COMMITTEE OF THE WHOLE - (WORKING SESSION) – MAY 9, 2006

PAVEMENT MANAGEMENT SYSTEM

Recommendation

The Commissioner of Engineering and Public Works in consultation with the Commissioner of Finance and Corporate Services and the Chief Information Officer recommends:

1. That the Pavement Management System presentation by Staff be received; and

2. That Council adopt for city owned roads, an overall average road network rating being a **Pavement Composite Index (PCI) of 70 out of 100** (possible points), as the **Level of Service Standard** for developing the future Capital Works Program for Roadway Maintenance and Rehabilitation; and

3. That the long term financial requirements to maintain this Level Of Service be incorporated into to the City's Long Range Financial Planning Model and be brought forward during future Capital Budget Deliberations; and

4. That Staff report back to Council with a refined analysis and a 5 Year Pavement Management Program after completing the 2006 Spring Road Tour.

Economic Impact

There is no economic impact to the City of Vaughan for the 2006 budget year as the necessary resources are allocated and approved as part of the Capital and Operating Budgets.

The implications of adopting the recommended Pavement Composite Index (PCI) of 70 out of 100 would require an investment of $200,000,000 (excluding financing costs) over the next 20 years. This compares to the $185,700,000 (excluding financing costs) which would be available over the next 20 years under the current funding allocation. The current allocation is funded through the issuance of debentures.

Purpose

The purpose of this report is to provide Council with an overview on the Pavement Management System Project function and results at a composite Network Level (see Attachment No. 1 for a definition), 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 (see Attachment No. 1 for a definition) and confirm funding requirements after the 2006 Spring Road Tour is completed.

Additionally, that Council consider for city owned roads, an overall average road network rating being a Pavement Composite Index (PCI) of 70 out of 100 possible points, as the Level of Service Standard for future Programs for Roadway Maintenance and Rehabilitation.

Background - Analysis and Options

Pavement Management System Project Initiation

On December 6, 2004, Council approved the contract award for the Pavement Management System Project. The purpose of a Pavement Management System (PMS) is to assist City staff in the coordination, planning and implementation of its roadway maintenance and rehabilitation programs. The system will also assist Staff to identify the needs of our road network through:

- Complementing the technical expertise, knowledge and data within the City;
- Promote self sufficiency and reduced dependency on external professional services with the exception of arising special needs or studies;
- Ranking, Prioritization and Optimization Analysis of road sections based on user-definable parameters for funding, life-cycle costs, treatment strategies and pavement performance models for pavement maintenance and rehabilitation at various network levels such as all roads, maintenance districts, political regions, functional classes, etc.;
- Developing multi-year maintenance and rehabilitation programs that complement longer term, strategic goals and philosophies;
- Calculate and analyze overall network condition;
- Predict future overall network and road section specific condition and performance;
- Analyze economic benefit and re-investment required to sustain and/or improve a given network condition over a period of time;
- Calculate Life Cycle (LCCA) costing on road sections;
- Produce Graphs and Reports on the data and analysis results.

Deighton Associates Limited and the dTIMS CT Software Tool was chosen to achieve the projects goals and objectives. Deighton's dTIMS CT software is widely used for Pavement Management in the United States of America, Europe, Australia, New Zealand and locally in Ontario by the following authorities:

Regional Municipality of York	City of Brampton
Regional Municipality of Peel	City of Cornwall
Regional Municipality of Durham	City of Oshawa
The Greater City of Sudbury	City of St. Catharines
Municipality of Clarington	Town of Whitby

The Pavement Management System does not model the Life Cycle of other classes of assets such as bridges, culverts, watermains, sewers, sidewalks, etc. These assets will be modeled separately and then integrated together.

Traditional Road Program Methodology

On June 27, 2005, Council endorsed in principle, Road Resurfacing, Road Reconstruction and Rural Roads Upgrading Programs for 2006.

Annually, staff brings forward a report to seek Council endorsement of the proposed 5 year road program and authorization to employ external professional engineering services for the preliminary engineering and detailed design of these proposed construction projects.

The adoption of the above program was to deal with the increasing backlog of deteriorating roads and to provide Council with a comprehensive plan for road upgrading across the City. These programs (Road Resurfacing, Road Reconstruction and Rural Road Upgrading) were prepared on a worst, first basis and road sections are evaluated utilizing factors such as traffic volumes and condition rating of the road facility. Consideration was also given to other factors such as roads in the same vicinity that are also deficient and that were constructed in the same era as well as needs identified regarding the condition of existing underground services such as sewers and watermains.

This last report advised Council that a new program would be coming forward with the implementation of a Pavement Management System.

New 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 Pavement Management System function and results will be presented.

Pavement Management System Function

The Infrastructure Management Systems section of the Engineering and Public Works Department is responsible for infrastructure records, engineering related data and data management and strategic analysis related to the City's civil infrastructure. The Section maintains road related data and undertakes the condition assessment of the City's roads annually in partnership with Design Services and the Public Works Department.

The base data required for the Pavement Management System is generated as a regular function of the Infrastructure Management Systems Section and will be fully integrated with the Enterprise G.I.S. Database. On a general note, the application complies with the policies, standards and procedures as defined through the Corporate G.I.S. initiative.

1. What do you have and where is it?

The current inventory of City owned active roads are summarized in the following table by Ward, Surface Material Type and Average Condition.

Table No.1

SUMMARY OF ROAD NETWORK - BY WARD AND SURFACE MATERIAL			
Ward	**Surface Material**	**Total Centre Line (km)**	**Total Lane (km)**
1	Gravel / Stone	24.23	48.46
	Asphalt	235.48	503.46
	Surface Treated	28.61	57.21
2	Gravel / Stone	8.50	17.00
	Asphalt	153.27	347.89
	Surface Treated	6.25	12.50
3	Asphalt	101.25	258.83
4	Asphalt	178.12	449.81
5	Asphalt	74.63	174.99
	Surface Treated	3.27	6.53
Total		**813.61**	**1876.68**

2. What is it worth?

Based on the Reconstruction unit rate used in the Pavement Management System, staff have estimated the replacement value of the City's entire road network to be approximately **$1.8 BILLION DOLLARS**. This figure does not include the value for underground servicing such as water and wastewater systems nor boulevard amenities such as sidewalk or street lighting.

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

The condition of a road is determined through a combination of field inspection and review of various analytical factors. Individual ratings and indices are combined into an overall index called a **Pavement Composite Index (PCI)** with an ascending range of 0 (worst) to 100 (best). This index is comprised of 3 major subsections being:

Health	The condition of a road which includes surface ride comfort, structural distresses and its ability to properly drain water away from the road's structural components;
Capacity	The current, measured traffic volume (Annual Average Daily Traffic) as compared to the theoretical capacity of a road;
Physical Environment	The remaining considerations surrounding the behavior of a road including skid resistance, safety and geometry.

Table No.5 in Attachment No. 1 defines in detail, the composition of PCI.

According to the Pavement Management System, our current average network condition for all City roads has a **PCI of 86.2 out of 100** possible points.

Please note that this average is abnormally high since the vintage of our Road Network is relatively young and is summarized for each decade and percentage of network by:

- 17% of our roads were constructed before 1970
- 11% of our roads were constructed between 1970 - 1979
- 31% of our roads were constructed between 1980 - 1989
- 22% of our roads were constructed between 1990 - 1999
- 19% of our roads were constructed between 2000 and the present

Staff from the Engineering and Public Works Department annually undertakes the condition inspection of our roads. The City is currently divided into 3 zones resulting in 1/3 of City roads being inspected annually. As the City continues to develop and the road network grows, these zones may be further refined into 4 quadrants.

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

For convenience in analyzing and reporting trends, the PCI is further grouped into broader categories based on the Ministry of Transportation (MTO) defined ranges for assessing municipal roads as shown in following table:

Table No.2

Pavement Management System Grouping	Value Range	MPMP Equivalent
Excellent	80 to 100	Adequate
Good	60 to 80	
Fair	35 to 60	Deficient

Pavement Management System Grouping	Value Range	MPMP Equivalent
Poor	20 to 35	
Very poor	0 to 20	

Based on these ranges, our current average network condition distribution for all City roads is summarized:

- 79.1% of our road network is in Excellent Condition
- 17.1% of our road network is in Good Condition
- 3.8% of our road network is in Fair Condition
- There are no roads in the Poor or Very Poor Condition

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

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

Goals and objectives are a normal part of any quantifiable practice in today's society. Examples are abundant with one being the Municipal Performance Measures Program (MPMP).

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

Staff recommends that Council endorse a **Level of Service Standard** for the average of our road network to be set at a **PCI of 70 out of 100** possible points.

70 is the average of the "Good" range as defined in Table No. 2 which technically represents a road with very little distress and needs and visually is appealing.

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 road condition. The following table lists the Treatments that have been identified as being critical to the sustainability of our Road Asset:

Table No.3

TREATMENTS			
Treatment	**Work Category**	**Traditional Funding Source**	**Subsequent Treatment**
Crack Seal	Operations and Maintenance	Operating Budget	Yes
Drainage Treatment	Operations and Maintenance	Operating Budget	Yes
LCB Upgrade to HCB	Rehabilitation	Capital Budget	No
LCB Surface Treatment	Rehabilitation	Capital Budget	Yes
Gravel to HCB	Rural Road Upgrade	Capital Budget	No
Gravel to LCB	Rural Road Upgrade	Capital Budget	No
Micro Surface	Rehabilitation	Capital Budget	Yes
Mill and Overlay	Rehabilitation	Capital Budget	Yes

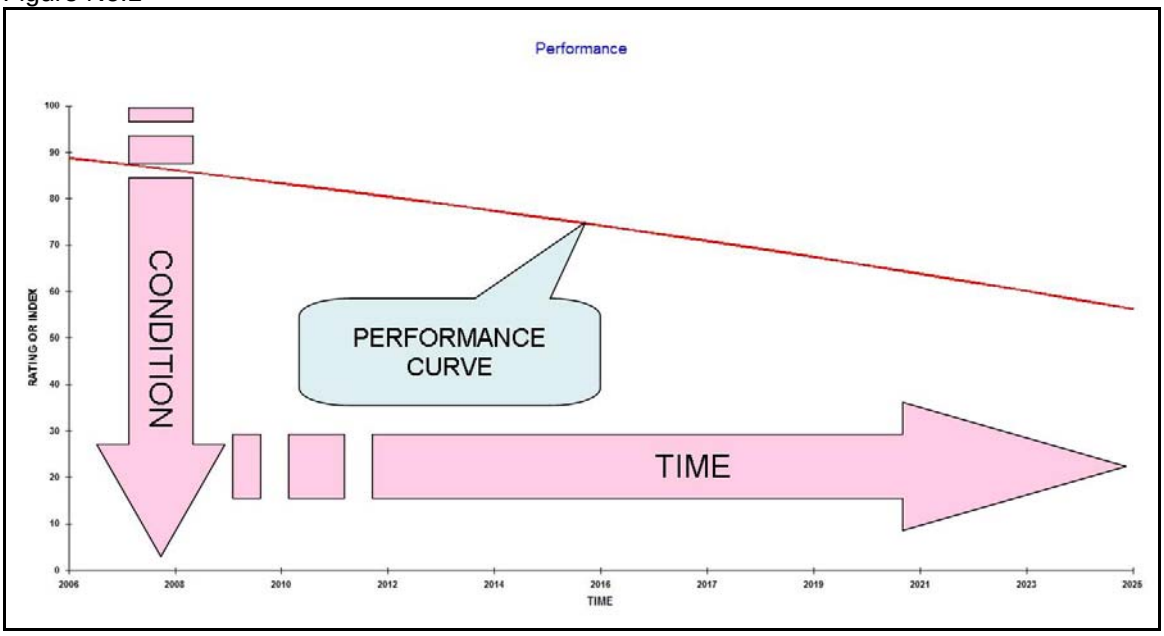
TREATMENTS			
Treatment	**Work Category**	**Traditional Funding Source**	**Subsequent Treatment**
Pulverize and Overlay	Rehabilitation	Capital Budget	No
Remove and Replace	Rehabilitation	Capital Budget	No
Complete Reconstruction	Reconstruction	Capital Budget	No

Those Treatments identified as a Subsequent Treatment within the Pavement Management System can be triggered as an independent treatment and also as a follow-up to the other treatments. For example, Crack Sealing can be triggered as a treatment unto itself and is also triggered as a follow-up to other treatments such as Complete Reconstruction, Remove and Replace, Pulverize and Overlay, Mill and Overlay, etc.

5. When do you need to do it?

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 road rating and index, time and the type of Treatment that can be performed to it. For example, less intrusive types of Treatments such as Crack Sealing, Micro Surfacing and Mill and Overlay can be performed to a road earlier in its Life Cycle as compared to more comprehensive Treatments such as Remove and Replace and Complete Reconstruction. On this basis, it would not be appropriate to trigger a Crack Seal for a road that is near the end of its Life Cycle.

The Pavement Management System will compute for every road, 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**.

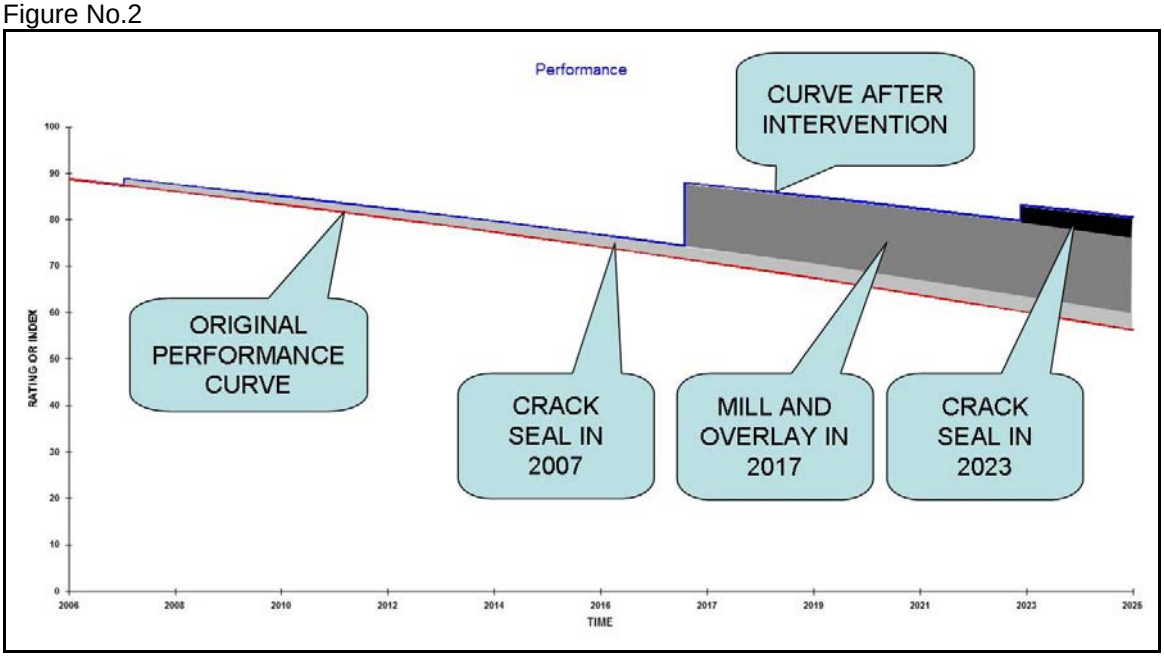
Benefit is the mathematical measurement representing the area between the Original Performance Curve and the Performance Curve after intervention as depicted in Figure No.2.

Cost is calculated by multiplying a Treatment unit rate by any given road section length.

The system will measure the benefit of any given treatment strategy compared to a road's remaining service life 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

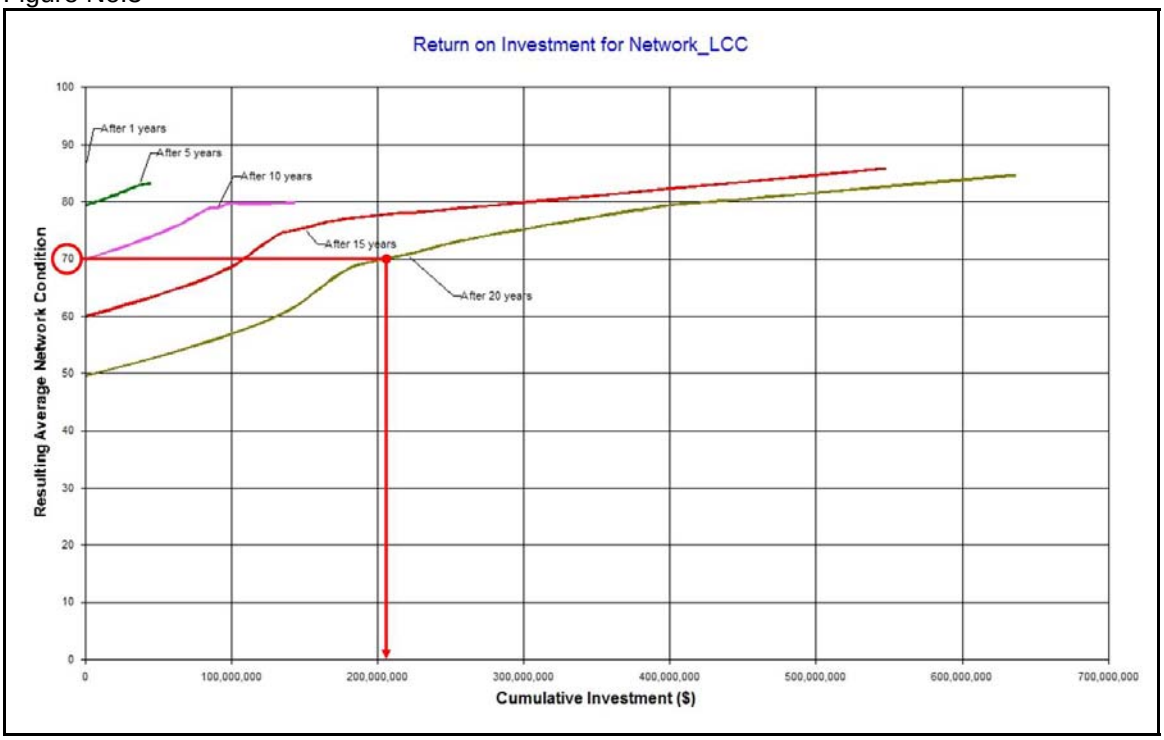


This computation is performed to the entire road network holistically before any decision support parameters such as budgetary limitations is applied.

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

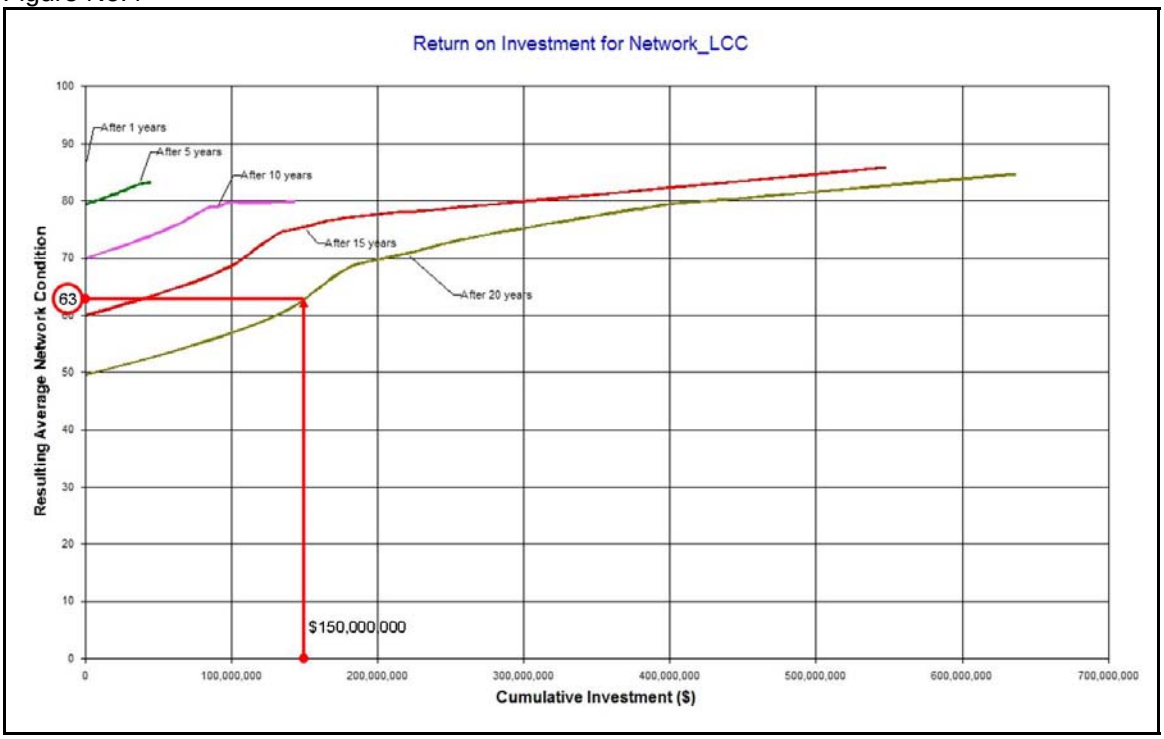
Having a **Level of Service Standard** set to an average network **PCI of 70 out of 100** possible points, Staff can leverage the "Return on Investment" tool within the system to better direct us toward the accumulative funding level needed to achieve the standard over the proposed analysis period. Figure No.3 demonstrates that in order to sustain a Level of Service PCI of 70, an accumulative investment greater than **$200,000,000** will be needed over the next 20 years.

Figure No.3



Hypothetically, should Council choose an accumulative investment over the next 20 years of $150,000,000, the estimated resulting PCI at the end of the period will be **63 out of 100** possible points and is illustrated in Figure No.4.

Figure No.4



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 and which leads to refined 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.4

BUDGET STRATEGIES	
Budget Strategy	**Description**
ASET_ALL_Do_Nothing	Scenario representing no funding and reflecting no intervention to the deterioration of the road network.
ASET_ALL_Status_Quo	Scenario representing current practice of allocating funding in the following manner: $285,000 towards Maintenance; $5,000,000 towards Reconstruction; $2,000,000 towards Resurfacing; and $2,000,000 towards Rural Road Upgrade.
ASET_ALL_Total_09m	Scenario representing $9,285,000 as a Total Annual Budget and allowing the system to distribute the funding according to Optimization.
ASET_ALL_Unlimited	Scenario representing an Unlimited amount of funding by allocating funds in the following manner: $1,000,000,000 towards Maintenance; $1,000,000,000 towards Reconstruction; $1,000,000,000 towards Resurfacing; and $1,000,000,000 towards Rural Road Upgrade.

Figure No.5 illustrates the resultant Average Network Condition of the various Budget Strategies tested in the system:

Figure No.5

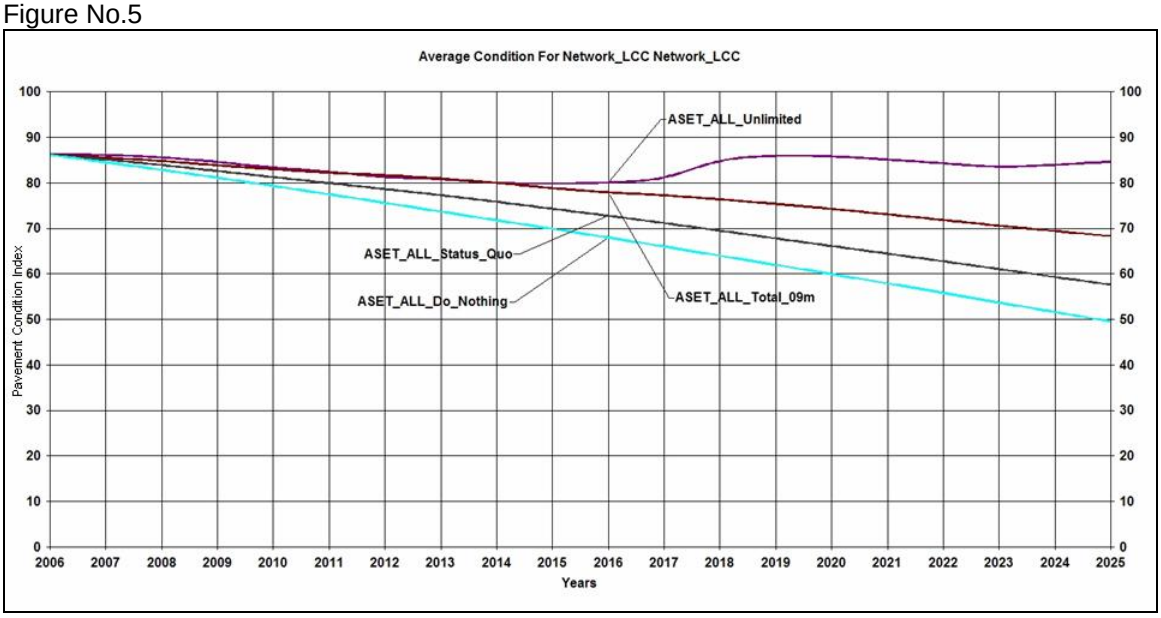


Figure No.5 clearly shows that proceeding over the next 20 years with our current funding levels and programs will result in an **Average Network Condition of 57.6 out of 100** with the average network condition distribution for all City roads is summarized:

- 8.8% of our road network is in Excellent Condition
- 43.6% of our road network is in Good Condition
- 31.8% of our road network is in Fair Condition
- 15.7% of our road network is in Poor Condition
- 0.1% of our road network is in Very Poor Condition

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.

Should Council set a Level of Service Standard, Staff will explore additional Budget Scenario(s) to meet the target.

Staff propose to make Pavement Management a 'dynamic' process. As new roads are added to the City's inventory and Staff continue assessing and recording the condition of all roads in our network, the Infrastructure Management Services Section 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 road 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 Pavement Management System and modeling these figures within the Long Range Financial

Planning Model so that future funding implications are are known and can be planned for at the earliest possible point in time and budgetary and/or program changes implemented accordingly.

Relationship to Vaughan Vision 2007

This report is consistent with the priorities previously set by Council and the necessary resources have been allocated and approved.

Service Delivery Excellence

We are able to develop and establish service level standards that are sustainable and provide effective and efficient delivery of service.

Manage our Resources

The City has a significant investment in infrastructure that requires a process and a plan to ensure that its repair and eventual replacement is properly managed.

Communications and Public Relations

Through endorsement of the InfraGuide Best Practices, we strengthen Corporate Image and identity.

Technology and Innovation

The proposal meets the requirements for Technology and Innovation based on conformance with the policies, standards and procedures as defined through the Corporate G.I.S. Initiative.

Conclusion

The purpose of this report is to provide Council with an overview on the Pavement Management System Project function and results at a composite Network Level and consider the information provided in this report as an overview drawing 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 2006 Spring Road Tour is completed.

Additionally, that Council adopt for City owned roads, an overall average road network rating being a Pavement Composite Index (PCI) of 70 out of 100 possible points, as the Level of Service Standard for future Programs for Roadway Maintenance and Rehabilitation.

Attachments

1. Attachment No. 1
2. Presentation (Handout at meeting)

Report prepared by:

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Respectfully submitted,

Bill Robinson, P. Eng.
Commissioner of Engineering and Public Works

Gary Carroll, P. Eng.
Director of Engineering Services

DSB/mc

Attachment No. 1

The Pavement Composite Index (PCI) is summary.

Table No.5

PAVEMENT COMPOSITE INDEX (PCI) RATING					
Category	Category Weight	Variable	Variable Point	Variable Weight	Methodology
Health	80%	Surface Condition	0 - 10	40%	MDC
		Structural Adequacy	0 - 20	40%	MDC
		Drainage	0 - 15	20%	R
Capacity	10%	Capacity	0 - 100	100%	MDC
Physical Environment	10%	Skid		0%	-
		Safety	0 - 100	50%	AC
		Geometry	0 - 100	50%	AC

Methodology Terminology

Model Deterioration Curve (MDC)	Subject has a separate life cycle model applied to it to predict future performance.
Rating (R)	Subject has a rating and forms part of a greater computation.
Analyze and Compute (AC)	Subject is studied for various conditions and a rating is computed based on the analysis.

General Terminology

Network Level	Reviewing a particular piece of information or state with respect to all City roads as a whole.
Project Level	Reviewing a particular piece of information or state with respect to an individual roads section as defined by a road, from an intersection, to an intersection.

Health Terminology

Surface Condition	Maximum 10 Point Rating related to driving ease, comfort and safety. Inadequacies for paved surfaces include excessive or uneven crowns, washboarding, raveling and bumpiness because of cracking, sealing and rough patching. Inadequacies on loose top surfaces do not include situations that can be readily corrected by maintenance blading.
Structural Adequacy	Maximum 20 Point Rating related to the capability of the surface and base courses to support a load and to resist deformation or rupture. Distress signs include cracking, rutting, heaving, pot-holing, roughness, alligatoring, dishing, breakup, distortion, frost boils, soft spots, etc.
Drainage	Maximum 15 Point Rating related the various elements to maintain a well drained surface on a stable subgrade: the height of the grade line; the cross slopes of the crown, shoulders and ditches; the slopes of gutters and frequency of outlets or catchbasins and the adequacy of the storm sewer system; the

	capacity of the cross-drains (culverts) and parallel and off-take ditches.

Capacity Terminology

Capacity	The Capacity index is a function of the annual traffic volume and the capacity of the road.

Physical Environment Terminology

Skid	A measure of skid resistance for future implementation
Safety	The safety index is a calculation which is a function of the AADT and the rate and severity of crashes on a road section.

Where Geometry is comprised of the following:

Horizontal Alignment	Maximum 10 Point Rating related to the number of Substandard Horizontal Curves and Substandard Horizontal Stopping Sight Distances per length of road section.
Vertical Alignment	Maximum 10 Point Rating related to the number of Substandard Grades and Substandard Vertical Stopping Sight Distances per length of road section.