COMMITTEE OF THE WHOLE (WORKING SESSION) – APRIL 15, 2008

MUNICIPAL STRUCTURES MANAGEMENT SYSTEM

Recommendation

The Commissioner of Engineering and Public Works in consultation with the Deputy City Manager/Commissioner of Finance and Corporate Services and the Commissioner of Community Services recommends:

1. That the Municipal Structures Management System presentation by Staff be received;

2. That all vehicular and pedestrian structures (consisting of bridges and large culverts) under the ownership and/or responsibility of the City of Vaughan, whether on road or in parks and open spaces, be integrated into the Municipal Structures Management System;

3. That Council set a target Level of Service using 2% of the total replacement value of all structures as the parameter for developing the future Capital Works Program for Structure Maintenance and Rehabilitation;

4. That Staff report back to a future Committee of the Whole meeting with a refined analysis and a 5 Year Municipal Structures Management Program after completing the 2008 Structure Inspections; and

5. That the long term financial requirements to achieve this target be incorporated into the City's Long Range Financial Planning Model and be considered annually during future Budget Committee deliberations.

Economic Impact

There is no economic impact to the Engineering Services Department for the 2008 budget year as the necessary resources are allocated and approved as part of the Capital and Operating Budgets for the bi-annual inspection of Municipal Structures on roads.

Should structures within parks and open spaces be integrated into the Municipal Structures Management System, funds will be required to undertake their inventory and inspection. A preliminary benchmark cost to integrate approximately 30 structures is estimated at $35,000 (excluding financing costs).

The implications of adopting the recommended 2% of the total replacement value of all structures as the target Level of Service standard would require an investment of approximately $24,500,000 (excluding financing costs) over the next 20 years. Current allocation is funded through the issuance of debentures.

Communications Plan

There has not been public consultation to this point other than to advise residents inquiring about structures that inspections are undertaken bi-annually and works are programmed into Capital Budgets as appropriate. Implementation of individual projects would be subject of the Engineering Services Department and Public Works Department standard communication with affected residents prior to and during maintenance or construction activities.

Purpose

The purpose of this report is to provide Council with an overview on the Municipal Structures Management System project, function and results at a Network Level and consider the

information provided in this report as an overview, setting out orders of magnitude at this time until a second report is brought forward to determine Project Level Program requirements and confirm funding requirements after the 2008 Structure Inspections are completed.

Additionally, that Council consider for structures that the City is responsible to maintain, 2% of the total replacement value of all structures as the target Level of Service Standard for developing the future Capital Works Program for Structure Maintenance and Rehabilitation.

Background - Analysis and Options

Amendments have been made to the Highway Traffic Act (Section 123(2)) and the Bridges Act (Section 2). The most recent regulations for municipal structures were introduced and came into effect on April 1st, 1997. Specifically Ontario Regulation 104/97 – Standards for Bridges.

Through this regulation, the City of Vaughan is responsible for the following:

- The structural integrity, safety and condition of every bridge (structure) shall be determined through the performance of at least one inspection in every second calendar year under the direction of a professional engineer and in accordance with the Ontario Structure Inspection Manual, and that

- Every bridge is kept safe and in good repair.

According to the regulations, a bridge is any structure with a span of more than 3 metres, which includes not only major crossings but culverts and overpasses. In the City of Vaughan, there are some unique structures that have a span less than 3 metres. These structures are included as apart of the inventory and assessed on that basis given their nature and function they provide.

The Infrastructure Management Division of the Engineering Services Department is responsible for managing infrastructure records, engineering related data and assessment and strategic analysis related to the City's civil infrastructure. The Section maintains structure related data and undertakes the condition assessment of the City's structures bi-annually in partnership with Design Services and the Public Works Department.

The Department conducts bi-annual inspections of its structures through a qualified structural engineering consultant and has programmed Capital Works as identified through needs analysis. Examples of these works are the Woodbridge Avenue Bridge and Clarence Street Bridge Rehabilitation.

The Municipal Structures Management System represents another step forward in a larger Asset Management Strategy within the department. Other examples of work in this field are the Historical Infrastructure Records Management System (HIRMS), Pavement Management System and 5 Year Program, Pole and Streetlight Maintenance and Rehabilitation Program and Piped Infrastructure Dataset.

The base data and inspection report required for the Municipal Structures Management System is generated as a regular function of the Infrastructure Management Division and is fully integrated with the Enterprise G.I.S. Database and available to staff through the Vaughan Viewer and Historical Infrastructure Records Management System (HIRMS) applications.

Purpose for a Municipal Structures Management System

The purpose of this project and the system, is to compile a detailed inventory of the City's municipal structures, visually inspect and assess their condition and configure the City's Asset Management and Analysis Software Tool to assist staff in the coordination, planning and implementation of its maintenance and rehabilitation programs.

The system will also assist Staff to identify the needs of our municipal structures inventory on a micro and macro level through:

- Maximize use of the Municipal Bridge/Culvert Appraisal data and historical information;
- Maximize knowledge and experience of City personnel and City policy;
- Knowledge transference;
- Collect a detailed, component based inventory for all municipal structures;
- Visually inspect the condition of all components;
- Ranking, Prioritization and Optimization Analysis of structure and components based on user-definable parameters for funding, life-cycle costs, treatment strategies and performance models for maintenance and rehabilitation under various scenarios such as but not limited to all structures, maintenance districts, political regions, functional classes;
- Developing multi-year (e.g. maximum up to 10 year forecast) maintenance and rehabilitation programs that complement longer term, strategic philosophies and goals;
- Calculate and analyze structure specific and overall inventory states and conditions through various indexes such as Ministry of Transportation (MTO) Bridge Condition, Sufficiency Index and other industry norm health type indexes;
- Predict future overall inventory and component specific condition and performance;
- Analyze economic benefit and re-investment required to sustain and/or improve a given network condition over a period of 10 years or greater or vice versa;
- Calculate value of structures;
- Calculate Life Cycle costing on inventory;
- Produce Graphs and Reports on the data and analysis results;
- Develop all configurations and parameters for the City of Vaughan's standard Asset Management and Analysis Software Tool, dTIMS CT by Deighton Associates Ltd. to effectively and efficiently manage our municipal structures asset.

Asset Management Methodology

On February 16, 2006, Council endorsed through resolution, InfraGuide and the best practices with respect to Asset Management. Through InfraGuide, a comprehensive business strategy involves 3 pillars: People, Information and Technology. The Essential Elements of an Asset Management Plan are:

1. What do you have and where is it?
2. What is it worth?
3. What is its condition and its expected service life?
4. What is the level of service expectation, what needs to be done?
5. When do you need to do it?
6. How much will it cost and what is the acceptable level of risk?
7. How do you ensure long term affordability?

People, Information and Technology in practice with the Essential Elements is the key to a successful implementation of an Asset Management Plan.

It is within this framework that the Municipal Structures Management System function and results will be presented.

1. What do you have and where is it?

The current inventory of 106 City owned structures on road consist of 35 bridges and 71 culverts (with a span greater than 1.2 meters). Definitions for a bridge and a culvert can be found in Attachment No.1.

There are approximately 30 additional structures within City parks and open spaces that the City is responsible to maintain. The Parks Development Department and Parks and Forestry Operations Department do not conduct formal inspections as outlined through regulation. Inspections are conducted as a part of regular duties for maintaining the walkway/trail system.

These structures can, with relative ease, be integrated into the Infrastructure Management System currently used by the Engineering and Public Works Commission. This would result in the bi-annual inventory data collection and condition inspection undertaken by a qualified engineer, as a part of the regular function that the Engineering Services Department partakes. Funding of this activity would need to be accounted for in the annual budget process.

Structures serving City facilities such as an Operations Depot would require further consideration.

The 106 structures on roads can be further summarized by type as shown in the following table:

Table No.1

SUMMARY OF STRUCTURES BY TYPE	
Structure Type	**Count**
Bowstring Arch	2
Earth Filled Arch	1
I-Beam or Girders	11
Arch Culvert	18
Ellipse Culvert	20
Rectangular Culvert	26
Round Culvert	10
Rigid Frame, Vertical Legs	4
Circular Voided Slab	1
Solid Slab	13

2. What is it worth?

Based on the reconstruction unit rate used in the Municipal Structures Management System, staff have estimated the replacement value of the City's structures on roads to be approximately $77 million dollars. This figure does not include any depreciation back to an original construction date.

3. What is its condition and its expected service life?

The condition of a structure is determined through a combination of field inspection and review of various analytical factors. Individual ratings and indices for each component of a structure are combined into 3 super categories being Deck, Super-structure and Sub-structure. These are further aggregated into an overall index called a Bridge Condition Index (BCI) with an ascending range of 0 (worst) to 100 (best). Further explanation of the categories can be found in Attachment No.1.

Structure performance over time behaves differently than that of a road. Structures could typically fail catastrophically and conversely, a road deteriorates gradually and when failed, continues to serve in a reduced capacity. It is difficult to predict through traditional deterioration curves, the performance of literally hundreds of unique structure components.

Therefore, BCI is an aggregate value based on the premise of measuring a structure's Residual Salvage Value. This is defined by taking a component's estimated current construction cost at new and reducing that value proportionally based on its current condition.

According to the Municipal Structures Management System, our current average network condition for all City structures has a BCI of 93.2 out of 100 possible points.

Please note that this average is abnormally high since the vintage of our structures is relatively young with 92% of all structures built within the last 50 years and is further summarized for each decade as follows:

- 6% of our structures were constructed before 1950
- 2% of our structures were constructed between 1950 - 1959
- 20% of our structures were constructed between 1960 - 1969
- 25% of our structures were constructed between 1970 - 1979
- 23% of our structures were constructed between 1980 - 1989
- 18% of our structures were constructed between 1990 - 1999
- 6% of our structures were constructed between 2000 to the present

Staff from the Engineering Services Department undertake the condition inspection of our structure bi-annually through a qualified structural engineer.

Ratings and indices are required in a management system to help determine when to apply a treatment, calculate the cost of a treatment and monitor the overall health of an asset network.

For convenience in analyzing and reporting trends, the BCI is further grouped into broader categories based on the Ministry of Transportation (MTO) defined ranges for assessing structures and is shown in following table including the percentage of the City's structures on road that fall into each category:

Table No.2

BRIDGE CONDITION INDEX GROUPING		
Category	**Range**	**% of Network**
Excellent	90 to 100	84%
Good	75 to 90	4%
Fair	60 to 75	8%
Poor	50 to 60	1%
Very poor	0 to 50	3%

4. What is the level of service expectation, what needs to be done?

Setting a Level of Service or a target is an important step in proper Asset Management.

Goals and objectives are a normal part of any quantifiable practice in today's society. Examples are abundant such as Vaughan Vision 2020 and Municipal Performance Measures Program (MPMP).

There are two major functions required within a Municipal Structures Management System. Technical analysis and costing computations are automated for targeted goals and objectives through an interpolative process by staff.

Our consultant recommends using 2% of the total replacement value of all structures for planning purposes, as an acceptable level of funding to maintain a system in adequate/good condition. This level assumes a design life for structures of 50 years and is generally in line with assumptions being developed for structure life for reporting purposes for Regulation 3150 of the Public Service Accounting Board (PSAB).

Staff recommends that Council endorse 2% of the total replacement value of all structures as the target Level of Service Standard for developing future Capital Works Program for Structure Maintenance and Rehabilitation.

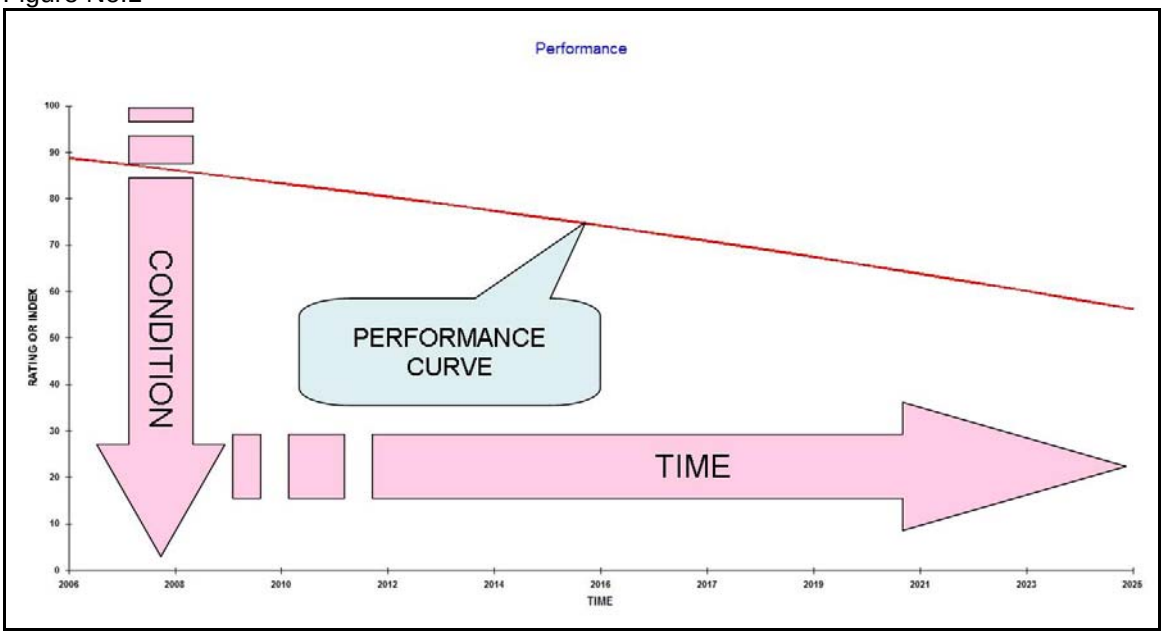
5. When do you need to do it?

Since we track a number of ratings and indices, through them we are able to determine what type of intervention or treatment is most appropriate given the current or future predicted structure condition. Treatments within the system are classified by broader categories. They are: Pre-emptive, Minor Rehabilitation, Major Rehabilitation and Replacement. Definitions for these treatments can be found in Attachment No.1. Actual tasks within each category are derived from recommendations within the detailed inspection reports for each structure.

A hierarchy of treatments for the structures is modeled based on real world fact. For example, rehabilitation or replacement of a deck may take place without any work occurring on either of the super-structure and sub-structure. Rehabilitation or replacement of a super-structure will also require rehabilitation or replacement of the deck at the same time, but it would generally not require work on the substructure. Major rehabilitation or replacement of a sub-structure will require rehabilitation or replacement of both the deck and super-structure at the same time.

There is a symbiotic relationship between ratings and indices with time. As time passes, ratings and indexes typically decrease in the absence of intervention. Figure No.1 represents a typical deterioration curve over time and is represented here for illustrative purposes only.

Figure No.1



There is a similar relationship between a structure rating and index, time and the type of treatment that can be performed to it. For example, less intrusive types of treatments such as Concrete Sealing, Bridge Washing and Spot Repairs can be performed to a structure earlier in its Life Cycle as compared to more comprehensive treatments such as Deck and Beam Rehabilitation and Complete Reconstruction. On this basis, it would not be appropriate to trigger a Concrete Seal for a structure that is near the end of its Life Cycle.

The Municipal Structures Management System will compute for every structure, every applicable Treatment Strategy in every possible year within its predicted remaining service life during the analysis period. The period of time used in our current configuration is set to 20 years starting from our current year. 20 years is a typical analysis period in the industry which represents a balance between data accuracy and modeled prediction.

The system will "Optimize" all feasible Treatment Strategies by determining which strategy provides the greatest Return on Investment. The technique used to accomplish the optimization is called the Incremental Benefit Cost Technique.

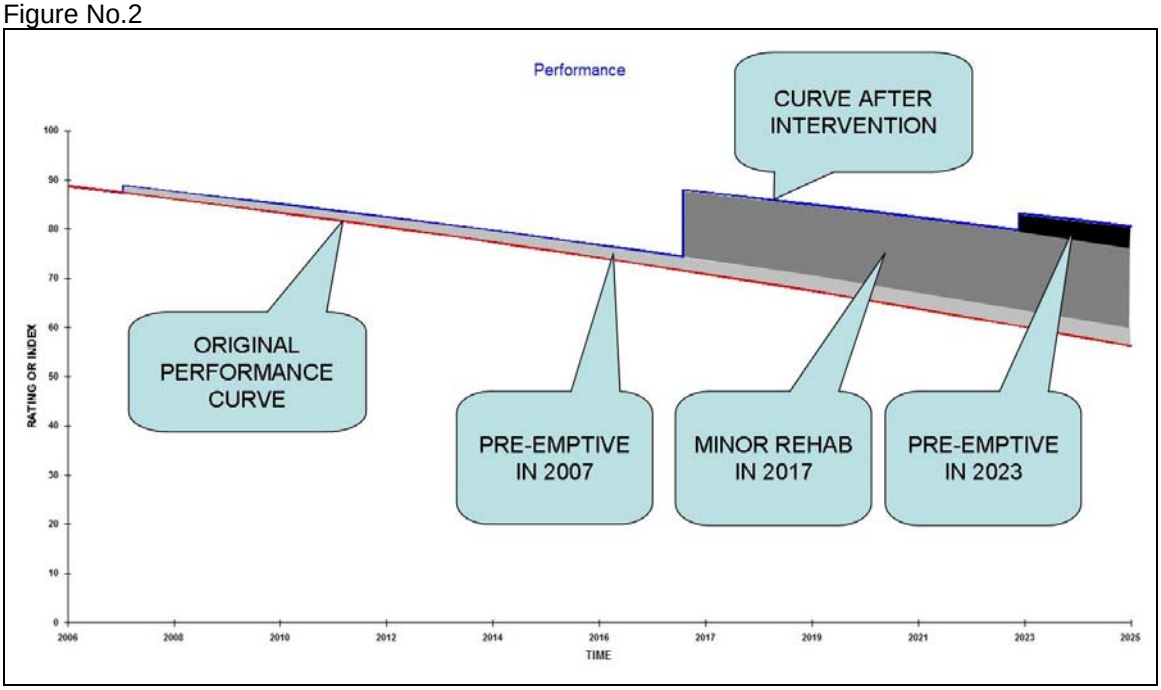
Benefit is the mathematical measurement representing the area between the Original Performance Curve and the Performance Curve after intervention as depicted in Figure No.2.

Cost is calculated by multiplying a Treatment unit rate by size of the structure's component.

The system will measure the benefit of any given treatment strategy compared to a structure's remaining service life (residual salvage value) and will also calculate its cost. The benefit and cost are then used to create an Incremental Benefit-Cost Ratio which is defined as the ratio between the increase in benefit to the increase in cost between successive treatment strategies.

An "Optimal" strategy is the one that has the greatest benefit for the least cost or Investment.

Figure No.2



This computation is performed to the entire structure inventory holistically before any decision support parameters such as budgetary limitations is applied.

6. How much will it cost and what is the acceptable level of risk?

Having 2% of the total replacement value of all structures as the Level of Service Standard is an important step for developing the future Capital Works Program for Structure Maintenance and Rehabilitation. This percentage equates to an assumed 50 year design life for each structure. This duration is the industry accepted norm for the lifespan of a structure in both the Engineering and Financial disciplines.

Determining an optimal program and its respective funding requirement is an interpolative process. Staff input into the system, Budget Scenario(s) consisting of set funding levels for each year over the length of the proposed analysis period. The strength of this system allows staff to run an infinite number of Budget Scenarios for analysis at will. The results are then studied further for trends, which leads to more refined scenarios and an ultimate Budget Strategy and Capital Works Program.

The results of each Budget Scenario can be reviewed and analyzed through the "Average Network Condition" tool within the system. The following table summarizes the various introductory Budget Strategies that have been run and reviewed by Staff:

Table No.3

BUDGET SCENARIOS	
Scenario Name	**Description**
Do Nothing	Scenario representing no funding over the next 20 years and reflecting no intervention to the deterioration of the structure network
1% Replacement Value	Scenario starting at $500,000 and increasing annually at a 2% rate of inflation over the next 20 years
2% Replacement Value	Scenario starting at $1,000,000 and increasing annually at a 2% rate of inflation over the next 20 years
3% Replacement Value	Scenario starting at $1,500,000 and increasing annually at a 2% rate of inflation over the next 20 years
Unlimited Funds	Scenario representing an Unlimited amount of funding over the next 20 years

Figure No.3 illustrates the resultant Average Network Condition of the various Budget Strategies tested in the system:

Figure No.3

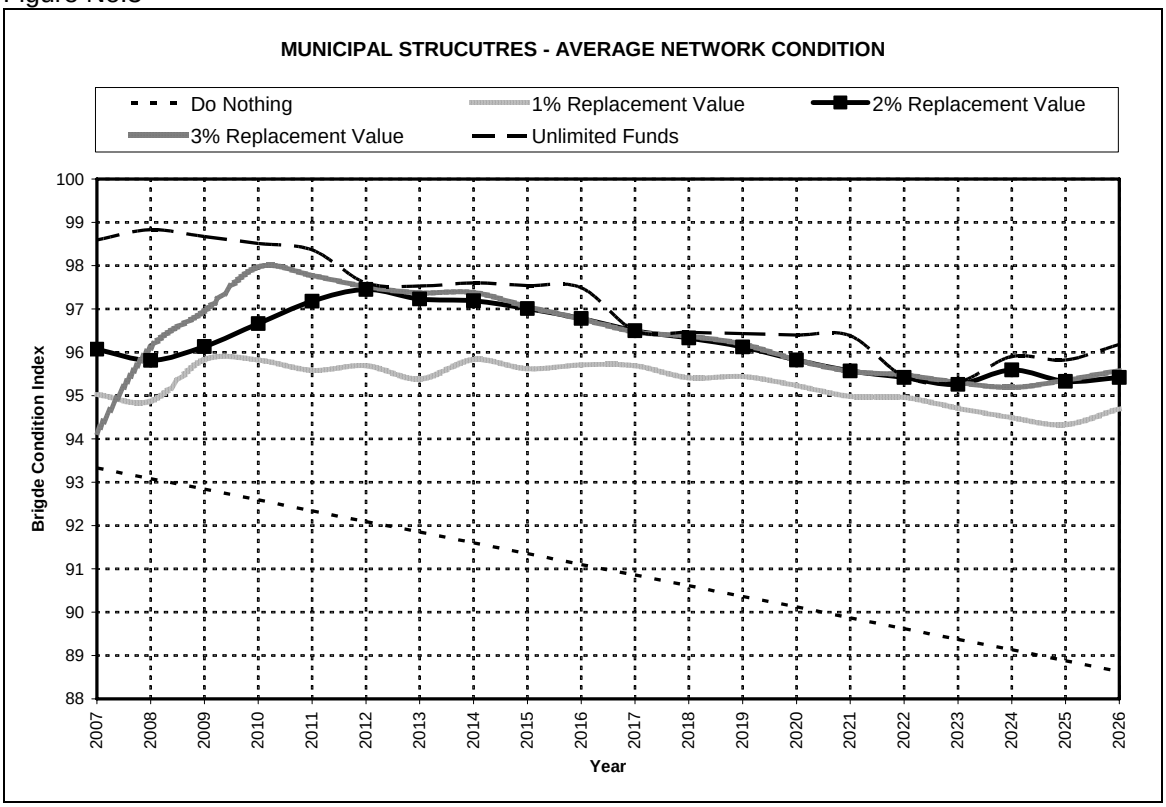


Figure No.3 clearly shows that proceeding over the next 20 years using 2% replacement value of all structures as a basis for funding levels and programs will result in an Average Network Condition of 95.4 out of 100.

The following table gives the resultant Condition Distribution of each Budget Scenario as a frame of reference for comparison after a 20 year analysis period.

Table No.4

CONDITION DISTRIBUTION OF NETWORK AFTER 20 YEARS					
	Unlimited	**3%**	**2%**	**1%**	**Do Nothing**
Excellent	93%	89%	89%	88%	73%
Good	7%	11%	11%	10%	15%
Fair					2%
Poor				2%	7%
Very Poor					3%

It is important to highlight that the results at end of the 20 year period, for the Budget Scenarios of 2% Replacement Value and greater reap similar results and those that are less than 2% Replacement Value show some percentage of the network condition falling into the Fair, Poor and Very Poor categories. The 1% Replacement Value and Do Nothing Budget Scenarios are not adequate to keep structures in a state of good repair.

An acceptable level of risk is ultimately determined by Council based on staff input. Annual funding levels directly impact future Level of Service results especially when programming work based on asset life cycle.

Staff propose to make Municipal Structures Management a 'dynamic' process. As new structures are added to the City's inventory and staff continue assessing and recording the condition of them, the Infrastructure Management Division will rerun the analysis annually which in-turn will continually refine and update the Network Level Projection for condition as well as update Annual Budgetary requirements and Program Level results.

7. How do you ensure long term affordability?

An efficient and well maintained structure network is an important factor in the overall economic health and quality of life in a community. Consequently, it is important for Council to understand the need for timely improvements required to protect, sustain and maximize the investment made in this principle asset class.

The Long Term optimization of resources can be achieved through City initiatives such as the Municipal Structures Management System and modeling these figures within the Long Range Financial Planning Model so that future funding implications are known and can be planned for at the earliest possible point in time with budgetary and/or program changes implemented accordingly.

Relationship to Vaughan Vision 2020

Management Excellence:	Maintain Assets and Infrastructure To optimize existing infrastructure through sound asset management practices.
Service Excellence:	Pursue Excellence in Service Delivery Enhance and Ensure Community Safety, Health and Wellness

This report is consistent with the priorities previously set by Council.

Regional Implications

Not Applicable.

Conclusion

The purpose of this report is to provide Council with an overview on the Municipal Structures Management System, project, function and results at a Network Level and consider the information provided in this report as an overview, setting out orders of magnitude at this time until a second report is brought forward to determine Project Level Program requirements and confirm funding requirements after the 2008 Structure Inspections are completed.

Additionally, that Council consider for structures that the City is responsible to maintain, 2% of the total replacement value of all structures as the target Level of Service Standard for developing the future Capital Works Program for Structure Maintenance and Rehabilitation.

Attachments

1. Definitions
2. Presentation (Handout at meeting)

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Respectfully submitted,

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DSB:mc

Attachment No. 1

Definitions

Bridge	A structure that transfers all live loads through a superstructure to a substructure and foundations.
Culvert	A structure that transfers all live loads through fill.
Note:	Box or open type structure having less than 600mm of cover have been appraised as a bridge and those with more than 600 mm of cover have been appraised as a culvert.
Deck	The deck of a bridge is the part of the structure that is above the girder level and supports and/or carries traffic. The deck of a culvert is the road (asphalt and fill and related items) over the culvert.
Super-structure	The super-structure of a bridge is the elements that support the deck, mainly the girders. The super-structure of a culvert is the barrel.
Sub-structure	The sub-structure of the bridge is the foundation and supports for the super-structure and the deck. The sub-structure of a culvert is the foundation.
Network level	Reviewing a particular piece of information or state with respect to all city structures as a whole.
Project level	Reviewing a particular piece of information or state with respect to an individual structure or a component of a structure.
Pre-emptive Treatment	Waterproofing (Any exposed surfaces subject to severe salt contamination) Safety railing sanding and/or painting/sealing Cleaning and repainting of the superstructure at the abutments Spot repairs (pothole, guiderail connection repair, replace missing railing, etc)
Minor Rehabilitation	Spot repairs (10% to 30% of the individual component – i.e. deck wearing surface, sidewalk, guide rails, bearing walls, foundations, etc) Superstructure cleaning and repainting Replacement of and/or installation of additional web stiffeners Seal replacement
Major Rehabilitation	Joint replacement Deck replacement Beam replacement (one up to all) Safety railing replacement Superstructure replacement
Replacement	Complete replacement of the structure