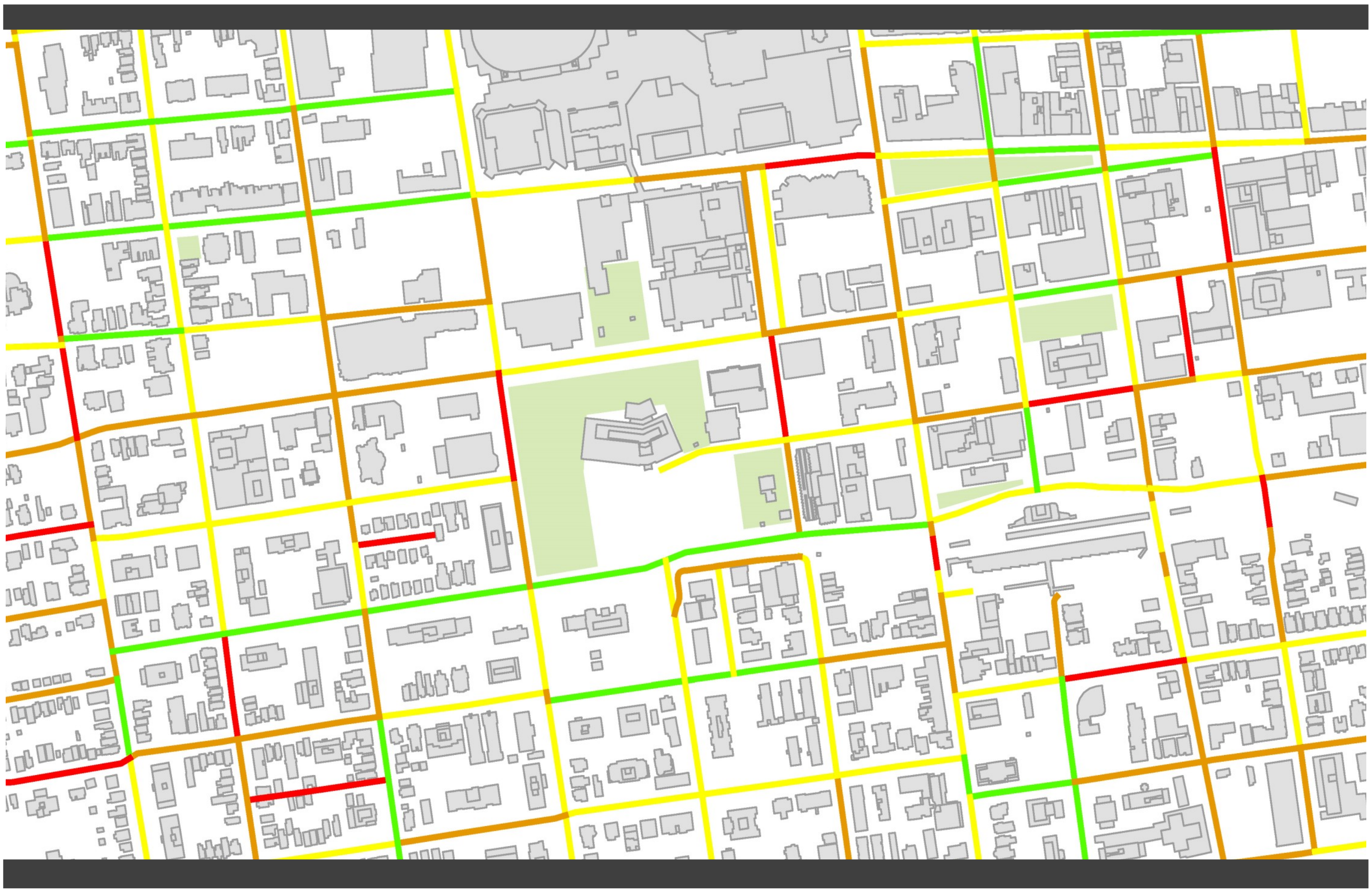
Hamilton
Office of the City Auditor

Roads Value for Money Audit



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Office of the City Auditor

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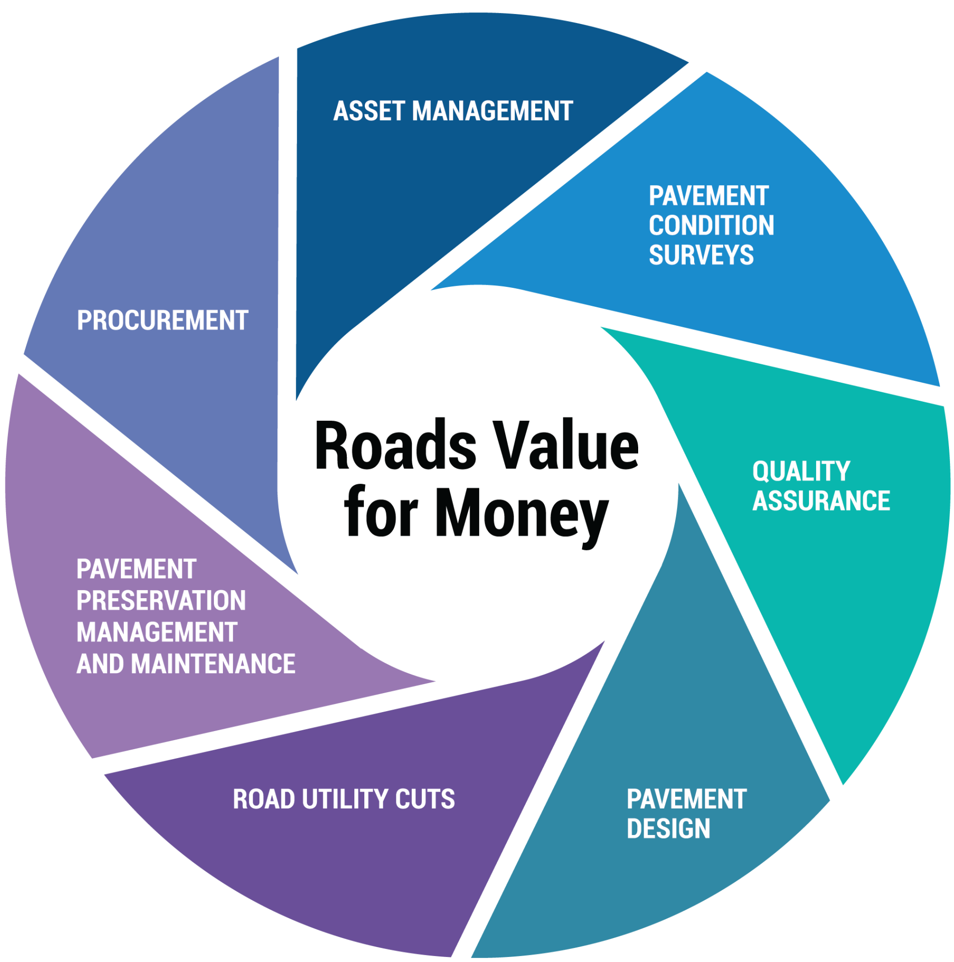
Contents

Executive Summary

1 At a replacement cost of over $4B dollars, the City of Hamilton’s investment in road assets or pavement is one of its largest. Obtaining optimal value for money in that investment requires a successfully coordinated and effective set of activities. These include asset management, planning, condition tracking, quality assurance, design, management of utility cuts, maintenance, preservation management, procurement, contract administration and financial management. Our audit was focused on ensuring these basic components were in place, and on identifying opportunities for improvement. The scope included all these activities which we consider pertinent to value for money. There was one exception however - we did not review matters pertaining to the management of skid resistance on City roads as that will be extensively covered by a Judicial Inquiry currently investigating events surrounding the Red Hill Valley Parkway.

2 Highlights of our findings are as follows:

The City spends about 1% of the replacement cost of its pavements on annual rehabilitation and reconstruction, which is lower than some municipalities. Fiscal realities and the slow rate of reconstruction over the last five years indicate that Hamilton will be challenged to ensure financial sustainability of its road assets. To optimize financial resources and obtain value for money, more efficient processes and innovative strategies that focus on quality, proactive preservation and extending the life of pavements will be crucial to success.



Executive Summary

Asset Management

3 Asset management is a function meant to ensure value for money in the City's infrastructure investments, and secure long-term service and financial sustainability. However, asset management insofar as pavement or road "right of way" assets is concerned has fallen short of those goals in some respects.

- The City currently lacks a mature process for identifying, tracking and reporting the infrastructure deficit or gap for roads, and needs to recalibrate its process to deliver effective decision support.
- SOTI (State of the Infrastructure) reports have not been a reliable tool for reporting the state of road infrastructure and tracking the City's path toward sustainability, and could be more effective as communications and decision-making tools if delivered more often, with a more streamlined, consistent process and with clearer, evidence-based metrics.
- Future asset plans will need a more robust approach for levels of service and risk management.
- The Roads Program should have a strategic plan to address its improvement opportunities, map out strategies for achieving long term sustainability, and implement key performance measures.
- The City's asset management approach relies heavily on resurfacing and reconstruction strategies with little emphasis on proactive preservation.
- There should be a mechanism/process for tracking the accuracy of predicted life cycle costs and deterioration curves.

Pavement Condition Surveys

4 Pavement condition surveys, which are conducted about every 5 years, are not reported in a consistent manner across different reporting mechanisms and time periods. Condition data is not collected frequently enough to present timely information on condition status and deterioration. Also, the index for pavement condition could be enhanced with the addition of a measure related to structural adequacy as some other municipalities have done.

Quality Assurance

5 For many years, roads management has had a problem managing contractor performance and achieving the quality expected. Quality assurance test results over the years show acceptance of pavements with high percentages of rejectable and borderline quality. Contractors have not been held appropriately accountable for poor performance, and to the extent they have been used in recent years, financial penalties and fines have been relatively insignificant and do not act as a deterrent against low quality.

6 The City does not have a systematic method of tracking contractor performance, and the constraints of the current procurement approach based on the lowest compliant bid limits its ability to manage risk. The City should consider implementing a contractor rating system similar to other jurisdictions.

Executive Summary

7 The Office of the City Auditor (OCA) has significant concerns with roads management not using two crucial asphalt tests that are important in determining quality for acceptance. This increases the City’s exposure to poorly performing asphalt.

8 OCA found there were no systematic, documented policies and procedures to ensure the quality of RAP (recycled asphalt pavement) that is introduced into paving projects will not adversely affect the pavement.

Pavement Designs

9 Pavements designs in Hamilton historically relied on simplified, “off the shelf” design methods not reflective of all parameters of the industry standards (AASHTO 93 and MEPDG). Improvements have been made but there still exists a lack of formal policies and procedures as to how these standards are to be used. OCA concluded that roads management should continue to move away from “boilerplate” design to embrace standards in a systematic way, and develop a design guide, protocols, and training to bring more sophistication to this important function.

Road Utility Cuts

10 The function of road utility cuts concerns excavations of City pavements for the purpose of repairing, installing or upgrading underground utility infrastructure. To mitigate the impact of the excavations on pavement quality and serviceability, processes need to be strictly controlled. A certain amount of degradation and loss of asset value is unavoidable so to compensate the City, “degradation fees” are charged. OCA found that the City had a well thought out process for the degradation fees compared to other cities. However, there has been no formal study done to determine whether the amount collected adequately compensates the City for the actual level of road degradation. In light of a review done by another municipality that suggested Hamilton’s fees are at the lower end, OCA recommends the adequacy of the current fee be reviewed.

Pavement Preservation Management and Maintenance

11 Pavement preservation management and maintenance activities we examined included warranty repairs on new, reconstructed and resurfaced roads; repairing deficiencies and defects that are potentially hazardous such as potholes; and applying preventive maintenance that can enhance, rejuvenate and extend the condition of the pavement surface.

12 For repair claims under warranty we noted contractors were slow to correct deficiencies. Some have not been corrected on contracts that have been out of warranty for periods ranging from two to eighteen months, and management is relying on verbal agreements to ensure they are corrected.

13 We noted that for “MMS” potholes - potholes that fall under provincial regulations governing how quickly they are repaired - the standards are being met. However, these only comprise 6% of the potholes. The rest are not governed by any

Executive Summary

standards and processes. To improve efficiency, accountability and transparency, all potholes, including non-MMS potholes as well as those derived from public complaints should be subject to remediation time standards that are tracked and publicly reported.

14 Preventive maintenance, or proactive pavement preservation, is a proven, highly cost-effective way of optimizing the life of the network. We saw very little evidence of preventive maintenance being applied in any systematic way on urban roads. Rather, preventive treatments are applied only sporadically in the form of crack sealing and surface treatments. This is symptomatic of a reactive system of asset management.

Procurement

15 With respect to procurement, a number of red flags were noted that signal risks related to market domination, bid suppression, cover bidding and low-bid/low-quality events, and which call for the need for vigilance by management in the tendering and monitoring of contracts.

16 OCA found several examples where large procurements were split into smaller projects so that the roster method could be used to procure road related construction goods or services. For example, one large procurement was divided into four separate procurements of $149,900 in order to come under the $150,000 roster limit and avoid lengthier procurement alternatives.

17 OCA found that rather than rely on Contractors to submit invoices for payment, City staff were themselves generating progress payment certificates (PPCs) and using that information as the basis for making payments to contractors – without an invoice – in violation of the *Construction Act*.

18 Instances were found where budgeted funds from completed projects with unspent/surplus balances were used to pay for unrelated contracts where there was no budget remaining. As an appropriation to move funds between these projects was not approved this contravenes the Capital Projects’ Budget Appropriation and Work-in-Progress Transfer Policy.

Audit Themes

19 The more significant areas or themes arising from our audit include:

- Bringing a more robust and mature approach to road or “right of way” asset management and pavement analysis.
- The need for a strategic plan that can act as the blueprint for improvement goals and strategies for sustainability.
- Developing more complete and effective systems of quality assurance and contractor management.
- Putting greater emphasis on preservation management as an asset management strategy.

Executive Summary

20 The construction, rehabilitation, and maintenance of roadways is a complex undertaking dependent on the successful coordination of many diverse activities, highly sophisticated expertise, and the collection and analysis of reliable data. The issues cited in our report happened over a long period of time, and will be challenging to address without a very organized approach. Current leadership has made improvements to some of these areas in the last 2-3 years and we urge them to continue to do so. To bring greater focus to these efforts OCA believes senior management should consider organizational changes to ensure the successful adoption and implementation of our recommendations. In particular, asset management with respect to the roads right of way could benefit from becoming a separately positioned and overseen function to ensure it has the independence necessary to develop a holistic and objective approach.

21 In conclusion, OCA would like to thank all staff in the City who participated in the audit, as well as many others outside the City who assisted us with their expertise.

Introduction and Background

22 The City’s road network is managed by the Public Works Department and consists of 6,491 lane-kilometers of roadways including expressways, arterials, collectors, local and rural roads.

23 The replacement value of strictly the roadway (pavement) network is $4.175B and expenditures over the last 5 years have averaged about $42M per year. From 2016 to 2020 inclusive the City has reconstructed 136 lane km of roads and rehabilitated 901 lane km. Of the City’s total 6,491 lane km of road pavement, 14% has been rehabilitated and 2% has been reconstructed at a cost of $203.7M during this five-year period. Expenditures over the coming 4 years are expected to be about $37M per year (Table 1). Thus, the expenditures on roads will diminish slightly from previous years. In the most recent budget, the road infrastructure backlog was reported as $1.65B with the annual estimated infrastructure deficit $72M (including traffic and bridges).

Table 1: Recent Investment in Reconstruction and Rehabilitation

	2016	2017	2018	2019	2020	Total
Investment in Pavement Infrastructure ($000's)	25,590	36,830	57,880	43,897	39,540	**203,737**

Source: Engineering Services, City of Hamilton.

Network Impact	2016	2017	2018	2019	2020	Total
Reconstructed Lane-km	53.3	28.1	19.7	21.2	13.3	**135.6**
Rehabilitated Lane-km	93.0	157.6	203.6	255.6	191.6	**901.4**
Total Reconstructed and Rehabilitated Lane-km	146.3	185.7	223.3	276.8	204.9	**1,037.0**

Source: Engineering Services, City of Hamilton.

24 The functions of road or "pavement" management are carried out by two divisions of Public Works – Engineering Services, and Transportation Operations and Maintenance.

25 The Engineering Services Division is responsible for Asset Management, Design, Construction, and Geomatics and Corridor Management. It is responsible for planning and prioritization of roadwork, coordination of the budget, tracking the state of the road infrastructure, design of pavements, development of technical specifications, tendering construction contracts, conducting quality assurance and oversight of contractors, and utility cuts.

26 The Transportation Operations and Maintenance Division is responsible for the day to day road inspection, maintenance and repairs. This includes snow clearing as well as identifying and repairing potholes and other minor road failures and overseeing road preservation projects designed to extend the life of the road pavement.

27 Construction and rehabilitation work, and some maintenance work is carried out by private contractors, while standard setting, technical specification, monitoring, oversight, contract management and inspection are conducted by in-house staff. In some cases, testing is carried out with the assistance of independent labs and other specialists, and design work is contracted to engineering consultants.

28 Roads are a considerable investment for the City. Obtaining optimal value for money requires well-timed and targeted investment for upkeep and renewal, design of roads appropriate for the environment and service requirements, tight specifications, strong quality assurance and monitoring over materials and construction, proper maintenance and proactive preservation management. Generally, roads are expected to last 15+ years before requiring significant rehabilitation such as resurfacing. With cycles of rehabilitation some roads can be expected to last 60-75 years before they must be rebuilt. Vital to the longevity and durability of any road is avoiding costly damage from any degradation that affects the underlying substructure. Road rehabilitation treatments that ignore problems with the underlying structure of the pavement typically result in poor return on investment.

Audit Objective

29 The overall objective of the audit was to assess the management of the City’s road assets in order to identify opportunities for improved economy, efficiency and effectiveness. The audit was approved by Council as part of the Term of Council Audit Workplan.

Audit Scope

30 The scope of work included processes related to the setting of policies and standards, the strategic, operational and tactical management of road assets through planning, analysis, design, engineering, construction, quality assurance, maintenance, and operations activities.

The information examined in this review included consulting work and various reports since 2005, project results since 2010 with emphasis on the most recent information. Historical data from previous calendar years was used for comparative benchmarking purposes or for specific audit procedures.

What We Did

31
- Gained an understanding of asset management systems and processes as it relates to the road pavement’s current condition, performance (i.e. pavement’s deterioration over time), future financial requirements and valuation; and related maintenance strategies.
- Gained an understanding of operational processes and standards regarding quality assurance testing and measurement, design standards, construction techniques, pavement issues.
- Assessed information about the performance of pavements over time and how this was used to manage road assets with due regard to serviceability, quality and longevity.
- Analyzed information indicative of whether the City is getting good value on its road reconstruction, rehabilitation and maintenance projects (including warranty usage) and identify potential opportunities to achieve greater value.
- Assessed procurement practices with respect to City road contracts.
- Obtained insights from experts in the field and practitioners in other municipalities.
- Reviewed financial information on road operations.

How We Did It

32
1. Researched scientific literature and consulted with experts in areas applicable to pavement management.
2. Interviewed various City staff and staff at other municipalities.
3. Evaluated internal controls and management practices including the inspection of documents.
4. Conducted site visits and made observations of the procedures followed.
5. Gathered and performed analysis of data.
6. Reviewed documented policies, procedures, regulations etc.
7. Compared practices and results with other municipalities and organizations.
8. Hired an independent third-party expert to assist with interpretation of technical information and formulation of audit findings.

What the Scope Did Not Include

33 As a result of issues concerning the Red Hill Valley Parkway uncovered in 2019, Council established a Judicial Inquiry to investigate certain matters pertaining to the reporting of the skid resistance characteristics of that roadway. In recognition that this area of pavement management is likely to be extensively covered by evidence, analysis and conclusions of the Inquiry we did not evaluate any City practices related to the management or reporting of skid resistance or friction in conducting this audit.

The construction of roads in new development neighborhoods is overseen by the Growth Division in Planning and Economic Development until such time as these roads become operational. After that they become the responsibility of Transportation Operations and Maintenance Division. We did not include the activities of this Division in our audit.

Key Terms

34 **Aggregate** – term used for the sand, gravel and crushed stone that is mixed in with asphalt cement to construct flexible pavements.

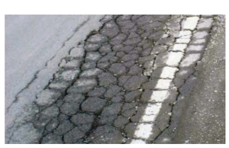
Asphalt Cement (or binder) - is the liquid bituminous material used to bond together the aggregate to form hot mix, the basic ingredient of flexible pavement.

Asphalt Concrete - the paving material used on roads. It is the dull black mixture of asphalt cement, sand, and crushed rock. After being heated, it is dumped out steaming hot onto the roadbed, raked level, and then compacted by a heavy steamroller.

Asset Management Plan – a tactical plan for managing an organization's infrastructure assets to deliver an agreed standard of service.

Condition Index – the pavement condition index is a numerical index between 0 and 100, which is used to indicate the general condition of a pavement section. It is based on the level of deterioration on the road as indicated by distresses in the pavement, roughness and various other variables.

Cracking (as it relates to Pavement) – Cracking refers to breaks or separations that are sometimes seen on the road pavement surface. The following are the most common types of cracks:



Alligator Cracking - is series of small interconnected cracks creating irregular shaped pieces of asphalt that when viewed as a whole look like alligator skin. This type of cracking is due to repeated heavy traffic loading.

Block Cracking - are interconnected series of cracks that divide the pavement into irregular pieces. They may be caused by lack of adequate compaction during road construction.

Photos used with permission. Source: Ministry of Transportation.

Key Terms

Edge Cracking - are cracks that begin at the edge of the pavement. They are the result of weak road shoulders and/or excess moisture from subsurface water.

Longitudinal Cracking - are cracks that run parallel to the centre line of the road. These are typically caused by frost heaving, joint failures or heavy load.

Slippage Cracking - are cracks that look like large crescents. The enclosed side of the crescent is depressed, or may have been filled in with surfacing material. Slippage cracks are usually caused by embankment slope instability or indicative of potential slope failure.

Transverse Cracking - are cracks that run at right angles to the centre line of the road. These cracks are often regularly spaced. They are typically caused by the same factors as longitudinal cracks.

Photos used with permission. Source: Ministry of Transportation.

Infrastructure Backlog - the accrued investment required to meet previously deferred repair, rehabilitation or replacement needs. It is sometimes reported as a cumulative infrastructure deficit or gap.

Infrastructure Deficit - a term used to indicate the annual quantum of needed but deferred investment in infrastructure repairs and renewal.

Lifecycle Management - set of planned actions throughout the asset’s full lifecycle that enables service levels to be delivered in a sustainable way, while managing risk, at the lowest lifecycle cost.

Pavement Management - the effective and efficient directing of the various activities involved in providing and sustaining pavements in a condition acceptable to the traveling public at the lease life cycle cost.

Preservation Management - well-timed and executed activities to proactively avoid or slow the rate of deterioration from observed pavement distress with treatments such as crack sealing, spray patching, micro surfacing.

Reconstruction - rebuilding of an existing roadway typically done at the end of its service life.

Rehabilitation - structural enhancements that renew and extend the service life of an existing roadway such as mill and overlay, resurfacing, etc.

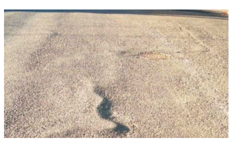
Key Terms

Road Pavement Surface Deformation - weaknesses appearing in one or more of the road pavement layers manifest as surface deformations that can be hazardous to traffic. The following are examples of such deformations:

Corrugation - the road pavement distorts so that it resembles a washboard. This deformation may be caused by too much asphalt cement, too much fine aggregate, or too rounded/smooth textured coarse aggregate. Corrugation usually occurs in places where vehicles accelerate/decelerate.

Depression - These are small localized bowl-shaped areas in the pavement, often accompanied by cracking. They are normally caused by the consolidation or the movement of the layers under the surface course due to their instability.

Rutting - is the displacement of asphalt concrete resulting in channels in the wheel path. The width of the rut indicates which asphalt layer has failed- a narrow rut usually indicates that the surface layer has failed, while a wide rut is the result of a failure of the subgrade layer.



Shoving - is distortion of the pavement resulting in localized bulging. The causes are similar to those noted above for corrugation.

Swells - are localized upward bulges on the pavement surfaces. They are caused by an expansion of the supporting layers beneath the surface course or the sub-grade usually due to frost heaving or moisture.

Photos used with permission. Source: Ministry of Transportation.

Stone Mastic Asphalt (SMA) - a type of asphalt concrete where coarser aggregate is used. It allows greater stone on stone contact than conventional dense grade asphalt.

Superpave - an acronym for “Superior Performing Asphalt Pavements” is an asphalt mix design method consisting of specifications, practices, tests, and analytical tools that are used to construct pavements that can accommodate the unique weather and traffic conditions of a given geography and provide predictable performance.

Utility Cut - occurs when it becomes necessary to excavate a small section of roadway in order to allow access to underground utilities, such as watermains, power lines, and telecommunications infrastructure for emergency repairs or planned upgrades to existing infrastructure.

Detailed Observations

General Observations

35 Roads management faces a very challenging environment in terms of fiscal constraints.

36 The annual budget for roads renewal and replacement has been averaging about $42M per year. To put this into perspective, that is about 1% of the replacement cost attributable to the City's pavements (does not include sidewalks, traffic signals, bridges). For comparison we selected some municipalities to assess what their level of annual spending was on their pavement renewal. It was difficult to obtain direct comparisons because of the way transportation infrastructure is reported – what is included/excluded. However, we made a reasonable estimate based on published data and found that London spends about 2% of replacement cost. Ottawa spends approximately 0.8%, Guelph 1.4% and Toronto 1.3%.

37 Another metric we looked at was the level of historical replacement of the pavement infrastructure. The conventional lifecycle for pavement forecasts decades of maintenance and renewal activities using preservation, resurfacing, and major rehabilitations until such time as each road segment needs reconstruction. At the most recent levels of investment, we noted the completion of reconstruction segments comprising 136 km over five years. From that rate of reconstruction intensity one can infer that it will take an estimated 240 years to cycle through the network. Clearly that is not realistic.

38 Another observation we made is that while the budget for renewal has remained relatively static at $42M – some years lower some years higher – construction prices continue to go up. Based on the construction price index average for the last 3 years (4% increase) the current level of spending of approx. $40M needs to increase by $1.6M just to realize the purchasing power of previous years.

39 In general, we concluded that with respect to the road infrastructure, optimization of financial resources and obtaining value for money through efficient processes is crucial to success. Innovative strategies that focus on quality, proactive preservation and extending the life of pavements will become more important and needs to replace the current "resurface and reconstruct" centric approach.

Asset Management

40 Asset Management is the integration of several disciplines and processes, to most effectively manage the deployment and operation of assets, so that service levels are realized, spending is optimized, and risks are appropriately mitigated. In the municipal context it is meant to ensure assets deliver value to the City and its stakeholders, in a sustainable and cost-effective way.

Detailed Observations

41 Some of the key activities of asset management include tracking the state of repair of infrastructure, accumulating data to predict the performance of assets over time, defining and measuring service levels, quantifying the needs of the asset network, planning for capital investment, tracking gaps in infrastructure funding, and reporting to stakeholders the state of repair, and strategies and plans for maintaining a sustainable network.

42 Hamilton has been involved in formal asset management since the early 2000’s. In fact, it was an early adopter of asset management principles.

43 Two main products of the asset management function in Roads (Engineering Services) is the formulation of an Asset Management Plan and periodic presentation of the State of the Infrastructure (SOTI) Report.

44 The City has produced four SOTI reports (2001, 2005, 2009, and 2016) and one Asset Management Plan (2014) with an update in 2017. Very recently OCA was provided another SOTI report dated March 2021.

45 The main reasons for the adoption of formal asset management was to ensure value for money in the City’s infrastructure investments, and secure long-term service and financial sustainability. However, with respect to the roads network it has fallen short of those goals in some respects and we note some areas for improvement.

Infrastructure Deficit

46 The infrastructure deficit or gap is the shortfall in spending that arises when the funding needs to maintain, repair or rehabilitate infrastructure are not met. By implication, the infrastructure deficit represents a backlog of repairs and rehabilitation that are deferred into the future, accumulating to an ever-growing amount that can result in more costly future repairs and deteriorating assets.

47 In our audit work we found that the City lacks a mature process for identifying, tracking and reporting the infrastructure deficit or gap. There are three main challenges faced by Public Works in the administration of the infrastructure deficit (ID).

- Lack of a transparent, repeatable, testable methodology;
- Unreliable and untimely data; and
- Lack of consistent goals that define what is meant to be accomplished in managing pavement infrastructure with respect to the gap and reporting regularly.

48 The infrastructure deficit (ID) for all City assets in 2015 was determined to be $195M annually, with the roads portion being $117M. At that time the cumulative deficit was estimated to be $3.3B for all infrastructure combined, and $1.9B for roads and bridges. We found the number of $195M for annual deficit to be

Detailed Observations

frequently alluded to in subsequent communications and analysis over the years, but when we asked to examine the back up for the roads portion, we were advised it was not available. In addition, the ID could reasonably be expected to change year by year as continued deferrals of needed road treatments would lead to more costly rehabilitation projections. However, there has been no structured approach to tracking and reporting how and why the ID may be growing or changing over time.

49 Another issue we encountered was that the infrastructure gap, cumulatively, is ostensibly growing by $117M per year (roads portion only), yet the SOTI (State of the Infrastructure) reports show net improvement to the condition of the road network. That disconnect calls into question the veracity of the methodology and/or the data. Also, the accumulated deficits reported in each year’s capital budget do not reconcile to previous year’s annual deficits.

50 In our view, in its current state, the infrastructure deficit is not a reliable tool for advocating needs and communicating strategies. What is needed is an approach that is repeatable and testable, based on objective, verifiable data.

51 In 2015, the infrastructure gap was consequential in garnering support for a 0.5% special capital levy to be added each year with the approval of Council. The levy was meant to “close” the infrastructure gap by accruing annual incremental increases of approximately $3.7M to the point that within 10 years it would reach $203M (covering the $195M gap). While it is true that the application of levies after 10 years does total the amount of annual infrastructure gap, it is erroneous to assume this closes the entire gap. The total of $203M is the accumulation total over a 10-year period; however, the $195M infrastructure gap is an annual shortfall. Essentially, what has been collected over 10 years of additional levies equates to 1 year of annual gap.

52 To summarize, we concluded that there is a need for recalibration of the infrastructure deficit, in terms of what it represents, the methodology, the amounts calculated, and the regularity of updates in order to provide effective support for decision making.

SOTI Reporting

53 SOTI, or State of the Infrastructure, serves as a report card to stakeholders. It evaluates the state of Public Works assets and predicts their future status using defined management approaches and funding levels.

54 SOTI is used to track the City’s path toward sustainability, identify trends and issues, and should be the starting point for strategic and operational plans. It generally follows a framework of principles published in the National Guide for Sustainable Public Infrastructure.

Detailed Observations

55 SOTI results contain ratings of each asset type along with discussions that identify trends and issues, particularly with respect to funding needs. SOTI reports were issued in 2001, 2005, 2009 and 2016 along with an update in 2011 specifically for the Road network.

56 In Table 2 below, a comparison of ratings of road assets over the years illustrates how the state of the road infrastructure has changed.

Table 2: Comparison of SOTI Ratings for Roads

Year	Rating	Comments	Trend
2005	D	A significant backlog exists in the road infrastructure and assets continue to deteriorate. This back log needs to be addressed to avoid a further slide in asset condition.	⬇
2009	D-	Capacities managed but major concern for backlog and lack of reliable funding.	⬇
2011	D+	None.	⬇
2016	C	None.	⬇

Source: State of the Infrastructure (SOTI) Reports 2005, 2009, 2011 and 2016, City of Hamilton.

57 The methodology used in all SOTI reports is a "blended rating system". Assets are evaluated with three separate ratings blended together:

- Condition and performance which refers to the state of repair/serviceability of the asset,
- Capacity vs. need which relates to the effectiveness of the asset in meeting demand,
- Funding vs. need which rates how adequately the asset is funded for its maintenance and upkeep.

58 The final rating combines these separate ratings equally, into one "blended" score in the form of a letter grade.

59 We have some concerns with this approach as it is potentially misleading to stakeholders.

60 First, the use of the blended rating conflates the issues of cause and effect. For example, lack of funding could very well be the cause of poor condition - the effect. Thus, it serves better as an explanation for the state of the infrastructure as opposed to it being a part of it.

Detailed Observations

61 Further, the use of capacity as a rating variable potentially conflates the true state of the asset with many other issues. The ability of a road asset to serve demand may have more to do with the effectiveness of demand management, traffic operations and network planning, and to a certain extent are sunk decisions. We also have concerns about how a blended rating is inherently skewed when it derives from a low score in funding adequacy. Once injected with funding the asset rating will instantly “improve” not necessarily because its state of repair has improved, rather because it has been given funding. This is potentially confusing to stakeholders and for the sake of their perception, a funding adequacy rating might be better positioned as a risk variable.

62 Using funding adequacy in the blended rating also puts great reliance on the accuracy of estimates of needed funding, which is a continuing challenge as we report elsewhere in this report.

63 In terms of clear, concise communication to stakeholders we note that other municipalities use more intuitive rating scales. Having said that, OCA acknowledges the importance of these ratings, on their own, because they portray three significant perspectives, the state of the infrastructure, the capacity of the infrastructure and the sustainability of the infrastructure, all useful information.

64 Another issue with SOTI reporting was with the data used to support the ratings. Our understanding with Roads ratings is that they are not structured out of hard data that is objective and verifiable. To a significant extent they are comprised of qualitative judgements made in workshop or group settings. This potentially creates consistency problems and confounds efforts to objectively know the true state of assets. From our review of the SOTI reports and asset management plans of other jurisdictions we note some have incorporated an indicator of the level of confidence in the data so that stakeholders are properly informed and able to better interpret the information. Such a practice would be beneficial to Hamilton.

65 We also had concerns about the ratings themselves. When viewed over time there were certain anomalies found in the SOTI results that were being reported.

66 As can be found in Table 2, the rating increased from a low of D- in 2009 to a C level in 2016. All through the years of SOTI reporting it was stated that funding levels continued to be inadequate, falling far short of what was necessary to maintain the rating at its original level and the trending analysis consistently predicted deterioration.

Detailed Observations

67 In 2011, Council requested a special report on Roads to establish a line of sight on the ratings and seek advice about improving them to a level B. The report back articulated a number of concerns about the state of the Road network – that fully 78% of road assets required some form of rehabilitation or reconstruction at that point in time, and that the Overall Condition Index (OCI) was 55.8 (out of 100). To maintain the status quo in the ratings, the report asserted it would require a substantial increase of funds – about $10M annually to total $50M per year. To reach an OCI of 60 (Level C) required resources of more than twice the existing annual funds to $83.5M per year. These levels of funding were never realized and even for the most recent 5 years reached an average of about $42M per year (roads only). Notwithstanding that estimated needs were not met, the rating score went up from D- to a C level, and the OCI improved from 55.8 to its current 66. This begs several questions about the veracity of the methodologies employed and the data used.

68 In our review of the SOTI consulting reports we noted recommendations that were meant to enhance the process toward becoming more mature in asset management reporting. Some areas where there is still room for improvement include:

- “Review the use of rehabilitation technologies in terms of cost vs impact on remaining useful life.”
- “Develop an implementation plan for each asset to move towards sustainable levels of funding.”
- “Match service levels with public expectations and willingness/ability to pay.”
- “Determine an appropriate % of replacement cost to be used as benchmarks for optimum funding.”

69 SOTI reports we reviewed were also consistent in citing the need to have a great deal of work done in developing and implementing levels of service and corresponding indicators that are robust.

70 Overall, we concluded the SOTI reports were not a reliable tool for reporting the state of infrastructure and tracking the City’s path toward sustainability. The reports could be more effective as communications and decision-making tools if delivered more often with a streamlined, consistent process, and with clearer evidence-based metrics.

Detailed Observations

Asset Management Plan

71 Hamilton issued its first formal asset management plan (AMP) in 2014, and it had already been implementing and evolving best practice principles in asset management for many years. In 2017, the Province established a new regulatory framework for asset management that requires a much greater level of sophistication in the management of assets, particularly for core assets such as water and road infrastructure.

72 From our review of current practices, we observe that the City should be well positioned to meet the requirements of Ont. Reg 588/17. An asset management policy has been approved and we understand work is well underway to deliver asset management plans that are compliant with both the 2021 and 2024 requirements although we did not review the latest proposed plan. However, based on a review of the 2014 Asset Management Plan, in comparison with the AMPs available from other jurisdictions, we noted some improvement opportunities for more robust and effective planning and support processes.

73 Fundamental to realizing value for money in asset management is finding the optimal balance between cost, risk, and desired service levels. Risk management is a tool in use by other municipalities that want to maximize the value of their processes and use resources most efficiently. The systematic use of a risk framework and tools could enhance the City’s efforts to find optimal solutions and cost-effective mechanisms to address the challenges of asset management where resources are constrained. While some risks were articulated at a high level in the 2014 plan, the City needs to acquire and establish the tools and processes for a more mature approach in identifying and evaluating the full spectrum of risks in a systematic way.

74 Hamilton has been an early adopter of asset management principles including the establishment of levels of service that can be used to define the outputs of each asset. However, the City will need to develop a more comprehensive framework for levels of service that can be tracked and used in investment decisions and for performance accountability to stakeholders. Setting service levels for pavement in line with public expectations will be challenging. A key part of making those determinations we suggest should involve not only desired service but the willingness to pay for those service levels. Metrics will need to be developed, targets set and tracked in order to demonstrate the extent to which levels of service are being delivered.

Detailed Observations

75 Other improvement opportunities are described in the following sections.

Strategic Plan for Road Network Activities

76 One important element of asset management is to have a strategic plan that articulates broad goals and plans. Such a plan should demonstrate how processes, standards and tools will evolve and improve, and it should communicate what the asset management activity will deliver. While the 2014 Asset Management Plan contains some aspirational goals, and some elements of improvement planning related to the road network, there were few details and no connections being drawn to bring together what was being done into a coordinated strategy. Our understanding is that there is no strategic plan for roads that identifies the full breadth of goals and strategies necessary to achieving systemic improvements in its pavement management systems, processes, standards or data, or for achieving and demonstrating long term sustainability of its road infrastructure.

77 In our view, asset management improvement plans are vital to attaining value for money and should be developed from current baseline practices toward the desired state through identified improvement opportunities. The City of Guelph for example has a robust articulation of its plans to reach targets in asset management maturity.

78 Also there needs to be a comprehensive strategy for how the City will achieve long term sustainability with its road assets. In the past information has been presented about options to variously attain certain condition scores, but no coherent strategy has been delivered on which to base future actions and measure progression toward the goal of ensuring optimal value from its road assets.

Performance Measurement

79 As stated in the “National Guide to Sustainable Municipal Infrastructure” a continuing challenge in managing assets is to “bridge the gap between those with operational knowledge and understanding of asset conditions and needs, and those making actual infrastructure funding decisions”. This can only be achieved through a robust regime of performance measures and metrics, and by expressing infrastructure needs and priorities in a manner that clearly shows the effect of decisions. Performance measures allow decision makers to evaluate the consequences of their decisions, ensuring they have the desired effects.

80 OCA concluded in another section in this report on the need to have a better line of sight on the accumulation of backlog and annual infrastructure gap. Similarly, the City needs to consider metrics that show clearly the effects of rehabilitation deferral.

Detailed Observations

81 With deferral it isn’t just a matter of deferring a cost until later. Assets, when not maintained at crucial stages, become more expensive to repair later. In our view it is insufficient to say what expenditure avoidance is yielded from a deferred treatment without including what the added downstream cost is of that deferral. Hence the need for some measurement of that impact.

82 One of the most important attributes for asset management to track is long term sustainability. Current indicators do not provide sufficient information on whether the City is gaining/losing on the infrastructure gap. Average OCI (overall condition index) gives an indication of the general trend, however OCA believes this could be much improved upon.

83 For example, backlog as a percent of replacement cost is a metric the City of Toronto uses. It is tracked every year with a 10 year roll forward estimate that predicts how the gap will grow or decline.

84 The Ontario Ministry of Transportation (MTO) sets a target for its infrastructure to be at least 66% in a state of good or better and keeps track of this statistic to understand their lifecycle stability. It was preferred over a simple average OCI because having a disproportionate level of poor, very poor is not only a drag on sustainability, but it can compound matters by encouraging a “worst first” strategy for renewal which usually ends up being counterproductive. According to the American Federal Highway Administration (FHWA) Office of Asset Management the practice of “worst first” - which means assigning the highest priority to reconstruction or rehabilitation of the worst roads - is detrimental to optimal asset management. The use of the MTO strategy to keep a high percentage of roads above a threshold encourages a more proactive, preservation management approach and is more cost effective in the long run.

85 Another indicator that could be useful is the investment rate, which is the level of infrastructure renewal spending as a percent of replacement cost. This enables comparisons of historical funding or of funding in relation to other jurisdictions.

86 Also useful is the time between major rehabilitations which could be applied to different classes of road assets and provide early warnings of problems with premature deterioration.

87 One of the most innovative approaches we encountered in our research was the Remaining Service Life (RSL) approach advocated by the National Center for Pavement Preservation and the FHWA Office of Asset Management. It tracks the remaining lane-km-years of the road network each year. It starts with the premise that each year the City’s road network loses 6,491 lane-km years of service and seeks to add at least that many lane-km years through improvements to different road segments. Given a finite budget that is notionally applied to proposed renewal projects, the network impact is measured with the number of lane-km years gained through alternative road treatments which can vary depending on how much of the road network is treated, and the type of work performed. For example, with $100,000 you may be able to resurface 2 lane-km extending the life and earning 15 years of life or 30 “lane km years” of renewal. Alternatively, it would be more cost effective to rout and seal 15 lane-km of roadway extending life by 5 years but earning 75 “lane-km years” of renewal.

Detailed Observations

88 The calculations offer a way of comparing and choosing the best suite of treatments for renewal and a method of tracking whether the network is gaining or losing service capacity overall. It offers an opportunity to strategically manage the network.

Emphasis on Preservation Management

89 One of the key components of an effective asset management system is the incorporation of preservation management regimes into the range of treatments analyzed and applied to road assets. Many road authorities are starting to recognize the benefits of moving away from the traditional approaches that rely on “resurface and reconstruct” toward an emphasis on preservation management. In Europe for example, there are roads that were paved in the 1930s or 1940s which have never been reconstructed or rehabilitated, and expensive removal of failed sections has never been necessary. Preservation strategies are considered so important that some road authorities have set annual dollar amounts for preservation based on percentages of replacement costs in the range of 2.5 to 3.5 percent. By using a strategic and systematic approach to preservation, pavement service life is prolonged and less costly in the long run.

90 In the management of road assets in Hamilton there has been over the years a preponderance of resurfacing and reconstruction and little emphasis on using preservation management solutions early in the life cycle in any systematic way. Preventive treatments have been applied on a sporadic basis and only in very incremental amounts. Part of the reason is that most of the roadway network has deteriorated to such an extent that preservation treatments are impractical and pointless. Thus, Asset Management needs to put plans together for how it can gradually build up a more proactive posture in treating pavement so that eventually preservation management can be successfully deployed.

91 Another important part of emphasizing the proactive management of road assets is to ensure there are adequate funds for preservation and maintenance when there is an expansion of the network – capital budgets should be proportionally increased.

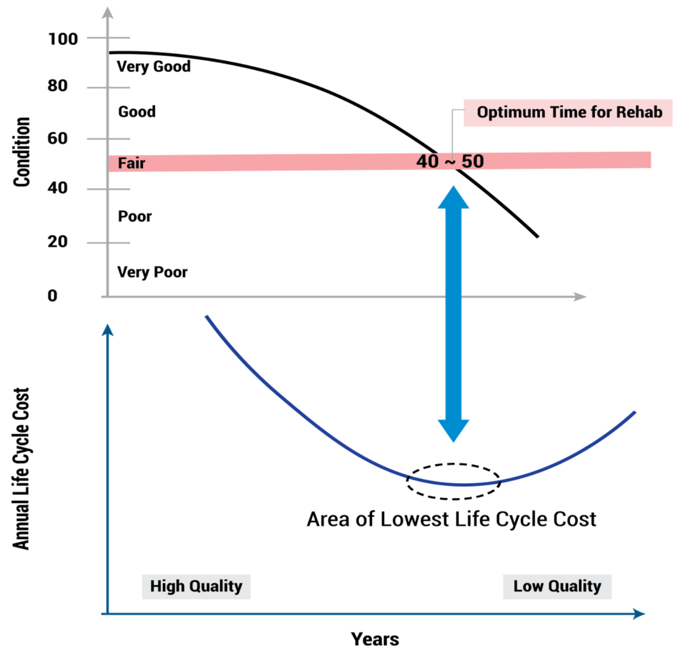
Life Cycle Management

92 When applied to road pavements, Life Cycle Costing (LCC) is a process that considers all the costs associated with a road asset throughout its anticipated service life. It maximizes the value delivered by the asset by choosing maintenance and renewal treatments that offer the best opportunity for minimizing total accumulated cost over the life of the asset.

93 It is an approach intended to make financial resources go as far as they can.

94 LCC includes the cost of the original construction, ongoing maintenance and repair, rehabilitation, and eventual re-construction discounted to their present value. In a fiscally constrained environment this approach to minimizing cost in relation to the service benefits optimizes value for money in the investment of road assets and is critical to financial sustainability. Box 1 below explains the concept of lowest life cycle cost.

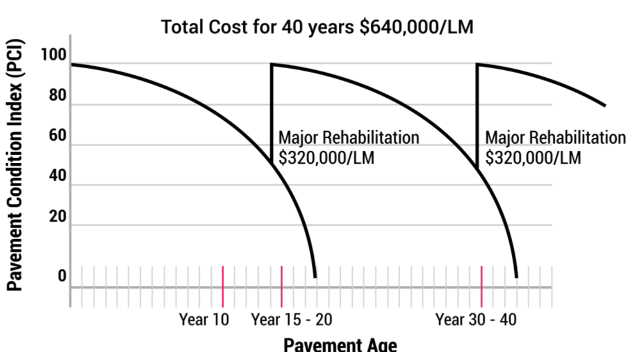
Box 1: The Concept of Optimizing to Lowest Life Cycle Cost



Source: Washington State Department of Transportation.

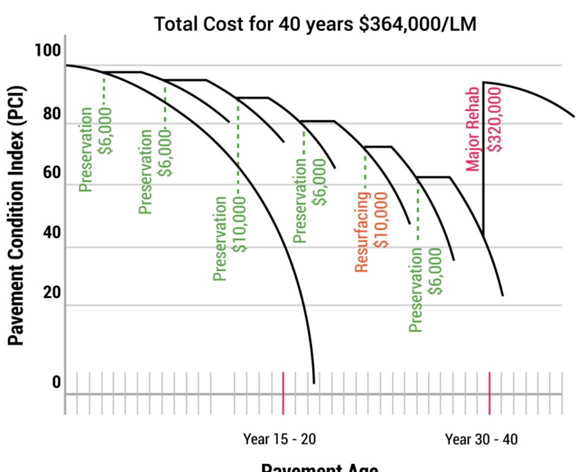
Optimizing to lowest life cycle cost combines two important ideas.

The first is identifying the deterioration point that is the optimum time for rehabilitation. This can be seen in the first diagram. Assume for illustrative purposes an optimum point in time for rehabilitation is identified through analysis and found to be when deterioration has reached a condition level of 45 (upper curve). This point will correspond to the point of lowest life cycle cost (lower curve). The reason an earlier rehabilitation is more costly is because the yield in pavement life is not as high. Later rehabilitation is more costly because beyond the optimal point deterioration results in more expensive repair.



Source: City of Durham, N.C.

The second idea involves the use of preservation management. With no preservation management (second diagram) the roadway is allowed to deteriorate to condition level 45 and will end up being rehabilitated twice in 30 years at a total cost over life of $640,000 per lane mile.



Source: City of Durham, N.C.

With preservation (third diagram) a combination of more cost effective treatments is used to extend the time it takes to reach the rehabilitation “trigger” point of 45. If the right combination of timely surface treatments is selected then the total spend over the life of the asset is lower (in this case $364,000 per lane mile).

95 In Hamilton we observed that LCC costing was used at the network level to predict long term financial requirements. According to the National Guide to Sustainable Municipal Infrastructure, life cycle analysis also plays a pivotal role in selecting the best pavement treatment strategies.

96 Options can be generated for particular road segments and then used to select the treatment strategies that will minimize LCC. However, we observed little evidence it was routinely being used for this type of purpose. For example, LCC analysis was prepared for the Red Hill Valley Parkway when being costed for planning and decision-making purposes (see Table 3 below).

97 A lowest LCC option was presented however the actual treatments, costs and timing ended up being significantly different. Rather than intermediate treatments at years 2012 and 2017 for $513K and a minor rehabilitation in year 2024 for $2.5M the actual spending was one major treatment in 2019 for $10M. This pattern of spending is closer to another LCC option presented in 2007 which was not optimal in value for money and contemplated the first treatment being a major rehabilitation of $10.3M in year 2024.

Table 3: Red Hill Valley Parkway Predicted Lowest Lifecycle Costs

Year	Analysis Year	Age	Activity	Expected Cost
2007		0	Construction	N/A
2012	5	5	Surface Treatment	$513,000
2017	10	10	Surface Treatment	$513,000
2024	17	17	Minor Rehabilitation	$2,565,000
2029	22	22	Surface Treatment	$513,000
2034	27	27	Surface Treatment	$513,000
2041	34	34	Minor Rehabilitation	$2,565,000
2046	39	39	Surface Treatment	$513,000
2051	44	44	Surface Treatment	$513,000
2058	51	51	Major Rehabilitation	$10,260,000
2063	56	56	Surface Treatment	$513,000
2068	61	61	Surface Treatment	$513,000
2075	68	68	Minor Rehabilitation	$2,565,000
2080	73	73	Surface Treatment	$513,000
2085	78	78	Surface Treatment	$513,000
2092	85	85	Minor Rehabilitation	$2,565,000
2097	90	90	Surface Treatment	$513,000
2102	95	95	Surface Treatment	$513,000
2109	102	102	Major Rehabilitation	New Cycle

Source: Pavement Sustainability Plan, 2007.

Detailed Observations

98 Tracking the accuracy of predicted life cycle costs is a measure necessary to developing sound financial projections and long-term financial impacts. It provides the opportunity to inform, improve and amend pavement deterioration predictions, treatment timing, cost estimates, and helps identify anomalies.

99 We found no evidence that the City systematically tracks predicted against actual outcomes for lifecycle costs and could be missing an opportunity to improve its methodologies, data capture and prediction assumptions.

Pavement Condition Data

100 The foundation of an effective asset management program is built on having comprehensive and reliable information on the current condition of the asset(s). Pavement condition information is used to monitor the need for renewal, to report to stakeholders the state of repair of roads, to support investment planning and decision-making, identify emerging issues in road deterioration, and to manage the network from a long-term sustainability perspective. In many jurisdictions, pavement condition is a level of service measure that when aggregated becomes a goal that signals whether past strategies and funding are on the right track.

101 Pavement condition surveys are conducted on a cyclical basis - in Hamilton about every five years. The condition of the City’s roads is assessed in surveys conducted by independent engineering consultants. These surveys combine measured and observed data into an evaluation of the level of distress and smoothness of ride.

102 Assessments were performed in 2001, 2006, 2011, 2015, and most recently in 2019. The City uses three measures to reflect the condition of the road: the surface condition index (SCI), the ride index (RI), and the overall condition index (OCI). The SCI quantifies the type and extent of visual defects on the road. That is, the extent and severity of cracks, rutting, potholes etc. The RI is a number that quantifies the roughness of the road with the aid of electronic sensors (i.e. how it feels to drive on the pavement). SCI and RI are measured on a scale of one to 100, where 100 is the condition of a new road. The OCI is the arithmetic average of the two scores.

103 To be effective as an index, the pavement evaluation methodology must be reliable and the data inputs sufficient, accurate and timely. That means having a frequency of collection that assures timely information about the asset, and procedures and standards that can be objectively relied on.

Detailed Observations

104 The City has a useful tool for capture and display of condition information, a system referred to as IRISS (Integrated Right-of-way Infrastructure Support System). This tool uses a map to show the location of each road segment in relation to other streets throughout the City, and provides information about them, including the intersecting cross streets, electoral wards, the type of road (i.e. urban/rural, arterial/local etc.), the road segment’s width and length, as well as the three measures of the road’s condition - the SCI, the RI, and the OCI. It also includes a Summary that reports the average OCI score for each City ward, as well as the average overall OCI score for the City as a whole. (The 2019 average overall OCI score was 63.)

105 Our findings on the processes for condition assessment are continued in the following sections.

Consistency and Reliability

106 In general, OCA found that the pavement condition indices are not reported in a consistent manner across different tracking and reporting mechanisms.

107 We previously reported in another section that the condition survey information did not correlate with the expected lower evaluation scores consistent with substantial underfunding assumptions. In the past five years the City has spent $203.7M on road rehabilitation and reconstruction, averaging to about $40.7M annually, far below the SOTI identified needs, resulting in a predicted downward trend. Yet over that same period the overall condition of the road has improved. The weighted average overall OCI score increased from 62 in 2015 to 66 in 2019.

108 The 2016 SOTI report Table 3.5 indicated that to improve the City’s overall SOTI score from a 62 to a 65 the City would need to increase spending to $617M over 10 years (averaging $61.7M annually). Yet the City has managed to achieve this target in half the time (five years instead of 10) while spending $21M less each year than the projected need. This implies either that there is no direct correlation between the amount spent on roads and the road’s condition, or that there is a vast difference in pavement assessment from one period to the next.

109 Another anomaly was in the published reporting of Hamilton’s MBNC results (Municipal Benchmarking Network Canada – formerly OMBI). The City’s 2011 SOTI reported only 29% of the network in good or very good condition, with 78% in a state requiring renewal or rehabilitation. Yet the 2011 MBNC (OMBI) report listed Hamilton as having 61% of roads in good or very good condition. The most recent reporting of SOTI results has 38% of roads in good or very good condition, whilst Hamilton’s MBNC reporting has 64% - a statistic that gives Hamilton the 4th highest rating of reporting municipalities across Canada and well above the median rating of 50.

Detailed Observations

110 We were advised that data collection methods have been evolving and efforts were recently made to increase reliability which is consistent with the following statement that appears on the Summary and Stats tab of the IRISS database: “As a result of the 2019 pavement condition assessment the results have identified an increase in ratings. The increase in ratings is related to the ongoing changes in the technology and way the data is captured. With knowledge and experience managing the road network, staff know that an overall improvement in condition data does not necessarily indicate an overall improvement in the physical condition. It is assumed that the margin of error in the ratings is +/-5%.”

111 The changes in technology referred to above imply that, over time, the instruments used to assess the SCI and the RI are becoming more sophisticated and accurate. This means there is a lower margin of error in the data obtained more recently than that from earlier periods and the data points may not plot as a curve. However, the data points should still be compared over time and an assessment of whether the road pavement improved or did not should still be made.

112 The City’s SOTI report (described in the previous section) uses OCI (overall Index) made up of SCI (surface condition index) and RI (roughness index) to assess the condition of the City’s roads.

113 Table 4 below demonstrates the OCI scores across functional road classes from 2001, 2006, 2011, and 2015 obtained from the 2016 SOTI report and includes the 2019 scores reported by Engineering Services to update the SOTI numbers.

Table 4: OCI Scores Across Functional Road Classes

Functional Class (Type of Road)	2001	2006	2011	2015	2019
Lincoln Alexander Parkway (Linc)	83	74	90	77	70
Red Hill Parkway (RHVP)	n/a	n/a	82	77	94
Total Expressway	83	74	87	77	81
Urban Arterial Major (UAMJ)	64	54	62	63	67
Urban Arterial Minor (UAMI)	60	54	61	61	63
Urban Collector (UC)	58	52	59	58	62
Urban Local (UL)	59	52	60	59	62
Urban Network	60	53	60	60	64
Rural Arterial (RA)	74	68	69	66	68
Rural Collector (RC)	67	64	69	67	69
Rural Local (RL)	61	59	71	67	67
Rural Network	65	62	70	67	69
Total	**62**	**56**	**64**	**62**	**66**

Source: Engineering Services, City of Hamilton.

Detailed Observations

114 From Table 4 on page 28, one notes that the total OCI score for the City’s road network is 66, up marginally from the score of 62 four years earlier. However, this differs from the total OCI score of 63 that is reported in the IRISS system. Management indicated that the reason for the discrepancy is that overall score is calculated by two different methods.

115 In SOTI the scores of all the road segments are weighted by their corresponding lane-kilometers; therefore, longer road segments contribute more to the overall score than their shorter road segment counterparts. In IRISS the score of each road segment is given the same weight when calculating the overall average score. This inconsistency makes it difficult to compare the state of the City’s road network. A weighted average score reflects the overall state of the City’s road condition more accurately.

116 In addition, we noted the City’s Road Pavement Index Scale is not consistent. The scale refers to the ranges used to place assets in various condition categories for information, decision and evaluation purposes.

117 Our review of literature and other road jurisdictions indicates that most other municipalities, such as Ottawa, London, Waterloo, Sudbury, Peel, Halton, Thunder Bay and Guelph, use a five-point scale modeled after the Canada Infrastructure Report Card which is also used by Hamilton for SOTI reporting purposes. However, these ranges are not consistent with information in use internally or for other purposes.

118 For example, the 2016 SOTI report and IRISS system differ on when to take various recommended corrective actions in dealing with the road deterioration process (see Table 5 below and Table 6 page 30).

Table 5: State of the Road, Condition Index and Corrective Action in SOTI

Condition Category	OCI Range	Action
Excellent	81 - 100	Not stated
Good	61 - 80	Not stated
Fair	41 - 60	Minor or Major Rehabilitation
Poor	21 - 40	Major Rehabilitation or Reconstruction
Fail	0 - 20	Total Reconstruction

Source: State of the Infrastructure Report 2016, City of Hamilton.

Detailed Observations

119 As per Table 5, in SOTI, roads with OCI scores ranging from 81 to 100 are considered in excellent condition. It is implied that these roads do not require corrective action. Roads with an OCI rating of 61 to 80 are deemed to be in good condition.

120 The SOTI report clearly states that roads with OCI between of 41 to 60 are in fair condition requiring minor or major rehabilitation, and that roads with an OCI reading between 21 and 40 are in poor condition requiring major rehabilitation or reconstruction. Finally, roads with an OCI below 20 are considered to have failed and require total reconstruction.

Table 6: State of the Road, Condition Index and Corrective Action in IRISS

Condition Category	OCI Range	Action
Good	70 - 100	Maintenance
Fair	55 - 70	Minor Rehabilitation
Poor	40 - 55	Major Rehabilitation
Fail	0 - 40	Reconstruction

Source: Integrated Right of Way Infrastructure Support System (IRISS), City of Hamilton, 2019.

121 Asset Management's own internal pavement management system (IRISS), has different categories (Table 6), explaining that roads with an OCI/SCI score of 70 to 100 require maintenance only. That is, crack sealing or repairing small potholes etc. Roads with an OCI/SCI score of 55 to 70 are considered to require minor rehabilitation. That is repairing more significant potholes, minor resurfacing i.e. "shave and pave", etc. Roads with an OCI/SCI between 40 and 55 require major rehabilitation while roads with an OCI below 40 require reconstruction. This would be a total road replacement, likely to include sidewalks and curbs, etc. Therefore, the scale used to indicate the point at which corrective actions are to be taken noted in the SOTI report, and communicated to Council, is not consistent with that used by Engineering Services' Asset Management section.

122 In the most recent SOTI report, received by OCA as we were drafting this audit report, it now shows a different scale from either the above. It has five levels, but the range definitions are different than previous SOTI reports.

Detailed Observations

123 As noted in Table 7 below, the City reverts to the more traditional five-point scale when calculating pavement degradation fees to charge utilities and other services cutting the City's roads to access their underground infrastructure. This is consistent with previous SOTI reports and other municipal road authorities.

Table 7: City of Hamilton - Utility Cut Surcharge Based on Road Condition

OCI Class	OCI Range	Utility Cut Surcharge Rate
1	81 - 100	52%
2	61 - 80	42%
3	41 - 60	31%
4	21 - 40	21%
5	1 - 20	10%

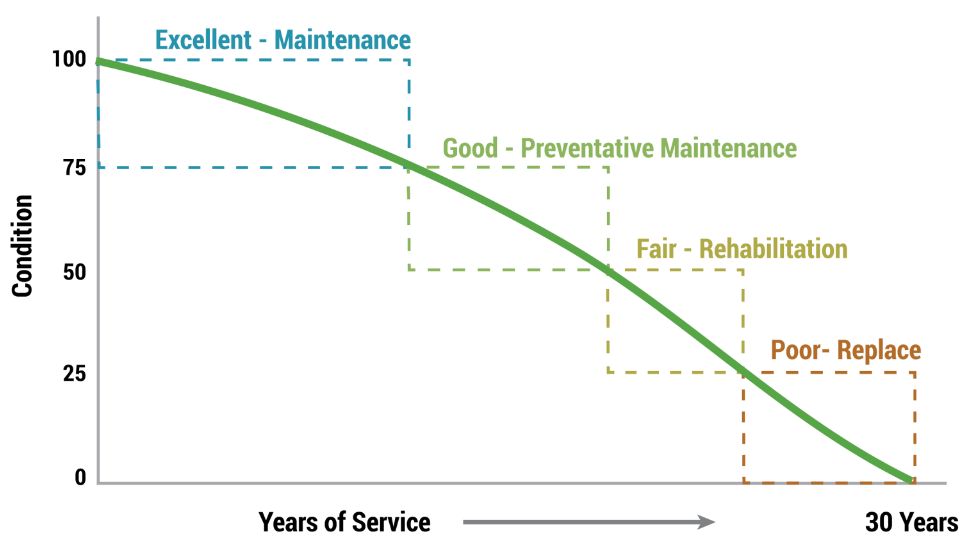
Source: Pavement Degradation Issues and Utility Cuts Report, Engineering Services, City of Hamilton.

Frequency

124 Another issue we examined was the frequency of pavement condition updates. Data needs to be collected frequently enough that it provides timely information for decision-making and includes sufficient data points for assessing, over time, the performance and deterioration history.

125 Pavement deterioration is known to follow a pattern best illustrated by a deterioration curve like the one below (Fig. 1). The data points collected in condition surveys is what maps out the actual curve. A segment of roadway that reaches "fair condition" is a prime candidate for rehabilitation.

Fig. 1: Pavement Degradation and Road Pavement Service Required



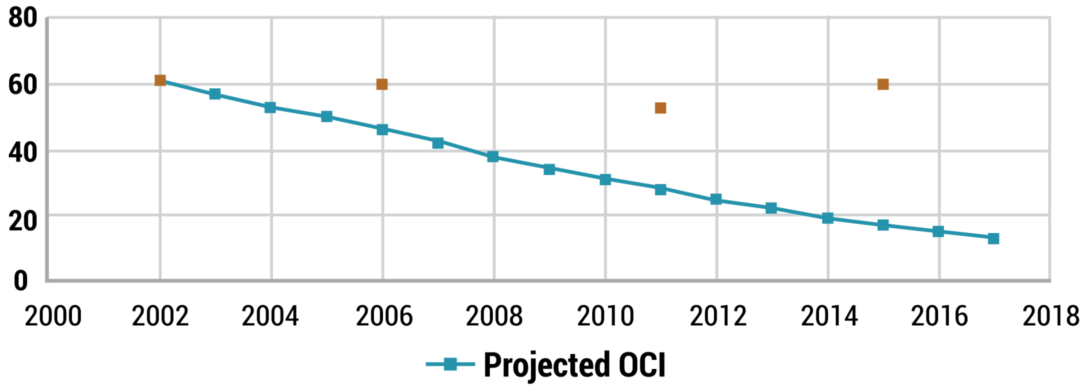
Source: Presentation, Asset Management, City of Hamilton.

Detailed Observations

126 Having frequent and timely data points allows pavement performance to be evaluated by comparing the actual deterioration of the pavement over time to its expected deterioration pattern.

127 The graph below (Fig. 2) shows one such a comparison: note the projected deterioration is in blue, and the actual deterioration is shown as the four brown squares reflecting the OCI score attributed to this road segment by the assessments performed in 2001, 2006, 2011, 2015.

Fig. 2: Typical Projected vs. Actual OCI
Asset: 3837



Source: Engineering Services, City of Hamilton.

128 This pavement deterioration curve is typical of what was provided by Asset Management when requested.

129 As can be seen there is very little correlation between predicted deterioration and the actual assessment values. In addition, the actual data points are few in number, spanning a long period of time, which confounds efforts to know the actual curve. One cannot know with confidence whether the prediction curves are unreliable, or the actual data points are inaccurate, or some other issue exists.

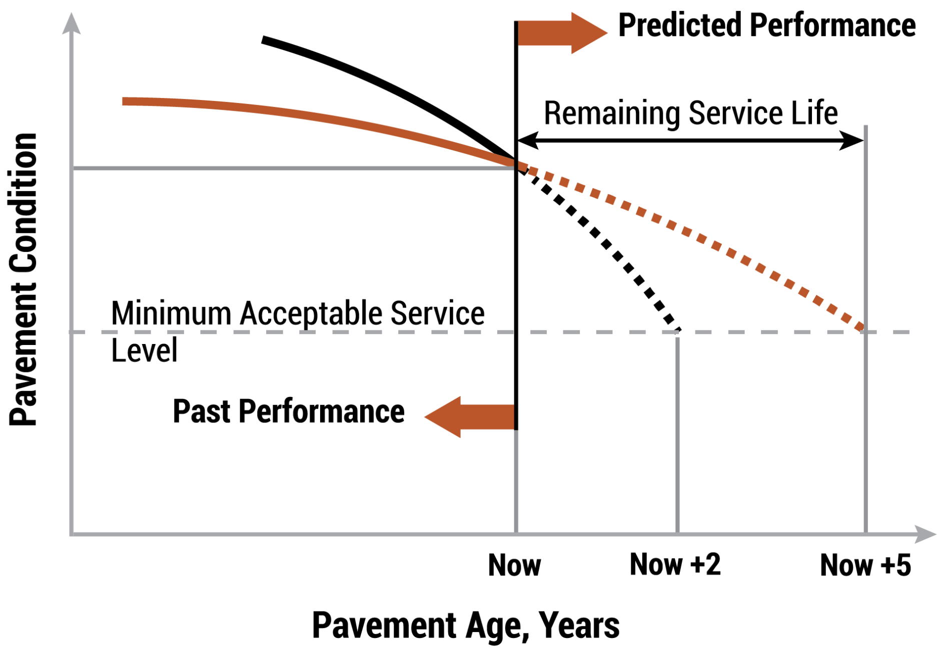
130 As to frequency of collection our research revealed that most State road authorities in the US collect condition data every 1 or 2 years. In Alberta, a study of municipal road authorities indicates the typical network is assessed over 3 years using a schedule of one-third of the network each year.

131 The next most common was a variation of this in which arterials would be assessed year 1, collectors in year 2, and local roads year 3 before repeating the cycle. In Ontario, we found there is a range of practice amongst municipalities however none were as infrequent as Hamilton. London for example, evaluates one quarter of the network annually. Ottawa completes pavement evaluations every 3 years for arterials, freeways, and every 5 years for local roads. Guelph is on a cycle of every 2 years. The City of Toronto has a collection cycle of every 2 years for expressway and arterials, and 4 years for collectors and local roads.

Detailed Observations

132 Having accurate curves of predicted and actual deterioration has a very great impact on planning because it is key to identifying future needs and the timing of those needs. For example, in the diagram below (Fig. 3) one can see the impact even a small change in curves has on when necessary maintenance needs to take place. Even a small change in deterioration assumptions can have great significance for the planned timing of critical maintenance and rehabilitation.

Fig. 3: Road Degradation Assumption vs. Timing of Maintenance/Rehabilitation



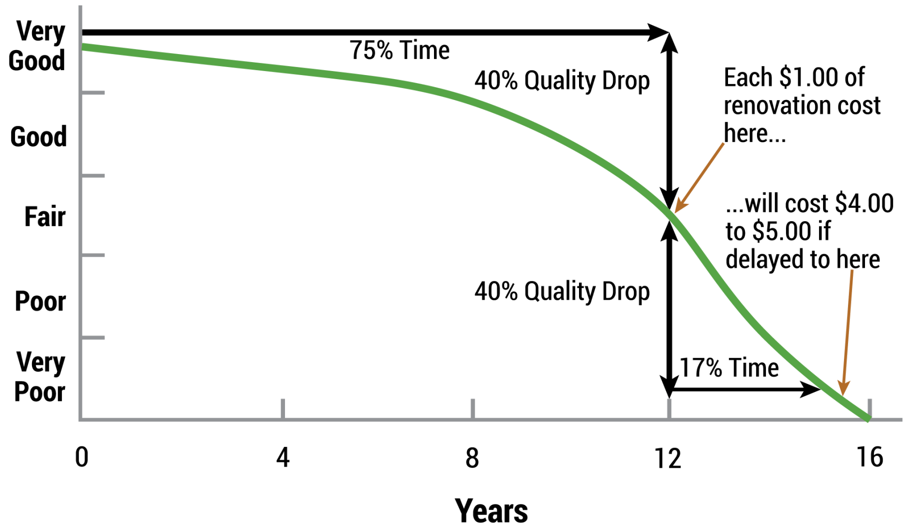
Source: Federal Highways Administration.

133 We concluded data is not collected frequently enough to adequately track road pavement performance, and the pavement deterioration does not map to the expected curve shape and presents risks that the model curves are not reflective of actual experience.

134 The reason these curves are so important to track in both predicted and actual form is the financial impact that deferral of maintenance has on the increased costs of future treatments. This can be seen in the generalized curve in Fig. 4 on page 34.

135 At a certain point, the cost of repairs accelerates such that any delay in intervention is very costly. Thus, for sound decision-making, planning and communications to stakeholders the City needs to have consistent, comparable methods, good data, frequent collection and effective predictive modeling.

Fig. 4: Pavement Degradation vs. Rehabilitation Costs



Source: Federal Highways Administration.

Completeness of Indicators

136 OCA also reviewed the current indicators used to manage pavements in light of better practices in other jurisdictions. We found that the index for road condition, which combines data on pavement distress with road roughness into an “Overall Condition Index” could be enhanced to be more fulsome, complete and useful.

137 With the goal of network management being to maintain an acceptable condition of pavement assets, it has been common practice for road authorities to rely on the assessment of observed road distress and measured smoothness, but less common to use evaluation of structural adequacy. However, some studies have shown the benefits of a more sophisticated and complete set of indicators for obtaining a fuller understanding of pavement condition.

138 In Alberta, several municipalities have incorporated the use of a structural indicator to more fully describe pavement condition and evaluate needs.

139 In our review of literature, a report to the American Federal Highway Administration (FHWA), also indicates that along with RI (roughness) and PCI (cracks and other distress), Structural Adequacy Index (SAI) is a third performance measure to consider when evaluating the performance of asphalt pavement. The SAI is important because it measures the load carrying capability of each road section by assessing its structural capabilities. Typically, the index is calculated using the results of falling weight deflectometer testing with an index of 0-100 being used to represent how adequately the structure is able to continue maintaining its current load.

Detailed Observations

140 The City of Hamilton considered using this index in 2006 when first setting up their pavement management system. At the time it was considered unnecessary because it was believed thought that structural adequacy could be verified by the other two measures (RI and SCI). It was also thought that during the design phase of a capital project the geo-technical analysis, which often includes bore-hole samples, would inform the road engineers of the structural integrity of the road base and provide similar results to the SAI. However, the FHWA report, published in 2012, strongly suggests that all three should be measured to understand the structural and functional condition of the

141 Intuitively it makes sense that the RI, which measures the roughness of the road, and the SAI are related. A road that is structurally not very sound will often be very rough or bumpy. However, this is not always the case.

142 On many local rural roads, the structural capacity of the road is low while the ride quality is adequate. This is true if traffic remains infrequent and light. On the other hand, there are cases where rough bumpy pavement with low OCI scores (both RI and SCI are low) are resurfaced instead of reconstructed.

143 When new, such pavement will show a much improved OCI score as both the pavement’s visual impact and its rideability are much better. However, if the road base was in poor condition and had not been repaired, the road will quickly deteriorate. The road’s true condition would only have been reflected if the SAI score was included.

144 The Structural Adequacy Index (SAI) is most commonly used as a third measure that is a component part of the Overall Condition of the pavement. This approach is used in some municipalities in Canada such as Ottawa, Edmonton and Calgary. Also, the MTO uses not only SAI to evaluate pavement performance but also rut depth and other measurements.

Quality Assurance

145 Quality assurance refers to the activities and procedures that have been established to ensure roadways are constructed and rehabilitated to meet City expectations. To achieve value for money the City must have adequate resources, processes and technologies at its disposal to ensure that standards exist for construction methods and materials, and are then met or exceeded when delivered by the contractor.

146 Certain components that are vital to ensuring quality include having detailed specifications for the characteristics of aggregates (crushed stone) and asphalt cement (tar-like bituminous material that binds the aggregates together); ensuring mixtures contain the optimal proportions of these materials for performance; and that construction methods adhere to required parameters.

Detailed Observations

147 In order to be effective, assurance of quality relies on a regime of clear standards and specifications, robust inspection and testing, timely problem identification and remediation, and strong accountability mechanisms to hold contractors to required performance levels.

Managing Contractors

148 Our audit found that for many years the City has had problems managing contractor performance and achieving the quality expected.

149 As far back as 2009, growing concerns with respect to the quality of new and rehabilitated pavement prompted the City to engage consultants to study the problem and address issues that were leading to underperforming pavements, including the adequacy of quality assurance. In fact, the City undertook several studies from 2009 to 2017 to determine the causes of poor performance and correct deficiencies in its processes.

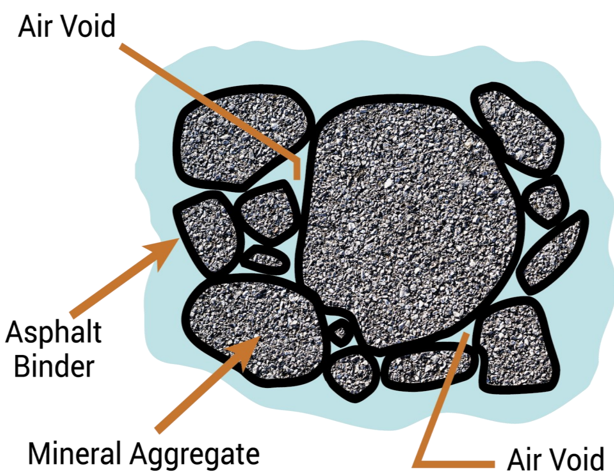
150 In the 2009 study, the report states that pavement distresses were appearing prematurely and likely attributable to poor materials, poor construction practices, poor quality assurance and insufficient inspection and specification, among other reasons. At the time, pavement construction was being completed under two different specifications – Marshall Mix and Superpave.

151 Superpave was a newer method that was thought to bring a more reliable specification and testing regime that would achieve long term performance that could be matched to service expectations. It came from research in the United States that linked certain tested properties of asphalt with predictions of performance.

152 However, in a summary of asphalt field and laboratory testing of the quality of construction projects in the 2009 study, the consultant found that only 24% of Marshall mixes passed (27% borderline, 49% fail) and only 32% of Superpave mixes passed (19% borderline, 49% fail).

153 In a follow-up 2012 study, consultants evaluated the state of practice using testing results from pavements constructed in 2010 and 2011 with a view to upgrading specifications.

AIR VOIDS
What are they and why do they matter?



The percentage of air voids in a mixture is a very important property. Air voids are pockets of air that exist between asphalt coated aggregate (stone) in the compacted mixture. The durability of pavement is a function of air void content. Air voids that are either too great or too low can cause a significant reduction in pavement life. Superpave mixtures typically design for 4% air voids in lab compacted mixtures.

154 The testing results were generally improved over the previous study while there was an identified problem with respect to “air voids”. Achievement of the correct percentage for air voids in an asphalt mix is considered a critical variable in the performance of a pavement over time.

155 Testing results indicated 48% acceptable (36% borderline, 16% rejectable) for 2010 pavements and 62% acceptable, (23% borderline, 15% rejectable) for 2011.

156 When asked to evaluate pavements that had been constructed in the 2007 to 2009, the consultants indicated the main causes of early pavement distress to be low asphalt cement content, poor compaction and poor gradation, as well as the potential impact of uncontrolled RAP (recycled asphalt pavement).

157 Further work was done in a study in 2013. Although much of that study focused on improving pavement design and the risks inherent in the use of RAP, a review of quality for projects delivered in 2012 and 2013 concluded there had been significant improvement in those years resulting from the implementation of new specifications advocated in the previous study.

Table 7: Quality Results from Testing in 2014, 2015, 2016 by Contractor

	Year	Total Number of Tested Samples	Samples that were Acceptable	Samples that were Borderline	Samples that were Rejectable
Contractor A	2014	59	10%	42%	47%
	2015	31	0%	32%	68%
	2016	118	7%	29%	64%
Contractor B	2014	7	14%	43%	43%
	2015	NA	NA	NA	NA
	2016	2	50%	50%	0%
Contractor C	2014	56	20%	61%	20%
	2015	64	16%	45%	39%
	2016	58	50%	31%	19%
Contractor D	2014	16	31%	31%	38%
	2015	39	46%	44%	10%
	2016	83	25%	39%	36%
Contractor E	2014	43	23%	40%	37%
	2015	12	33%	42%	25%
	2016	33	9%	67%	24%
Contractor F	2014	79	22%	54%	24%
	2015	13	23%	38%	39%
	2016	6	50%	50%	0%
Contractor G	2014	76	26%	36%	38%
	2015	10	20%	50%	30%
	2016	42	14%	50%	36%

Source: Consulting Report from Engineering Services Division, City of Hamilton, 2017.

Detailed Observations

158 The final study, issued in 2017 was a review of quality assurance testing results for the years 2014, 2015 and 2016. This study broke down the results by contractor and revealed quality that was worse than even the 2009 study. For 2014 and 2016 only 21% of asphalt samples were acceptable, while in 2015, 22% were acceptable. Results are summarized in Table 7 (see page 37).

159 One can see that rejectable samples for certain contractors in any given year went as high as 68% whereas the rate of acceptable samples was as low as 0%. In commenting on these results, the consultant referred to drastically low air voids, which is an issue that was previously identified in the 2012 study.

160 These results clearly indicate that the City has had persistent problems obtaining the quality of work that was specified in its contracts.

161 As part of this audit, the OCA performed an analysis of test results for 2017 and 2018. Overall, we found that in these two more recent years, there has been an improvement. The percentage of rejectable samples appears to be down considerably – 13% of 184 samples in 2017, and 12% of 118 samples in 2018. However, the number of samples in the borderline range is still quite high - 30% in 2017 and 25% in 2018. In conclusion, while the quality of the asphalt used on road pavements laid in 2017 and 2018 appears better than it was in the prior three-year period, there is still room for improvement.

162 In our view, the substantial numbers of borderline acceptances over the years is concerning. It therefore may be prudent to re-examine whether the acceptance of borderline results is a beneficial policy. The rationale, presumably, is that borderline acceptances reduces the number of disputes in testing results. However, it may also reflect the fact that Hamilton is more tolerant of marginal performance. Contractors have no incentive to ensure results meet the “acceptable” criteria, since the City is equally accepting of borderline results. We noted in our research that a number of municipalities have adopted a pass/fail system with no borderline category whatsoever. It may be prudent for the City to consider such an approach.

163 Another issue we examined was the degree to which the City ensures there are consequences for substandard performance and unmet quality criteria. We concluded that for many years, contractors have not been held appropriately accountable for poor performance. Despite our enquiries, we could not find any examples where significant penalties had been levied for quality deficiencies. This was consistent with observations made in the consulting studies from 2009 to 2017 where they reported repeatedly on the lack of corrective action being taken to address quality concerns.

Detailed Observations

164 OCA did find that beginning in 2018 some minor financial penalties were issued to contractors who used asphalt materials that did not meet the City’s specifications, but the penalties issued were very insignificant when compared to the contract value. In one contract, only about two thirds of samples had the AC content at an acceptable level and only 60% had air voids at the acceptable level. Yet this contractor only paid $2,433 as an "Unacceptable Asphalt Material Reduction” on a $3.4M contract. In a second contract, only 11 of the 20 samples tested were at the acceptable level for asphalt content, and only 13 of the 20 samples had air voids that were in the acceptable range. Yet, this contractor was only issued a financial penalty of $37,267 on a $1.2M project. In 2019 a contractor was penalized $20,000 for unacceptable asphalt on a $1.13M project; and in 2020 a contractor was penalized $39,169 on a $1.5M contract. While it is an improvement to see penalties for poor performance occurring more frequently, they are relatively insignificant and far less aggressive than some other municipalities. We are not aware of any instances where road sections had to be completely removed and replaced as a result of unacceptable quality.

165 Overall, OCA concluded the City has not taken adequate action to correct asphalt that was of lesser quality than specified, nor has it adequately penalized contractors for poor performance. Penalties and fines for poor quality, to the extent they have been used in recent years, are relatively insignificant and do not act as a deterrent against low quality.

166 In evaluating Table 7 (see page 37) regarding the delivery of quality by contractor (or lack thereof), it can be observed that contractors who have delivered poor results in the past would nevertheless be awarded work in subsequent years. The current procurement framework is based on the lowest compliant bid regardless of past experiences with quality delivered by contractors. We observed that over a five-year period, 2014 to 2018 one contractor’s performance was very poor, particularly from 2014 to 2016 when the percent of acceptable samples ranged from 0% to 10%. Although this contractor was not producing acceptable asphalt pavements, this same company continued to be awarded contracts. According to our analysis, some contractors deliver better results than others. Yet the constraints of the current procurement approach provide little relief.

167 This situation is exacerbated by the fact that the City does not have a systematic method of tracking performance by contractor. Therefore, the City has very limited mechanisms through which it can manage and mitigate the risk of poor quality by contractors that repeatedly deliver substandard performance. A contractor evaluation and rating system, which is something in use by other road authorities, could assist the City in identifying recurring issues with specific contractors, and further, could be used to limit or modify future contract awards.

Detailed Observations

168 In Ottawa, for example, they have a system similar to the MTO which uses evaluations that are completed after each job as the basis to rate each contractor. The ratings for each job when averaged on a three-year rolling basis result in an "overall vendor score". The overall vendor scores can fall into 5 categories from outstanding to not satisfactory. Vendors with lower overall vendor scores are given more scrutiny by the City. Furthermore, bidding on any future work takes account of these scores in the bid evaluations. In fact, the bid evaluations consist of a score based 70% on price and 30% on the overall vendor score. Therefore, the use of overall vendor score or "rating" as a bid criterion can be effective in that the lowest bidder may be bypassed in favour of an historically better performing contractor. This also reduces any tendency for the lowest bidders to cut corners on the quality delivered.

Testing of Asphalt

169 Superpave - an acronym for "Superior Performing Asphalt Pavements" is an asphalt mix design method consisting of specifications, practices, tests, and analytical tools that are used to construct pavements that can accommodate the unique weather and traffic conditions of a given geography and provide predictable performance. It has been in use in Ontario since the late 1990's. Use of the Superpave method involves a battery of unique tests designed to ensure asphalt is mixed and laid down with the expected attributes to ensure pavements meet or exceed their design lives. There are tests specific to aggregate properties, and for the asphalt cement or "binder" and its characteristics, as well as for the mixture and proportions as a whole.

170 One notable aspect introduced by the Superpave method was a grading system for the asphalt cement. Under this system called Performance Graded Asphalt Cements (or PGAC), the asphalt binder material used in a specific pavement project, as modified, would be graded based on its response to temperature and ageing. The road authority specifies the grade it wants for each pavement project which can then be validated for acceptance using tests that are part of the Superpave system.

171 The other benefit of this grading system is that grades can be specified in accordance with environmental conditions and thereby deliver the required performance in terms of resistance to low temperature cracking, fatigue and high temperature deformation.

172 However, since about 2000, excessive, premature cracking began to appear in pavements throughout Ontario and the northern United States. Early investigation led some experts to believe that the problem stemmed from the PGAC system of grading in that it allowed asphalt cement to be modified with the addition of cheaper alternatives such as recycled engine oil, paraffin base oils, biobinders, waxes, acids and the use of air blowing. The use of these modifications was economically advantageous to suppliers while at the same time it allowed them to pass the existing tests and meet the required asphalt "grade".

Detailed Observations

173 As a result of these concerns, MTO, in collaboration with Queen’s University, embarked on years of research to study the causes of premature cracking and conducted trials to investigate improved PGAC test methods.

174 This effort led to the conclusion that one of the primary causes of early/excessive cracking in pavement was the poor quality of asphalt cement. They estimated it was a problem significant enough that it was costing $100’s of millions every year and was resulting in pavement overlays lasting only half as long.

175 The team at MTO and Queen’s also developed and advocated new tests that were better at predicting performance and which could be used as acceptance criteria. These were:

LS 308 - Extended Bending Beam Rheometer “EBBR”
LS 299 - Double Edge Notched Tension “DENT”

176 In addition, they recommended the use of two other tests:

LS 227 - Ash Content Test
Multiple Stress Creep Recovery Test “MSCR”

177 Two of these four crucial tests – the EBBR and DENT tests are not used by the City of Hamilton despite their being significant in determining quality. The DENT test is a measure of the asphalt’s ductile properties at low temperature and is associated with the material’s ability to stretch and resist cracking. The EBBR is a modification of an existing Superpave test and measures how adequately the asphalt meets its low temperature grade specification under a longer period (72 hours). Meeting the requirements of this test mitigates a pavement’s susceptibility to cracking over time.

178 These tests were implemented by a number of large municipalities in Ontario as far back as 2015, and became part of the Ontario Standard Specification for municipalities “OPSS MUNI 1101” in 2016. OCA interviewed experts at MTO and Queen’s University about the importance and efficacy of these tests, as well as engineers at two municipalities currently using them. There was consensus that these tests are vital to ensuring the quality and suitability of the asphalt cement used in paving, and the value for money ultimately obtained through a long lasting, durable product.

179 OCA has significant concerns about the City not using these tests based on the opinion of experts we have consulted, as it increases the exposure of the City to poorly performing asphalt. As we have seen in our other findings, Hamilton already has had issues in ensuring that contractors satisfy its current regime of tests, albeit with some improvement in recent years that we noted. However, without a regime that includes these tests as acceptance criteria, the City will have far less assurance in obtaining the quality of asphalt that it pays for, and needs, in order to have lasting, sustainable pavements.

Detailed Observations

180 Another issue in testing we found was the fact that Hamilton does not test the asphalt cement that is recovered from the actual mix being laid down on each project. Rather it performs asphalt cement tests on a supplier basis. Each contractor’s supply is tested once for the grades of asphalt that will be needed for Hamilton road projects, perhaps long before the actual job. The risk is obvious: the City isn’t necessarily testing the actual asphalt cement being used in the project. In some cases, there are exceptions where asphalt tests are sampled from the project. However, in these instances, samples are extracted from tanks at the asphalt plant. Experts at MTO and other municipalities advised that it would also be prudent practice to test recovered samples from the job site to mitigate against poor quality. Recovered samples are when the asphalt cement is extracted out of the actual laid down mix and they give the greatest assurance of quality and of meeting specification.

181 Based on a walkthrough of the process on one project that OCA attended, the method of inspection of laid down mixtures and for ensuring samples are appropriately drawn, and custody chain maintained until delivery to independent labs was found to be adequate. However, in general we had some reservations about the sufficiency of quality assurance resources. Management needs to rationalize the level of resources to ensure it can provide a consistent level of diligence in these processes.

Use of RAP (Recycled Asphalt Pavement)

182 Reclaimed asphalt pavement or “RAP” consists of asphalt that is recovered from existing pavements and reused as part of the mixes of new or rehabilitated pavements. The benefits of using recycled asphalt are obvious, lower cost and better for the environment. However, to some knowledgeable practitioners and experts it is controversial. Some of the issues include the fact that RAP can come from a wide variety of sources of varying or unknown quality, it has already oxidized and aged, and its ability to blend in with the virgin asphalt is uncertain. If the introduction of RAP changes the quality of pavement to the extent it is detrimental to durability and life of the pavement then it may well be that the assumed environmental benefits may not be realized, since the pavement will have to be redone many more times than would otherwise be the case.

183 In Ontario, practices vary. There are some road authorities that have had a bad experience with RAP and do not allow any of it, and others that allow it but limit the extent of its use to a specified percentage commensurate with what they believe to be the risk. MTO allows RAP but not on its surface layers of pavement. Hamilton allows RAP but places an upper limit of 15% on the proportion of reclaimed asphalt in a given mix. OCA is not in a position to comment on the efficacy of its use generally. The matter is highly technical, and

Detailed Observations

many studies have been and continue to be done. It appears from our review of literature that there is some consensus that properly controlled, and responsibly used, it can offer benefits while minimizing risk. However, we would expect there to be controls in place to ensure the quality, uniformity and suitability of RAP for each project. Such controls could include specifying specific sources that can be used, criteria for what is acceptable, conditions for storage and removal of debris, and fulsome procedures for sampling and testing the RAP.

184 As far as the City is concerned, OCA found it had no systematic, documented policies and procedures to ensure that the quality of RAP introduced into paving projects will not adversely affect the pavements they are used in. Further, the issue we raised about the City’s procedure that relies on tank samples for testing the quality of asphalt cement is also relevant. The introduction of RAP happens downstream of any such test thus the information relied on for the quality of asphalt binder won’t necessarily reflect the actual quality in the combined blend.

Pavement Design

185 The most important function of pavement is to be able to withstand the loads applied by vehicles using the road. In order to have lasting durability for fulfilling this mission, pavements must be properly designed, taking account of the strength of the underlying subgrade, its drainage characteristics, various construction materials and techniques, and many other variables. Pavement design involves calculations and design determinations across the entire cross section of roadway and right of way, so that the road subgrade, subbase, base, asphalt binder and surface layers of pavement work in tandem. In doing so, design brings about the desired performance characteristics of the pavement such as load carrying, smoothness, durability, safety and aesthetics, with the most effective designs achieving a balance between cost and these functional characteristics. In our audit we focused on design of flexible (asphalt) pavements.

186 In industry, practices in design have been evolving for many years and have been codified in two recognized standards AASHTO 93 and the more recent MEPDG.

AASHTO 93

187 AASHTO 93 is the most widely used pavement design guide in the United States, Canada, and many other countries around the world. The design guidance and procedures were developed and published by the American Association for State Highways and Transportation Officials (AASHTO) in 1993. It is based on a program of continuous research and improvement on pavements beginning with data obtained from road tests between 1958 and 1960. The guide provides procedures based on empirical relationships and underlines the importance of traffic loads, roadbed soils, construction materials, environment, and drainage.

Detailed Observations

188 While AASHTO 93 was a milestone at the time, the design procedures are considered insufficient to fully address modern traffic levels, advances in materials science, and the testing and construction methods of today. Industry has come to recognize the need for more advanced abilities to model pavement behavior over time.

MEPDG

189 MEPDG, the Mechanistic Empirical Pavement Design Guide was developed in 2004 to update the 1993 AASHTO guide and improve on its shortcomings. MEPDG uses advanced inputs and mechanistic models that relate stresses and strains to the mechanisms of pavement failure which are then correlated with field results to ensure accuracy. MEPDG will not only account for deterioration due to loading but also for a complete range of distresses.

190 In mechanistic-empirical design, different trial designs of the pavement structure are run through models using MEPDG software which computes how each design will respond to loads and environmental stresses. The models simulate how damage will accumulate for each design trial, leading to final selection of the design parameters that will best meet needs.

191 Clearly, the effort and research that has been put into the development of these pavement design protocols indicates the importance of pavement design. Both protocols are complex undertakings and pavement engineers require a lot of training, guidance and experience to most effectively implement and use AASHTO 93 and MEPDG. Toronto and Saskatoon are two cities that have formalized their approaches to AASHTO 93 with documented standards and procedures. In the case of Toronto, which introduced its "Pavement Design and Rehabilitation Guideline" in 2019, the city is moving towards implementation of AASHTO 93 along with MTO's corollary guideline "MI-183 Adaptation and Verification of AASHTO Pavement Design Guide for Ontario Conditions" for the verification of all rehabilitation works. They go on to suggest that future enhancements to their guidance would include MEPDG.

192 Hamilton's approach, historically, has been rooted in practices which based designs on empirical observation, experience and engineering judgement, supported by the use of templates which reflected a "boilerplate approach" to design. Essentially the method relied on the design engineer selecting a predetermined pavement structure based entirely on the type of road (i.e. local, collector, minor arterial, and major arterial).

193 This was a highly simplified approach to design and in a report in 2009, one consultant observed that "one of the major causes of poor performance of some pavements was poor pavement design." They advocated moving away from "off the shelf approaches" toward the formal design methods of AASHTO 93 and concluded that designs needed to take account of many more site-specific factors.

Detailed Observations

194 The consultant’s 2009 report stated:

> “It is our opinion that the off the shelf method of pavements for residential and industrial roads used currently by the City on some of the projects drastically oversimplifies the pavement design procedures. They do not reflect the traffic loadings, soil and water conditions and other important factors. As a solution, the pavement design methodology reflected in AASHTO 93 should be followed; however, its implementation requires significant experience and practical training is recommended for pavement design engineers.”

195 In a follow-up report in 2012 the consultant reiterated:

> “Currently the City uses an “off the shelf method” for pavement design. This oversimplifies the pavement design process and, in some cases, may result in poor pavement performance. It does not reflect, traffic loading, soil and water conditions. It is recommended that, as a short-term solution, the pavement design matrix should be expanded to reflect the soil and traffic conditions. As a long-term solution, the pavement design methodology outlined in AASHTO 93 should be followed especially for major roads with higher traffic volumes. Ultimately, Mechanistic Empirical Pavement Design Guide (MEPDG) should be followed. However, its implementation requires significant experience and practical training is recommended for pavement design engineers.”

196 Notable in the above is that the consultant was indicating how to improve the templated approach to design, referred to as a “design matrix” but only in the short term. In the long term they were still advocating for formal AASHTO 93.

197 In a follow-up report in 2013 the consultant noted some improvements to the “design matrix” that had been recommended as a short-term solution, but made many other observations for further efficacy. There were still many missing design inputs, and in particular a lack of subgrade/geotechnical factors.

198 The consultant stated:

> “The existing design matrix that is used by the City staff takes traffic volumes into consideration only based on the classification of a particular roadway.”

> “Our review of the existing design matrix showed that no particular consideration is given to the different soil conditions that may be encountered by the City, when the structural design of a pavement is being selected. In discussion with City staff it was noted that lack of subgrade soil conditions in the design analysis was one of the primary shortcomings of the existing design matrix.”

Detailed Observations

199 Therefore, despite the issue of incomplete pavement design methodology being brought to the attention of management at the time, they were slow to implement the required changes, and subgrade soil/geotechnical conditions were still not being considered in pavement design even four years after the recommendation had been made. This was likely a contributing factor in the poorer quality of the roads that were reconstructed and rehabilitated at the time.

200 With the assistance of an external consultant, OCA assessed the current situation with respect to the above issues. We determined that improvements have been made to take subgrade strength more formally into account in design by enhancing the design matrix, and through the evaluation of subgrade conditions on roads with heavier traffic. In certain situations, consultants are being employed to undertake cores and boreholes for internal design use, and in some cases full pavement design takes place on higher volume roads, with appropriate consideration of geotechnical issues.

201 OCA concluded management is generally aware of the importance of using AASHTO 93 and MEPDG guidelines in pavement design, though there appears to be little interest in MEPDG. However, the City has not formalized its processes to reach the level of maturity that some other cities have, nor that advocated by the original consultant recommendations. There still exists a lack of formal policies and procedures documenting how AASHTO 93 and MEPDG are to be used. The templated off the shelf method of pavement design is still being used in lower traffic volume roads.

202 Accordingly, OCA believes the City should continue to move away from boilerplate design to embrace AASHTO 93 and MEPDG in a systematic way, where feasible and economic. It should develop a design guide and associated procedures and protocols to codify expectations, and bring more sophistication to design, in order to help staff understand the requirements and provide guidance to consultants. In addition, there should be formal training provided to staff to enable use of the guidelines and equip them with a more expansive understanding of better practices in pavement design and related geotechnical knowledge.

203 In the absence of formal guidelines and training, employees will rely on personal understanding and experience. This could result in incorrect, incomplete or inconsistent practices. It would also be problematic for any new employee commencing duties and lacking this important knowledge.

204 In addition to these measures OCA believes that consideration should be given to having a designated position or updates made to existing position description(s) to ensure continued development and improvement in design toward a more mature state.

Detailed Observations

Road Utility Cuts

205 A road or utility cut is the excavation of a hole or trench on a City pavement, usually performed in urban areas, to repair or install utilities such as water mains, drainage structures, sewers, and gas mains. Since pavements are an important City asset and cutting into pavements may lead to their damage and premature degradation, road cuts need to be strictly controlled in order to minimize loss of serviceability and other costly impacts.

206 No matter how well a road is repaired after a road cut, a certain amount of degradation is unavoidable and for that reason some road authorities charge a degradation fee to the utility to compensate for these damages.

207 In addition, jurisdictions will typically have policies to minimize costly damage. This includes mutual planning to coordinate utility cuts with other planned rehabilitation work, compliance requirements and monitoring activities to ensure the highest quality of repair, encouraging the use of trenchless technology, and ensuring the financial burden of the road cut is borne by the utility.

208 In the past four years, the City of Hamilton has had between 2,300 and 3,300 road cuts per year. (At the time of this audit many 2020 numbers were not available.)

Number of Road Cuts and Restoration Costs Per Year

	2016	2017	2018	2019
Number of Road Cuts	3,300	3,050	3,330	2,363
Restoration Costs	$7.2M	$6.15M	$6.13M	$5.04M

Source: Engineering Services, City of Hamilton.

209 On average, over the past two years road cuts cost the City about $165 per square metre before recovery.

Cost/Square Metre Charged by the Contractor

	2018	2019
Cost/Square Metre	$163.98	$168.23
	% Increase	**2.60%**

Source: Engineering Services, City of Hamilton.

Detailed Observations

210 In the audit OCA found overall that a well-defined process exists to ensure minimal damage, adequate inspection and recovery of costs. The City has a utility cut policy outlining that an excavation permit must be purchased from the City, and a prescribed process must be followed to ensure timely and acceptable restoration of the pavement, and recovery of costs. The utility must complete a temporary restoration at their expense, which is meant to be followed within 18 months by a permanent repair carried out by the City at the expense of the utility.

211 OCA reviewed the process and took a random sample of 55 road cuts completed in 2020 which indicated that it takes from as little as 18 days to as much as 166 days to restore road cuts. On average it takes about 132 days (or about 4 months).

212 A utility company, or bonded contractor needing to excavate a hard surface must purchase an excavation permit and in 2020 that fee was $593. The only utility exempt from this fee is Hamilton Water, however what it does in lieu is to transfer commensurate compensation of a flat $500K per year to the City’s Administration Fees Account.

213 Once an excavation permit holder has completed their utility work, they place a temporary asphalt patch on the road and notify the City. The City inspects the initial road repair and arranges for permanent restoration through its own contractor. The repair is made in the presence of a City representative to ensure the contractor is adhering to the terms of the contract. Each month the City pays the contractor for these “pavement restoration costs” (PRCs) and seeks compensation from the utility.

214 The table below (Table 8) summarizes the breakdown of PRCs paid in 2019. Note that Hamilton Water was responsible for about 78% of road cut restoration costs.

Table 8: City of Hamilton 2019 Road Cut Expenditures

	Description	2019 PRC $000’s	% of Total
Hamilton Water	Water	$2,807	54.7%
	Wastewater	$1,188	23.1%
Utilities and Third-Party Water and Sewer Contractors	Contractual Services	$1,004	19.6%
Other Restorations	Catch Basins	$38	0.7%
	Minor Work	$61	1.2%
	Streetlighting	$14	0.3%
Other Associated Costs	N/A	$22	0.4%
Total 2019 Pavement Restoration Costs (PRC)		**$5,134**	**100.0%**

Source: Finance and Administration, City of Hamilton.

Detailed Observations

215 The City recovers the repair costs by invoicing the utility companies and adds a 15% administration charge and a pavement degradation fee. The table below (Table 9) summarizes the 2019 recoveries by category.

Table 9: City of Hamilton 2019 Road Cut Recoveries

	Description	2019 Recovery (in $000’s)	% of Total
Hamilton Water	Water	$2,802	38.0%
	Wastewater	$1,200	16.3%
Utilities and Third-Party Water Contractors	Utilities and Third-Party Contractors	$977	13.2%
Other Revenues	Admin Fees	$653	8.8%
	PDF[a]	$1,184	16.0%
	Excavation Permit Fee	$565	7.7%
Total 2019 Cost Recovery and Other Revenues		**$7,381**	**100.0%**

[a] Pavement Deterioration Fee transferred to Capital accounts by journal at year end.

Source: Finance and Administration, City of Hamilton.

216 From the above information (Table 9), it can be seen that the City recovered all of its PRCs from Hamilton Water and substantially all of its PRCs from third parties. In addition, there are charges for a “pavement degradation fee” (PDF). Due to the exposure to loss of service life and future higher costs of repairs, progressive cities have dealt with the degradation in value caused by road cuts in various ways - most commonly with a pavement degradation fee.

217 OCA reviewed the fees charged by Hamilton specifically looking for evidence that they were adequate to compensate for the potential damage that can result from road cuts. We reviewed the practices of other cities and researched the literature for studies and guidance in this area.

218 According to the US Department of Transportation Federal Highway Administration, road cuts “…almost always increase the roughness of the pavement structure in both the immediate and surrounding areas of the cut. Not only do cuts increase pavement roughness, but they also introduce discontinuities in the pavement structure. Both can cause the pavement's expected life span to decrease.”

219 In a 1999 study conducted by the former Regional Municipality of Ottawa-Carleton (RMOC) noted that “utility trenching was found to shorten the overall lifecycle of the RMOC’s urban pavements by 7.8%.”

Detailed Observations

220 In 2018 the City of Saskatoon, completed the most comprehensive study we could find of the impact of utility cuts on its roads network covering a three-year period from 2014 to 2017. The study examined roadway condition data, using both International Roughness Index (IRI) and Pavement Condition Index (PCI), comparing road sections with and without utility cuts that were performed during the above period. It found that both the IRI and PCI measures decreased more significantly in pavement with utility cuts. The study also found that the impact of utility cuts could be quantified, and a reduction in roadway asset value and pavement serviceability was calculated. The authors determined a cost impact per square metre of utility cuts to different road classes using both ICI and IRI for condition measures. The study found degradation in value that ranged from a low of $34 per square metre for collector roads in fair condition to a high of $163 for arterial roads in very good condition. The reason that roads in fair or poor condition have lower degradation cost is because they are already degraded and depreciated in value - thus the incremental amount of degradation is less. The average degradation across all road classes in the study was found to be approximately $91 per square metre of road cut.

221 In terms of what other cities do with respect to degradation fees, Toronto instituted a pavement degradation fee (PDF) in June 2010. This fee is collected from all utility companies and anyone else that accesses underground equipment services or structures. The fee is based on the size of the cut (measured in square metres) and is adjusted for type of pavement, type of road (arterial vs local/collector roads) and the age of the road (note that actual condition is not a consideration). The fee is not charged if the pavement is scheduled for reconstruction in the five-year capital program.

222 Ottawa introduced a PDF in 2000 to compensate the City for the structural damage and shortened pavement life from utility cuts. The fees are similar to those used by the City of Toronto and are charged on a sliding scale based on the age of the road surface being cut. The newer the road surface the greater the per square metre assessment of the fee.

223 The City of London adopted a flat fee for pavement degradation starting in July 2003 and phased it in over a 2.5-year period. The fee was also charged to City departments beginning in 2004.

224 The City of Hamilton began charging a PDF in 2007. However, the Overall Condition Index (OCI) score is used to assess the status of the road segment, which we believe is a more relevant measure as opposed to age. The fee charged is a percentage of the total cost incurred to restore the road and depends on the condition of the road at the time of the pavement cut. A different recovery percentage is assigned to each of the five OCI levels, with roads having OCI scores in the very good range being levied at a 52% surcharge and roads in very poor condition calculated as 10%. Thus, the recovery percentage, quite reasonably, increases in step with the OCI score.

Detailed Observations

225 In general, OCA concluded that the City had a well thought out process for the degradation fees compared to other cities. Charging a fee based on the percentage of the restoration cost helps keep the recovery in line with the rise in construction prices and the use of actual condition rather than age makes the fee more relevant and defensible. Both the City of Toronto and the City of Ottawa base their PDF on the age of the pavement and the amount charged depends on the size of the road cut in square metres as opposed to being based on repair cost.

226 Insofar as adequacy of the fee is concerned, it was difficult to determine whether the City’s pavement degradation fee is sufficient to cover the full cost of the deterioration caused by road cuts. No study has been done to determine whether the amount collected compensates the City for the actual level of road deterioration. Also, the percentages for recovery have remained unchanged since 2007.

227 When we examined the estimated damages calculated in the study done by Saskatoon, we noted that their estimate of the degradation costs incurred from road cuts ranged from a low of $34 per sqm to $163 per sqm with the average being $91 per sqm. In Hamilton, the fees in 2019 averaged $39 per sqm. OCA concluded it would be prudent for Hamilton to undertake a review of the adequacy of its current degradation fee structure in light of the higher amounts of estimated damages suggested by this information.

Other Findings

228 In addition to the above, OCA found two issues in the course of the reviewing road cuts that it brought to management’s attention.

229 A number of cases were found where pavement degradation fees were under collected for a period of five months in 2020 due to an error in administration. The dollar value of this error was $385,000 ($309K related to Hamilton Water and $76K to other utilities).

230 A complaint was received through the Fraud & Waste Hotline that the City had overpaid the road cuts repair contractor. OCA substantiated that a premium charge meant for repairs performed during winter months was being paid for work completed during non- winter months. The dollar value of this error was $79,000.

Detailed Observations

Preservation and Maintenance

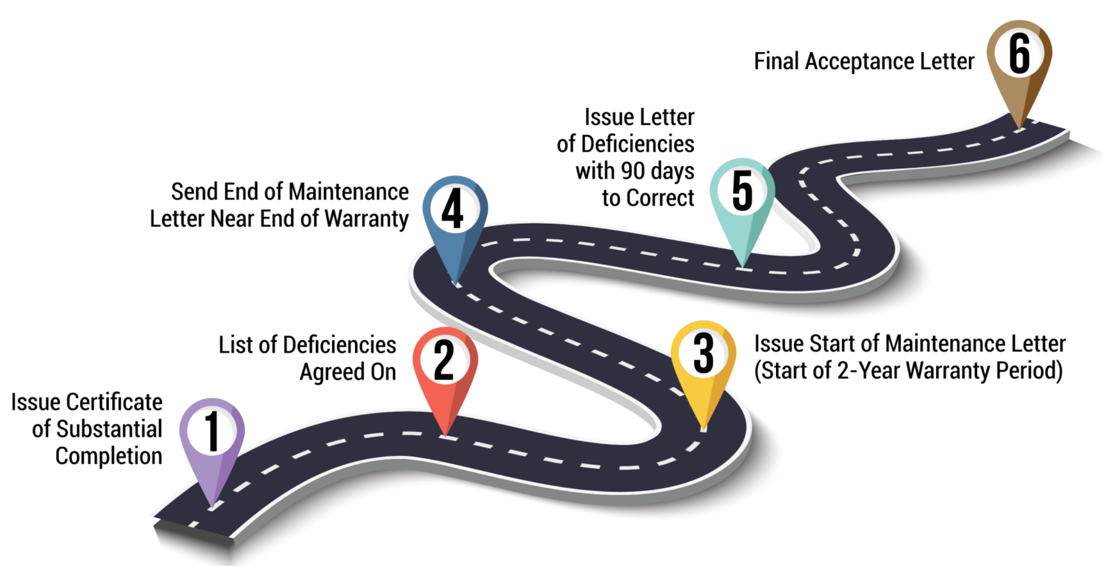
231 The objective of preservation and maintenance is to properly maintain pavements in order to maximize life and service. Aspects of the City's program that we included in our audit were warranty repairs on new, reconstructed and resurfaced roads; repairing deficiencies and defects that are potentially hazardous such as potholes and road shoulder drop offs; and applying preventive maintenance in the form of pavement preservation that can enhance, rejuvenate and extend the condition of the pavement surface.

Warranties

232 When a road construction project is substantially complete, the project manager issues a certificate of substantial performance and sends it to the contractor. They then meet to walk through the site, noting all deficiencies and determining whether they will be dealt with immediately or before the end of the maintenance period (warranty period).

233 Once the deficiencies have been addressed (Fig. 5), a "Start of Maintenance" letter, informing the contractor of the beginning of the two-year warranty period, is prepared and sent to the contractor. Thirty days prior to the end of the maintenance period an End of Maintenance letter, reminding the contractor that the maintenance/warranty period is about to end is delivered to the contractor. A final inspection is conducted, and a documented list of the deficiencies is made by the project manager. The contractor is given 90 days to correct the deficiencies after which the City issues a Final Acceptance Letter. From this point on the contractor is no longer responsible for any deficiencies that may arise.

Fig. 5: Warranty and Final Acceptance Timeline



Detailed Observations

234 OCA had the following observations with respect to warranty administration.

235 In some cases, the End of Maintenance Letters are sent five or six months before the warranty period expires instead of 30 days. According to management this occurs when there are many deficiencies for the contractor to correct and management wants to provide the contractor with advance notice.

236 Despite being given End of Maintenance Letters earlier than normal, contractors take their time to correct the deficiencies – in some cases an extraordinary amount of time.

237 For example, in seven of the ten contracts OCA reviewed that were deemed substantially completed in either 2017 or 2018 the outstanding deficiencies were still not corrected as at February 2021. In fact, these contracts have been out of warranty for a period ranging from two months to 18 months.

238 Given that all holdbacks have been released to the contractor there appears to be little financial incentive for contractors to execute timely remediation which in some cases could have a deleterious impact on the road asset. Also, these contracts are out of warranty and management is relying on verbal agreements with the contractors to correct the deficiencies noted. The verbal agreement often specifies the date by which the deficiency is expected to be repaired (i.e. spring 2021).

239 OCA also observed that Transportation Operations and Maintenance (TOM) staff, who ultimately maintain the road after final acceptance, are not involved in identifying any of these deficiencies, nor do they appear to be made aware of them formally.

240 OCA believes there should be greater information sharing about the issues surrounding new or rehabilitated pavements to alert Operations to potential issues down the road and to give that Division some voice in the adequacy and timeliness in which contractors address deficiencies since they will be responsible for maintaining the roads in adequate state of repair.

Potholes

241 The City classifies potholes according to the Minimum Maintenance Standards in Ontario Regulation (O.Reg) 239/02. The potholes are identified by City Road Patrols and/or by citizen complaints. If the potholes meet or exceed the standard surface area and depth noted in this regulation, they are marked by road patrol crews and counted as Minimum Maintenance Standard (MMS) potholes. It they are smaller in size, they are counted as non-MMS potholes. Note that O.Reg 239/02 sets a standard timeframe within which potholes are to be repaired once the City becomes aware of its existence. However, this time standard does not apply to non-MMS potholes.

Detailed Observations

242 The following table (Table 10) shows the number of potholes identified and their cost of repair for the years 2017 to 2020.

Table 10: City of Hamilton - Number of Potholes Reported and Repaired by Year

	2017	2018	2019	2020	2017 to 2020 Total
Non-MMS Potholes	34,340	44,398	31,984	35,338	146,060
MMS Potholes	2,421	2,124	1,140	787	6,472
Total Number of Potholes	**36,761**	**46,521**	**33,124**	**36,125**	**152,532**
Non-MMS ($000’s)	$2,617	$3,863	$3,105	$3,048	$12,663
MMS ($000’s)	$180	$346	$159	$88	$773
Total Pothole Repairs ($000’s)	**$2,797**	**$4,209**	**$3,264**	**$3,136**	**$13,406**
Average Cost/sq.m	**$76.12**	**$90.50**	**$98.54**	**$86.81**	**$87.89**

Source: Transportation Operations and Maintenance, City of Hamilton.

243 As can be seen in the Table 10 above, the vast majority of potholes are non-MMS. In fact, only about 6% (by dollar value) of the potholes are MMS. That means the strict timeframe standard for remediation only applies to a very small portion of the City’s potholes. We confirmed that the time standard for MMS was consistently met. However, since non-MMS sized potholes are not covered by this regulation, these potholes are not repaired as quickly. As a matter of accountability and transparency, OCA believes standards should be in place and public information made available on the achievement of those standards for MMS, non-MMS as well as for pothole complaints submitted by members of the public.

244 In the table below (Table 11), over the four-year period from 2017 to 2020, claims against the City by motorists whose vehicles were damaged by potholes totalled $218K, but more than half of those claims occurred in 2018.

Table 11: Number and Amount (in $000’s) Paid Out for Pothole Claims per Year

	2017	2018	2019	2020	2017 to 2020 Total
Number of Claims	114	533	185	66	898
$000’s Paid Out	$42.3	$121.6	$39.1	$15.1	$218.1
Average Pothole Claim (in $)	**$371.40**	**$228.14**	**$211.35**	**$228.90**	**$242.87**

Source: Risk Management, City of Hamilton.

Detailed Observations

245 OCA notes there is a strong correlation between the number of non-MMS potholes and claims filed by motorists against the City. This is likely due to the fact that MMS potholes, potholes that are larger and subject to rigorous standards for remediation, are only a small fraction of the problem. In addition, we observed that MMS potholes are being remediated consistently according to standards. It seems logical to us that to reduce pothole claims the City should focus its attention on the non-MMS potholes starting with a standard timeframe for remediation.

246 While the City of Hamilton identifies and classifies potholes in a manner consistent with other large municipalities in Ontario (MMS vs non-MMS), it is inherently difficult to assess the level of effort and productivity achieved in pothole repair since pothole sizes can vary widely. To mitigate this challenge, one method we came across in our research and used by the City of Edmonton, calculates the number of “potholes” filled by defining a standard pothole size in terms of the weight of asphalt placed.

247 The number of standard potholes can be determined from the total weight of asphalt placed in the season. This enables the City to more accurately compare the activity levels using the number of standard sized potholes from one year to the next. This can be valuable information to have alongside the current approach that relies on pothole “sites”.

248 Overall, we concluded that to improve efficiency, accountability and transparency MMS potholes, non-MMS potholes as well as those derived from public complaints should be subject to remediation time standards that are tracked and publicly reported.

Pavement Preservation Management

249 A key aspect of operating the road system is pavement preservation management. Pavement preservation consists of carefully selected treatments performed to prevent premature deterioration of the pavement or to retard the progress of pavement defects. The objective is to slow down the rate of deterioration and effectively increase the useful life of the pavement. Examples of preventive maintenance are crack sealing, thin overlays and microsurfacing.

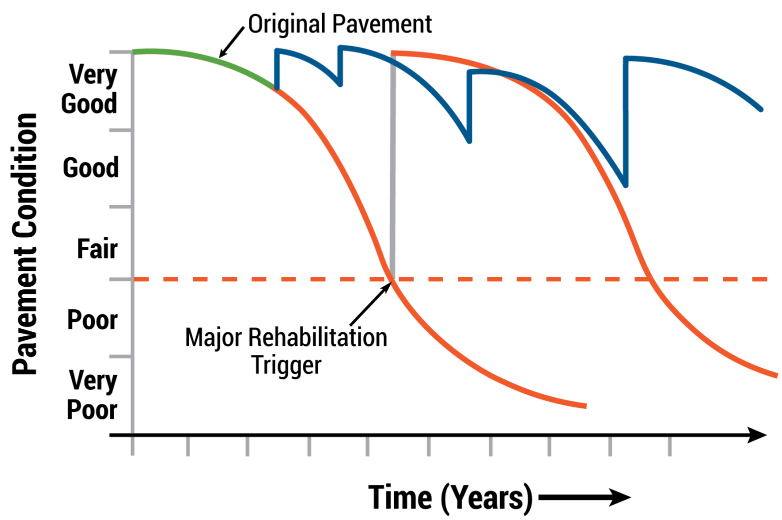
250 Preservation management, or proactive preservation, is a proven, highly cost-effective way of optimizing the life of the network. However, it requires investment outlay in the earlier years of the life of pavement. According to the Federal Highways Administration, for successful pavement preservation “a longterm commitment and financial support is required. Pavement preservation is more than just a collective set of specific pavement-maintenance techniques. It is a way of thinking and guiding force behind an agency’s financial planning.”

Detailed Observations

251 In Hamilton, we saw very little evidence of preservation management being applied in any systematic way on urban roads. Rather, preventive treatments are applied only sporadically in the form of crack sealing and surface treatments. Some years the budget for crack sealing treatments has been zero with the high end of spending being $100,000. One exception was in 2017 where there was an extensive program of crack sealing.

252 The reason preservation management is so critical is that the investment can be small, yet significant leverage realized in the form of extended time before rehabilitations, as can be seen in the following diagram (Fig.6).

Fig. 6: The Pavement Preservation Concept



Source: National Center for Pavement Preservation.

253 Lack of systematic preservation management is symptomatic of a more reactive system of asset management. As previously discussed in this report there has been no prominent role for preservation management in optimizing the condition of City roads.

254 In the past, consultants engaged by the City have advocated for a broader range of surface applications, however the use of these techniques in Hamilton remains limited.

255 As noted previously, the crack sealing program is inconsistent. In addition, the City’s surface treatment program is primarily performed on rural roads (annual expenditure $2.5M).

256 Surface treatments that are used consist mostly of chip sealing – both single and double course; and bonded wearing course.

257 The road preservation techniques listed in the adjacent box are examples of different techniques recommended by the consultant that could be used economically to extend pavement life by four to fifteen years.

Box 2: Types of Preservation Management Treatments

Crack Sealing

This process is performed routinely by some municipalities when cracks appear in the pavement surface. Crack sealing prevents water from entering the pavement top course and involves routing or sawing a reservoir, preparing the reservoir through abrasive blasting, and thoroughly cleaning it with compressed air. Hot-poured, rubberized asphalt sealants are most commonly used to seal the reservoir.

Slurry Seal

Slurry seal treatments are used to cap the existing pavement surface, slow surface raveling, close small cracks and improve surface friction. Slurry seals are a mixture of aggregate (fine and well graded gravel), slow setting asphalt emulsion, water and mineral filler (most often Portland cement). The construction of slurry seals is covered by OPSS 337 “Construction Specification for Slurry Seals”.

Micro-Surfacing

Micro-surfacing is applied on roads that carry a medium to high volume of traffic, on high speed roads and also on airport tarmacs. Micro-surfacing provides a high-quality skid resistant surface for an existing asphalt concrete pavement, seals the pavement surface, restores surface profile, eliminates hydroplaning, and provides a surface that is more resistant to rutting and shoving. The construction of a micro-surfacing is covered by OPSS 336 “Construction Specification for Micro-Surfacing”.

Bonded Wearing Course

Like the other preventive maintenance treatments, the placement of bonded wearing course does not improve the structural capacity of the road, but this treatment greatly improves ride quality. The bonded wearing course provides very good frictional characteristics, seals the pavement surface, stops surface distresses, and reduces hydroplaning.

Chip Sealing

Chip sealing is a two-step process where the pavement is sprayed with a coat of asphalt and then covered with coarse aggregate. The seal coat is normally an asphalt emulsion with a high viscosity to help embed the aggregate in the asphalt. Chip sealing helps improve surface friction and seals pavement with mild non-load related cracking. On low-volume roads, a chip seal may be used as a wearing course.

Seal Coat

The top course of the pavement can loosen over time because of weather conditions, gasoline/oil spills, and normal wear and tear. This causes erosion of the top layer allowing moisture penetration and subsequently asphalt cracking. The application of a seal coat over an old worn top course helps to restore and protect it.

Thin Asphalt Overlay

Different types of thin asphalt overlays are used to accommodate different needs and correct different surface deficiencies. For example, thin asphalt overlay can restore skid resistance to a pavement whose surface has begun to polish; they can seal existing pavement from external moisture; and, since they use smaller aggregate particles, they have a tighter finish resulting in a more pleasing appearance. Thin asphalt overlays can be used on various types of roadways, from low-volume city streets to high-volume interstates. If the existing pavement is structurally sound, the component materials of good quality, the asphalt mixture properly designed, the mix design accurately replicated by the plant, a thin asphalt overlay can last over 15 years.

Photos used with permission. Source: Ted Phillips, McIntosh Perry Consulting Engineers Ltd.

Detailed Observations

Procurement, Contract and Financial Management

258 In response to issues cited in other municipalities, such as in the report, "Detection of Warning Signs for Potential Bid Rigging Should be Strengthened" (Auditor General's Office, City of Toronto), the Office of the City Auditor assessed whether there was any indication of irregularities in procurement that would be indicative of a lack of competition, or that pose a risk to achieving value for money. OCA reviewed 50 road resurfacing contracts and eight road surface treatment contracts covering the period from 2013 to 2019 inclusive. A number of red flags were noted that signal risks related to market domination, bid suppression, cover bidding and low bid-low quality events, and which call for the need for vigilance by management in the tendering and monitoring of contracts.

259 In the case of road resurfacing, during a seven-year period between 2013 and 2019, one contractor was awarded 52% (26 of the 50) of the tenders reviewed worth $36.0M of the $77.8M total. Three contractors accounted for 90% (45 of the 50) of all road resurfacing tenders worth $71.2M of the $77.8M.

260 Also, for these road resurfacing tenders, one contractor bid 24 times without winning a tender while another bid 28 times winning only two. In 22 of the 50 bids reviewed, the highest bid submitted exceeded the lowest (winning) bid by 30% or more, and in six cases the highest bid exceeded the winning bid by 50% or more.

261 In the case of the one contractor that won the majority of the bids tendered for road resurfacing during the seven-year period this is the same contractor that was singled out for poor quality by an engineering consultant's report. In our opinion, this is indicative of a low bid low quality red flag. A vendor who has been incapable of meeting the standards specified by the City in a prior contract should not be rewarded with a new one if quality cannot be assured.

262 In the case of surface treatments, a pattern was noted regarding projects over multiple years. Many different contractors (up to ten contractors in the seven-year period between 2013 and 2019) have paid for and picked up tender documents for the surface treatments of roads. Yet, during this seven-year period only the same two contractors ever bid on this project.

263 It appears that contractors offering generalized road resurfacing work do not bid on specialized surface treatment contracts and vice versa. The yearly tender issued by the City for the surface treatment contract requires vendors to perform activities such as crack sealing, micro-surfacing, bonded wearing course, slurry seal, etc. The two road contractors that have bid on this recurring job in the past possess the specialized equipment needed to perform this work. In 2019 management made it easier for these two contractors to divide the market even further by splitting the surface treatment tender into two – surface treatment and bonded wearing course. As a result, the contractor that won the surface treatment contract did not bid on the bonded wearing course contract.

Detailed Observations

Change Orders

264 In the course of completing road construction work, situations may arise requiring changes that were not specified in the contract. These changes are referred to as Extra Work or more commonly as Change Orders. Since the work necessitated by Change Orders was not specified in the original agreement it is subject to greater risk and could result in the City overpaying for the work, or the work not being performed to the City’s standards.

265 The following lists the OCA’s findings on a sample of 16 Change Orders from five contracts that were reviewed.

266 Overall, OCA concluded that the extra work respecting the 16 Change Orders was legitimately required and was not covered in the original contract. Work that needed to be done was identified by the City after the contract was issued. However, we also identified that:

- For 44% of the sampled Change Orders the work could and should have been factored into the project design or specifications.
- For 56% of the sample unforeseen circumstances that could not have been reasonably predicted were the cause of the Change Orders.

267 Some items that caused the Change Orders above have been included in the specifications of subsequent contracts and tender documents and will likely not result in future Change Orders.

268 The total costs of all the Change Orders reviewed were not significant when compared to the contract amount. They ranged from 0.36% - 2.78% of the successful bid. This is well below the standard contingency applied to most construction contracts. Therefore, in the cases reviewed, the contingency was enough to absorb the Change Order costs. Also, in four of the five contracts reviewed the amount bid by the successful bidder plus the cost of the Change Orders was less than the amount bid by the lowest unsuccessful bidder.

269 However, in most cases the Change Orders were not approved in writing by the Project Manager before the work was performed as required by Form 200.

270 Although the OCA was able to validate certain components of the cost calculations (contractual mark-up rate, labour and equipment hours, labour rates etc), in some instances the documentation was inadequate and OCA was unable to determine whether the amounts charged on the Change Orders were appropriate. Management should consider documenting expected minimum rates in an internal document that may be used as a common point of reference for all project managers; and requiring contractors to document the make/model or specifications of equipment on the Time and Materials Summary for Payment sheet that may be matched up to the Ontario Provincial Standard Specification (OPSS) 127 Schedule.

Detailed Observations

Roster Management

271 The purpose of the roster is to have competitively chosen, pre-selected consultants available to make the procurement process timelier for smaller dollar-value projects. It applies to procurements of up to $150,000 (previously $100,000) and balances the need to ensure value for money through a competitive process with the ability to realize beneficial efficiencies.

272 The OCA assessed whether, when the roster was used to procure road related construction goods or services, management divided one assignment (i.e. “split” the assignment) into two or more smaller ones in order to remain within the $150,000 roster limit and avoid lengthier procurement alternatives. Analysis on various projects indicates that this splitting has occurred.

273 In one case there were four separate Purchase Orders (POs) issued for $149,900 that related to one job, three of which were in the same calendar year. The total amount eventually spent on the work was $546,640. Management should have known in advance that since the project was being rolled out in different phases the roster limit would be exceeded.

274 There were several other examples of split POs as well.

275 In relation to QA/QC testing OCA identified 8 situations of split POs issued to vendors which exceeded the $150,000 roster limit. In general, QA/QC testing is problematic because the services do not relate to a stand-alone project and the volume of testing in a given year will far exceed the $150,000 roster limit. Management at the City’s Procurement section confirms that using the roster for QA/QC testing does not fit or embody the same intent as other roster assignments.

276 With respect to consultants hired to complete design work, OCA identified eight road construction projects where the consultants initially hired through the roster to complete the preliminary designs were also contracted through the roster to complete the detailed designs for the same projects using separate POs. This also resulted in the $150,000 roster limit being exceeded. In these situations, the consultant hired for the preliminary design was later contracted for other related tasks on the same project (e.g. detailed design, construction administrative services, etc.) due to their familiarity with the project.

277 If management is going to procure multiple tasks with the same vendor because of the knowledge they gained in the project design phase, then the vendor should not be procured through the roster.

Detailed Observations

278 The OCA also identified several examples where either:

- The scope of work was expanded during the project which pushed the consultant’s costs over the roster limit; or
- The consultant was hired to perform the same work at different locations but the total for that service was greater than the roster limit.

279 In these later examples, there was no indication that management purposely split the work to take advantage of the roster, but it is also unclear whether management underestimated the extent of work required when the roster was initially used. There may be an opportunity for management to better define the scope of work at the beginning of the project so that another procurement method may be used at the onset. Otherwise, management should be reporting these overages as Policy 11s or work with Procurement to find another way to handle scope extensions during roster assignments.

Vendor Management

280 Vendor management is important to ensure that value for money is achieved in road construction contracts. While this audit was in progress, a Fraud and Waste report was received by the Office of the City Auditor related to vendor management and project management practices.

281 A detailed review was conducted the results of which are included in this report. Five PO’s were reviewed. Several issues were noted including:

- Budgeted funds from completed projects with unspent/surplus balances were used to pay for two unrelated contracts at different locations where there was no budget remaining. The proper procedure should be to show the projects coming in above or below budget as appropriate. This was challenging to detect as the details recorded in the PeopleSoft Financial system did not reflect where the actual work was performed. While this action has no effect on the overall balance of roads spending, such practice makes it difficult to track underspent/overspent projects. Also, since the appropriation to move funds between these projects was not approved, it contravenes the Capital Projects’ Budget Appropriation and Work-in-Progress Transfer Policy.

Detailed Observations

- Progress payment supporting documentation did not always correctly identify the exact location of the work completed. It is important that project budgets be adhered to and are utilized for their intended purpose. Without accurate progress payment documentation, it is challenging for project budget controls and monitoring to be effective.

- Per the Construction Act, an invoice is required for every payment that is made to a contractor. Yet OCA found that Contractors were not submitting invoices for payment. Instead, City staff were generating progress payment certificates (PPCs) and using that information as the basis for making payments to contractors – without an invoice. OCA has two issues of concern with this practice. First, it violates the Construction Act. Second, it constitutes poor controllership. If an error is made in the calculation the City runs the risk that an undetected overpayment will be made in favour of the contractor.

282 It is important that project budgets be adhered to, payments are properly controlled and allocated, and project budgets are utilized for their intended purpose.

Recommendations

283 Please refer to Appendix “B” to Report AUD21006 for a list of Recommendations and the related Management Responses that will strengthen controls and enhance the value for money achieved in the Roads Program.

Conclusion

284 The OCA has brought forward several observations and recommendations to strengthen controls and enhance the value for money achieved in the Roads Program. Public Works has an opportunity to undertake transformative change in this area.

285 The OCA is confident that the dedication shown by staff throughout this audit can be harnessed to undertake courageous change. The OCA would like to thank Engineering Services Division and Transportation Operations Division staff and other participants for their contributions throughout this project. We look forward to following up with management in the future to see the progress of their action plans and their impact on achieving value for money in service delivery.

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