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Memorandum

To/Attention	Municipality of Meaford	**Date**	2021-04-26
From	IBI Group	**Project No**	124140
cc			
Subject	**Meaford Transportation Master Plan Bridge Rehabilitation Strategy**		

1 Background

In 2016 Meaford retained Ainley Consulting to develop the *State of the Infrastructure Report, Municipal Bridges and Large-Span Culverts.* The report identified that a number of Meaford's bridges are aging and in need of major rehabilitation or replacement, and the cost of this work would exceed available maintenance budgets.

The purpose of this memo is to build on the prior work and provide guidance on prioritizing bridge maintenance / rehabilitation based on a number of criteria. The Structure Priority Number method proposed herein follows other municipalities in their approach to assess bridges. The memo also provides an overview of structure types and considerations for repair and replacement, tailored to Meaford's use.

Definitions

The Municipality's bridge structures can be categorized into two types of structures; culverts and bridges. For the purposes of identifying and classifying structures in the Municipality's inventory, the definitions are as noted in the Canadian Highway Bridge Design Code (CHBDC) and the Ontario Structure Inspection Manual (OSIM):

- **Bridge:** a structure that provides a roadway deck or walkway for the passage of vehicles, pedestrians, or cyclists across an obstruction, gap, or facility and that is greater than 3 metres in span.
- **Culvert:** a structure that forms an opening through the ground, with soil or fill above the structure and below the road surface.

2 Structure Types

The most common structure types in Meaford are different forms of culverts, rigid frame bridges and beam bridges. There are eighty one structures in Meaford, including the following structure types:

Culverts

- Concrete Arch Culvert
- Concrete Box Culvert
- Concrete Rigid Frame Culvert
- Double Concrete Box Culvert
- Multi-Plate Steel Arch Culvert
- Multi-Plate Steel Ellipse Culvert
- Precast Concrete Box Culvert
- Twin CSP Pipe Arch Culvert
- Twin Multi-Plate Steel Culvert

Bridges

- Concrete Rigid Frame/T-beam
- Concrete Slab on Steel Girder
- Concrete T-Beam
- Precast Concrete (placed)
- Cast-in-place Slab on Precast Concrete Box Girders
- Cast-in-place Slab on Precast Girder
- Timber Deck on Steel Girders

Additional details are provided in the following sections of this memo.

3 Structure Replacement Alternatives

There are numerous structure types that can be used when designing and constructing a bridge, ranging from precast or cast-in-place concrete box and arch culverts; CSP pipe and arched or elliptical culvert structures; concrete girder bridges; steel girder bridges; cast-in-place rigid frame bridges; post-tensioned voided slab bridges; steel truss bridges; and composite structures of fiberglass or other materials.

Each of these structure types has advantages and disadvantages and must be assessed in the context of a specific location. There is no universal best practice or general conditions where certain structures are favored over others. The structure type must be decided by the structural engineers designing the culvert or bridge. At that point, engineers can assess various structure types based on applicability and suitability for the specific context, up front capital costs, ongoing operating costs, life-cycle costs, etc. and determine the optimal structure type for a given location.

In general, alternates for culvert replacements would include open or closed bottom precast culverts or Multi-plate steel structures. (Con-Cast, Atlantic Industries, et al.)

Considerations for longer span replacement crossings (up to 15m) would usually include pre-cast rigid frame units, precast arch units, multiplate structures. (con-Cast, Atlantic Industries) or conventional cast-in place solutions.

Longer span requirements are usually met utilizing pre-cast concrete girder systems which are generally the most cost-effective solution.

Intermediate spans can also be accomplished using proprietary systems such as prefabricated steel super-structures (Atlantic Industries) or fiberglass encased deck systems (Guardian Bridge Rapid Construction Inc.). These are generally lighter weight solution permitting rapid construction and often retention of existing sub structures. Lessard Modular Bridge also provides competitive options for low volume roads as defined in OHBDC.

Bid and contract documents can include language indicating opportunities for alternative bridge construction methods to be submitted to allow a cost optimized solution at any site.

Optimal materials and structure type should be determined through lifecycle cost analysis by the structural engineers designing new and replacement bridges. A summary matrix is presented in Appendix A. A further guide to relative costing of bridge works can be found in MTO Publication “Parametric Estimating Guide, Contract Management Office, Estimating Section, 2016”

Temporary Works

In lieu of full bridge replacement, there are alternative strategies to prolong bridge life that may be appropriate to Meaford. Typically, these approaches can reduce short term cost, though long-term costs could be higher.

Some deficiencies of bridges are not in the bridge structure but in traffic or pedestrian protection. This category also includes temporary guide-rail/bridge deck barrier installations. It is suggested that these items be addressed on an ongoing basis by municipal staff for risk management and liability purposes. Critical areas can be protected on an interim basis using temporary concrete barriers or steel beam guide-rail sections on the face of parapets.

Complete structure replacement includes structure removal works which account for substantial costs in a capital construction project. As a temporary alternative the existing bridge can be retained, and a pre-fabricated modular bridge erected over the existing bridge without imposing additional loads on the existing bridge. Bridge foundations can be built behind existing bridge abutments by utilizing micro-piles or helical piles independent of the existing bridge foundations. The pre-fabricated modular bridge can either be purchased or be leased for a long-term period. This long-term lease could also help bring down construction costs. One disadvantage to note is that this type of bridge construction requires raising the bridge approach grades. However, the advantages including cost-effective construction and speedy erection likely outweigh this disadvantage. Consideration for this strategy could be included in bridge and culvert replacement terms of reference for engineering consultants.

A final category of temporary work would include short-term repairs to manage bridge deterioration. This should be undertaken as identified in the OSIM reports.

4 Prioritization of Work Methodologies

Given that maintenance and rehabilitation needs in Meaford exceed available budget, prioritization of bridges is needed. The Municipality currently uses a manual prioritization approach which is reviewed below. An alternative structure priority number (SPN) approach is detailed and is recommended to help prioritize fund allocation as it can provide greater resolution on risk areas.

Simplified Method (Manual Prioritization) – Current Approach

The State of the Infrastructure Report – Municipal Bridges and Culverts includes a broad-based prioritization of the bridge rehabilitation needs based on the 2014-2015 OSIM reports. Each category grouping can be prioritized on a rational basis driven by the factors of public safety (e.g. deficiency requires immediate attention or closure of the roadway), structural integrity (e.g. requires immediate attention or closure/posting of the structure), roadway importance (e.g. can the structure be closed) and cost (e.g. budget, how the rehabilitation is financed), all in conformance with the defined Asset Management Strategy of the Municipality. This can readily form the basis of a prioritized work program.

Within the report, the work requirements are categorized as:

- **Category 1 – Urgent:** Structure represents a risk to the public which should be addressed immediately, or the structure closed or posted with load limits. Prioritization will generally be driven by funding availability and local importance of the structure to the infrastructure system.

  It is noted that this category includes several guide-rail/bridge deck barrier installations. It is suggested that these items be addressed on an ongoing basis by municipal staff. Critical areas can be protected on an interim basis using temporary concrete barriers or steel beam guide-rail sections on the face of parapets

  The 2014/2015 OSIM identifies five major structures within this category to be prioritized manually. With closures and postings, it may be possible to spread implementation over multiple years subject to budget constraints.

- **Category 2 – Required in 1-2 years:** Five significant expenditures are programmed in the 1-2 year window. These represent major rehabilitations to avoid deterioration to a 'category I' status. Rehabilitation could be prioritized using the OSIM BCI numbers in conjunction with engineering judgment of the structure importance, potential safety issues, cost and budget availability.

- **Category 3 – Required in 3-5 years:** Ten significant expenditure predictions fall with-in the 3-5 year window. These are primarily programed replacements.

  It is recommended that the replacement options be further explored. It is noted that structures such as Structure 70 may only require superstructure replacement at a significantly lower cost than noted in the OSIM report.

- **Category 4 – required in 6-10 years:** The primary long range forecast includes nine major replacements. This forecast should be reviewed on a semi annual basis.

Structure Priority Number Approach

A Structure Priority Number (SPN) can be developed to serve the Municipality's need to prioritize the structures in need of repair/rehabilitation or replacement works. This methodology is generally adopted by upper tier municipalities and other municipalities with larger complex inventories of structures. The approach is usually integrated in a bridge management software suite.

Several factors are taken into account in the prioritization methodology such as Bridge Condition Index (BCI), Annual Average Daily Traffic (AADT), Current Replacement Value (CRV), performance deficiencies, maintenance needs, total repair/rehabilitation cost and detour distances. Each factor has a weighting as shown in Exhibit 4.1.

Exhibit 4.1: Structure Priority Number Criteria Weighting

Criteria	Weight
Bridge Condition Index	50
Average Annual Daily Traffic	10
Current Replacement Value	15
Performance Deficiencies	5
Maintenance Needs	5
Total Repair/Rehabilitation Cost	5
Detour Distance	5
TOTAL	**100**

Structures with the SPN of zero (0) do not require any repair/rehabilitation or maintenance, while structures with the SPN of 100 is in the most urgent need of either replacement or repair/rehabilitation.

A description of each of the criteria and how they are scored is summarized below and further detailed in Appendix B.

Bridge Condition Index

The Bridge Condition Index (BCI) was developed by the Ministry of Transportation Ontario (MTO) as an indication of the overall condition of the bridge, based on the quantities of each structural element in each of four condition states (excellent, good, fair, and poor). The BCI is essentially a weighted average of all elements in different condition states with a degree of loss considered.

Average Annual Daily Traffic

The maximum value for Average Annual Daily Traffic (AADT) is be 20,000. If the AADT is greater than the AADT Cap Value, then AADT Score = 10. If less than 20,000, the score is pro-rated.

Current Replacement Value

The current replacement value (CRV) is the monetary value of a structure without depreciation taken into account. The CRV can be calculated based on the deck area and the CRV factor depending on structure and material types.

Performance Deficiencies

Performance deficiencies are identified through the structure investigation process consisting of detailed visual inspections of all structures as prescribed in the Ontario Structure Inspection Manual (OSIM). The inventory of structural components and corresponding quantities should be maintained in accordance with the OSIM and be updated as required.

Common material defects would include delamination, cracking and spalling of concrete in most elements of concrete structures, particularly in the areas under more severe environmental conditions. Exposure to water and salt spray often correlates with these common material defects.

Common performance deficiencies would include settlements at bridge approaches or bridge abutments; seized bridge bearings causing additional stresses due to the bridge’s thermal movements; leaking bridge expansion joints expediting concrete deterioration at the deck ends; partially or fully blocked watercourses under bridges with excess vegetation growth and/or debris within the stream; and unstable embankments due to severe erosions.

Maintenance

Maintenance scores based on quantity of maintenance needs within different ranges of High/Low. Maintenance needs can be identified in accordance with Table 6.1 in Section 6 of the MTO OSIM Manual, which generally includes bridge cleaning, bridge railing system maintenance, bridge deck joint repair, bridge bearing maintenance, minor repair of structural steel, minor repair of concrete surface, and bridge deck drainage maintenance.

Repair/Rehabilitation Cost

Repair/rehabilitation work is defined as any type of work that requires the issuing of a capital construction project. Work required is to improve the structural capacity of defective elements, engineering directions and drawings are generally required. Recommended repair/rehabilitation works can be categorized into minor and major rehabilitation works.

Detour Distance

Detour distance scores based on detour distance required during rehabilitation/replacement works.

5 Additional Investigations

Once the municipality has identified a structure for maintenance or rehabilitation, they will hire an engineering consultant to prepare a design. This approach applies to most bridge and culvert rehabilitation projects, though some minor maintenance can be quoted by a contractor directly and managed and administered by municipal staff, following current practices.

The consultant will need to investigate permitting requirements with the appropriate conservation authority. Depending on early investigations it may be necessary to conduct an environmental assessment, which depending on the type may include public consultation, though this applies mainly to larger projects involving higher cost or changing the function of a bridge (e.g. widening).

Site-specific structure investigations can include detailed deck condition surveys, fatigue investigations of steel girders, structural evaluations of the load bearing capacity of culverts, monitoring of continuous settlement or movement, and underwater investigation of footings. These additional investigations could provide enhanced data for the determination of rehabilitation work as well as potential load restriction postings.

Similar investigations are also suggested or identified in the bi-annual OSIM Inspections. If it were suspected that severe material defects or performance deficiencies (e.g. severe deterioration of deck top, an excessive section loss of a steel member, a scour of footings under the water, excessive structural deformations, settlements or movements) could affect structural capacity, it may warrant additional structure investigations to find out in detail whether or not the structure is still in a safe condition and if the structural capacity needs to be restored.

6 General Maintenance

General maintenance works are defined as the types of work which do not require the initiation of a capital construction project. General maintenance works are important part of maintaining the service life of a structure and include items such as stream works, erosion control, trimming overgrown plantings and trees, clearing of debris; and the provision of gabion baskets, and rip rap surface protection. Other maintenance works include deck cleaning, sealing of asphalt surfaces and cleaning expansion and construction joints, and repair of some railing systems and repairs rising from vehicular impacts.

It should be noted that most of these items can be corrected through regular maintenance by the Municipality’s staff (bridge or road maintenance crew), including cleaning, clearing and other maintenance activities.

Additional guidelines can be found in TAC Publication Guide for Bridge Repair and Rehabilitation.

7 Bridge Closure Needs

Meaford is maintaining bridges near the end of their service life with safety and maintenance needs, that accommodate low traffic volumes, for which alternative routes are available.

Further study is recommended for the potential bridge closures identified in the State of the Infrastructure – Bridges report and should consider the availability of a detour route, the ease of navigation of that route for heavy vehicles or agricultural equipment and impacts to residents and businesses near the proposed closure.

Appendix A - Replacement Matrix

This matrix provides a reference for which types of new structures (rows) are suitable for replacing which type of existing structures (columns). Additional comments are provided where possible.

			Existing Culvert Structure							Existing Bridge Structure									
Cate-gory	Primary Replacement Structure Type	Comments	Cast-in place box culvert 3 m – 6 m span	Cast-in place rigid frame culvert 3 m – 6 m span	Double concrete box culvert	Multi-plate steel arch	Multi-plate steel ellipse culvert	Twin CSP pipe arch	Twin multi-plate steel culvert	Simple span existing abut-ments to be retained	CIP concrete arch	Concrete rigid frame	Concrete T-beam	Pre-cast units	CIP topping on pre-cast box girder	CIP slab on pre-cast girder	CIP slab on steel girder	CIP slab on pre-cast box girder	Timber deck on steel girder
Culvert	Precast box culvert open or closed bottom	Standard sizes 3 m – 6 m (OPSS); Open footing up to 14m; Multiple suppliers; is generally the lowest cost type of culvert	✓	✓	✓			✓	✓										
	Corrugated steel pipe	Multiple source availability	✓					✓											
	Steel plate culvert	Rapid erection; usually competitive with pre-cast concrete; water quality can cause issues		✓		✓	✓	✓	✓										
	Precast rigid frame units (con-span or equivalent)	Spans ranging 6 m – 14 m			✓	✓					✓	✓		✓					
	Pre-cast concrete arch units (BEBO Arch)	Standard spans 3.7m – 25.6 m; T series (flat arch) 10 m – 30 m; minimum 0.6 m cover required; is generally the most expensive type of culvert							✓		✓								

			Existing Culvert Structure							Existing Bridge Structure									
Cate-gory	**Primary Replacement Structure Type**	**Comments**	**Cast-in place box culvert 3 m – 6 m span**	**Cast-in place rigid frame culvert 3 m – 6 m span**	**Double concrete box culvert**	**Multi-plate steel arch**	**Multi-plate steel ellipse culvert**	**Twin CSP pipe arch**	**Twin multi-plate steel culvert**	**Simple span existing abut-ments to be retained**	**CIP concrete arch**	**Concrete rigid frame**	**Concrete T-beam**	**Pre-cast units**	**CIP topping on pre-cast box girder**	**CIP slab on pre-cast girder**	**CIP slab on steel girder**	**CIP slab on pre-cast box girder**	**Timber deck on steel girder**
Short Span	Cast-in-place (CIP) rigid frame	Generally used for widening exiting rigid frames									✓								
	Precast core-slab with CIP topping (simple span on abutments)	Spans ranging 5 m – 25 m; generally used for deck replacements; is generally the lowest cost short span solution								✓				✓				✓	
Medium Span	Pre-stressed pre-cast box girder with CIP deck slab or topping	Spans ranging 15 m – 30 m								✓	✓	✓		✓	✓			✓	
	Pre-stressed girder with CIP deck slab	Spans up to 45m; is generally lowest cost for medium span bridge replacements								✓		✓	✓		✓	✓	✓	✓	✓
	Steel girder with CIP deck slab	Spans up to 50m; lighter weight compared to precast girders; is generally the most expensive option for medium-span replacement								✓		✓							

			Existing Culvert Structure							Existing Bridge Structure									
Cate-gory	Primary Replacement Structure Type	Comments	Cast-in place box culvert 3 m – 6 m span	Cast-in place rigid frame culvert 3 m – 6 m span	Double concrete box culvert	Multi-plate steel arch	Multi-plate steel ellipse culvert	Twin CSP pipe arch	Twin multi-plate steel culvert	Simple span existing abut-ments to be retained	CIP concrete arch	Concrete rigid frame	Concrete T-beam	Pre-cast units	CIP topping on pre-cast box girder	CIP slab on pre-cast girder	CIP slab on steel girder	CIP slab on pre-cast box girder	Timber deck on steel girder
Proprie-tary System	Fiberglass / timber system	Single source suppliers; relatively short track records; competitive pricing, rapid field installation due to pre-fabrication; light weight for deck replacements								✓		✓							✓
	Prefabricated steel units	Panel appropriate for rapid deck replacement; alternative suppliers								✓		✓							
	Bailey type systems	Generally used for emergency or temporary installations; can generate noise during operation																	

Appendix B - Structure Priority Number

A Structure Priority Number (SPN) can be developed to serve the Municipality's need to prioritize the structures in need of repair/rehabilitation or replacement works. Several factors are taken into account for prioritization such as BCI, Annual Average Daily Traffic (AADT), Current Replacement Value (CRV), performance deficiencies, maintenance needs, total repair/rehabilitation cost and detour distance. Each factor has different weighting as shown in Exhibit B.1.

Exhibit B.1: Structure Priority Number Criteria Weighting

Criteria	Weight
Bridge Condition Index	50
Average Annual Daily Traffic	10
Current Replacement Value	15
Performance Deficiencies	5
Maintenance Needs	5
Total Repair/Rehabilitation Cost	5
Detour Distance	5
TOTAL	**100**

Structures with the SPN of zero (0) do not require any repair/rehabilitation or maintenance, while structures with the SPN of 100 is in the most urgent need of either replacement or repair/rehabilitation.

A description of each of the criteria and how they are scored is presented below.

Bridge Condition Index

The Bridge Condition Index (BCI) was developed by the Ministry of Transportation Ontario (MTO) as an indication of the overall condition of the bridge, based on the quantities of each structural element in each of four condition states (excellent, good, fair, and poor). The BCI is essentially a weighted average of all elements in different condition states with a degree of loss considered. When a bridge is new, the BCI is 100 and when all elements are in poor condition, the BCI is zero (0). The BCI is a commonly used measure of urgency associated with structural repair or rehabilitation.

BCI Score = $50 - \frac{\text{BCI}}{2}$

Average Annual Daily Traffic

The maximum value for Average Annual Daily Traffic (AADT) is be 20,000. If the AADT is greater than the AADT Cap Value, then AADT Score = 10. If less than 20,000, the score is calculated as follows:

ADT Score = $\frac{\text{AADT}}{\text{Cap Value}} \times 10$

Current Replacement Value

The current replacement value (CRV) is the monetary value of a structure without depreciation taken into account. The CRV can be calculated based on the deck area and the CRV factor depending on structure and material types. The following formula illustrates how the CRV can be calculated:

- (Total deck area(m^2) x CRV factor x Unit price) + Approaches + Utilities = CRV SUBTOTAL
- CRV SUBTOTAL + 20% of CRV Subtotal for engineering + 10% of CRV Subtotal for contingencies = TOTAL CRV

The CRV factors range from 0.6 to 1.5 corresponding to different combinations of the structure and material types as shown in Exhibit B.2. The unit price can be estimated to be around $4,000 per m^2 of deck area which reflects the present-day construction cost. Other costs related to approaches and utilities are added if needed. Translating the CRV into a score for the Structure Priority Number is shown in Exhibit B.3.

Exhibit B.2: Suggested CRV Factors

Structure Type	Material Type	CRV Factor
Box Beams of Girders	Cast-in-place Concrete	1
Box Beams of Girders	Precast Concrete	0.85
Box Beams of Girders	Steel	1
Box Beams of Girders	Weathering Steel	1
Half-through Beams of Girders	Cast-in-place Concrete	1
Half-through Beams of Girders	Precast Concrete	0.85
Half-through Beams of Girders	Steel	1
Half-through Beams of Girders	Weathering Steel	1
I-beam or Girders	Cast-in-place Concrete	1
I-beam or Girders	Precast Concrete	0.85
I-beam or Girders	Steel	1
I-beam or Girders	Weathering Steel	1

Structure Type	Material Type	CRV Factor
T-Beam	Cast-in-place Concrete	1
T-Beam	Precast Concrete	0.85
T-Beam	Steel	1
T-Beam	Weathering Steel	1
Arch Culvert	Cast-in-place Concrete	1.1
Arch Culvert	Precast Concrete	1
Arch Culvert	Steel	0.7
Ellipse Culvert	Cast-in-place Concrete	1.1
Ellipse Culvert	Precast Concrete	1
Ellipse Culvert	Steel	0.7
Rectangular Culvert	Cast-in-place Concrete	1.1
Rectangular Culvert	Precast Concrete	1
Rectangular Culvert	Steel	0.7
Round Culvert	Cast-in-place Concrete	1.1
Round Culvert	Precast Concrete	1
Round Culvert	Steel	0.7
Deck Truss	Wood	0.6
Deck Truss	Steel	1.5
Deck Truss	Weathering Steel	1.5
Half-Through Truss	Wood	0.6
Half-Through Truss	Steel	1.5
Half-Through Truss	Weathering Steel	1.5
Through Truss	Wood	0.6
Through Truss	Steel	1.5
Through Truss	Weathering Steel	1.5
Arch Culvert	Corrugated Steel	0.7
Ellipse Culvert	Corrugated Steel	0.7
Rectangular Culvert	Corrugated Steel	0.7
Round Culvert	Corrugated Steel	0.7
Rectangular Tunnel	Corrugated Steel	0.7
Rectangular Tunnel	Cast-in-place Concrete	1.1
Rectangular Tunnel	Precast Concrete	1
Rectangular Tunnel	Steel	0.7

Exhibit B.3: CRV Scoring for Structure Priority Number

Low	High	CRV Score
$ 0	$ 500,000	3
$ 500,000	$ 1,000,000	6
$ 1,000,000	$ 2,000,000	9
$ 2,000,000	$ 5,000,000	12
$ 5,000,000	$ 100,000,000	15

Performance Deficiencies

Performance deficiencies are identified through the structure investigation process consisting of detailed visual inspections of all structures as prescribed in the Ontario Structure Inspection Manual (OSIM). The inventory of structural components and corresponding quantities should be maintained in accordance with the OSIM and be updated as required.

Common material defects would include delamination, cracking and spalling of concrete in most elements of concrete structures, particularly in the areas under more severe environmental conditions. Exposure to water and salt spray often correlates with these common material defects.

Common performance deficiencies would include settlements at bridge approaches or bridge abutments; seized bridge bearings causing additional stresses due to the bridge's thermal movements; leaking bridge expansion joints expediting concrete deterioration at the deck ends; partially or fully blocked watercourses under bridges with excess vegetation growth and/or debris within the stream; and unstable embankments due to severe erosions.

It should be noted that if the material defects and/or the performance deficiencies are left unaddressed and unrepaired longer than the recommended period, they will deteriorate further and will be at a higher risk of requiring full structure replacement.

The findings from the structure investigations should form the basis of determining the work scope and timeframe required for deteriorated structures. Scoring is shown in Exhibit B.4.

Exhibit B.4: Performance Deficiencies Scoring

Criteria	Weight
None	0
Load carrying capacity	5
Excessive deformation	3
Continuing settlement	3
Continuing movement	3
Seized bearings	1
Bearing unstable	3
Jammed expansion joint	1
Pedestrian/vehicular hazard	5
Rough riding surface	1
Surface ponding	1
Deck drainage	1
Slippery surface	1
Flooding/channel blockage	1
Undermining of foundation	5
Unstable embankment	3
Other	0

Maintenance

Maintenance scores based on quantity of maintenance needs within different ranges as shown in Exhibit B.5. Maintenance needs can be identified in accordance with Table 6.1 in Section 6 of the MTO OSIM Manual, which generally includes bridge cleaning, bridge railing system maintenance, bridge deck joint repair, bridge bearing maintenance, minor repair of structural steel, minor repair of concrete surface, and bridge deck drainage maintenance. Based on the number of maintenance needs identified, the following conversion can be made for the SPN:

Exhibit B.5: Maintenance Scoring

Low	High	Maintenance Score
0	1	1
1	2	2
2	3	3
3	4	4
4	100	5

Total Repair or Rehabilitation Cost

Repair/rehabilitation work is defined as any type of work that requires the issuing of a capital construction project. Work required is to improve the structural capacity of defective elements, engineering directions and drawings are generally required. Recommended repair/rehabilitation works can be categorized into minor and major rehabilitation works.

The minor rehabilitation works include concrete patch repairs and seal cracks in wearing surfaces. The cost estimation of these minor rehabilitation works is driven by the quantity of defects in the poor condition state. For the asphalt wearing surface repairs and concrete patch repairs on any structural element made of concrete, the following criteria can be used as a basis of the cost estimation:

Exhibit B.6: Suggested Cost Estimates for Wearing Surface and Concrete Patch Repair Works

*Total Defective Area (m^2)	Repair/Rehabilitation Cost
$0\ m^2 <$ Total defective area $< 1\ m^2$	$ 4,000
$1\ m^2 \leq$ Total defective area $< 5\ m^2$	$ 7,000
$5\ m^2 \leq$ Total defective area $< 10\ m^2$	$ 10,000
$10\ m^2 \leq$ Total defective area	$ 15,000 ~ 30,000

** Total defective area = Poor area + associated Fair area surrounding the Poor area*

The major rehabilitation works include improvement work to the bridge deck to restore its overall condition and structural capacity, such as patch-waterproof-pave rehabilitation, deck overlay and deck replacement. Therefore, the cost estimation of such major rehabilitation works is driven by the deck area rather than the quantity of material defects.

Deck replacement costs can be based on the unit cost estimate of $700 / m^2 of deck area and deck overlay-waterproof-pave costs can be based on the unit cost estimation of $500 / m^2 of deck area. For patch-waterproof-pave costs, the costs of concrete patch work on the deck top can be based on the unit cost estimates of $4,000 ~ $7,000 / m^2 of total defective area, and the costs of waterproofing + pave can be based on the unit cost estimate of $100 / m^2 of deck area.

Associated works include the works required for repair/rehabilitation works to be completed, such as construction of approaches if a major rehabilitation work is to be completed on the deck, traffic controls if major or minor rehabilitation works are to be completed on the wearing surface and utilities-related work if the structure carries any utility lines.

The construction of approaches can be estimated to be a lump-sum amount of $50,000 for a total of two approaches, and the cost of utilities-related work can be estimated to be $25,000 per utility line.

The cost estimates for traffic controls can be differentiated between major and minor rehabilitation works. For major rehabilitation works, the cost of traffic controls would be dependent more on AADT than the total defective area of wearing surface. If AADT is higher than 10,000, the cost of traffic controls can be estimated as $100,000 and if AADT is between 5,000 and 10,000, the cost can be estimated as $80,000 and if AADT is lower than 5,000, the cost can be estimated as $50,000. For minor rehabilitation works, the cost of traffic controls can be based on the quantity of the total defective area of wearing surface. If the total defective area is measured to be less than 5 m², the cost of traffic controls can be estimated as $5,000 and if the total defective area is measured to be larger than 5 m², the cost can be estimated as $10,000 ~ $20,000.

The work to be issued as a capital construction project requires engineering directions and drawings. Therefore, approximately 20% of total repair/rehabilitation cost can be assigned to the engineering cost and approximately 10% of total repair/rehabilitation cost can be assigned to a contingency cost.

Scoring is based on estimated repair or rehabilitation cost based on the ranges shown in Exhibit B.7.

Exhibit B.7: Total Cost Scoring

Low	High	Cost Score
$ 0	$ 100,000	1
$ 100,000	$ 250,000	2
$ 250,000	$ 500,000	3
$ 500,000	$ 1,000,000	4
$ 1,000,000	$ 100,000,000	5

Detour Distance

Detour distance scores based on detour distance within different ranges as shown in Exhibit B.8.

Exhibit B.8: Detour Distance Scoring

Short detour (km)	Long detour (km)	Detour Distance Score
0	2	2
2	5	4
5	10	6
10	20	8
20	1000	10