construction costs.

Note: *All benefits and costs should be expressed in net present value.*

In general, the base case is selected as the *Do Nothing (Deferral)* alternative (i.e. Alternative A). As a result:

Benefits = $CC_n - CC_A$

Costs = Estimated Construction Costs $_n$ - Estimated Construction Cost $_A$

Note: *All benefits and costs must be expressed in present worth.*

Once benefits and costs are calculated a benefit/cost analysis can be performed.

B/C = Benefits/Costs

Note: *If more that one alternative have B/C ratios, that are greater than 2.0, an incremental benefit/cost analysis will be required to determine which alternative is most cost-effective.*

3.0 Example

Problem:

A rigid base luminaire support (concrete pole) is located 3 m from the edge of pavement, which is also the edge of the through lane. Since the hazard is within the clear zone, current ministry policy requires that this pole be relocated, protected or made forgiving. Is it cost effective to:

A) leave the pole as is (i.e. defer replacing pole with a frangible base pole).
B) replace the pole with a frangible base pole now.
C) relocate the pole outside the clear zone (assuming it is feasible).
D) protect pole with a run of steel beam guiderail (SBGR).

Given:

2 lane, undivided rural King's Highway
Lane width = 3.5 m, unpaved shoulders
Design speed = 90 km/h (General clear zone required = 6.0 m)
AADT = 10,000 (50:50 directional split)
Traffic growth rate = 0%
Encroachment rate = 0.00045 events/km/year
Concrete pole diameter = 0.5 m (therefore, j=1.0)
Projected service life = 10 years
Frangible base pole cost = $5000 (Alternative B)
Relocation cost = $10,000 (Alternative C)
Relocation distance = 3.0 m (i.e. 6.0 metres total from the edge of pavement)
Protection cost = $11,500 (Alternative D)
(Note: Protection costs based upon 25m of SBGR w/two end treatments)

Calculations:

For all alternatives:

Ef = (0.00045)(0.5)(10,000)
= 2.25 collision/km/y/direction

Alternative A: Do Nothing

Base on:

Cf_A = (Ef/2000) [(L + 19.2) P[Y≥A] + 5.14∑ P[Y≥(A+ 1.8 + (2J-1)/2)]]

with: L = 0.5 m
A = 3.0 m (adjacent lane), A =6.5 m (opposite lane)
W = 1.0 m (rounded to nearest m)

= (2.25/2000) [(0.5 + 19.2)(0.56) + (5.14)(0.36)]
+ (2.25/2000) [(0.5 + 19.2)(0.3) + (5.14)(0.21)]
= 0.022 collisions/year

Note: 1) P[Y>...] determined from MTO Roadside Safety Manual, Figure 1.2.3.
2) Both encroachment directions combined.

CC_A = (0.022 collisions/year)($162,000/collision)

Note: Severity Index (Concrete Pole) = 5.5 ------> $162,000/collision

= $3,564/year

NPV = $3,564 (P/A, 6%, 0% growth, 10y)
= $3,564 (7.36) *(From Appendix C, Table C1)*
= $26,231

Alternative B: Replace

Cf_B = 0.022 collisions/year (same as Cf_A)

CC_B = (0.022 collision/year)($13,800/collision)

Note: Severity Index (Frangible Base Pole) = 2.8 ------> $13,800/collision

= $304/year

NPV = \$304 (P/A, 6%, 0% growth, 10y)
= \$304 (7.36) *(From Appendix C, Table C1)*
= \$2,237

Alternative C: Relocate

Cf_C = (2.25/2000) [(0.5 + 19.2)(0.34) + (5.14)(0.22)]
+ (2.25/2000) [(0.5 + 19.2)(0.2) + (5.14)(0.16)]
= 0.014 collisions/year

Note: Both encroachment directions combined.

CC_C = (0.014 collision/year)(\$162,000/collision)
= \$2,268/year

Note: Severity Index (Concrete Pole) = 5.5 ------> \$162,000/collision

NPV = \$2,268 (P/A, 6%, 0% growth, 10y)
= \$2,268 (7.36) *(From Appendix C, Table C1)*
= \$16,692

Alternative D: Protect

Cf_D = (2.25/2000) [(25.0 + 19.2)(0.34) + (5.14)(0.22)]
+ (2.25/2000) [(25.0 + 19.2)(0.2) + (5.14)(0.16)]
= 0.029 collisions/year

Note: Both encroachment directions combined.

CC_D = (0.029 collision/year) (\$15,088/collision)
= \$438/year

Note: Severity Index (SBGR) = 3.0 ------> \$15,088

NPV = \$438 (P/A, 6%, 0% growth, 10y)
= \$438 (7.36) *(From Appendix C, Table C1)*
= \$3,165

Summary of Alternatives

Alternative	CC_n	Cost
A	$26,231	$5000 (in 10 years)
B	$ 2,237	$5000 (now)
C	$16,692	$10,000 (now)
D	$ 3,165	$11,500 (now)

With A selected as the base case, the following relative benefits and costs were calculated:

Summary of B/C Calculations

Alternative	Benefits (PW)	Costs (PW)	B/C	Notes	ΔB/ΔC
B[1]	$23,994	$ 2,208	10.9		
C	$ 9,539	$ 7,208	1.3	<2.0 therefore this alternative is dropped	-0.14[2]
D	$23,066	$ 8,708	2.6		

[1] - ***Alternative B: Sample Calculations*** *(per Appendix C)*

Benefits (PW) $= CC_B - CC_A$ *(PW - Present Worth)*
= $2,237 - $26,231
= -$23,994
= $23,994 *(Note- Reduction in collision costs is considered a benefit and is, therefore, treated as a positive value.)*

Costs (PW) *= Cost of Alternative B -Cost of Alternative A*
= $5,000 - $5,000(P/F, 6%, 10y)
= $5,000 - $5,000(0.5584) *(from Appendix C, Table C2)*
= $2,208

B/C *= $23,994/$2,208*
= 10.9

Since two of the alternatives have B/C ratios are greater than 2.0, an incremental benefit/cost analysis should undertaken to determine which is the most cost-effective.

[2] - ***Incremental Benefit/Cost Analysis: Sample Calculations*** *(per Appendix C)*

ΔB	*= Benefits (PW) of Alternative D - Benefits (PW) of Alternative B*
	= \$23,066 - \$23,994
	= -\$928 (Note - This is a reduction in the rate of collision reductions and, therefore, the negative value is appropriate.)
ΔC	*= Costs (PW) of Alternative D - Costs (PW) of Alternative B*
	= \$8,708 - \$2,208
	= \$6,500
$\Delta B/\Delta C$	*= -\$928/\$6,500*
	= -0.14

Since $\Delta B/\Delta C$ is less than 2.0, Alternative B is the most cost-effective. It should be noted that while the analysis has recommended the installation of a frangible base pole at an offset of 3.0 m, the pole should still be installed as great a distance from the edge of pavement as possible without incurring any additional costs.

Project Activity #4: DRAINAGE

4.0 INTRODUCTION

The guidelines contained in Project Activity #4 are not categorized as being applicable to either Provincial Level Highways or Regional/Area Level Highways and as a result, apply equally to both.

4.1 CROSS CULVERTS

Functional drainage is vital to the structural integrity of the highway. As a result all cross culverts should be maintained in good working condition. Cross culverts should be assessed from the following perspectives:

Drainage

Undersized cross culverts, especially those that have a demonstrated drainage problem, should be given priority for immediate replacement. Cross culverts that are marginally undersized, with no demonstrated drainage problems, should be deferred.

Structural

Cross culverts that are structurally inadequate should be given priority for immediate replacement. In determining structural adequacy, designers should examine whether complete replacement of the existing cross culverts could be deferred until the next reconstruction project with minimal maintenance or strengthening.

Additional Considerations

- Depth of fill
- Type of fill required (i.e. rock vs. earth)
- Detour/diversion potential
- Culvert type
- Scope of project (i.e. resurfacing vs. reconstruction)

4.2 OTHER CULVERTS

Entrance and side road culverts are important elements in proper drainage of a highway facility. As a result, all entrance and side road culverts should be maintained in good working condition. These culverts should be assessed from the following perspectives:

Drainage

Undersized culverts, especially those that have a demonstrated drainage problem, should be given priority for immediate replacement. Culverts that are marginally undersized, with no demonstrated drainage problems, should be deferred.

Structural

Culverts that are structurally inadequate should be given priority for immediate replacement. In determining structural adequacy, designers should examine whether complete replacement of the existing cross culvert could be deferred until the next reconstruction project with minimal maintenance or strengthening.

Additional Considerations

- Depth of fill
- Type of fill required (i.e. rock vs. earth)
- Detour/diversion potential
- Culvert type
- Scope of project (i.e. resurfacing vs. reconstruction)
- Commitments in property agreements

4.3 CURB AND GUTTER

Curb and gutter should only be upgraded, or repaired, in locations where it is required from a hydraulic or road safety perspective. Current specifications for curb and gutter remain unchanged, though consideration should be given to alternatives that may reduce the need for this treatment, such as fully paved shoulders, asphalt bull-noses, etc. Consideration should also be given to eliminating curb and gutter at locations that no longer require it.

Project Activity #5: STRUCTURES

5.0 INTRODUCTION

The guidelines contained in Project Activity #5, Sections 5.1 through 5.16, are categorized as being applicable to Provincial Level Highways or to Regional/Area Level Highways, per Ontario's Highway Network Classification System. A detailed explanation of this classification system has been provided in Appendix D.

5.1 REPLACE STRUCTURE *(Provincial Level Highways)*

Benchmarks/Considerations

Life Cycle Cost Analysis

Using methods as described in the Structural Financial Analysis Manual, and these guidelines, structure replacement is the least cost satisfactory option. Where acceptable alternatives have equal life cycle costs, select the alternative with the lowest initial cost.

Benefit/Cost Analysis

Where replace structure is proposed to improve a level of service, or a safety deficiency; using methods as described in the Structural Financial Analysis Manual and these guidelines, structure replacement must have B/C ratio of at least 2.0.

Functional Requirement

Structural: Structure replacement is required to address critical immediate or impending structural deficiency.

Special Considerations

Structure replacement is required for non structural reasons (e.g. road realignment, road widening, etc.).

Options

- Deferral, with required maintenance
- Strengthening or rehabilitation
- Widening

5.2 WIDENING STRUCTURES *(Provincial Level Highways)*

Benchmarks/Considerations

Collision History/ Potential

Deficient structure width has been identified as a cause of collisions.

Life Cycle Cost Analysis

Using methods as described in the Structural Financial Analysis Manual and these guidelines, widening structures is the least cost acceptable option.

Where acceptable alternatives have equal life cycle costs, select the alternative with the lowest initial cost.

Benefit/Cost Analysis

Where widening of a structure is proposed to improve a level of service, or a safety deficiency; using methods as described in the Structural Financial Analysis Manual, and these guidelines, widening structure must have B/C ratio of at least 2.0.

Functional Requirements

Functional: Structure widening is required to address a critical level of service deficiency.

Special Considerations

Structure widening is required to accommodate widening of approach roadway or represents cost effective option for maintaining traffic during construction.

Options

- Deferral

5.3 STRENGTHENING STRUCTURES *(Provincial Level Highways)*

Benchmarks/Considerations

Life Cycle Cost Analysis

Using methods as described in the Structural Financial Analysis Manual and these guidelines, strengthening structure is the least cost acceptable option.

Where acceptable alternatives have equal life cycle costs, select the alternative with the lowest initial cost.

Benefit/Cost Analysis

Where strengthening structure is proposed to improve a level of service, or safety deficiency; using methods as described in the Structural Financial Analysis Manual and these guidelines, strengthening structure must have B/C ratio of at least 2.0.

Functional Requirements

Structural: Structure strengthening is required to address critical load carrying deficiency on a route.

Options

- Deferral, if safe
- Lower cost alternative for strengthening

5.4 REPLACE/REHABILITATE COMPONENTS *(Provincial Level Highways)*

This activity includes the replacement or rehabilitation of structure components, not including decks, expansion joints or barrier walls and railings: eg. Piers, abutments, floor beams, bearings, etc.

Benchmarks/Considerations

Life Cycle Cost Analysis

Using methods as described in the Structural Financial Analysis Manual and these guidelines, rehabilitation / replacement is the least cost acceptable option.

Where acceptable alternatives have equal life cycle costs, select the alternative with the lowest initial cost.

Benefit/Cost Analysis

Where replace/rehabilitate components is proposed to improve a level of service, or safety deficiency, using methods as described in the Structural Financial Analysis Manual and these guidelines, replacement / rehabilitation must have B/C ratio of at least 2.0.

Functional Requirements

Structural: Rehabilitation / replacement is required to address a critical load carrying deficiency on a route.

Options

- Deferral, with required maintenance

5.5 BARRIER WALLS/RAILINGS *(Provincial Level Highways)*

This activity includes the replacement or rehabilitation of bridge barrier wall and railings, including replacement to a higher standard.

Benchmarks/Considerations

Collision History/ Potential

Inadequacy of existing barrier wall / railing system has been identified as contributing to a high collision frequency or severity at site, or at similar sites; or

Current system has been shown to be seriously deficient through experience, evaluation or crash testing.

Policy & Warrants

Severity index for the site, as determined in accordance with the OHBDC exceeds 2x maximum for the performance level of the existing system (where PL of existing system can be determined).

Where existing system is known to be seriously deficient and a PL2 or higher system is warranted.

Life Cycle Cost Analysis

Using methods as described in the Structural Financial Analysis Manual and these guidelines, barrier replacement or rehabilitation is the least cost acceptable option.

Where acceptable alternatives have equal life cycle costs, select the alternative with the lowest initial cost.

Benefit/Cost Analysis

Where barrier wall replacement/rehabilitation is proposed to improve a level of service, or safety deficiency; using methods as described in the Structural Financial Analysis Manual and these guidelines, barrier / railing replacement / rehabilitation must have B/C ratio of at least 2.0.

Functional Requirements

Structural: Barrier rehabilitation / replacement is required to address critical structural deficiency of the current system, (eg damaged, deteriorated or missing members).

Functional: Current barrier or railing system is critically deficient functionally; eg. open railing configuration on sidewalk adjacent to school or playground.

Options

- Deferral
- Local Repair
- Modification
- Rehabilitation or Strengthening of existing system

5.6 EXPANSION JOINTS *(Provincial Level Highways)*

Benchmarks/Considerations

Life Cycle Cost Analysis

Using methods as described in the Structural Financial Analysis Manual and these guidelines, rehabilitation / replacement of expansion joint system is the least cost acceptable option.

Where acceptable alternatives have equal life cycle costs, select the alternative with the lowest initial cost.

Functional Requirements

Structural: Rehabilitation / replacement is required to prevent damage to critical structural members.

Options

- Deferral
- Repair (eg. seal replacement)
- Lower cost system meeting criteria appropriate for site

5.7 DECK REHABILITATION *(Provincial Level Highways)*

Benchmarks/Considerations

Life Cycle Cost Analysis

Using methods as described in the Structural Financial Analysis Manual and these guidelines, proposed rehabilitation / replacement strategy is the least cost acceptable option.

Where acceptable alternatives have equal life cycle costs, select the alternative with the lowest initial cost.

Functional Requirements

Structural: Rehabilitation / replacement is required to address current or anticipated critical load carrying deficiency on a route.

Options

- Deferral, with required maintenance
- Lower cost rehabilitation strategy
- Local vs complete rehabilitation or replacement

5.8 STRUCTURE COATING *(Provincial Level Highways)*

Benchmarks/Considerations

Life Cycle Cost Analysis

Using methods as described in the Structural Financial Analysis Manual and these guidelines, coating is determined to be the least cost option (vs not coating or other options).

Where acceptable alternatives have equal life cycle costs, select the alternative with the lowest initial cost.

Options

- Deferral
- Lower cost system
- Partial vs total coating
- Local maintenance"Touch up"
- Overcoating

5.9 REPLACE STRUCTURE *(Regional/Area Level Highways)*

Benchmarks/Considerations

Volume

For replacement of single lane structures, AADT > 400.

Life Cycle/Cost Analysis

Using methods as described in the Structural Financial Analysis Manual, and these guidelines, structure replacement is the least cost acceptable option.

Where acceptable alternatives have equal life cycle costs, select the alternative with the lowest initial cost.

Benefit/Cost Analysis

Where replace structure is proposed to improve a level of service, or safety deficiency; using methods as described in the Structural Financial Analysis Manual, and these guidelines, structure replacement must have B/C ratio of at least 2.0.

Functional Requirement

Structural: Structure replacement is required to address critical immediate or impending structural deficiency.

Special Considerations

Structure replacement required for non structural reasons (eg. road realignment, road widening, etc.).

Options

- Deferral, with required maintenance
- Strengthening or rehabilitation
- Widening
- Load posting
- Local detour
- Temporary structure

5.10 WIDENING STRUCTURES *(Regional/Area Level Highways)*

Benchmarks/Considerations

Volume

For widening of single lane structures, AADT > 400 AADT.

Collision History

Deficient structure width has been identified as a frequent cause of collisions.

Life Cycle Cost Analysis

Using methods as described in the Structural Financial Analysis Manual and these guidelines, widening structures is the least cost acceptable option.

Where acceptable alternatives have equal life cycle costs, select the alternative with the lowest initial cost.

Benefit/Cost Analysis

Where widening of a structure is proposed to improve a level of service, or safety deficiency; using methods as described in the Structural Financial Analysis Manual, and these guidelines, widening structure must have a B/C ratio of at least 2.0.

Functional Requirement

Functional: Structure widening to address critical Level of Service deficiency.

Special Considerations

Structure widening to accommodate widening of approach roadway.

Options

- Deferral
- Load posting
- Local detour
- Twinning using temporary structure

5.11 STRENGTHENING STRUCTURES *(Regional/Area Level Highways)*

Benchmarks/Considerations

Percent Commercial

Route carries significant commercial traffic volumes.

Life Cycle Cost Analysis

Using methods as described in the Structural Financial Analysis Manual and these guidelines, strengthening structure is least cost acceptable option.

Where acceptable alternatives have equal life cycle costs, select the alternative with the lowest initial cost.

Benefit/Cost Analysis

Where strengthening a structure is proposed to improve a level of service, or safety deficiency; using methods as described in the Structural Financial Analysis Manual, and these guidelines, strengthening structure must have a B/C ratio of at least 2.0.

Functional Requirement

Structural: Strengthening structure is required to address intolerable load carrying deficiency on a route.

Options

- Deferral, if safe
- Load posting
- Local Detour
- Lower cost alternative for strengthening

5.12 REPLACE/REHABILITATE COMPONENTS *(Regional/Area Level Highways)*

This activity includes the replacement or rehabilitation of structure components, not including decks, expansion joints or barrier walls and railings: eg. Piers, abutments, floor beams, bearings, etc.

Benchmarks/Considerations

Life Cycle Cost Analysis

Using methods as described in the Structural Financial Analysis Manual and these guidelines, rehabilitation / replacement is the least cost acceptable option.

Where acceptable alternatives have equal life cycle costs, select the alternative with the lowest initial cost.

Benefit/Cost Analysis

Where replace/rehabilitate components is proposed to improve a level of service, or safety deficiency; using methods as described in the Structural Financial Analysis Manual, and these guidelines, rehabilitation / replacement must have a B/C ratio of at least 2.0.

Functional Requirement

Structural: Rehabilitation / replacement is required to address an intolerable, critical load carrying deficiency on a route.

Options

- Deferral, with required maintenance
- Load posting
- Local detour

5.13 BARRIER WALLS / RAILINGS *(Regional/Area Level Highways)*

This activity includes the replacement or rehabilitation of bridge barrier wall and railings, including replacement to a higher standard.

Benchmarks/Considerations

Volume

AADT > 400 AADT

Precent Commercial

Lower standard rails may be acceptable in the absence of trucks.

Design Speed

>30 km/h: Lower standard railings may be acceptable for sites where higher speeds are unlikely.

Collision History

Inadequacy of existing barrier wall/railing system has been identified as a contributing to higher than average collision frequency or severity at site or at other similar sites, or

Current system has been shown to be seriously deficient through experience, evaluation or crash testing.

Policy & Warrants

Severity index for the site, as determined in accordance with the OHBDC exceeds 2x maximum for the performance level of the existing system (where PL can be determined).

Where existing system is known to be deficient and a PL2 or higher system is warranted.

Life Cycle Cost Analysis

Using methods as described in the Structural Financial Analysis Manual and these guidelines, barrier replacement or rehabilitation is the least cost acceptable option.

Where acceptable alternatives have equal life cycle costs, select the alternative with the lowest initial cost.

Benefit/Cost Analysis

Where barrier wall replacement/rehabilitation is proposed to improve a level of service, or safety deficiency; using methods as described in the Structural Financial Analysis Manual, and these guidelines, barrier replacement or rehabilitation must have a B/C ratio of at least 2.0.

Functional Requirement

Structural: Barrier replacement or rehabilitation is required to address critical structural deficiency of the current system (e.g. damaged, deteriorated or missing members).

Functional: Current barrier or railing system is critically deficient functionally (e.g. open railing configuration on sidewalk adjacent to schools or playground.).

Options

- Deferral
- Local repair

- Modify barrier
- Rehabilitation or strengthening of existing system

5.14 EXPANSION JOINTS *(Regional/Area Level Highways)*

Benchmarks/Considerations

Life Cycle Cost Analysis

Using methods as described in the Structural Financial Analysis Manual and these guidelines, rehabilitation / replacement of expansion joint system is the least cost acceptable option.

Where acceptable alternatives have equal life cycle costs, select the alternative with the lowest initial cost.

Functional Requirement

Structural: Expansion joint rehabilitation / replacement is required to prevent damage to critical structural members.

Options

- Deferral
- Repair (eg. seal replacement)
- Temporary sealing system
- Lower cost system meeting criteria appropriate for site

5.15 DECK REHABILITATION *(Regional/Area Level Highways)*

Benchmarks/Considerations

Life Cycle Cost Analysis

Using methods as described in the Structural Financial Analysis Manual and these guidelines, proposed rehabilitation / replacement strategy is the least cost acceptable option.

Where acceptable alternatives have equal life cycle costs, select the alternative with the lowest initial cost.

Functional Requirements

Structural: Rehabilitation / replacement is required to address current or anticipated intolerable, critical load carrying deficiency on a route.

Options

- Deferral, with required maintenance
- Lower cost strategy (patch, waterproof and pave vs overlay)
- local vs complete rehabilitation or replacement
- Load posting

5.16 STRUCTURE COATING *(Regional/Area Level Highways)*

Benchmarks/Considerations

Life Cycle Cost Analysis

Using methods as described in the Structural Financial Analysis Manual and these guidelines, coating is determined to be the least cost option (vs not coating or other options).

Where acceptable alternatives have equal life cycle costs, select the alternative with the lowest initial cost.

Options

- Deferral
- Lower cost system
- Partial vs total coating
- Local maintenance"Touch up"
- Overcoating

Project Activity #6: SAFETY

6.0 INTRODUCTION

The guidelines contained in Project Activity #6 are not categorized as being applicable to either Provincial Level Highways or Regional/Area Level Highways and as a result, apply equally to both.

General Comments For Safety Features

- Exposure to roadside environment safety risks are primarily a function of traffic volumes; as a result many of the guidelines for the application of certain safety features are heavily influenced by traffic volumes.

- The ministry's computerized database for collision information is not accurate for site specific analysis. Site specific analysis can require the manual review of 100's or 1000's of accident report and thus may not always be feasible. Sectional collision histories can be derived fairly readily and can be reasonably compared with the performance of similar sections. A minimum of three years (most recent data available) should be used for analysis. Five is preferable. Improvements should be seriously considered whenever a collision rate or type of occurrence is clearly above average for key indicators. Averages should be based on regional data for similar highway types.

- Benefit/cost analyses have been performed based on favourable geometrics (0% grade, tangent) and using widely accepted "average" encroachment rates, severity indices, accident costs, etc. It should be remembered that these are for average conditions and the characteristics of a specific site may not be captured - for example, the encroachment rate for a combined downgrade and curve is 50% higher than the "average" value used in many of these benefit/cost calculations.

- A B/C ratio of 2.0 is to be considered the minimum acceptable for a road safety feature. If a roadside feature does not meet the B/C ratio it may still be necessary based on a site specific history or due to key collision database indicators being above the regional average for a similar facility.

- If the roadside environment's safety risk is increased by an infrastructure improvement, the roadside features must also be mitigated (e.g. a resurfacing may raise the profile, and as a result, the guiderail height must be adjusted). If the roadside environment's safety risk remains unchanged, then the guidelines can be employed to make sure the opportunity to identify and address the high risk location(s) is not ignored.

- In general, the clear zone policy should still be applied. Attention should be paid to high severity objects such as : trees greater than 10 cm diameter; utility poles; non-frangible base signals or illumination poles; bridge and culvert appurtenances. A site-specific benefit/cost analysis may aid decision making. The Highway Planning and Design Development Section, Surveys and Design Office, can provide advice on this issue.

6.1 TRAFFIC SIGNALS (new, temporary, upgrades)

Generally these are identified based on a regional priority list and MTO traffic signal warrants.

Benchmarks/Considerations

Collision History

Must rank high on the regional intersection priority list. This list should contain warranted signals and those approaching the warrant. Typically, this priority list is based on collision frequency. Collision severity and possibly rates (based on number of entering vehicles) may also assist in determining regional priority.

Intersections that do not rank highly should be deferred unless a clear benefit in terms of safety and higher level of service can be demonstrated. Signals for intersections of this type should not be initiated as a stand alone project, but should only be considered as part of a concurrent highway project.

Special Considerations

Commitments by the current Government should be given priority. Non-warranted signals committed by previous Governments should be deferred. Improvements must provide a clear benefit in terms of safety and higher level of service.

6.2 PAVEMENT MARKINGS (durable vs. painted)

These are mandatory, a life cycle cost analysis may be considered for paint vs. durable markings.

6.3 ROADSIDE SIGNS

All signage should be in conformance to the Manual of Uniform Traffic Control Devices of Ontario (MUTCD) and the Kings Highway Guide Signing Policy Manual (KHGSPM)

Benchmarks/Considerations

Functional Requirements

Consider only replacement of existing signage with immediate deficiency in retroreflectivity or structural integrity; for regional/area level highways consider only regulatory, warning and emergency services signage for replacement on highways with less than 5000 AADT.

Special Considerations

Replacement of signage as part of 911 Emergency Service Expansion should continue as per existing ministry policy and agreements with local municipalities.

Commitments by current government, EA process, etc. should remain.

Options

- Existing signage should be inventoried and assessed on a regional basis for replacement as part of an annual preservation management program (this system may need to be created in some regions).

6.4 OVERHEAD SIGNS

Benchmarks/Considerations

Functional Requirements

Overhead signs permit the driver to obtain information more readily in difficult driving environments; the signs are more fully within the cone of vision and the function of specific lanes can be identified.

Typically, these are used only in a complex, multi-lane driving environment with high traffic volumes and insufficient right-of-way available to ground mount correctly sized signs.

Special Considerations

Some types of overhead signing may be employed where there are demonstrated operational problems with drivers selecting the proper lanes, etc. In such a case, a benefit/cost analysis may be warranted, which will require the nature and extent of the operational problem to be quantified.

Options

- Ground mounted, cheaper overhead sign structure designs, and cantilever type signs should be considered.

6.5 ILLUMINATION

Illumination is primarily a road safety feature; properly applied it can significantly reduce collisions during the hours of darkness, while facilitating policing and road maintenance activity.

Benchmarks/Considerations

Policy & Warrants

Directive B-6 provides numerous criteria and guidelines for the provision or upgrading of illumination.

Functional Requirements

In general the provision of partial illumination for decision points is highly cost effective. A decision point should be evaluated with respect to the complexity of the driving task (volume, operating speed, geometrics, number of choices), the impact of a wrong decision (safety, out-of-way travel), and glare and adaptation problems (outside light sources, lack of uniformity).

Collision history during the hours of darkness should be examined to see if either frequency or severity is over-represented compared to regional averages for similar highway types. Future collision potential should also be considered with respect to traffic volume growth, roadside development, etc.

A life cycle cost analysis should be calculated prior to including future provisions.

A life cycle cost analysis should also be performed for the upgrading of existing illumination. Upgrading should only be considered where there are significant functional deficiencies, or where an acceptable benefit/cost ratio of 2.0 (calculated over a period of 5 years or less) can be demonstrated.

Options

- In borderline cases where there is not an overwhelming functional deficiency or collision concern, increased roadside delineation or enhanced pavement markings should be considered.

6.6 GUIDERAIL SYSTEMS

Guiderail systems are intended to provide additional protection to a motorist once a vehicle leaves the roadway. A guiderail system is intended to protect the occupants from a more severe hazard and should significantly reduce the degree of injury and damage.

Over the past 30 years guiderail systems have evolved significantly with almost constant improvements to design. As a result, much of the older guiderail plant is significantly less effective than modern systems. Some systems are also significantly more expensive to maintain than others. Component 6.6 primarily addresses the issue of upgrading existing guiderail installations. New installation will be addressed in accordance with the Roadside Safety Manual.

Benchmarks/Considerations

In general, the need for upgrading of guiderail systems should be evaluated primarily based upon collision history and potential (i.e exposure to risk). In some cases a benefit/cost analysis has been performed to aid in the decision. The detailed explanation of the benefit/cost calculations can be obtained from the Highway Planning and Design Development Section, Surveys and Design Office.

Options

- Borderline cases may be placed on a regional safety improvement list for prioritization.
- In some cases a benefit/cost analysis of the elimination of the roadside hazard may be a useful option.

6.6.1 Length of Need

Benchmarks/Considerations

Collision History

Sectional collision histories should be considered and compared for above average rates (compared to Regional rates for similar highway types) for run-off-the-road, and collisions with fixed objects or guiderail systems. Site specific histories should also be examined.

Policy & Warrants

The design standard for length of need has changed considerably over the last 20 years. Older guiderail installations will need to be evaluated.

The MTO Roadside Safety Manual provides current guidelines.

Extension generally should not need to be considered if the length is within 10% of the current standard.

Functional Requirements

Collision potential typically takes into account adverse geometrics and the implications of bypassing the guiderail system (i.e. the severity of the hazard - reference Project Activity 3.4 Clear Zone).

6.6.2 Cable/Rail Height Adjustments

Benchmarks/Considerations

Collision History

For highways with lower AADT's, the sectional collision history should be examined for above average (regional) incidence of run-off-the-road, single vehicle, fixed object or guiderail system hits. There may also be site specific history.

Policy & Warrants

Cable guiderail systems and box beam systems are "small target" systems whose effectiveness is significantly diminished if the mounting height is too high or too low. Current mounting heights and tolerances are indicated in the MTO Roadside Safety Manual.

Functional Requirements

Investigations are currently being undertaken to attempt a benefit/cost analysis approach to determine the acceptable thresholds for guiderail height and adjustments.

In the interim:

i) Where outside tolerance, 3CGR or 6CGR height adjustments should be undertaken. This may involve using the existing posts or the replacement of the posts. In certain cases CGR may be more cost effectively replaced by a steel beam system - a benefit/ cost analysis should be performed.

ii) Where system replacement of box beam is required due to being over/under height, a specific cost benefit analysis will be required to determine the need for replacement with steel beam - see discussion for component 6.9

Options

- In many cases the cable guiderail height can be adjusted using existing posts. Even if new posts are required, the existing anchors can often be re-used.

6.6.3 End Treatment and Crash Cushions

End treatments are intended to provide a safe termination to a guiderail system. The standards for end treatments have also evolved significantly over the past 30 years. Crash cushions are intended to provide protection from fixed objects which are at high risk of being hit. Typically they are located at divergent roadways.

Benchmarks/Considerations

Volume (AADT/ADT)

A benefit/cost analysis has been performed for the upgrading of steel beam buried end treatments under "average" highway conditions. In general, these end treatments should be upgraded in accordance with Table 6.1.

A benefit/cost analysis has been performed for various types of crash cushion treatments under "average" highway conditions in Table 6.2. These provide the designer with an indication of the cost effective threshold for a given type of treatment.

Collision History

For lower AADT Sections, the collision history should be examined for above average (based on Regional Average for similar highway types) occurrence of single vehicle collisions and run-off-the-road, fixed object or guiderail system hits. There may also be site specific history to consider.

Functional Requirements

The type of crash cushion is selected by the designer, primarily based on the characteristics of a specific site (i.e. width of hazard). Alteration of local characteristics (if possible) may allow the use of a lower cost treatment.

6.6.4 Connection to Structures

Many of the older designs for connections to structures have very limited effectiveness. If a structure is being rehabilitated, the guiderail connections should be upgraded to the current standard. The following deals with connections where the structure is not being rehabilitated.

Benchmarks/Considerations

Volume (AADT/ADT)

Unconnected guiderail treatments should be upgraded to the current standard. For "butt-ended" connections with insufficient posts for stiffening, a benefit/cost analysis has been performed based on "average" highway conditions in Table 6.3.

Collision History

An analysis of the sectional collision history may be considered for lower AADT's. The rate of occurrence for single vehicle collisions and run-off-the-road, fixed object and guiderail system collisions should be compared to the regional average. Site specific history should also be considered.

Table 6.1: Cost Effectiveness Guidelines for the Upgrading of Turned Down SBGR End Treatments to Eccentric Loaders/Extruders.

Facility Type	Operational Environment	Threshold Volume (B/C = 2.0) AADT[4]			
		0% Annual Traffic Growth		2% Annual Traffic Growth	
		Approach End	Leaving End	Approach End	Leaving End
King's Highways					
2 lane/undivided[1]	rural	7,500[3]	15,800	6,250	13,100
2 lane/undivided	urban	7,500	15,800	6,550	13,750
4 lane/undivided	rural/urban	10,500	40,000	9,150	35,000
Freeways[2]					
4 lane/divided	rural/urban	12,500	n/a	11,250	n/a
6 lane/divided	rural/urban	27,500	n/a	24,150	n/a

[1] - based on a 20 year life cycle, versus a 15 year life cycle for all other facility types.
[2] - physically divided by either a grass median or median barrier wall.
[3] - AADT (both directions combined)
[4] - Threshold Volume (program year's actual/projected AADT)

Table 6.2: Cost Effectiveness Guidelines for the Upgrading of Gore Area Hazard Protection Through the Installation of Crash Cushions.

Crash Cushion Type	Initial Cost	Threshold Volume (B/C = 2.0) AADT[2]	
		0% Annual Traffic Growth	2% Annual Traffic Growth
CAT	$12,500	8,200[1]	7,100
GREAT (Permanent)	$25,000	19,150	16,650
HI-DRO	$45,000	35,000	30,000

[1]- AADT (approach volume only)
[2]- Threshold Volume (program year's actual/projected AADT)

Table 6.3: Cost Effectiveness Guidelines for the Upgrading of Sub-Standard SBGR Butt-Ended Connections to Structure, to Standard SBGR Butt-Ended Connections Through the Installation of Additional Posts.

Facility Type	Operational Environment	Threshold Volume (B/C = 2.0) AADT[4]			
		0% Annual Traffic Growth		2% Annual Traffic Growth	
		Approach End	Leaving End	Approach End	Leaving End
King's Highways					
2 lane/undivided[1]	rural	4,300[3]	9,150	3,500	7,850
2 lane/undivided	urban	4,300	9,150	3,750	7,900
4 lane/undivided	rural/urban	5,900	16,650	5,277	14,350
Freeways[2]					
4 lane/divided	rural/urban	7,500	n/a	6,450	n/a
6 lane/divided	rural/urban	15,800	n/a	13,650	n/a

[1] - based on a 20 year life cycle, versus a 15 year life cycle for all other facility types.
[2] - physically divided by either a grass median or median barrier wall.
[3] - AADT (both directions combined)
[4] - Threshold Volume (program year's actual/projected AADT)

It should be noted that Tables 6.1, 6.2 & 6.3 were generated based on typical encroachment rates for level, tangent sections of highway. While these serve as a useful first screen, the effect of horizontal curvature and grade cannot be discounted. For example a 2 lane, undivided, rural King's Highway with 0 % traffic growth would generate the threshold volumes as shown in Table 6.4.

Options

Where additional posts are required but there is a low AADT (<4300 (per Table 6.3)), an overlap section on the end panel may be considered. This treatment remains substandard pending replacement of the installation, but provides some increased protection for a minimal expenditure.

Table 6.4: Effect of Grade and Curvature on Encroachment Rates

Geometric Conditions	Encroachment Rate[1] (events/km/y)	Volume (B/C=2.0) (AADT)
0% Grade, Tangent (As per Table 6.1) (Design Speed = 60 km/h)	0.0004500	7500
0% Grade, Horizontal Radius = 130m (Design Speed = 60 km/h)	0.0005625	5940
6% Down Grade, Horizontal Radius = 130m (Design Speed = 60 km/h)	0.0006750	5000

[1] - Typical encroachment rates, including horizontal and vertical adjustment factors are available from TAC - *Manual of Geometric Design Standards for Canadian Roads* (Reference Project Activity 3.4 - Clear Zone).

6.6.5 Removal of Adjacent Curb and Gutter

The presence of non-mountable curb in front of guiderail greatly diminishes its effectiveness. Small target systems (cable guiderail and box beam) are particularly vulnerable.

Benchmarks/Considerations

Collision History

Serious consideration must be given to the removal of curb and gutter that fronts small target guiderail systems. Sectional or site specific collision history should be considered.

More complex situations (e.g. requiring the replacement of drainage system) may require a benefit/cost analysis. The Highway Planning and Design Development Section, Surveys and Design Office, may be contacted for assistance.

6.7 REPLACING SINGLE CABLE SYSTEMS

The single cable guiderail system is an outdated system, with little or no effectiveness.

Benchmarks/Considerations

Removal of single cable guiderail must be undertaken. If a replacement system is in question, the hazard should be reassessed and other mitigating measures should be considered.

Options

- In some cases, the single cable system may present more of a hazard than the hazard it was originally installed to protect. In such cases, even if replacement is questionable, removal of the guiderail may still be a preferred option.

6.8 UPGRADING GUIDERAIL SYSTEMS

Benchmarks/Considerations

Existing guiderail systems may be considered for replacement due to:

Volume

Higher traffic volumes and greater potential occurrences of collisions.

Commercial

Need for increased effectiveness (e.g. truck incidents, rate of penetration).

Policy & Warrants

Guidelines exist within the MTO Roadside Safety Manual.

Benefit/Cost Analysis

A site specific benefit/cost analysis will be required to assess the need. This will typically involve:

- The identification of any particular safety issue through an analysis of sectional collision history and comparison to regional averages for similar highway types.
- A determination of the occurrence rate for guiderail system hits and penetrations.
- The differential in collision severity (and the associated cost) between the existing and upgraded system.
- The differential in maintenance costs.
- The additional cost of the upgraded barrier system.
- A determination of system life and the appropriate discount rate.

The Highway Planning and Design Development Section, Surveys and Design Office, can offer assistance for this calculation and provide standard values.

Functional Requirements

Lower maintenance costs are sometimes a consideration. Replacement may be driven by the need to upgrade companion components - lighting, drainage, etc.

6.9 MEDIAN BARRIERS/NEW

New median barrier systems represent a major expenditure and typically must be carefully evaluated as a stand alone capital project. The decision to install new median barrier is usually a program level decision.

Benchmarks/Considerations

Collision History

Typical criteria for evaluation include crossover rate and accident severity. Several regions are currently developing priority lists for median barrier needs.

Life Cycle/Cost Analysis

New median barrier systems for a specific site should ideally be evaluated against other median barrier needs both on a regional and a provincial basis.

Benefit/Cost Analysis

Transportation Engineering Branch, in conjunction with the three southern regions, has developed a procedure to aid in the determination of need for "new" median barrier projects. The procedure utilizes a benefit/cost methodology. The resulting benefit/cost ratios can be used to develop priority rankings. Copies of the procedure can be obtained directly from the Highway Planning and Design Development Section, Surveys and Design Office, Transportation Engineering Branch.

Options

- In borderline or "deferred" cases, partial or full width paved shoulders should be considered (for both shoulders). These improvements typically decrease the frequency of crossover type accidents.

6.10 MEDIAN BARRIERS/UPGRADE

Refer to the discussions for components 6.8 and 6.9

In addition to the discussion in 6.9 and 6.10, barrier penetration may be another important evaluation criteria. This typically requires an extensive manual analysis of collision records to determine the frequency and severity of the occurrences.

Median barriers systems which involve the use of 6 cable guiderail centered in a ditch cross section with cross slopes of steeper than 10:1 should be eliminated.

Benchmarks/Considerations

Benefit/Cost Analysis

A benefit/cost analysis can be performed using the PCC benefit/cost methodology. The Highway Planning and Design Development Section, Surveys and Design Office, can provide assistance with the calculation methodology and standard values.

Project Activity #7: FACILITIES

7.0 INTRODUCTION

The guidelines contained in Project Activity #7 are not categorized as being applicable to either Provincial Level Highways or Regional/Area Level Highways and as a result, apply equally to both.

7.1 COMMUTER PARKING FACILITIES

Unlike physical elements of highway design (geometrics, structures, etc.), Commuter Parking Facilities are often developed based on specific needs, warrants, MTO policy, MTO commitments, provincial studies, program level decisions, or special site conditions. For this reason, care must be taken in recommending the deferral of these facilities. Generic and quantifiable benefit-cost relationships are not available for Commuter Parking Facilities.

Parking availability is a means of regulating the flow of traffic. When parking in urban areas becomes more scarce and expensive, the number of vehicles entering the area will be reduced. Some people will shift to transit or car pools; others will park at the periphery of the city where space is available at more reasonable rates. For the above reasons care should be taken in deferring the construction of these facilities as their location is often the product of transportation network or provincial initiatives.

In other cases, these facilities are recommended for the relief of illegal parking and/or awkward traffic movements resulting in collisions or undesirable delays. These operational problems should be considered on a site by site basis.

7.2 HIGHWAY SERVICE CENTRES

Unlike physical elements of highway design (geometrics, structures, etc.), Highway Service Centres are often developed based on specific needs, warrants, MTO policy, MTO commitments, provincial studies, program level decisions, or special site conditions. For this reason, care must be taken in recommending the deferral of these facilities. Generic and quantifiable benefit-cost relationships are not available for the analysis of Highway Service Centres.

These facilities should be considered on a site by site basis as they are often the product of business negotiations, EA provisions and provincial requirements. In general, deferral should be recommended unless all costs are by others, or approval is granted by the Regional Director.

7.3 REST AREAS

Unlike physical elements of highway design (geometrics, structures, etc.), Rest Areas are often developed based on specific needs, warrants, MTO policy, MTO commitments, provincial studies, program level decisions, or special site conditions. For this reason, care must be taken in recommending the deferral of these facilities. Generic and quantifiable benefit-cost relationships are not available for the analysis of Rest Areas.

7.4 PARK & PICNIC AREAS

Unlike physical elements of highway design (geometrics, structures, etc.), Park & Picnic Areas are often developed based on specific needs, warrants, MTO policy, MTO commitments, provincial studies, program level decisions, or special site conditions. For this reason, care must be taken in recommending the deferral of these facilities. Generic and quantifiable benefit-cost relationships are not available for the analysis of Park and Picnic Areas.

These facilities should be considered on a site by site basis. Park and picnic areas may be introduced where recommended by the District Engineer and approved by the Regional Director.

7.5 TRUCK INSPECTION STATIONS

Unlike physical elements of highway design (geometrics, structures, etc.), Truck Inspection Stations are often developed based on specific needs, warrants, MTO policy, MTO commitments, provincial studies, program level decisions, or special site conditions. For this reason, care must be taken in recommending the deferral of these facilities. Generic and quantifiable benefit-cost relationships are not available for the analysis of Truck Inspection Stations.

These facilities should be considered on a site by site basis. If the facility is required by operations, then deferral should be avoided. Warrants for these facilities are beyond the scope of this document.

7.6 PATROL YARDS & BUILDINGS

Unlike physical elements of highway design (geometrics, structures, etc.), Patrol Yards & Buildings are often developed based on specific needs, warrants, MTO policy, MTO commitments, provincial studies, program level decisions, or special site conditions. For this reason, care must be taken in recommending the deferral of these facilities. Generic and quantifiable benefit-cost relationships are not available for the analysis of Patrol Yards and Buildings.

These facilities should be considered on a site by site basis. Warrants for these facilities are beyond the scope of this document.

7.7 BIKE PATHS & SHOULDER BIKEWAYS

Unlike physical elements of highway design (geometrics, structures, etc.), Bicycle Facilities are often developed based on specific needs, warrants, MTO policy, MTO commitments, provincial studies, program level decisions, or special site conditions. For this reason, care must be taken in recommending the deferral of these facilities. Generic and quantifiable benefit-cost relationships are not available for the analysis of Bicycle Facilities.

Although most of the existing highway and street systems can be used by cyclists, it is often necessary to carry out improvements to these facilities to provide for the safety of bicycle riders.

The decision to construct or defer these facilities should be considered on a site by site basis. In general, the facility should be deferred unless:

- approved by the Regional Director (due to significant bicycling activity);
- on MTO regionally approved plan;
- on a Comprehensive Community Plan;
- paid for by others and acceptable to MTO in terms of bicyclist and motorist safety.

7.8 PEDESTRIAN FACILITIES

Unlike physical elements of highway design (geometrics, structures, etc.), Pedestrian Facilities are often developed based on specific needs, warrants, MTO policy, MTO commitments, provincial studies, program level decisions, or special site conditions. For this reason, care must be taken in recommending the deferral of these facilities. Generic and quantifiable benefit-cost relationships are not available for the analysis of Pedestrian Facilities. Special consideration should be given to locations that have a demonstrated collision history of incidents involving pedestrians.

Sidewalks and other pedestrian facilities are often provided on roads in urban areas, but very seldom are they provided in rural areas. Rural high-speed highways may require sidewalks at areas with high pedestrian concentrations, such as adjacent to schools, industrial plants, and local businesses. In general, these facilities should be included when MTO construction conflicts with existing installations.

7.9 SNOWMOBILE CROSSINGS

Unlike physical elements of highway design (geometrics, structures, etc.), Snowmobile Crossings are often developed based on specific need, warrants, MTO policy, MTO commitments, provincial studies, program level decisions, or special site conditions. For this reason, care must be taken in recommending the deferral of these facilities. Generic and quantifiable benefit-cost relationships are not available for the analysis of Snowmobile Crossings. Special consideration should be given to locations the have a demonstrated collision history of incidents involving snowmobiles.

Snowmobile crossings may be desirable in a northern region where the snowmobile is a common mode of transportation and/or an important part of the local economy. Provision of a snowmobile crossing may be considered on a site by site basis where a provincial highway intersects with a major trail forming part of the provincial snowmobile trail network. This crossing will be at the expense of others.

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Project Activity #8: OPERATIONAL IMPROVEMENTS

8.0 INTRODUCTION

The guidelines contained in Project Activity #8 are not categorized as being applicable to either Provincial Level Highways or Regional/Area Level Highways and as a result, apply equally to both.

The benefits of an operational improvement can be in the form of collision avoidance or delay reduction. The purpose of this section is to help the designer consider if a recommended operational improvement is truly cost-effective. Due to the varied nature of these improvements, only Sections 8.1 and 8.4 provide a benefit/cost calculation. The other sections provide guidelines for these components and their possible advantages and disadvantages.

8.1 TRUCK CLIMBING LANES AND PASSING LANES

Truck climbing lanes are used as a means for overcoming the operational and safety problems attributed to heavy trucks and other slow moving vehicles on up grade sections of two-lane highways. Due to the limited climbing abilities of heavy vehicles, a substantial drop in the speed can result in:

- restricted opportunities for overtaking slow vehicles;
- increased platooning;
- reduced average speed;
- increased collision potential.

No relationships exist for the cost-effectiveness of truck climbing lanes on multilane highways.

The purpose of this section is to outline one possible method of calculating the cost of delay, and the cost of collisions associated with an uphill grade on a two lane highway. These costs can be added together and compared to the construction cost. If the benefit/cost ratio exceeds 2.0, then it is recommended that the climbing lane be constructed as a cost-effective solution to an operational problem.

A study entitled "Cost-Effectiveness of Climbing Lanes", conducted in 1990 by A.M. Khan, N.M. Holtz and Z. Yicheng was funded by the Ministry of Transportation of Ontario. The purpose of this study was to develop a methodology for assessing the cost-effectiveness of climbing lanes on two-lane highways, based on level of service improvement, reduction of delay, increased safety, and cost of providing a climbing lane.

The following pages outline one possible technique, based on the above study, for completing a benefit/cost calculation.

This information sheet will aid in the calculation of the benefits of a truck climbing lane. These techniques are to be used as a guide only as existing conditions, local needs and collision history should always be considered. The major benefits of a climbing lane are the reduction of delay and the reduction in collision potential. An example of the use of this analysis is included at the end of the section.

1. Calculation of Delay

$$D_{veh}=[\frac{3600}{S_u}-\frac{3600}{S_a}]\times\frac{L}{1000}$$

$$D_{yr}=D_{veh}\times AADT\times P\times\frac{365}{3600}$$

Note: it is assumed that the approach speed is equal to the operating or observed speed.

without climbing lanes, overtaking allowed:

$S_u = 127.47 - 0.015989V - 0.129015P - 5.06126G - 0.005077L - 0.274405T - 0.218653RV$

without climbing lanes, no overtaking allowed:

$S_u = 125.38 - 0.015989V - 0.129015P - 5.06126G - 0.005077L - 0.274405T - 0.218653RV$

with climbing lanes ending beyond crest, overtaking allowed:

$S_u = 118.93 - 0.003619V - 5.20828G - 0.00999L + 0.0084L_{cl} - 0.009316 V_c - 0.05421V_t - 0.00282V_{RV}$

with climbing lane ending beyond crest, no overtaking allowed:

$S_u = 117.95 - 5.45491G - 0.010884L + 0.009575 L_{cl} - 0.014782 V_c - 0.061663 V_t - 0.001976 V_{RV}$

where:

D_{yr} = total annual delay (hrs.)

D_{veh} = single vehicle delay (s)

S_u = up-grade speed (km/hr)

S_a = approach speed (km/hr)

V = two way volume (vph) (DHV)

P = percent traffic up-grade direction

G = percent grade

L = length of grade (m)

T = percent trucks

RV = percent RV vehicles

L_{cl} = length of climbing lane (m)

V_t = truck volume up-grade direction (vph) = V × P × T

V_{RV} = RV volume up-grade (vph) = V × P × RV

V_c = car volume up-grade direction (vph) = V × P × (1 - T- RV)

***for an up-grade section containing both "no overtaking" and "overtaking" zones*:**

$$S_u = [\frac{100-X}{100}] S_u^o + \frac{X}{100} S_u^n$$

where:

X = percent of "no overtaking" zones

Note: superscripts "o" and "n" refer to "overtaking zone" and "no overtaking" zones, respectively.

$$\Delta D = D_{no} - D_{cl}$$

where:

ΔD = delay reduction (hrs/yr)

D_{no} = delays without climbing lane (hrs/yr)

D_{cl} = delays with climbing lane (hrs/yr)

2. Collision Reduction

Acc = 132.441 + 22.085 (ΔS) ⇨ for ΔS up to 15 km/h

Acc = -992.853 + 95.470 (ΔS) ⇨ for ΔS over 15 km/h

where:

Acc = collision involvement rate (collisions per 100 million vehicle-km of travel)

ΔS = speed reduction in km/h

= $S_a - S_u$

In order to determine the reduction of potential collisions due to the introduction of a climbing lane, collision rates before and after the improvement must be compared:

ΔAcc = Acc (before improvement) - Acc (after improvement)

$$\Delta A = \frac{\Delta Acc \times AADT \times 365}{100{,}000{,}000} \times \frac{L_{cl}}{1{,}000}$$

where:

ΔA = number of collisions reduced per year

AADT = annual average daily traffic

L_{cl} = Length of the climbing lane (m)

3. Benefit / Cost Analysis

Potential delay cost savings = ΔD × VT

where:

ΔD = delay reduction in hours per year

= delays without climbing lanes - delays with climbing lanes

VT = value of time in $/vehicle hour *(Reference Appendix E)*

Potential collision cost savings = $\Delta A \times VCC$

where:

ΔA = reduction in collision involvements/year

VCC = value of reducing one collision involvement, in constant dollars of the base year

Annual Benefit = (50% of potential delay cost savings +100% of potential collision cost savings) for Provincial Level Highways

Annual Benefit = (20% of potential delay cost savings +100% of potential collision cost savings) for Regional/Area Level Highways

Benefit = Net present worth of above cost savings over the service life, taking into account growth in traffic, using a discount rate of 6%.

Costs = Estimated construction costs.

B/C = Benefits / Costs

4. Example

Problem:

A 1.6 km stretch of a non-Provincial Level, 2 lane, undivided King's Highway has a grade of 4%. Determine whether it is cost-effective to provide a truck climbing lane now, or to defer the improvement one service life.

Given:

2 lane, undivided rural King's Highway

Service Life = 15 years

Traffic Growth = 0%

Operating Speed (or Observed Speed) = 85 km/h

AADT = 6,000 (50:50 Directional Split)

DHV = 1170 vph (approximately 19.5% of AADT)

Length of Section = 1600 m

Length of Proposed Climbing Lane (ending beyond crest) = 1000 m

Trucks = V_t = 8%

Recreational Vehicles = V_{RV} = 6%

Grade = 4%

100% No Overtaking

Estimated Construction Cost = $1,500,000

VCC = $23,500 *(Highways - Reference Appendix E.)*

Calculations:

Up-grade Direction:

number of trucks = 1170 vph × 50% up-grade × 8% trucks = 50 trucks per hour

number of recreational vehicles = 1170 vph × 50% up-grade × 6% RVs = 35 RVs / hour

number of cars = 1170 vph × 50% up-grade × (1-8% - 6%) = 500 cars per hour

BEFORE IMPROVEMENT

S_u (without climbing lane, no overtaking allowed)

= 125.38 - 0.016(1170) - 0.129(50) - 5.061(4) - 0.00508(1600) - 0.274(8) - 0.219 (6)

= 68.3 km/h

$$D_{veh} = [\frac{3600}{68.3} - \frac{3600}{85}] \times \frac{1600}{1000} = 16.6 sec \qquad D_{yr} = 16.6 \times 6000 \times 50\% \times \frac{365}{3600} = 5050 \textit{hours}$$

ΔS = 85 - 68.3 = 16.7 km/h

Acc = - 992.853 + 95.470 × 16.7 = 600 collisions / 100 MVKM

AFTER IMPROVEMENT

S_u (with climbing lane ending beyond crest, no overtaking allowed)

= 117.95 - 5.455 (4) - 0.0109 (1600) +0.0096 (1000) - 0.0148 (500) - 0.0617 (50) -0.0020 (35)

= 77.7 km/h

$$D_{veh} = [\frac{3600}{77.7} - \frac{3600}{85}] \times \frac{1600}{1000} = 6.4 sec \qquad D_{yr} = 6.4 \times 6000 \times 50\% \times \frac{365}{3600} = 1950 \textit{hours}$$

ΔS = 85 - 77.7 = 7.3 km/h

Acc = 132.441 + 22.085 (7.3) = 290 collisions / 100 MVKM

NET CHANGES DUE TO IMPROVEMENT

$\Delta D = 5050 - 1950 = 3100$ hours

Potential delay cost savings = 3100 × \$10 = \$31,000/year

Note: Value of Time (Non-Commercial) = \$10/vehicle hour - Reference Appendix E

$\Delta acc = 600 - 290 = 310$ collisions / 100 MVKM

$$\Delta A = \frac{310 \times 6000 \times 365}{100{,}000{,}000} \times \frac{1{,}000}{1{,}000} = 6.8$$ collisions per year

Potential collision cost savings = ΔA(VCC) = 6.8 × \$23,500 = \$159,800/year

Benefits = [20% × \$31,000 + 100% × \$159,800]

= \$166,000 per year for 15 years with no predicted increase in AADT

Note: The 'Not Constructed' alternative was selected as the base case (Reference Appendix C). As a result the benefits are equal to:

Benefits = *Benefits to Construct - Benefits to Not Construct*

= \$166,000/year - \$0/year

= \$166,000/year

Benefits(PW) = \$166,000(P/A, 6%, 0% growth, 15 years)

= \$166,000 (9.712) (from Table C1, Appendix C)

= \$1,612,192

Costs = \$1,500,000

Note: The 'Not Constructed' alternative was selected as the base case (Reference Appendix C). As a result the costs of construction are equal to:

Costs (PW)	=	*Costs to Construct - Costs to Not Construct*
	=	$1,500,000 - $0
	=	$1,500,000
B/C	=	$1,612,192 / $1,500,000
	=	1.07

Since the B/C ratio is less than 2.0, construction of a truck climbing lane is not recommended.

8.2 INTERSECTIONS

Research shows that intersections have substantially higher collision rates than average highway sections. However, quantitative relationships between specific intersection improvements and reduction in collision rates are not available.

For the purpose of PCC, intersections should be considered on a site-specific basis. While intersection upgrades should generally be deferred, each intersection should be checked for collision and operational problems. Where these problems are identified, the intersection upgrades proposed should be scrutinized to ensure that they address the correct problem. In order to assist in this analysis, the following notes are offered on the effects of physical and operational features on the safety of intersections (source: "Designing for Safer Roads" - Reference #22, Appendix A).

Number of Approaches

The hazard of at-grade intersections increases as the number of approaches increases. For example: 3-legged (T-type) intersections are safer than 4-legged (cross-type), which are safer than 5-legged. The increased hazard is due to more conflict points, more driver decisions, signing and pavement marking difficulties, and inferior surface drainage. One study (Reference #3, Appendix A) concluded that the collision rate for Y-type is higher than that for T-type intersections. This study was based both on stop and signalized intersections.

Intersection Angle

The preferred angle is 90°. Significant deviation means that drivers cannot detect the presence of, and/or effectively and accurately judge the speed of, and/or the lane position of other approaching vehicles. In addition turning maneuvers are more difficult.

Number of Through Lanes

Collision rates are higher when approaching roadways having a large number of lanes.

Sight Distance

Safety is enhanced as sight distance is increased Increased sight distance is less significant under traffic-signal control.

Alignment

Curvature, either vertical or horizontal, which impairs sight distance will increase intersection collisions. Vertical gradient also becomes a liability as stopping distance on downward approach increases, and acceleration on an upgrade away from the intersection is reduced. Horizontal curves make it more difficult for drivers to note the proper approaching vehicle paths.

Turn Lanes

Turn lanes have a beneficial impact on safety as they accommodate the deceleration, acceleration and waiting of turning vehicles which in turn reduces the potential for collisions and delays to through vehicles. The benefits are dependant on volumes of, number of conflicting intersection movements, and vehicle approach speeds. The construction of turn lanes is an important factor in reducing collisions on the same approach, in particular rear-ends. Left turn lanes have a greater potential to reduce collisions than right turn lanes.

Left Turn Lanes

Left turn lanes provide significant reduction in collision rates, particularly at unsignalized intersections.

Friction

Tire-pavement friction affects primarily multi vehicle collisions occurring on wet or icy pavement. It is most critical when a large number of vehicles are stopping, with high approach speeds.

Turning Radii

Safety is reduced when vehicles must encroach on existing lanes, or slow excessively in the through lane in order to turn. Right turns are more critical than left.

Other Features

Lighting, driveway locations, signage, approach speeds and on-street parking may also be sight specific factors at an intersection that should be examined closely.

8.3 CONSTRUCTION TRAFFIC MANAGEMENT - MINIMIZE STAGING SOPHISTICATION

Staging is a complex issue which introduces numerous site specific and project specific issues. As a result, the use of PCC is very much project specific and general guidelines are not realistic. However, typical areas that should be considered to minimize staging sophistication and cost are listed below.

Consideration of Detours on Local Roads

Traffic may be able to be detoured around the construction zone by utilizing existing off-site roadway facilities. This could occur on a very site specific basis such as a bridge replacement or on a longer stretch of roadway rehabilitation. In either case, a consideration of all pro's and con's related to the off-site detour should be included. These should include, but are not limited to:

- User delay (if used in a benefit/cost analysis, user delay should be discounted to 50 percent for Provincial Level Highways and 20 percent for Regional/Area Level Highways);

- Any costs associated with using the off-site detour such as municipal levies or local roadway upgrades;
- Duration of detour operations, and;
- Driveway accesses to roadway under construction.

Consideration of Lane Reductions (Reductions in Lane Widths)

Lane reductions should be considered instead of detours, especially detours requiring excessive utility relocations and/or excessive impacts to adjacent properties.

Additional Consideration

Consideration should be given to:

- Creating a driveable paved shoulder for use as a roadside diversion, possibly in conjunction with lane reductions.
- Allowing vehicles to drive over exposed granular grade with speeds adjusted appropriately.
- Use of reversible lanes, and;
- Extended lane closure hours.

8.4 AUXILIARY LANES

Side Road Tapers

Where a demonstrated maintenance or operational need exists, sideroad tapers should be constructed.

Two-Way Left Turn Lanes (TWLTL)

The majority of two-lane highways carry relatively low traffic volumes and experience few operational problems. However, considerable safety and operational problems exist on some higher volume highways, particularly in suburban fringe and commercial areas. Such problems are often related to the numerous turn movements, especially left turns, that characterize these areas. Excessive turn movements, combined with high traffic volumes, often result in high collision rates and reduced through capacities.

Traditional MTO practice to address such situations has been to upgrade these highways through the addition of a TWLTL, and additional through lanes. While this solution addresses both the safety and capacity problems, by providing left turning vehicles with a refuge area and through vehicles with the opportunity to avoid right turning vehicles, it is often not cost-effective.

It should be noted that MTO's traditional approach has been to construct five-lane cross sections with a median TWLTL. Such a cross section is often recommended as the ultimate stage for a project. Because the costs associated with upgrading a highway from two-lanes to five can be prohibitive, such projects are prime candidates for deferral. Consideration should be given to constructing an interim three-lane cross section, composed of two through lanes and a TWLTL. Often as a result of the elimination of the left turning vehicles through a TWLTL, through capacity requirements can be met. This stage could function until additional through capacity is required. It is possible that the three lane cross section could replace the traditional five-lane section on many highways where through volumes are never forecasted to be sufficient enough to warrant additional lanes.

It should be cautioned that while the introduction of TWLTL's may reduce some problems, additional problems may be created. For example, in rural locations where passing zones exist, using TWLTL's can create additional problems with respect to same direction passing maneuvers. Users should exercise engineering judgement when selecting multi-lane design alternatives, as numerous operational, safety and cost factors need to be considered. Research has indicated that TWLTL's have the potential to reduce collisions, so failure to examine this alternative could potentially result in a missed opportunity to increase road safety.

This section outlines one possible method of determining whether three-lane or five-lane cross sections with a TWLTL are cost-effective from a road safety perspective. In general such an analysis would only be undertaken if, as a result of a standard highway capacity analysis, it was determined that because of the elimination of left turning vehicles sufficient through capacity remained. If the demand volume were to still exceed the available through capacity, the user would have to attempt to factor associated delay costs into the analysis.

A study entitled "NCHRP Report No. 282, Multilane Design Alternatives for Improving Suburban Highways" was conducted in 1986 by D.W. Harwood and was funded by the Transportation Research Board, USA. The purpose of this study was to examine the safety, operational and cost characteristics of multi-lane designs for suburban areas. The user should also note that while the collision rates that resulted from this study represent the most reliable information available, the results should still be used with caution.

This information sheet will aid in the calculation of the benefits of a TWLTL from a road safety perspective. These techniques are to be used as a guide only as existing conditions, local needs, and collision history should always be considered. The major benefits of a TWLTL are maintenance of through lane capacity, and a reduction in collision potential. An example of the use of this analysis is included at the end of this section.

1. Collision Reduction

Table 8.1 Basic Collision Rates (collisions/MVKM)

Type of development	**Design Alternative**				
	2 lane undivided	***3 lane undivided including TWLTL***	***4 lane undivided***	***4 lane divided with one-way left turn lane***	***5 lane divided including TWLTL***
Commercial	2.81	2.48	4.74	4.73	3.60
Residential	2.96	2.21	2.47	2.55	2.01

Adjustment Factors			
Entrances/km	≤19 -0.25	19-37 -0.02	≥37 +0.22
Intersections/km	≤3 -0.62	3-7 +0.17	≥7 +0.86
% trucks	≤3 +0.25	3-7 -0.09	≥7 -0.44

Note: 1) Average collision rates for suburban arterial highways (including non-intersection and unsignalized intersection collisions.

2) Adjustment Factors are added to or subtracted from the base rate to determine the overall theoretical collision rate.

3) Collision Rate is reflective of all reportable collisions, involving fatalities, injury and property damage only.

4) The user should note that these collision rates and adjustment factors were derived from a limited sample of typical suburban roads and thus may not be reflective of all geometric and operational conditions.(i.e. alignment and operating speeds). For a more complete discussion consult Reference #8 and #30, Appendix A.

Potential Collision Reduction Factor (PCR)

$$= \frac{AR - ARp}{AR}$$

where:

AR = collision rate of existing cross section (collisions/MVKM)

ARp = collision rate of proposed cross section (collisions/MVKM)

2. Benefit / Cost Analysis

Benefits = Potential collision cost savings

Note: Benefits are calculated using the PCR factor in conjunction with an indicator of collision frequency and severity. Caution should be exercised when attempting to quantify a collision indicator. For example, if only average collision rates and collision severity information are available, then this data should be used, but caution should be exercised in that average rates may under estimate the benefits of the proposed improvement.

Costs = Estimated construction costs.

B/C = Benefits/Costs

3. Example

Problem:

A 4.0 km stretch of King's Highway requires upgrading to address capacity and safety deficiencies. MTO's current design practice has recommended that a five-lane cross section with a TWLTL be constructed. A capacity analysis has indicated that with the elimination of left turning vehicles from the through flow, additional lanes will not be required for at least 10 years. Is it cost-effective to construct a five-lane cross section with a TWLTL now, or should an interim three-lane cross section with a TWLTL be considered?

Given:

2 lane, undivided King's Highway

Length = 4.0 km

Service life = 10 years

Traffic Growth = 0%

Entrances / km = 20

Intersections / km = 4

% trucks = 7

Construction costs:	5 lanes = $2,300,000
	3 lanes = $800,000

AR = 3.3 collisions/MVKM (based upon all reportable collisions)

6 fatalities in the last 5 years (from collision reports)

Calculations:

Note: For this example only fatality information is available. As the costs of a fatality are substantially larger than any other collision type, the majority of benefits of a proposed improvement will be accounted for in the analysis. For a more robust analysis, consideration could be given to including other collision types, but their effects would be marginal.

Scenario A Five lane cross section with a TWLTL

ARp	=	2.01	Base Collision Rate (Residential) *from Table 8.1*
	-	0.02	20 entrances/km
	+	0.17	4 intersection/km
	-	0.09	7% trucks
	=	2.07 collisions / MVKM	

PCR	=	(3.30-2.07) / 3.30
	=	0.373

*Note: It is important for users to realize that PCR effectively represents the potential drop in **all** collision types.*

Assumption: From the collision records for the site it was observed that 6 fatalities have occurred in the last 5 years that were related to cross section. It is reasonable to assume that the rate of fatalities will decrease proportionately with the overall collision rate reduction.

Fatality Rate = (6 fatalities)/5years = 1.2 fatalities/year

Benefits = (PCR)(Fatality Rate)(Cost/Fatality)

= (0.373)(1.2)($875,000)

Note: Cost/Fatality = $875,000. (Reference Appendix E)

= $391,650/year

Note: The 'Not Constructed' alternative was selected as the base case (Reference Appendix C). As a result the benefits are equal to:

Benefits = *Benefits to Construct - Benefits to Not Construct*

= $391,650/year - $0/year

= $391,650/year

Benefits (PW) = $391,650 (P/A, 6%, 0% growth, 10 years)

= $391,650 (7.36) *(from Table C1, Appendix C)*

= $2,882,544

Costs = $2,300,000

Note: The 'Not Constructed' alternative was selected as the base case (Reference Appendix C). As a result the costs of construction are equal to:

Costs (PW) = *Costs to Construct - Costs to Not Construct*

= $2,300,000 - $0

	=	$2,300,000
B/C	=	$2,882,544 / $2,300,000
	=	1.25

Since the B/C ratio is less than 2.0, a five-lane cross section with a TWLTL is not recommended solely on the basis of potential reductions in collisions. Consideration should be given to including all collision severity types, and if there are any foreseen capacity constraints, possible reductions in delay costs could be quantified and factored into the analysis.

Note: Delay costs should be discounted per the PCC Benefit/Cost methodology.

Scenario B Three-lane cross section with a TWLTL

ARp	=	2.21	Base Collision Rate (Residential) *from Table 8.1*
	-	0.02	20 entrances/km
	+	0.17	4 intersections/km
	-	0.09	7% trucks
	=	2.27	collisions / MVKM

PCR	=	(3.30-2.27) / 3.30
	=	0.312

Benefits	=	(PCR)(Fatality Rate)(Cost/Fatality)
	=	(0.312)(1.2)($875,000)

Note: Cost/Fatality = $875,000. (Reference Appendix E).

	=	$327,600 /year

Note: The 'Not Constructed' alternative was selected as the base case (Reference Appendix C). As a result the benefits are equal to:

Benefits	=	*Benefits to Construct - Benefits to Not Construct*
	=	$327,600/year - $0/year

= $327,600/year

Benefits(PW) = $327,600 (P/A, 6%, 0% growth, 10 years)

= $327,600 (7.36) *(from Table C1, Appendix C)*

= $2,411,136

Costs = $800,000

Note: *The 'Not Constructed' alternative was selected as the base case (Reference Appendix C). As a result the cost of construction is equal to:*

Costs (PW) = *Costs to Construct - Costs to Not Construct*

= $800,000 - $0

= $800,000

B/C = $2,411,136 / $800,000

= 3.01

Since the B/C ratio is greater than 2.0, a three-lane cross-section with a TWLTL is therefore recommended.

Note: *If both alternatives had a B/C ratio greater than 2.0, an incremental B/C analysis would have been required to determine the preferred alternative.*

8.5 RESERVED BUS LANES (RBL)

Unlike physical elements of highway design (geometics, structures, etc.), RBL facilities are developed based on specific needs, warrants, MTO policy, MTO commitments, provincial studies, program studies, program level decisions, or special site conditions. For this reason, care must be taken in recommending the deferral of these facilities. Generic and quantifiable benefit/cost relationships are not available for RBL facilities.

RBL's are conceived and planned as part of a network. Deferring the construction of these facilities over the length of a rehabilitation project, may effect the network as a whole.

8.6 HIGH OCCUPANCY VEHICLE FACILITIES (HOV)

Unlike physical elements of highway design (geometrics, structures, etc.), HOV facilities are developed based on specific needs, warrants, MTO policy, MTO commitments, provincial studies, program studies, program level decisions, or special site conditions. For this reason, care must be taken in recommending the deferral of these facilities. Generic and quantifiable benefit/cost relationships are not readily available for HOV facilities.

HOV lanes are conceived and planned as part of a network. Deferring the construction of these facilities over the length of a rehabilitation project, may effect the network as a whole.

8.7 BUS BAYS

Unlike physical elements of highway design (geometrics, structures, etc.), bus bays are developed based on specific needs, warrants, MTO policy, MTO commitments, provincial studies, program studies, program level decisions, or special site conditions. For this reason, care must be taken in recommending the deferral of these facilities. Generic and quantifiable benefit/cost relationships are not available for bus bays.

APPENDIX A

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APPENDIX B

Prioritized Contract Content Initiative Introduction

memorandum

Ontario

Telephone: (905)704-2088
Facsimile: (905)704-2050

To: Regional Directors
Managers of Engineering

May 6, 1996

From: Stephen C.J. Radbone
Director
Transportation Engineering Branch

Re: "Prioritized Contract Content" (PCC) Initiative

The "prioritized contract content" initiative is introduced to manage reduced capital budgets now and in the future. The initiative is the reconsideration of which components are included in upcoming contracts and rehabilitation projects in order to redirect our scarce resources towards our most pressing needs.

The traditional approach from project initiation to contract preparation has been to review a particular geographic section of highway to identify and to remedy deficient elements within the defined project limits. The inherent assumption in our work has been that a "contract" should include all work necessary to bring all elements of a section of roadway up to current accepted standards. Being in a particular vicinity or looking at a particular geographic area does not necessarily constitute a mandatory reason to restore or repair. Other grounds for action, for example, collision propensity, structural integrity and financial ability, impact on our decisions to do work.

In the context of the present fiscal reality the deterioration of the infrastructure requires remedial action to be prioritized not only by the geographic location of contracts but by the deficient elements themselves. It is necessary to focus our work on the basic infrastructure: pavements, structures and safety requirements. "Design creep" or "nice to have" improvements will be eliminated and design upgrades solely to bring roadway sections to current Ministry standards will be identified and deferred.

The Ministry formulated a "condition holding strategy" in 1993 aimed at maintaining the roadway in an acceptable condition while temporarily postponing major rehabilitation work. The funding restrictions we now face requires a new approach. The "prioritized contract content" initiative provides a strategy to extend our limited capital funds to address our most basic deficiency needs and prioritize all components of rehabilitation work to ensure that our funds and efforts are optimally allocated.

...2/

To achieve this Regional staff are charged with the task of reviewing their current contract packages and design projects to remove contract components that are not immediately essential to construct. The choice of when to apply standards is crucial to determining what may or may not be included in our contracts.

In general, the Ministry's documented design standards are not reduced or minimized by this initiative although the scope of work in our contracts and projects will change. The designer should continue to evaluate each project for all elements that would bring the roadway up to standard as directed in the Ministry manuals and directives. They should then evaluate each specific item against immediate needs or warrants, removing those components or items that can be deferred and completed at a later date. The components removed from the contract package must be recorded and retained for future prioritization and construction programming. Detailed guidelines are currently being developed to assist project managers in the application of the "prioritized contract content" initiative.

This policy on prioritizing contract components provides greater flexibility in defining a contract. It allows selective project work to be packaged based on current and future warrants/needs, with current needs being addressed first and future needs being deferred.

Planning and Design work should continue as before with the scoping activity in project initiation and justification still including a full right-of-way review and needs assessment. The subsequent breakdown of project components will be prioritized and contract packages then defined.

In order to ensure regional consistency while this initiative is being implemented, each region is asked to set up a PCC Review Committee to review and approve the removal/deferral of contract components. Details of the prioritized contract content and the minutes of the PCC Review Committee will be recorded and a copy forwarded to the Manager, Highway Planning & Design Development, Transportation Engineering Branch. The Manager will promote consistency among the 5 regions, to the extent that regional differences permit and produce a provincial consolidation for the initiative.

Stephen C.J. Radbone
Director
Transportation Engineering Branch

SCJR:JAB/mrf

c.c. C. Vervoort, ADM, Q & S
C. Hennum, AADM, Operations
I.V. Oliver, Director RMB
M. Brady, Counsel, Legal Services Branch

APPENDIX C

Introduction to Present Worth & Benefit/Cost Analysis

PRESENT WORTH & BENEFIT/COST ANALYSIS

INTRODUCTION

There are a number of valid financial tools and approaches in use in MTO. The Prioritized Contract Content (PCC) evaluation process suggests the use of *Present Worth Analysis* and *Benefit/Cost Analysis* for several components. In order to ensure consistency and that analyses match the prescribed *benchmarks*, some requirements should be noted when carrying out such analyses for PCC evaluations.

GENERAL NOTES

Helpful Hint: For a first time user many of the subtleties within the 'General Notes' may be overlooked. However, after reviewing the examples in this appendix they should become more clear. As a result, it is suggested that the 'General Notes' be reviewed in conjunction with the examples.

- When *Benefit/Cost Analysis* is required, a minimum benefit/cost ratio of 2.0 should be achieved, unless otherwise specified.
- Simple benefit/cost ratios should not be used for comparison of options. Either *Present Worth Analysis* or an *Incremental Benefit/Cost Analysis* should be used for such comparisons. If an *Incremental Benefit/Cost Analysis* is used, a minimum incremental benefit/cost ratio of 2.0 should be achieved, unless otherwise specified.
- All future costs, benefits and disbenefits should be expressed in present worth.
- *Costs* should include only the initial project costs.
- All future expenditures necessary to compare alternatives (e.g. interim resurfacing etc.) should be considered as *Benefits* or *Disbenefits*.
- Increases or decreases in the costs associated with collisions or maintenance should be considered as *Benefits or Disbenefits*.
- For all PCC analyses constant dollars should be used. Based on current economic forecasts, an after inflation **discount rate of 6%** should be assumed for all PCC calculations.
- Traffic growth rates should be included in determining overall life cycle collision costs.
- Benefit/cost and life cycle analysis parameters should be verified over a reasonable range of values. (e.g. Discount Rate ±3%, Traffic Growth Rate ±3%)
- The time period selected for life cycle calculations should be long enough to minimize errors resulting from differing option service lives. Calculations assuming perpetual service life (with assumptions for maintenance, rehabilitation and replacement), or residual values are recommended.

- Where project deferral is being considered, the maximum period of the deferral must be established to reflect the intent of warrants, or tolerable decreases in component condition and levels of service.

  If Ministry policy requires upgrading of a feature, and the option is to defer this improvement for prioritization reasons, the improvement should be assumed to be addressed in a timely manner. For example, in the development of the roadside safety portion of PCC, it was assumed that deferred safety upgrades would be built, at the latest, during the next rehabilitation cycle for that segment of highway.

- Costs, benefits and disbenefits should be valued as follows:

Valuation of Costs, Benefits, and Disbenefits for PCC Benefit/Cost Analysis				
Costs, Benefits and Disbenefits Classification			**Ontario Highway Network**	
			Provincial Level	**Regional Level or Area Level**
Agency Cost[1]	Capital-Initial Costs	Cost	100%	100%
	Capital-Future Costs	Benefit/Disbenefit		
	Maintenance	Benefit/Disbenefit		
Collision Costs[2]		Benefit/Disbenefit	100%	100%
Other Road User Costs[3]		Benefit/Disbenefit	50%	20%

[1] - Direct costs to MTO.
[2] - Costs to the road user only.
[3] - Delay costs etc.

BASE CASE ALTERNATIVES AND ASSOCIATED COSTS

As Ministry standards are not changed by PCC, the alternatives selected for any benefit/cost analysis requires special attention. Given the limited resources available to the Ministry, contract components that are **required** by standards or specifications, will be evaluated using the deferral alternative as the base case*. Contract components that are only **recommended**, suggested or are just 'nice to have items', will be evaluated using the not constructed alternative as the base case*.

*The base case is the level from which the magnitude of all benefits, disbenefits and costs are measured.

Item Under Consideration	**Base Case Alternative**
Required by Standard/Specification	Deferral
Recommended by Standard/Specification or Other	Not Constructed

Example 1: Base Case Alternative - Deferral

If Ministry standards and specifications **require** that a component be included, there will usually only be two alternatives under examination:

1. Constructed Now
2. Deferral.

For example:

An improvement required by Ministry standards has been shown to reduce collisions by 20%. The costs associated with its construction are valued at $50,000. Determine whether this improvement is cost-effective using PCC. The annual cost of collisions is presently $20,000 and the project's service life is expected to be 10 years. No traffic growth is expected.

As the improvement is required by Ministry standards, "Deferral", must be considered as the base case.

Base Case - Deferral	**Alternative - Constructed Now**
Collision Costs = $20,000/y *(For Years 0-9)*	Collision Costs=(0.80)($20,000)=$16,000/y *(For Years 0-9)*
Initial Cost = $50,000 *(Start of Year 10)*	Initial Costs=$50,000 *(Now, i.e. Start of Year 0)*

The collision costs after Year 9, and the maintenance costs for all years, are equal in the two options and thus can be ignored.

B/C Calculation

Benefits = Collision Costs of Alternative - Collision Costs of Base Case
= $16,000 - $20,000
= -$4000/y

Note: *1) The negative sign implies that collision costs have dropped. This value is treated as a positive since a reduction in collisions costs is considered a benefit.*

2) Collision Costs are valued at 100%.

Benefits = $4000/y

Benefits (PW) = $4000(P/A,6%,0%growth,10y) *(PW - Present Worth)*
= $4000(7.36) *(P/A factor from Table C1)*
= $29,440

Costs (PW) = Construction Costs of Alternative - Construction Costs of Base Case
= $50,000(Start of Year 0) - $50,000(Start of Year 10)
= $50,000 - $50,000(P/F,6%,10y)
= $50,000 - $50,000(0.5584) *(P/F factor from Table C2)*
= $22,080

B/C = \$29,440/\$22,080
= 1.33

The alternative, "Constructed Now", is not cost-effective as the B/C ratio is less than 2.0. Therefore, PCC Guidelines recommend deferral of this improvements on the basis of its cost-effectiveness.

Example 2: Base Case Alternative - Not Constructed

If Ministry standards or specifications **do not require**, but rather recommend or suggest, that an contract component be included there will usually only be two alternatives under examination:

1. Constructed Now
2. Not constructed

Deferral does not need to be considered, as improvements of these types are not required.

For example:

An improvement recommended by Ministry standards has been shown to reduce collisions by 20%. The costs associated with its construction are valued at \$50,000. Determine whether this improvement is cost-effective using PCC. The annual costs of collisions are presently \$20,000 and the project's service life is expected to be 10 years. No traffic growth is expected.

As the improvement is recommended by Ministry standards, " Not Constructed" must be considered as the base case.

Base Case - Not Constructed

Collision Costs = \$20,000/y
(For Years 0-9)

Initial Cost = \$0/y
(Start of Year 0)

Alternative - Constructed Now

Collision Costs=(0.80)(\$20,000)=\$16,000/y
(For Years 0-9)

Initial Costs=\$50,000
(Now, i.e. Start of Year 0)

B/C Calculation

Benefits = Collision Costs of Alternative - Collision Costs of Base Case
= \$16,000 - \$20,000
= -\$4000/y

Note: 1) The negative sign implies that collision costs have dropped. This value is treated as a positive since a reduction in collision costs is considered a benefit.

2) Collision Costs are valued at 100%.

= \$4000/y

Benefits (PW) = \$4000(P/A,6%,0%growth,10y) *(PW - Present Worth)*
= \$4000(7.36) *(P/A factor from Table C1)*
= \$29,440

Costs (PW) = Construction Costs of Alternative - Construction Costs of Base Case
= \$50,000 - \$0
= \$50,000

B/C = \$29,440/\$50,000
= 0.59

The alternative, "Constructed Now", is not cost-effective as the B/C ratio is less than 2.0. Therefore, PCC Guidelines do not recommend proceeding with this optional improvements on the basis of its cost-effectiveness.

INCREMENTAL BENEFIT/COST ANALYSIS

Simple Benefit/Cost Analysis

A simple benefit/cost analysis consists of only two alternatives. In such an analysis, one of the alternatives is selected as the base case. By determining the benefits and costs of the other alternative relative to the base case, a simple benefit/cost ratio can be calculated. If this ratio is greater than the specified threshold ratio, then the non-base case alternative is deemed to be more cost-effective.

Consider a situation where there are more than two alternatives. As before, an alternative is selected as the base case and the benefits and costs of the remaining alternatives are calculated relative to it. Now consider for a moment that all the alternatives have benefit/cost ratios greater than the specified threshold. Which alternative is the most cost-effective?

Example 3: Simple B/C Ratios

Alternative	Benefits	Costs	B/C
Alternative 1 (Base Case)	\$0	\$0	n/a
Alternative 2	\$250,000	\$80,630	3.10
Alternative 3	\$260,000	\$110,770	2.34
Alternative 4	\$472,117	\$186,400	2.53
Alternative 5	\$440,000	\$236,820	1.85

Note: All values are expressed in present worth.

All alternatives, except Alternative 5, are deemed to be cost-effective as they have simple B/C ratios greater than 2.0. From these results it would appear that Alternative 2 would be the most cost-effective solution as it has the highest B/C ratio. However, simple B/C ratios cannot be used to compare alternatives as the cost-basis for each varies. Therefore, in order to determine which of the alternatives, with a simple B/C ratio of 2.0 or greater, is the most cost-effective, an incremental benefit/cost analysis must be undertaken.

Incremental Benefit/Cost Analysis

The objective of the PCC incremental benefit/cost analysis procedure is to select the highest cost alternative that has an incremental B/C ratio of 2.0 or greater over the next lowest cost alternative.

1) The simple B/C ratios for each alternative relative to the base case must be calculated. These are in turn arranged in order of increasing costs *(Reference Example 3: Simple B/C Ratios)*.

2) The alternatives that exceed the minimum B/C threshold are then selected for further examination, For the purposes of PCC the B/C threshold has been set at 2.0.

3) The second lowest cost alternative is then selected for comparison against then the next lowest cost alternative. Using the alternatives from Example 3, Alternative 3 will be compared against Alternative 2.

ΔB = Benefits of Alternative 3 - Benefits of Alternative 2
= $260,000 - $250,000
= $10,000

ΔC = Costs of Alternative 3 - Costs of Alternative 2
= $110,770 - $80,630
= $30,140

ΔB/ΔC = $10,000 / $30,140
= 0.33

Since ΔB/ΔC is less than 2.0, Alternative 3 **is not cost-effective** over Alternative 2. In other words, the marginal benefit associated with spending an extra $30,140 on Alternative 3 is not justified by the $10,000 benefit of doing the additional work. As a result Alternative 2 is carried forward for comparison against Alternative 4. Had Alternative 3 been cost-effective over Alternative 2, Alternative 3 would have been carried forward.

4) Alternative 4 is now compared against Alternative 2.

ΔB = Benefits of Alternative 4 - Benefits of Alternative 2
= $472,117 - $250,000
= $222,117

ΔC = Costs of Alternative 4 - Costs of Alternative 2
= $186,400 - $80,630
= $105,770

$\Delta B/\Delta C$ = \$222,117 / \$105,770
= 2.10

Since $\Delta B/\Delta C$ is greater than 2.0, Alternative 4 is cost-effective over Alternative 2. As a result, Alternative 4 is the most cost-effective all alternatives. It accordance with the PCC Guidelines, Alternative 5 is not considered in the incremental benefit/cost analysis as its simple B/C ratio is less than 2.0.

The incremental B/C ratios are shown against the simple B/C ratios in the following table:

Example 4: Incremental B/C Ratios

Alternative	Benefits	Costs	B/C	$\Delta B/\Delta C$
Alternative 2	\$250,000	\$80,630	3.10	
Alternative 3	\$260,000	\$110,770	2.34	0.33 (Alt. 3 compared to Alt. 2)
Alternative 4	\$472,117	\$186,400	2.53	2.10 (Alt. 4 compared to Alt. 2)

Note: All values are expressed in present worth.

Additional Notes

1) If all alternatives in an analysis have simple B/C ratios of less than 2.0, then the 'Base Case' should be selected (i.e. 'Deferral' or 'Not Constructed') as the preferred alternative.

2) If all alternatives in an analysis have incremental B/C ratios of less than 2.0, then the lowest cost alternative with a simple B/C ratio of 2.0 or greater should be chosen as the preferred alternative.

Table C1: Uniform Series Present Worth Factors with a Discount Rate Equal to 6% for Selected Traffic Growth Rates and Service Lives

(P/A, 6%, growth, n)

Year n	Traffic Growth Rate(%)					
	0%	*2%*	*4%*	*6%*	*8%*	*10%*
1	0.943	0.953	0.962	0.971	0.980	0.989
2	1.833	1.870	1.906	1.943	1.979	2.016
3	2.673	2.752	2.832	2.914	2.997	3.082
4	3.465	3.601	3.741	3.885	4.034	4.187
5	4.212	4.418	4.632	4.856	5.091	5.335
6	4.917	5.204	5.507	5.828	6.167	6.526
7	5.582	5.960	6.365	6.799	7.264	7.761
8	6.210	6.688	7.207	7.770	8.381	9.044
9	6.802	7.388	8.033	8.742	9.520	10.374
10	7.360	8.062	8.844	9.713	10.680	11.755
11	7.887	8.711	9.639	10.684	11.862	13.188
12	8.384	9335	10.419	11.655	13.066	14.676
13	8.853	9.936	11.185	12.627	14.293	16.219
14	9.295	10.513	11.936	13.598	15.543	17.820
15	9.712	11.069	12.673	14.569	16.817	19.482
16	10.106	11.605	13.396	15.541	18.114	21.207
17	10.477	12.119	14.105	16.512	19.436	22.996
18	10.828	12.615	14.801	17.483	20.784	24.854
19	11.150	13.092	15.484	18.454	22.156	26.781
20	11.470	13.550	16.154	19.426	23.555	28.781
21	11.764	13.992	16.811	20.397	24.979	30.857
22	12.042	14.417	17.456	21.368	26.431	33.010
23	12.303	14.825	18.088	22.340	27.910	35.246
24	12.550	15.219	18.709	23.311	29.417	37.565
25	12.783	15.597	19.318	24.282	30.943	39.972

Table C2: Single Payment Present Worth Factors with a Discount Rate Equal to 6% for Selected Service Lives

(P/F, 6%, n)

Year n	Single Payment Factor
1	0.94340
2	0.89000
3	0.83962
4	0.79210
5	0.74726
6	0.70496
7	0.66506
8	0.62742
9	0.59190
10	0.55840
11	0.52679
12	0.49698
13	0.46884
14	0.44231
15	0.41727
16	0.39365
17	0.37137
18	0.35035
19	0.33052
20	0.31181
21	0.29416
22	0.27751
23	0.26180
24	0.24698
25	0.23300

FINANCIAL ANALYSIS REFERENCES

The following references provide additional information on financial analysis, including *Present Worth Analysis, Benefit/Cost Analysis, Incremental Benefit Cost/Analysis* and other financial issues related to transportation projects:

- Roadside Safety Manual: MTO
- Structural Financial Analysis Manual[1]: MTO
- Manual of Geometric Design Standards for Canadian Roads: TAC
- Highway User Cost Tables: TAC
- MicroBENCOST (Computer Program): McTrans
- Pavement Design and Rehabilitation Manual: MTO
- Manual of User Benefit Analysis for Highway and Bus Transit Improvements: AASHTO
- Roadside Design Guide - Appendix A (January 1996)[2]: AASHTO
- Life Cycle Costing for Design Professionals (Second Edition): McGraw-Hill

1 - Provides an excellent discussion of financial analysis: includes LOTUS spreadsheets for present worth/life cycle costing and incremental benefit/cost analysis applicable to structures and other transportation projects.

2 - Provides methodology for determining collision potential, frequency, severity and associated costs. Includes discrete compounding interest factors adjusted to reflect various traffic growth rates.

APPENDIX D

Ontario Highway Network Classification System

ONTARIO'S HIGHWAY NETWORK

A recent direction of government is to focus limited resources on programs and activities which effectively support and enhance the broader interests of the province in the best possible manner. The Ministry of Transportation is therefore developing a strategic approach to transportation that emphasizes the economic and social importance of the various levels of the network.

- The Ontario Highway Network is divided into three levels:

Provincial	-	link major urban centres in excess of 50,000 population and carry high volume, long distance movements.
Regional	-	link smaller urban centres with population in excess of 20,000 and provides connection to other provincial highways, county roads.
Area	-	remainder of the provincial highway system performing a local mobility function.

- The Provincial Level accounts for only 28% of Ontario's highway network and yet serves more than 82% of Ontario's population.
- A primary objective of stratifying Ontario's Highway Network is to invest future capital on provincial highway assets which maximizes the return on benefits.
- Allows the ministry to focus on highways which provide for the safe and efficient movement of people and goods.
- An aid to decision making for selecting appropriate highway projects, setting priorities and allocating funds, whether for safety, renewal or expansion activities.
- Identification of highways within the Provincial Level classification is complete. Work is well underway on the identification of highways within the Regional and Area Level classifications, for both Southwestern and Northern Ontario. Preliminary network studies have been initiated in Eastern and Central Ontario.

PROVINCIAL LEVEL

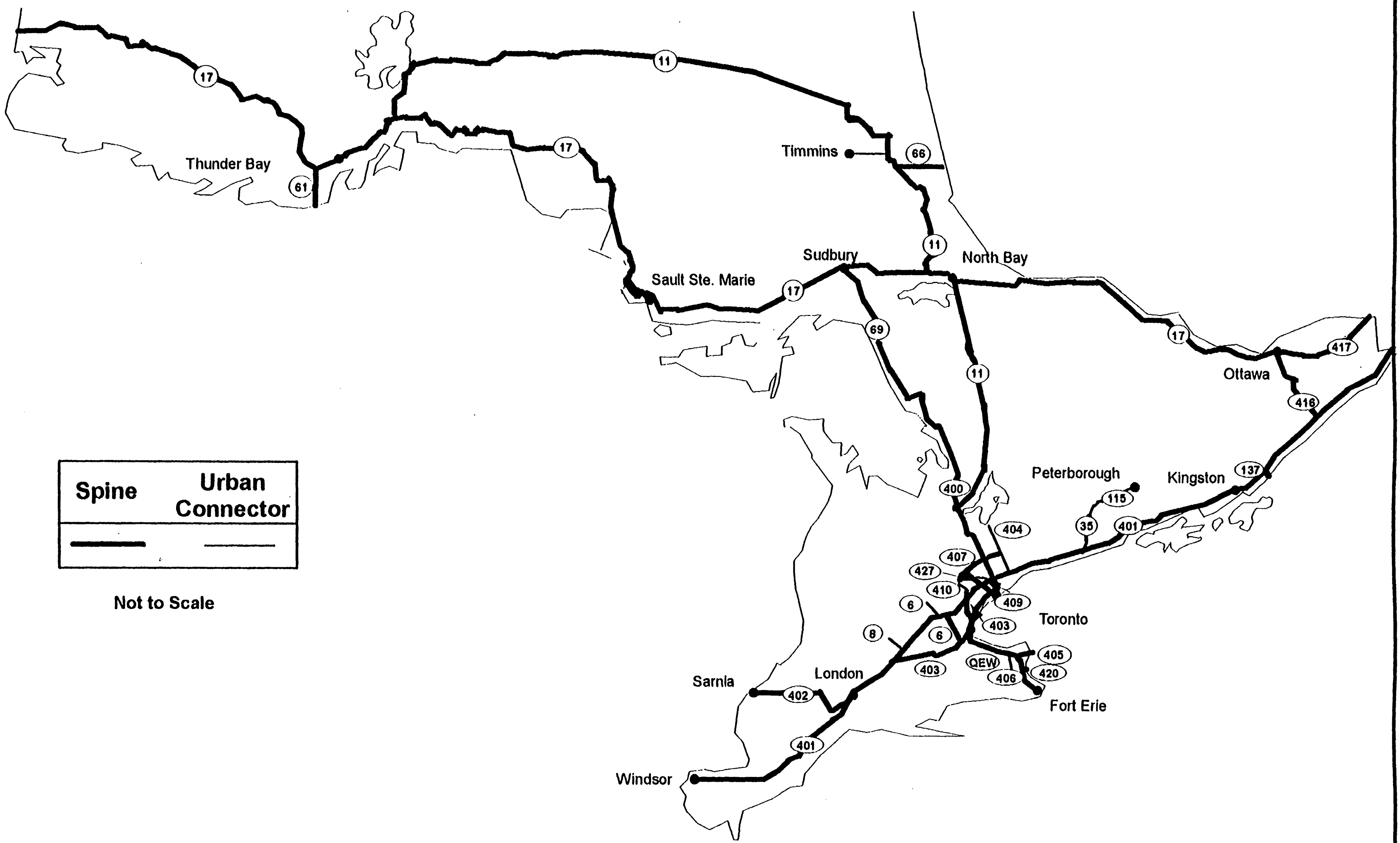
Highway#	Description
401	Windsor to Quebec Border
402	Sarnia to London
8	Hwy 401 to Hwy 7
6	QEW to Hwy 401
6	Hwy 401 to Hwy 7 (Woodlawn Rd)
403	Woodstock to Brantford
403	Ancaster to Burlington, QEW Ford Drive to Hwy 401
QEW	Hwy 427 to Fort Erie
405	QEW to International Crossing
420	QEW to International Crossing
406	QEW to Thorold
410	Hwy 401 to Hwy 7
427	QEW to Hwy 407
409	Hwy 401 to Pearson International Airport
400	Hwy 401 to Hwy 69
404	Hwy 401 to Newmarket
407	Hwy 410 to Hwy 404
69	Hwy 400 to Sudbury
11	Barrie to Nipigon
66	Hwy 11 to Quebec Border
101	Hwy 11 to Timmins
17	Ottawa to Nipigon
11/17	Nipigon to Shabaqua Corners
17	Shabaqua Corners to Manitoba border (includes Kenora By Pass)
61	Thunder Bay to International Crossing
35/115	Hwy 401 to Peterborough
137	Hwy 401 to International Crossing
16/416	Hwy 401 to Ottawa
417	Hwy 17 (west of Ottawa) to Quebec Border

To be added once constructed:

403	Ancaster to Brantford
407	Hwy 403 (Mississauga) to Hwy 410
407	QEW to Hwy 403 (Mississauga)
407	Hwy 404 to Hwy 35/115

HIGHWAY NETWORK CLASSIFICATION

Provincial Level



Date: 96-10-18
Provincial Planning Office

APPENDIX E

Collision Rates, Vehicle Collision Costs and the

Value of Time

COLLISION RATES AND VEHICLE COLLISION COSTS

INTRODUCTION

Several portions of the PCC Guidelines require that a benefit/cost analysis be undertaken. For such an analysis, it is necessary to quantify the benefits of a proposed improvement. In most cases these benefits will be composed predominantly of a reduction in collision costs. The calculation of these costs will often require the use of collision frequency and severity rates, and/or average collision costs.

COLLISION RATES

Collision Data

The selection of what collision data should be used to generate these rates is critical to the validity of any PCC analysis. The collision data sample should be sufficiently large enough to adequately represent the operational characteristics of the highway segment under examination. Limited data could lead to skewed results in that collision rates and severity types could be misrepresented. It is also possible that limited data may fail to reflect the potential for certain collision and/or severity types to occur. In other cases such as horizontal alignment, lane width, shoulder width, clear zone and climbing lanes, theoretical collision rate reductions are built into the B/C equation and do not require separate quantification.

In order to gain confidence that the collision data being used to generate a specific rate adequately reflects the operational characteristics/collision history of the highway, a comparison to a more generalized rate, if available, should be undertaken. This more generalized rate should, if possible, be representative of similar highway conditions. A rate substantially below that of a more generalized rate should be examined closely, as this may be an indicator that the collision data sample being used may be too small to properly capture the highway's collision history. A rate substantially higher than a more generalized rate may indicate a highway location experiencing operational problems.

In cases of extremely limited collision data, or the complete lack of collision data, rates from more generalized data should be used. These should then be compared to even more generalized rates, if possible, in order to gain sufficient confidence. If rates determined from more generalized data are not available, users should exercise engineering judgement in determining whether the selected rate adequately reflects observed highway operations.

It is important that users understand the limitations of collision data. While there may be an extensive collision history, it should be noted that not all collisions are reported and, therefore, any calculated rate will be under representative. The magnitude of this deviation from the true rate will require the use of engineering judgement.

Procedural Notes

The PCC Guidelines are to be applied on a project wide basis. As a result, rates should be calculated using data from within the project limits. Data should be collected over a minimum period of three years, with five years of data being optimum. If the operational or geometric characteristics of a highway vary within the project limits, separate rates should be calculated for each geometric and operational segment. For improvements that require a localized rate, site specific data should be used.

If the data obtained within the project boundaries is limited, consideration should be given to using sectional data. A sectional rate should be calculated over a length of highway of at least two to three times that of the project's. Caution should be exercised in that the segment of highway used to calculate the sectional rate should exhibit similar geometric and operational characteristics.

If sectional data is also limited, consideration should be given to using data for the entire portion of the highway within the region with similar geometric and operational characteristics. If such data is also limited, then consideration should be given to using data from similar regional facilities. As a last resort, consideration should be given to using rates developed from provincial data.

Once a rate is calculated and confidence in its validity is gained, it can be used in a Benefit/Cost analysis. If as a result of the analysis, the proposed improvements are deferred on a project wide basis, consideration should be given to using site specific collision data to justify localized improvements.

Sources of Collision Data

The Ministry's Accident Information System (AIS) allows for the manipulation of collision data. Its ability to filter data allows the user to generate collision reports that can be used to develop specific collision rates. Highway, regional and provincial rates can also be determined. In addition to collision rates, collision severity rates can be determined; specifically fatal, injury and property damage only rates. AIS information can be obtained through the regional Traffic Section.

VEHICLE COLLISION COSTS

For benefit/cost analysis, a dollar value must be assigned to a collision event to determine the benefit of a reduction in collisions. This amount is referred to as Vehicle Collision Cost (VCC).

The method for determining VCC is dependant on which type of collision data is used (variations introduced earlier in this section). For projects where a complete set of collision data is available, it is expected that the percentages of fatalities, injury, and property damage only (PDO) will be available. In these cases the following collision severity costs should be used to determine the total benefits associated with potential collision reduction;

Fatal	$875,000
Injury	$27,000
PDO	$6,000

Using the distribution as found in the collision data the VCC (in dollars) would be calculated by using the following formula:

VCC = (% fatalities x 875,000) + (% injury x 27,000) + (% PDO x 6,000)

For projects where complete collision data records are not available, more generic averages based on provincial data should be used. These averages and their respective VCC's are summarized as follows:

Highways:	Fatal	1.27 %	
	Injury	30.46 %	
	PDO	68.27 %	VCC = $23,500
Freeways:	Fatal	0.57 %	
	Injury	25.05 %	
	PDO	74.38 %	VCC = $16,200
Overall:	Fatal	0.97 %	
	Injury	28.18 %	
	PDO	70.85 %	VCC = $20,300

VALUE OF TIME

For any PCC analysis that requires the calculation of costs involving the value of time, the following should be used:

Non-Commercial	$10/vehicle hour
Commercial	$50/vehicle hour

APPENDIX F

Prioritized Contract Content Recording Procedure

PRIORITIZED CONTRACT CONTENT RECORDING PROCEDURE

INTRODUCTION

As the PCC process does not change any ministry standards or specifications, but rather introduces a prioritization mechanism, it is necessary that all PCC decisions be thoroughly documented. While a recording process may seem onerous, it allows for prioritization decisions to be reviewed for consistency and provides a mechanism to track deferred contract components.

POLICY: **Each Region is responsible to track all deferred contract components for future programming.**

DOCUMENTATION PHASE

The first part of the recording procedure is a documentation phase where the results of each PCC analysis undertaken, whether it resulted in a deferral recommendation or not, will be recorded. It is foreseen that this phase will become an integral part of the detail design process. The form **PCC - Contract Components Considered** should be completed as analyses are undertaken. A complete copy of all calculations and/or assumptions made must be provided as an appendix to this form and stored in the ministry's project files for future review.

DEFERRAL SUMMARIZATION PHASE

The second part of the recording process is a simple summarization of the details associated with contract components that will be deferred. The form **PCC - Deferral List** should be completed with a copy included in the ministry's project files.

POLICY: **Completed copies of the PCC-Contract Components Considered form (minus the appendix) and the PCC-Deferral List form must be sent to the Highway 1Planning and Design Development Section, Surveys and Design Office, Transportation Engineering Branch upon completion of detail design.**

PCC - CONTRACT COMPONENTS CONSIDERED FORM

Contract Component

The specific name of all contract components that were considered under the PCC process, whether deferred or not, should be listed. If the recommendations generated through the PCC process vary for a particular contract component, then separate entries should be made for each recommendation. For example, guiderail recommendations may vary by location within a project, therefore, separate entries should be made for the deferred and non-deferred locations.

Existing Deficiencies

A brief statement describing the deficiencies associated with a contract component should be listed. This should include all deficiencies for which a PCC analysis was undertaken.

PDR Recommendations

1 - Projects with a Preliminary Design Report (PDR)

A summary of all recommendations related to the contract component under consideration contained in the project's approved PDR and corresponding Design Criteria (DC) should be included. In addition, this summary should also include references to all standards/specifications that current ministry policies, and/or regional policies, require/recommend be applied to the contract component.

2 - Projects with no Preliminary Design Report

A summary of all recommendations related to the contract component under consideration contained in the project's approved DC should be included. In addition, this summary should also include references to all standards/specifications that current ministry policies, and/or regional policies, require/recommend be applied to the contract component.

PCC Recommendations

A summary of all recommendations/policy statements contained in the PCC Guidelines related to the contract component under consideration should be included. This summary should also include a reference to any benefit/cost analysis that was undertaken, and should note the resulting B/C ratio.

Note: A complete copy all calculations undertaken as part of any PCC analysis, including documentation of any assumptions made, **must** be included as an appendix to this form.

Construction Costs

An estimate of all construction costs associated with the contract component under consideration should be noted.

Comments

Any unusual issues related to the contract component under consideration should be noted. This could include items such as political commitments, requirements under the project's Environment Assessment, or senior management directives.

Certification

Certification is required as to the accuracy of the application of the PCC guidelines, including all PCC calculations: This certification is to be provided by the following:

Consultant Design Projects :	Consultant Project Manager
MTO In-House Projects:	MTO Project Engineer/Manager

PCC - DEFERRAL LIST FORM

Project Description Area

This area should be completed in full. The *Work Type* should be consistent with that in the project's approved Justification Report. The *Program Year* should reflect the project's current location on the Multi-Year Construction Program and should be consistent with that used in any PCC analysis.

Contract Component

The specific name of all contract components that, as a result of the PCC process, are to be deferred should be listed.

Construction Costs

An estimate of all construction costs associated with the contract component under consideration should be noted.

Note: The final **Deferral List** sheet should include a total of all deferred contact components' construction costs.

Comments

Comments should include:

- Deferral year used in PCC calculations (usually assumed).
- Program tracking reference (e.g. Hazard Protection Program, new GWP#, etc.).
- Any unusual issues related to the contract component under consideration.

Deferral Approval Area

This area should be provided on the final **Deferral List** sheet and must be completed in full.

Ministry of Transportation

Ontario

Prioritized Contract Content

Deferral List

GWP #: ____________ Region: __________ District #: ________ Hwy #: _______

Location: ____

Work Type: ________________ Program Year: __________ Page ____ of _____

Contract Component	Construction Costs	Comments

______________________________ ______________________________

Recommended by Date Manager, Engineering Date

Date

Ministry of Transportation

Ontario

Prioritized Contract Content

Contract Components Considered

GWP#:________________ Page _____ of _____

Contract Component	Existing Deficiencies	PDR Recommendation	PCC* Recommendation	Construction Costs	Comments

PCC Certification ____________ Date

* - All PCC calculations must be provided as an appendix to this form.