# The Highway Element Investment Review (HEIR) Guidelines: Making the Right Decisions in Ontario

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Paper prepared for presentation

at the Implications of P3 Projects for Geometric Design Session

of the 2008 Annual Conference of the
Transportation Association of Canada
Toronto, Ontario

## ABSTRACT

The Canadian Council for Public-Private Partnerships defines public-private partnerships (P3s) as “a cooperative venture between the public and private sectors, built on the expertise of each partner, that best meets clearly defined public needs through the appropriate allocation of resources, risks and rewards” [1]. P3 projects are becoming an increasingly popular mechanism for providing infrastructure works in Canada, however, challenges remain. In terms of highway infrastructure, a P3 project may meet standard, but standard and safe are not synonymous – standards represent minimum requirements that are intended to be met or exceeded. How can the public be assured that the design achieves a level of safety that is comparable to other projects, that safety has not been compromised in order to reduce costs?

The Highway Element Investment Review (HEIR) Guidelines recently developed by the Ontario Ministry of Transportation provide one means of ensuring that P3 projects look beyond standards in developing the highway design. Within the guidelines, an approach is given for comparing the cost of a particular measure against the anticipated safety and operational benefits. Such information provides a basis for justifying design decisions and selecting among alternatives. The guidelines apply to new construction and rehabilitation projects involving both traditional and non-traditional (e.g., P3) funding arrangements, allowing decisions to be made that include explicit consideration of cost-effectiveness.

This paper provides a general introduction to the HEIR Guidelines and outlines their potential value for P3 and non-P3 projects alike.

## INTRODUCTION

In 1997, a safety review of Ontario’s first major P3 highway project, Highway 407, found deficiencies with the approach of relying on design standards as the sole guarantor for the safety of a highway. By this approach, safety is considered only “implicitly” (by use of the standards) but not “explicitly” (such as by assessing the impacts to safety of design decisions and changes). [2] As the authors of the Highway 407 Safety Review found, this leads to a problem: “If the standard is unnecessarily stringent, money is wasted; if the standard is too lax, too many or too severe accidents may ensue.”

As one of the observations in that report stated: “It is possible, perhaps likely, that the role of the private sector in road building will increase. This possibility underscores the need for the guardians of public safety to proclaim the relationship between cost and safety on a realistic basis . . . It is the task of the government to provide guidance about what trade-offs are consistent with the public interest: How much are we willing to spend to improve safety and what sacrifice is not worth the attendant cost saving?”

The Highway Element Investment Review (HEIR) Guidelines were developed by the Ontario Ministry of Transportation (MTO) to help select and prioritize highway improvements. In some cases, limited budgets make it impossible to bring all highway elements to standard; in others, operational and safety benefits may justify the cost of

going beyond standard. The HEIR Guidelines provide a process for determining “the right investment, in the right place, at the right time.”

While not expressly made for P3 projects, the HEIR Guidelines help answer questions posed by P3: How can agencies ensure decisions made by private partners or consultants are consistent with agency practice? How can agencies ensure proper documentation of deferrals and reasons for deferred work? How can they keep track of deficient items? What is appropriate to be built for new construction when restrictions such as environmentally sensitive areas or property constraints limit the ability to achieve standards? When is it appropriate to exceed design standards to enhance performance? And, as stated above, how can the agency and the public be assured that safety has not been compromised to reduce costs?

The HEIR Guidelines distill principles of engineering decision-making used by the Ministry and found in literature but previously unavailable in a single document or standard. Included are discussions on the relationship between safety, standards, and cost-effectiveness and considerations that go into the design trade-off process. Within the guidelines, equations are given for assessing the cost-effectiveness of highway improvements on the basis of safety and, in some cases, operational benefits, using principals of economic analysis. In carrying out such analysis, Collision Modification Factors (CMFs) found to be both statistically sound and applicable to Ontario highways are used. The guidelines are accompanied by a powerful spreadsheet calculation tool that makes collision-benefit and benefit-cost calculations substantially easier and quicker.

The results of benefit-cost calculations add insight into decision-making. Additionally, the guidelines recognize the importance of factors not easily quantified in dollar terms. For each measure, narrative guidance is given with respect to such considerations.

Application of the HEIR Guidelines requires production of HEIR Reports. These reports help fulfill the requirements of documenting design decisions. Well-defined reporting responsibilities are also included, helping ensure that results will be available for future work, and that the guidelines are applied consistently across the province.

Design standards continue to evolve, capital budgets continue to be strained, and more work continues to be performed by private partners and consultants. Under such conditions, design standards cannot serve as the sole basis for decision-making. The HEIR Guidelines help make design decisions more consistent, economically justified, and well-documented.

The HEIR Guidelines are not intended to supercede any of the Ontario Ministry of Transportation’s design standards or policies. Instead, they are an aid for selecting and prioritizing roadway improvements. The guidelines were developed for Ontario Ministry of Transportation projects on Ontario highways.

This paper provides an overview of the new HEIR Guidelines – their purpose, application, and guiding principles – and describes how they can be used to improve design decisions for both P3 and non-P3 projects alike.

## HISTORY

In 1997, the Ontario Ministry of Transportation issued the Prioritized Contract Content (PCC) Guidelines to provide highway engineers and designers working on MTO highway design projects with a systematic methodology for evaluating highway elements and prioritizing improvements [3]. A key component of the guidelines included the use of benefit-cost analysis to assess the merits of potential measures, select among alternatives, and determine the most appropriate implementation time-frame.

In recent years, there has been considerable development in the areas of highway safety and design. Accordingly, a project was initiated in 2005 to update the PCC Guidelines. Particular emphasis was placed on improving the methodology used to calculate safety benefits through the use of Collision Modification Factors (CMFs) deemed to be appropriate for Ontario highway conditions. The new guidelines that were developed as part of this initiative were renamed the Highway Element Investment Review (HEIR) Guidelines to reflect substantial changes in content and approach [4]. The old PCC Guidelines employed prescriptive rules for determining when improvements should be built; the new HEIR Guidelines recognize that benefit-cost calculations are only one input to the decision-making process, and that engineering judgment is required to determine the preferred solution.

To foster greater use of the HEIR Guidelines, a spreadsheet calculation tool was developed. The tool automates the benefit-cost calculations, substantially reducing the level of effort required to evaluate alternatives. The resulting information is considered against other non-quantifiable factors to determine what project elements to construct as part of current and future highway contracts.

The following sub-sections contain additional information on the process used to develop the HEIR Guidelines, in particular, the results of the user survey and literature review that were carried out. Following this discussion, the HEIR Guidelines are presented in detail.

### Survey Results

As part of the process of updating the old PCC Guidelines, a survey of MTO staff was carried out to examine how the guidelines were being used, and identify opportunities for improvement. The survey confirmed that the PCC Guidelines were not being used frequently or consistently. The major barriers to the effective use of the PCC Guidelines included: a perception that the guidelines were unreliable; a prescribed benefit-cost threshold that could not be met in many instances when improvements were required; and calculations that were difficult and complex. Other barriers included a lack of training and a perceived conflict between the PCC Guidelines and other Ministry standards or policies. Respondents also noted that it was unclear where in the design

process the PCC Guidelines would best be applied. It was clear from the survey that the old PCC Guidelines needed to be revamped.

Based on the limitations noted above, respondents recommended a number of improvements to make the guidelines more user-friendly, practical, and effective. One prominent recommendation was that the guidelines be used earlier in the design process. Other recommendations included:

- Providing more worked examples to aid users
- Providing standard spreadsheets to simplify the calculations and use of the guidelines
- Considering design consistency and other factors relevant to low-volume roads
- Improving the calculation of safety benefits

These recommendations steered the development of the new HEIR guidelines. In particular, the new guidelines include discussion on non-quantifiable factors that should be considered in the decision-making process, including design consistency. A spreadsheet tool was developed for carrying out the calculations, an improved methodology for calculating safety benefits was introduced and numerous worked examples were developed. In addition, an ambitious training program was undertaken to ensure Ministry staff and consultants will have the information needed to use the guidelines effectively.

Literature Review

To ensure the latest technical information was considered for project level decision-making, a literature search was carried out at the outset of the project. The objective of the literature search was to familiarize the Study Team with the various guidelines, tools, methodologies, and practices available for evaluating and prioritizing highway improvements. The literature review examined how highway safety tools are being used in the design processes of various agencies, and the methods used for prioritization and justification of specific highway improvements.

Documentation was compiled from six U.S. state Departments of Transportation (DOTs), three Canadian provincial transportation authorities, as well as federal transportation authorities on both sides of the border (including TAC, AASHTO, FHWA, and NCHRP). In addition, correspondence was carried out with representatives of various transportation authorities. These representatives provided examples of different tools and methodologies used to support decision-making in real-world applications, and the lessons learned in the process of developing and implementing them.

The majority of the methodologies examined use benefit-cost analysis as the primary measure of cost-effectiveness. However, other approaches are used as well. It is generally acknowledged that there are limitations to expressing benefits such as traffic operations and safety in dollars, and that safety benefits in particular can sway

dramatically with changes in assumed collision costs. At best, benefit-cost calculations provide an estimate of the true benefits and costs, given the uncertainty associated with predicting future conditions and the imprecise models used to assess impacts. Benefit-cost analysis also fails to capture impacts that cannot be readily quantified in dollar terms. As a result, some agencies have developed alternative approaches for assessing the merit of highway projects (such as multi-criteria evaluation frameworks), while others supplement the results of benefit-cost analysis by also considering factors that cannot be quantified.

While benefit-cost analysis provides important information on whether the benefits of a particular initiative exceed the costs, it cannot be used as the sole basis for decision-making unless a benefit-cost threshold is established as a matter of policy. However, determining such a threshold is not necessarily a simple task. From the practices of other agencies, a number of potential barriers were identified to setting a fixed benefit-cost threshold for highway improvements.

- Experience is required using the formulas and software to determine what the fixed benefit-cost ratio should be. Without detailed information, it is difficult to determine the benefit-cost ratios at which improvements are regularly being constructed.

- Fluctuating needs and funding resources in different years may impact the benefit-cost ratio at which an authority can afford to make improvements. Representatives of other transportation authorities indicated that the benefit-cost ratios at which they were making improvements was not constant year-over-year.

- A single, fixed benefit-cost threshold may not be suitable for all situations. For example, a single threshold could prevent important improvements from being made on low-volume roads because of the impact that traffic volume often has on the benefit-cost calculations. In general, the use of fixed or prescribed benefit-cost thresholds precludes consideration of non-quantifiable factors that may be relevant.

- With fixed benefit-cost thresholds, there may be a tendency to bias the calculations to obtain a certain result.

- Benefit-cost ratios are affected by changes in the discount rate, value of time, and collision costs. If such values are changed over time, it is difficult to prescribe a benefit-cost threshold to determine which project elements should be constructed.

From the results of the literature review, benefit-cost analysis was selected as the most appropriate measure for assessing cost-effectiveness in the new HEIR guidelines. However, the guidelines also recognize the importance of non-quantifiable factors, which are to be explicitly included in the decision-making process. Prescriptive benefit-cost thresholds are not employed in the new guidelines, in part due to a lack of

information on what benefit-cost ratios are currently being achieved on the project elements being constructed.

The review of agency practice in North America revealed that spreadsheets are commonly to aid in project decision-making and that this platform can be effective. This finding, combined with feedback from the user survey, resulted in the development of a spreadsheet calculation tool to accompany the new guidelines.

The following sections provide an introduction to the HEIR Guidelines, beginning with a discussion on their general content and application.

## CONTENT OF THE GUIDELINES

The HEIR Guidelines do not replace or supercede any of the Ministry's other standards or policies, but are instead intended to complement existing practices by extending the design process to include consideration of cost-effectiveness.

In terms of content and structure, the guidelines are divided into the following four sections:

- **Part I: General** provides an introduction to the HEIR Guidelines, how they were developed, and their intended role. Part I includes a step-by-step outline of how the guidelines are to be used and at what stage in the design process. It also describes a number of guiding principles for addressing safety and operational performance in design.

- **Part II: Principles of Analysis** provides an overview of the principles of economic analysis and the approach used to assess cost-effectiveness. It describes the input parameters needed to conduct the analysis, and explains how to calculate costs. It also outlines the non-economic criteria that should be considered in evaluating improvement options.

- **Part III: Evaluating Alternatives** provides direction on how specific improvement alternatives are to be evaluated. It outlines the methods for calculating the benefit-cost ratio, how benefit-cost results are to be considered along with relevant non-economic factors, and how multiple safety improvements are evaluated together. For each highway element included in the guidelines, narrative discussion is provided outlining design considerations that may be relevant. Where quantitative relationships are available for calculating safety and operational benefits, additional information is provided on how to apply the equations, including the necessary input data and conditions for use. Also in Part III, instruction is provided for using the Excel spreadsheet calculation tool that accompanies the guidelines.

- **Part IV: Documentation** describes the procedure for storing the output from an analysis so that this data can be referred to in the future.

## APPLICATION OF THE GUIDELINES

The HEIR Guidelines apply equally to new construction and to rehabilitation and reconstruction projects.

In the case of new construction, the HEIR Guidelines can help to justify decisions to construct a project element to less than standard in situations where the cost of meeting standard is excessive due to property requirements, environmental factors, or other constraints. Perhaps more importantly in new construction, however, the HEIR Guidelines can also help determine when design standards should be exceeded. Design standards typically represent the minimum acceptable condition for ensuring adequate safety and operational performance. In design, the objective is to meet or exceed standards. Knowing the standard is easy; knowing when to go beyond standard, and by how much, is more difficult to discern. By assessing cost-effectiveness, such issues can be resolved.

For projects involving existing roadways, the guidelines provide a basis for deciding which project elements to improve given the anticipated safety and operational benefits. Where insufficient funding is available to improve all highway elements to standard, the guidelines provide information which can be used to prioritize improvements and justify deferrals. The guidelines can also provide insight into which highway elements should be improved beyond standard where significant benefits can be achieved by doing so.

The HEIR Guidelines focus on safety and operational improvements that are typically (but not always) implemented as part of larger projects. Highway elements covered in the guidelines include:

- Pavement
- **Highway Geometrics***
- **Roadside***
- Drainage
- **Structures***
- Traffic Signals, Pavement Markings, and Signing
- Barrier Systems
- **Medians***
- **Illumination***
- **Operational Improvements***
- Facilities

For each broad category, narrative guidance is provided outlining design considerations and potential improvement measures. For certain improvements, equations are given for quantifying the safety and/or operational benefits. Highway elements for which quantitative equations are available are identified in the above list with an asterisk (*) and bold text.

The HEIR Guidelines apply to all stages of the planning and design process, and can also be used in making asset management decisions. In general, the earlier a decision is made, the less risk of changes in project schedule or scope. From a practical implementation perspective, the HEIR guidelines need not be applied to every element within a given highway project.

Table 1 presents the screening criteria that can be used to determine when the guidelines apply. As Table 1 illustrates, an HEIR analysis is required whenever the highway element does not meet standard, the collision frequency is greater than expected for the type of road under consideration, or there is some other reason to suspect a potential safety hazard may exist.

**Table 1 – Screening Criteria**

| Does Highway Element Meet Current Standards? | Collision Frequency Above Expected Levels | Other Reason to Believe Potential Safety Hazard | Perform Analysis |
|---|---|---|---|
| No | Yes | Yes | Yes |
| | | No | Yes |
| | No | Yes | Yes |
| | | No | Yes |
| **Yes** | Yes | Yes | Yes |
| | | No | Yes |
| | **No** | Yes | Yes |
| | | **No** | **No** |

The general process for applying the HEIR guidelines is presented in Figure 1. The process is structured so that each step is completed in sequence, with results from one step feeding into the next. The first step of the process requires the analyst to be familiar with the HEIR Guidelines, and in particular, the guiding philosophy and principles. This step lays the foundation for the steps that follow, and is thus of critical importance to the success of the overall process.

In Step 2, the screening criteria of Table 1 are applied. Once it has been determined that the highway element meets the screening criteria, the input data needed to analyze each option are collected. This forms Step 3. Many of the inputs are multi-disciplinary, involving development of traffic forecasts, analysis of collision data, and design of improvement options. This information is used in Step 4 to calculate the anticipated safety and operational benefits of each option in relation to the costs. The resulting benefit-cost ratio provides one input to the decision-making process. In Step 5, non-quantifiable factors are considered, and weighed against the results of the benefit-cost analysis. A decision is made, and the results of the analysis are documented and stored in a central location (Step 6).

For measures without quantifiable safety or operational benefits, the analyst can go directly from Step 2 to Step 5. Again, non-quantifiable factors are considered, and a decision is made.

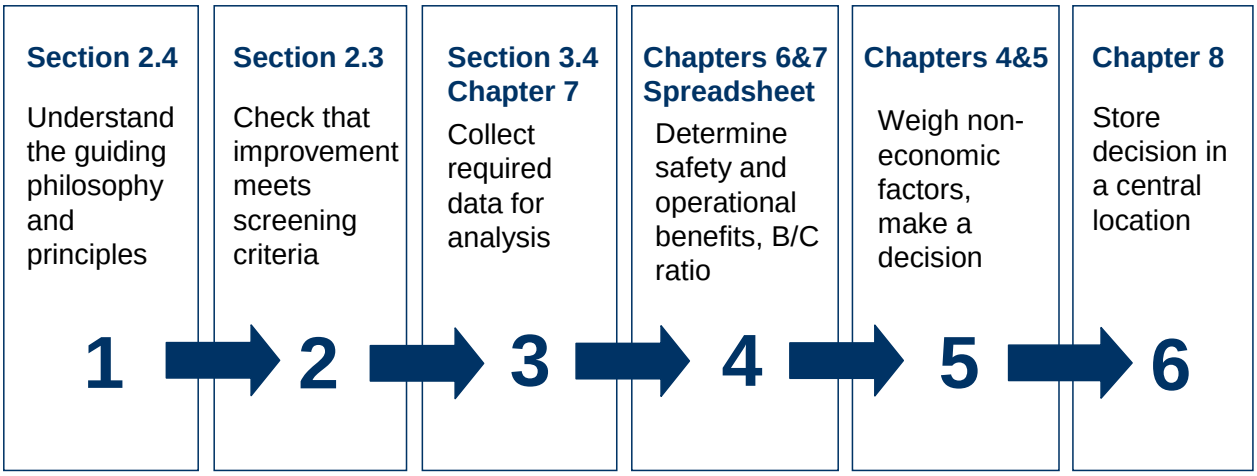


**Figure 1 – The Evaluation Process**

To partially satisfy the requirements of Step 1 of the evaluation process, a number of training sessions were held across Ontario for MTO staff and consultants. These training sessions provided an introduction to the HEIR guidelines and accompanying spreadsheet calculation tool. Additionally, a self-study course was developed with numerous worked examples.

## GUIDING PRINCIPLES

One of the distinguishing features of the new HEIR Guidelines is a set of guiding principles for designing highway elements and selecting among alternatives. These principles set the context for incorporating safety in design, moving beyond the application of standards as the sole indicator of safety performance. Several of the principles contained in the HEIR Guidelines were adapted, with permission of the publisher, from the contents of the Report of the Highway 407 Safety Review Committee [2]. This report was commissioned by MTO and published by Professional Engineers Ontario.

A summary of the guiding principles found in the HEIR Guidelines is provided below.

- **Highways cannot be classified as safe or unsafe. Highways can only be built safer or less safe** – All highways carry some risk of collision, and therefore no highway can be described as completely safe. However, a highway can be designed to be more or less safe. In comparing two highway designs connecting the same two points and carrying the same traffic, the one that is likely to have fewer or less severe collisions is the safer highway.

- **Facilitating driver expectations contributes to safer highways** – Drivers adapt their behaviour based on the cues received from the driving environment. If conditions are different than expected, the potential for collisions increases. At the corridor level, the concept of driver expectation implies that similar highway elements should be designed to a similar standard.

- **“Standard” does not equal “safe”; “substandard” does not equal “unsafe”** – Generally speaking, meeting a standard is understood to be a guarantee of quality, while something that is substandard is understood to be deficient. This meaning does not apply to safety in highway design. There are three reasons why this is so. First, the safety of a highway does not change abruptly at the point at which the highway becomes substandard, particularly if the extent of the deficiency is minor. Second, many highway standards are minimum standards. That is, they represent the agreed-upon minimum tolerable design for a highway element—not the pinnacle of highway safety. Thus, designing to standard is not the goal; the aim of design is to meet or exceed standards. Third, highway design standards are constantly evolving over time. Just because the standard changes does not mean all existing highways suddenly become unsafe.

- **Incremental improvements usually result in incremental benefits** – The safety of a highway is a continuum. If some dimension of the travelled way or roadside environment is improved, a corresponding improvement in safety will typically be achieved as well. For example, building a wider median, placing obstacles farther from the travelled lanes, providing more pavement friction, designing curves with larger radii, typically all make for safer highways.

- **Marginal benefits usually decrease as an improvement is increased** – Safety improvements are often subject to the law of diminishing marginal returns; that is, for every improvement of a fixed amount, the benefit gained decreases a little each time. For example, increasing the width of a median from 10 m to 20 m will have a greater impact on collisions than increasing it from 50 m to 60 m.

- **There is a point at which further improvements are not justified** – Eventually, a point will be reached at which further improvements cannot be justified because the safety and operational benefits are too small in comparison to the cost of the measure. It is important that funds be directed where they are most needed and where they will achieve the most benefit. The objective is to determine what level of improvement is cost-effective.

- **It is necessary to identify “real benefits"** – Before a particular benefit is included in the assessment of cost-effectiveness, it is important to confirm that the benefit will actually be realized by highway users. This is particularly relevant for measures which reduce travel time. If a measure alleviates congestion at one location only to have drivers delayed at a downstream bottleneck, the benefits are unlikely to be realized. Likewise, if drivers save only a few seconds of travel time per trip, it is unlikely that they would consider such a savings a tangible benefit, even though the overall reduction in travel time could be quite large when multiplied over thousands of drivers.

- **Formulas alone are not enough; engineering judgment is required** – Not all factors relevant to decision-making can be captured in benefit-cost relationships. Moreover, even where equations are available to quantify safety benefits, our knowledge of highway safety is evolving; any calculated benefit can at best be

considered an estimate of the true safety performance. Equations also rely on input assumptions that are often uncertain, such as the future traffic growth rate. Clearly, engineering judgment is needed to interpret analytical results within the context of the problem, and ensure all relevant factors are considered in decision-making, whether quantifiable or not.

## ANALYSIS APPROACH

The analysis approach adopted in the HEIR Guidelines recognizes the importance of both quantifiable and non-quantifiable factors in making design decisions.

Quantifiable Factors – Calculation of Benefit-Cost Ratios

Within the HEIR Guidelines, the measure of cost-effectiveness used to evaluate improvement options is the benefit-cost ratio. Benefit-cost analysis is a systematic process for calculating and comparing the benefits and costs of a given measure [5]. It can be used to help determine whether an improvement is a good investment, how it compares to other options, and whether it should be implemented now or later. To be able to perform benefit-cost analysis, benefits and costs must be quantifiable in dollar terms and expressed in present value.

To calculate collision benefits, Collision Modification Factors (CMFs) are employed. CMFs provide an indication of the collision reduction associated with a particular improvement measure. The CMFs used in the HEIR Guidelines were subject to a rigorous review to assess their reliability and applicability to Ontario highways. CMFs are not available for all improvement measures included in the HEIR Guidelines. However, as research in the field progresses, it is anticipated that new CMFs will be added in the future.

The magnitude of the collision reduction depends not only on the ability of the proposed measure to reduce collisions, but also the prevailing collision experience on the road section under investigation. To account for the observed safety performance, the CMFs are applied in conjunction with Operational Performance Functions (OPFs) calibrated for Ontario highways. OPFs estimate the expected number of collisions on a road section as a function of its physical and operational characteristics, and are used as part of the Empirical Bayes process to “smooth” historical collision data for use in calculating the collision reduction.

In addition to safety benefits, some improvement measures also consider operational benefits in the form of travel-time savings. Once all benefits have been calculated, they are compared to the cost of the measure, and used to generate a benefit-cost (B/C) ratio. Generally speaking, if the B/C ratio is greater than 1.0, the benefits exceed the costs and the option is considered viable from an economic perspective. However, in some cases, it may be appropriate to construct an improvement measure if the B/C ratio is less than 1.0 (particularly in regions with lower traffic volumes). In other cases, an option may not be constructed even though the B/C ratio exceeds 1.0. The B/C ratio is

just one input to the decision-making process; other non-quantifiable factors must also be considered.

Non-Quantifiable Factors

Not all factors relevant to a particular improvement option can be quantified in dollar terms. Nonetheless, these non-quantifiable factors are often important, and should be considered in the decision-making process. In some cases, such factors may determine the preferred decision. The guidelines describe several considerations that may be relevant, including:

- Adjacent highway environment
- Design consistency
- Environmental impacts
- Long-term corridor plans and the corridor vision
- Mobility and community connectivity
- Risk (particularly for structural improvements)
- Staging considerations
- Project timing

In addition, for each highway element included in the guidelines, narrative discussion is provided on specific design considerations that may be relevant for improving safety or operational performance. Again, many of these considerations may not have quantifiable impacts, but may nonetheless influence the preferred option.

On P3 projects, issues related to design consistency are particularly relevant. Although a highway may be designed, built, or operated by a private partner, it should be consistent with other provincial facilities. Simply adhering to standards may not be sufficient to ensure this occurs.

Making Decisions

The HEIR Guidelines recognize that benefit-cost data can improve the quality of highway infrastructure decision-making in Ontario; with more information, more informed decisions can be made. The calculations found in the HEIR Guidelines provide a basis for assessing the cost-effectiveness of improvement options, choosing among alternatives, establishing construction timing, and developing priorities. However, the results of such calculations are just one input to the decision-making process; other non-quantifiable considerations may sometimes determine the preferred solution.

Rather than employ a prescriptive approach, the HEIR Guidelines rely on the judgment of the design team to weigh the various quantitative and qualitative factors and determine the best course of action given the available funding.

Though the HEIR Guidelines were not expressly made for P3 projects, a tool such as this could be applied in several ways to aid in making decisions in P3 projects. For example:

- In establishing a scope of work for a P3 project before tender (including identifying acceptable exceptions to standard and desirable improvements beyond standard, etc.)

- In assessing innovation plans submitted by P3 bidders on the merits of safety and/or travel-time benefits

- In evaluating the merits of change requests or requests for additional work that include safety or operational improvements

Moreover, if an agency offers an incentive to the private partner based on actual safety performance of a P3 project, the private partner may elect to use a tool such as the HEIR Guidelines to aid in determining which improvements are likely to have the most safety benefits. A safety performance incentive for has been used on a P3 highway project in California.

## DOCUMENTATION PROCESS

The HEIR Guidelines contain a clearly defined documentation process for ensuring that all relevant information is available for future reference, including analysis results, input assumptions, decisions, and supporting rationale. Roles and responsibilities are also detailed in terms of who is responsible for producing, reviewing, approving, and filing HEIR reports. This documentation and reporting process is needed to:

- Fulfill the requirements for documenting design decisions

- Track variations from current standards, including deferred work

- Assess the consistency of the approach used to prioritize capital work

- Examine the benefit-cost ratios that are being used in project decisions

With information on what project elements are being constructed and at what level of cost-effectiveness, appropriate benefit-cost thresholds can be established for different types of improvements on different types of roads. In the future, such thresholds may be used as a general indication of the level of cost-effectiveness needed for an improvement to proceed.

## THE SPREADSHEET CALCULATION TOOL

A spreadsheet calculation tool was developed to assist in carrying out the benefit-cost calculations contained in the HEIR Guidelines. The tool calculates the costs and benefits of a given improvement option for each year of the analysis period based on input data provided by the user. These costs and benefits are then discounted to present value and used to compute a benefit-cost ratio for inclusion in the decision-making process.

Within the spreadsheet calculation tool, the user specifies the initial cost of constructing the option, and also describes various characteristics of the option which influence its safety/operational performance. Other input requirements include the year of construction, next construction opportunity if the improvement is deferred, projected traffic growth rate, and observed collisions. This information is used by the tool to calculate the reduction in collision and/or travel time costs associated with the proposed measure. The tool also considers the cost of constructing the measure, the cost of reconstructing the measure if it reaches the end of its service life within the analysis period, and any residual value remaining at the end of the analysis period, so that all life-cycle costs are accounted for appropriately. Default values are provided for key input parameters such as the discount rate, however, all defaults can be over-ridden by the user as required to account for project-specific factors.

The spreadsheet calculation tool substantially reduces the level of effort required to evaluate alternatives. The tool:

- Is easy to use without extensive training
- Incorporates inputs that are readily available from the planning and design process, with default parameters provided where appropriate
- Reflects the ‘look and feel’ of the Ministry’s other tools and programs (where possible)
- Is based on an open design, with all calculation steps fully documented

The tool also ensures that all benefit-cost calculations are conducted in a consistent way, and provides convenient output reports for storing calculation results in accordance with the documentation requirements outlined in the HEIR Guidelines.

Additional information on the spreadsheet calculation tool can be found in Reference [6], from which much of the above discussion on the calculation tool was drawn. Screen captures showing the general layout of the tool are presented in Figure 2.

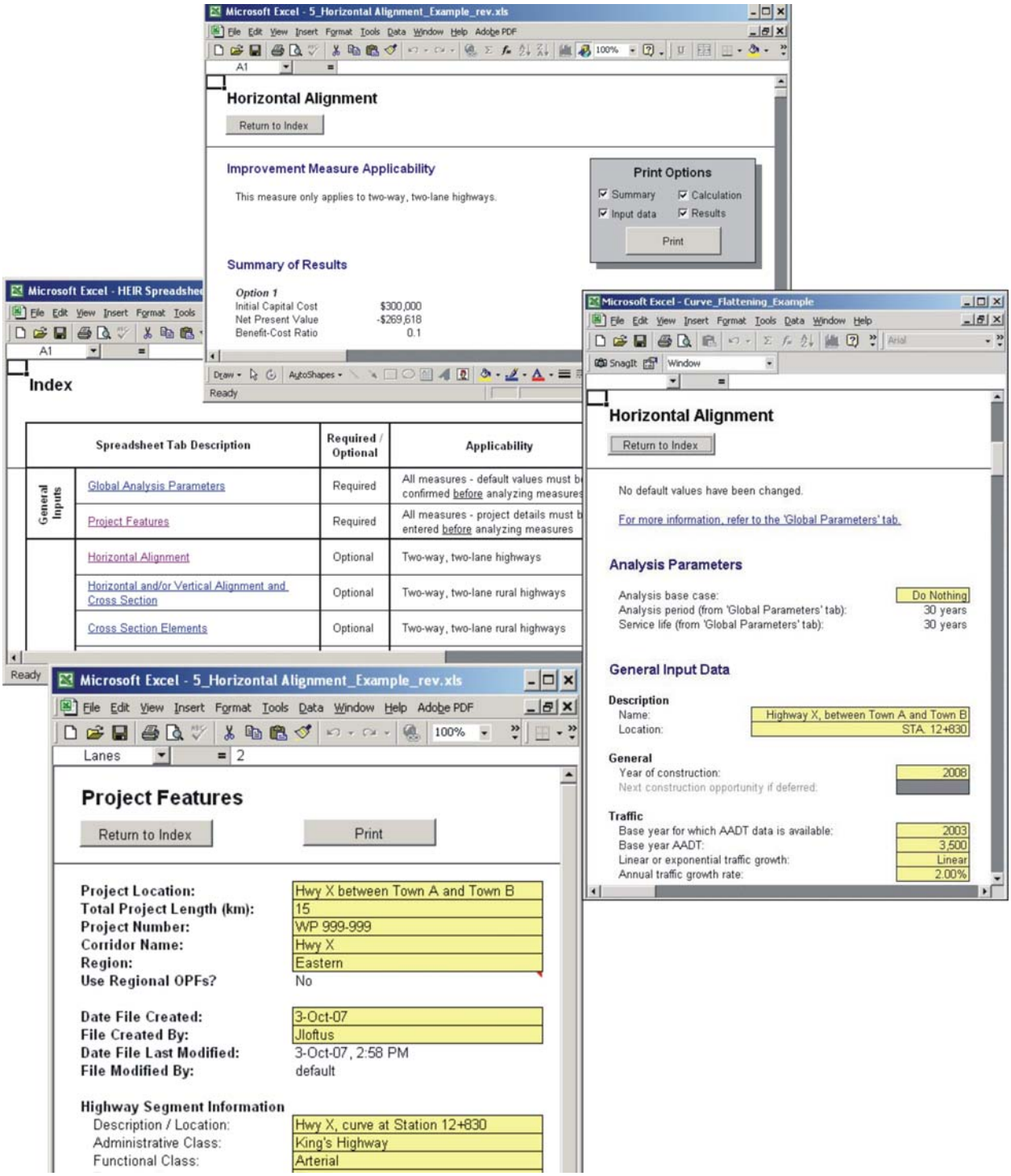


**Figure 2 Miscellaneous Screen Captures of the Spreadsheet Calculation Tool**

## CONCLUSIONS

The HEIR Guidelines were developed by the Ontario Ministry of Transportation to improve the quality of highway infrastructure decision-making in Ontario by helping to make the next investment dollar spent the best investment dollar.

By helping to quantify the benefits of highway improvements and compare these benefits to costs, and through narrative guidance that helps to deliver sound, cost-effective decision-making, the HEIR Guidelines can help MTO better meet public needs with its available funds. This is a goal at the heart of both the P3 initiative and the traditional funding regimes alike.

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