Performance Audit: Pavement Condition Measures

October 2008

City Auditor
City of Lawrence, Kansas

October 2, 2008

Members of the City Commission

The city measures the condition of streets and uses the information to plan maintenance and provide information to the City Commission and the public about the condition of city streets. This performance audit reviewed the city's condition measures and found them to provide reliable information on the condition of city streets.

Based on this performance audit, I made four recommendations. The city should better document the database used to store and analyze the condition information. The city should develop a policy on backing up the information. The city should plan to update the condition information because more data are necessary for the information to remain useful. Finally, the city should either enforce the excavation permit ordinance or develop a revised approach to managing the right-of-way.

I provided the City Manager and directors of Public Works and Information Systems with drafts of this report on September 24, 2008. Management's response is included in the report.

I appreciate the cooperation and assistance I received from the City Manager's Office, the Information Systems Department, and the Public Works Department, as I conducted this performance audit.

Michael Eglinski
City Auditor

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Results in Brief

The city's pavement condition measures provide reliable information on the condition of the city streets. Reliable information helps the city identify pavement maintenance and repair projects, evaluate design standards, and determine appropriate maintenance. With appropriate maintenance, the overall condition of the city's streets should improve in a cost effective manner.

The Public Works Department should plan to regularly measure the condition of city streets and update the information in the pavement management system. As the city develops a longer history of pavement condition and maintenance information, the city will be in a better position to plan and evaluate maintenance efforts and forecast the future conditions of city streets.

City staff should better document the database and develop formal policies and procedures for backing up the database. Doing so would make using and maintaining the information easier in the future.

The city should enforce the existing requirement for an excavation permit for anyone digging in or under city streets and sidewalks. Although the city code currently requires such permits, the city has not been issuing them. Before enforcing the existing ordinance, the City Manager should consider reviewing the city's overall approach to managing the right-of-way. Managing the city right-of-way protects the public interest and minimizes damage to infrastructure.

While the city's pavement measures reliably reflect the street conditions, those measures do not always match residents' perceptions of street conditions. Drivers tend to notice bumps and smoothness, while pavement managers measure all defects, including those that have little immediate effect on the ride. Understanding some of the differences between those two points of view, helps put the results of citizen surveys and measures of the condition of pavements in context.

City inspectors look for visible distresses and evaluate the severity and extent of those distresses. These photos illustrate some of the types of problems seen by inspectors.

Performance Audit: Pavement Condition Measures

Introduction

The city measures the condition of city streets and then uses those measures to help allocate resources for maintenance, monitor the results of maintenance, identify policy issues, and make budget projections. The 2009 Budget includes about $5 million for street maintenance. Reliable measures help the city best maintain the streets.

Lawrence residents expressed dissatisfaction with the condition of city streets in the 2007 citizen survey. Residents identified the condition of city streets/infrastructure as the area the city should most emphasize over the next two years. They also rated the maintenance of city streets and infrastructure as the major service they were least satisfied with. When asked about specific aspects of maintenance and public works, residents were least satisfied with the condition of major city streets and the timeliness of street repairs.

This performance audit addresses the city's measures of pavement conditions, specifically:

- Does the information in the pavement management system accurately reflect the conditions of city streets?

Public Works Department staff designed the pavement measurement system. Staff inspects city streets to identify defects, enters those results into a database, and analyzes the information in the database. Inspectors completed a survey of all of the streets in the city 2005, and reinspected about 35 percent of the streets as of May 2008.

The city has been using the pavement management system since finishing the first round of inspections. Among the uses have been: identifying specific projects and types of repairs, predicting maintenance needs, estimating the effects of maintenance, identifying budget needs, and analyzing existing street conditions within a redevelopment area.

Components of a pavement management system

Regularly collect pavement condition data. Public Works staff inspects streets, notes defects, and enters the inspection results into the database. Information Systems staff enters new street segments and updates work history.

Database to sort, store, and map the data. Information Systems staff maintains the pavement information in a geodatabase format which stores both tables and spatial information.

Analysis to evaluate repair and preservation strategies and identify cost effective projects. Public Works and Information Systems staff work together to develop questions, analyze the data, and generate reports for management and the City Commission.

Pavement management systems involve collecting information on basic surface distresses and then using those distresses to calculate a pavement condition index (PCI). A pavement with no visual distresses rates 100. Points are deducted for each distress, adjusted for both severity and extent of the distress, to calculate the PCI for a segment of street.

Pavement measures and work history provide reliable information on the condition of streets

The city's pavement measures and work history provide reliable information about the condition of city streets. City staff inspected streets, identified and quantified defects, and calculated pavement condition scores. Those scores combined with recent maintenance work and an understanding of how pavement deteriorates over time provides reliable information on the condition of city streets.

The City Auditor tested both inspection and work history data and found no discrepancies that would lead to a high risk of errors when using the information to judge the condition of streets, evaluate repair and preservation strategies, and identify cost effective projects The auditor compared the physical conditions of 40 randomly selected street segments with the inspection results. In a few cases, the auditor followed up with public works staff to confirm the results of the inspections. The auditor also reviewed work history records and traced those records to the work history information in the pavement database. The auditor noted some potential discrepancies, but follow up work cleared up the discrepancies or determined that the effect was insignificant. Table 1 provides examples of potential discrepancies and their resolution

Table 1 Examples of potential discrepancies and resolution

Potential discrepancy	Resolution
The pavement database noted patching on a segment of W 8th Court, but the defect was not readily apparent when visited by the City Auditor.	Public Work staff identified small areas of patching at the edge of the road that would not have affected the ride but could allow water to get under the pavement.
The pavement database noted debonding along a segment of Missouri Street, but the defect was not visible when visited by the City Auditor.	Public Works staff identified a concrete patch that repaired the debonding. The patch was made after the initial inspection.
Public Works records indicated that a segment of Rhode Island Street was overlayed in 1966 but the pavement system doesn't include that work.	Asphalt was removed – exposing the current brick surface – in the 1980s. The discrepancy would not affect estimates of deterioration or measures of the current condition.
City contract files indicate that a segment of Peterson Road was treated with chip and seal in 1991, but the pavement system doesn't include that work.	The pavement system includes a 1996 street reconstruction. Any work prior to 1996 would not affect the condition of the street after the reconstruction.

City staff have taken steps to strengthen the reliability of the pavement condition information. For example, staff:

- Maintain the pavement data in a database and intend to update the information regularly;
- Collect field data using computer-based forms that guide the process, prevent inconsistencies, and automate calculating the pavement condition index (PCI) scores;
- Define and illustrate defects through an inspection manual to ensure consistency;
- Document some aspects of the data within the database;
- Back up the database, so information could be restored;
- Limit access to the data files to authorized users, protecting the security of the data;
- Make the information available to the public; and
- Use the pavement information to understand conditions and provide information to management, the City Commission, and the public.

Reliable information on the condition of city streets provides a sound basis for allocating maintenance and providing information to the City Commission and public.

Regular updates necessary to maintain reliable information

The pavement condition measures will need regular updates to remain useful. Updates will require the city to continue to devote staff and other resources to inspecting streets and maintaining the database.

To provide better information on the condition of streets and to better estimate the rate of deterioration of pavement in Lawrence, the city will need to conduct several condition inspections for each street segment and continue to maintain the data. To date, the city has inspected the entire city once and about 35 percent of the city a second time. With several cycles of inspection results, the pavement system should be able to predict local conditions – including deterioration rates – with reasonable accuracy.

Currently, the city estimates how streets deteriorate based on relatively few inspection results. As a result, the average rates reflect a wide range of deterioration. For example, on average arterial streets lost 3.26 PCI points each year, but individual streets lost between 0 and 11.8 PCI points each year. Pavement management systems can provide very accurate information, but several cycles of inspections are needed. Having more information should allow the city to develop more accurate deterioration estimates, providing better information for making decisions and understanding the effects of those decisions.

The city will also need to collect and maintain information on work done to maintain and repair streets in the pavement database. Having a record of the specific maintenance done on street segments will allow the city to estimate the effects of maintenance on pavement conditions and deterioration rates.

Collecting and maintaining the pavement condition information requires staff resources for inspecting streets, entering the data into the database, maintaining the database, and analyzing the information. Two inspectors – working primarily on inspecting streets – can be expected to collect data on about 1.5 miles of streets in a day. At that rate, inspecting each street once every four years would require about 50 workdays of two inspectors' time. Maintaining the database and analyzing the information would be a significant job function of a GIS analyst, representing about 1/3rd of an analyst's work.

Previous Pavement Management System Wasn't Maintained

The city used a pavement management system before, but was unable to maintain the system. In the late 1980s, the city used Micro PAVER, a pavement management program developed by the U.S. Army Corps of Engineers. Four interns inspected the street system, completing paper forms to record the inspection results. Staff entered inspection results and some maintenance history into the software.

The city's efforts to use Micro PAVER weren't maintained. City staff suggested that the reasons included a lack of staff to continue inspections after the interns left, problems with computer hardware and software, and a lack of institutional support for the pavement management system.

While the city's Micro Paver system didn't last, city staff used Micro PAVER records to help develop detailed work histories for streets as part of the current pavement management system.

The director of Public Works should plan to provide adequate resources to maintain the pavement management system. Maintaining the information over the coming years addresses the risk that the information becomes out of date, weakening the basis for allocating maintenance spending.

Better documentation of pavement database would strengthen reliability

The city should better document the pavement database and write policies on backing-up and restoring data. Doing so would make the information easier to use and provide a basis for maintaining the information in the future. Because the pavement information needs to be maintained over several years, documenting the system and writing policies are particularly important to ensure continuity of the system.

Better documenting the database would help use and maintain the pavement management system in the future. Currently, documentation includes some information in the distress manual, staff notes, and information within the database itself. Much of the information about the database resides with one staff person. Compiling documentation, such as information on the structure of the data and instructions on how to use the

system, should help ensure the system remains useful in the future and the city does not lose use of the information if one staff person is unavailable.

Information Systems regularly backs-up the pavement databases, but the process follows no formal policies. Writing policies and procedures for backing up the database, perhaps as part of a broader business continuity plan, would help administrators restore data following a problem, such as an equipment failure, or an accident.

City should enforce excavation permit requirement

City Code requires people to get permits before excavating on streets or sidewalks, but the city has not been issuing or enforcing the requirement. Street inspectors consider restored excavations when they rate streets and the excavations affect the overall PCI score for a street. Excavation permits help cities manage use of the right-of-way, improve traffic safety, reduce user inconvenience, and minimize damage to city infrastructure.

City Code requires that before digging in or under a city street or sidewalk, a person must have an excavation permit issued by the city. The City Engineer reviews and approves permit applications and the City Clerk issues permits after an applicant pays a $15 fee.[1] The city established the requirement in 1904 and most recently updated the ordinance in 1976. Franchised utilities are subject to city rules and ordinances relating to permits such as the excavation permit.

While the city issues permits for temporary use of the right-of-way and constructing driveways, the city does not currently issue excavation permits. City staff was not aware of why the city doesn't issue excavation permits or when the city may have stopped issuing the permits.

Other Kansas municipalities require excavation permits. Searching the web pages of municipal governments found excavation permit requirements for Wichita, Overland Park, Wyandotte County/Kansas City, Topeka, Olathe, Shawnee, Manhattan, Salina, and Lenexa.

The city should issue the permits required by the Code. However, rather than developing a method to issue and enforce the existing excavation

[1] The City Commission set the current permit fee of $15 by ordinance in 1976. The fee was set to cover, in part, the cost of regulations of street excavations and issuing excavation permits. Because of inflation, a $15 fee in 1976 would have the buying power of $58 in 2008.

permit requirement, the City Manager should consider reviewing the city's overall right-of-way management approach.

Right-of-Way Management

Managing the right-of-way helps a city minimize traffic safety concerns, avoid unnecessary traffic hindrance, and minimize damage to streets, curbs, drainage structures and sidewalks. State law allows cities to collect fees related to right-of-way:

- Permit fee to cover processing
- Excavation fee for pavement cuts to cover costs related to reduced life of the street
- Inspection fee
- Repair and restoration costs related to restoring the public right-of-way

Source: *Guide for Accommodating Utilities within Right-of-Way for Counties & Small Cities in Kansas*, Kansas Local Technical Assistance Program, Kansas University Transportaion Center, March 2007.

User perceptions of streets differ from pavement measures

The pavement condition index evaluates streets from the perspective of pavement managers, which differs from the perspective of drivers and other users of the streets. Recognizing the differences helps understand the results of pavement measures and the use of those results for public performance reporting.

Table 2 Different perspectives on streets

	User point of view	Pavement manager point of view
Focus	Focus on bumps and smoothness experienced while using the streets.	Measure all defects, including those that have little immediate affect on smoothness or bumps, while systematically inspecting the streets.
Measures	Experience conditions through trips and specific experiences. One bad bump can affect perceptions of the entire trip.	Measure conditions as part of planned inspection process that considers the entire network of streets.
Conclusions	Draw conclusions about overall condition of street system and about overall performance of the local government.	Draw conclusions about overall condition of street system and efficiency and effectiveness of pavement maintenance.

Everyone experiences the streets

Virtually everyone – residents, visitors, pedestrians, passengers, commercial and private car drivers and anyone with a window-view of a block front – experiences the streets and observes their condition. People know that it is city government's responsibility to maintain them. For many, then, the performance of local government itself is evaluated by the condition of the streets.

Source: *How Smooth are New York City's Streets?*, Fund for the City of New York, September 1998, page 28.

Recommendations

The City Auditor recommends:

1. The Director of Public Works should identify the resources needed to maintain the pavement management information and should request those resources in future budget submittals.

2. The Director of Public Works should compile documentation of the database to help maintain and use the information in the future.

3. The Director of Information Systems should develop a policy on backing up data.

4. The City Manager should develop a method to enforce the ordinance requirement for an excavation permit or consider revising the city's processes for managing the right-of-way.

Performance Audit: Pavement Condition Measures

Scope, methods and objectives

Assessing the reliability of the city's pavement condition measures provides the City Commission with assurance that the information, which is used to help allocate resources for maintenance and evaluate the results of maintenance, accurately reflects the conditions of the city's streets.

The City Auditor identified the topic as significant because the city spends a lot of money to maintain streets, the street system is a major city asset, and residents identified the condition of streets and infrastructure as the area the city should most emphasize.

This performance audit was designed to answer:

- Does the information in the pavement management system accurately reflect the conditions of city streets?

The City Auditor reviewed the pavement inspection handbook and documentation for the database; reviewed pavement data and the computer programs to calculate the pavement condition index; interviewed city staff involved in pavement management; reviewed the databases; compared the condition of streets with inspection records; compared historical records to the street work histories; and reviewed literature related to pavement conditions and management.

The City Auditor conducted this performance audit in accordance with generally accepted government auditing standards. Those standards require planning and performing the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for the findings and conclusions based on the audit objectives. The City Auditor believes that the evidence obtained provides a reasonable basis for the findings and conclusions based on the audit objective.

The City Auditor compared the physical conditions of 40 randomly selected street segments with the pavement database.

Table 3 Segments selected for comparison

Street category	Total segment in pavement database	Segments included in City Auditor comparison
Brick	25	0
Composite – asphalt over brick or concrete	681	14
Flexible – full-depth asphalt	1135	23
Rigid - concrete	154	3

The City Auditor and a Public Works staff person visited several of the segments where the auditor had identified potential discrepancies between the street conditions and the information recorded in the database. All of the discrepancies were resolved.

The City Auditor compared historical records for 40 streets with the pavement database. The auditor selected streets judgmentally from the sources Public Works used to develop initial work histories.

Table 4 Records selected for comparison

Source	Number in sample
3x5 card street inventory	10
Micro Paver reports	10
Project contract files	20

The City Auditor evaluated each potential discrepancy to determine if it would be likely to lead to incorrect estimates of deterioration rates or of the current condition of the street. The auditor followed up with Information Systems staff, as well. All of the discrepancies were resolved.

Appendix: Examples of street information

To illustrate the type of information the city maintains in the pavement database, this appendix provides simple histories of 4 street segments and a list of the frequency of pavement defects found through inspections.

The PCI for the four streets are near the average PCI for residential, collector, and arterial streets.

Table 5 Average PCI by street class

Street class	Number of segments	Average PCI
Arterial	139	66.25
Collector	182	70.28
Residential	1674	68.55

Table 6 provides examples of the information maintained in the pavement databases. Except for the traffic counts, all of the information about the four street segments comes from the pavement management system.

Table 6 Examples of pavement data

	N 5th (Lincoln to Lyon)	Kenginston (29th-30th)	E 27th (Cranley to Kensington)	W 9th (Emery to Avalon)
Type	Residential without curbs and gutters.	Residential	Collector	Arterial street on a truck delivery route
History	Chip and seal street, constructed in 1952. Over the years, N 5th has been treated with additional chip and seal as well as asphalt overlays, including an overlay in 2000.	8 inch asphalt street, constructed in 1994. Recent maintenance includes crack sealing in 2006 and microsurfacing in 2007.	10 inch asphalt street, constructed in 1992. Recent maintenance includes crack sealing in 2006 and microsurfacing in 2007.	10 inch asphalt street, resconstructed in 1988. Before reconstruction the street was 7 inches of concrete and had been overlayed with asphalt several times.
Most severe problems	Edge cracking. These cracks, running along the edge of the street, are common on streets without curbs and gutters.	Patching. The valley gutter at 29th has severe cracking, joint spalling, and patching.	Patching and transverse cracking. Transverse cracks run across the street and are frequently noticeable to a driver as a distinct bump.	Patching. Some localized areas at Emery have severe rutting.
Most extensive problems	Debonding, raveling, crack sealing, and transverse cracks	Potholes, raveling, crack sealing, and rutting.	Raveling, crack sealing, and rutting.	Crack seal and rutting.
PCI	68.5 (October 2005)	66.1 (March 2005)	74 (March 2005)	66.4 (August 2005)
"Unacceptable" PCI	< 55	< 55	< 60	< 65
Recent history	Crack sealed in 2008. Staff plan to add 2008 maintenance information to the pavement management system in October or November.	Reinspected and scored 68.1 in February 2007. When reinspected, the valley gutter at 29th was in good condition.	Reinspected and scored 70.5 in February 2007.	Nothing in the pavement management system.
Estimated PCI (2008)	53 to 55, In the "unacceptable" range.	66 to 66.	68 to 69.	50 to 57 In the "unacceptable" range.
Notes	The street is 18 feet wide, 8 feet narrower than the average for residential streets.	Between inspections, the street PCI increased slightly.	Collector streets generally carry more traffic than residential streets. Traffic counts for E 27th show over 3200 vehicles in 24 hours. By comparison, a nearby residential segment of Harper had just over 500 vehicles in 24 hours.	Arterial streets carry the highest amount of traffic. Traffic counts for W 9th show over 17,000 vehicles in 24 hours. Truck delivery routes carry heavy vehicles. Compared to cars, heavy vehicles cause much more stress to pavement.

The following tables show the portion of street segments that have each pavement defect.

Table 7 Frequency of defects on flexible pavement

Flexible pavement defect	Percent of segments
Crack sealing deficiency	88%
Raveling/weathering	82%
Transverse cracking	79%
Rutting	75%
Wheel track/fatigue/alligator cracking	72%
Longitudinal cracking	59%
Potholes	55%
Patching/utility cuts	44%
Block cracking	26%
Debonding	22%
Settlements/depressions	20%
Edge cracking	13%
Corrugations/shoving	6%
Bleeding	2%

Table 8 Frequency of defects on composite pavement

Composite pavement defect	Percent of segments
Crack sealing deficiency	96%
Longitudinal cracking	95%
Raveling/weathering	86%
Potholes/debonding	76%
Transverse joint reflective cracking	75%
Patching/utility cuts	72%
Base failure	71%
Intermediate transverse cracking	62%
Rutting	62%
Pressure damage/upheaval	59%
Transverse cracking (brick)	20%
Corrugations/shoving	13%

Table 9 Frequency of defects on rigid pavement

Rigid pavement defect	Percent of segments
Transverse joint spalling	95%
Longitudinal joint spalling	92%
Surface deterioration/popouts	89%
Transverse cracking	88%
Longitudinal cracking	84%
Faulting	82%
Corner breaks	76%
Shattered slab	66%
Patching/utility cuts	65%
Settlements/depressions	19%
Pressure damage	12%
Pumping	1%

Table 10 Frequency of defects on brick pavement

Brick pavement defect	Percent of segments
Spalling	100%
Settlements/depressions	96%
Joint separations	96%
Potholes	84%
Patching/utility cuts	84%

Performance Audit: Pavement Condition Measures

Management's Response

City of Lawrence
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October 1, 2008

Mr. Michael Eglinski
City Auditor
City of Lawrence, Kansas

Re: Pavement Condition Measures Performance Audit

Dear Michael,

Pursuant to City law you have provided me with a copy of the draft pavement condition measures performance audit. We are very pleased with the findings which confirm the reliability of both our measurement processes and the resulting data. We also agree with your four recommendations for improving various elements of this very important City program. As you would expect, these recommendations largely focus on staffing resources and priorities.

As we understand your first recommendation, it is to continue doing what we are already doing: provide regular updates to our pavement condition measurements. We plan to do this. We are challenged with providing the appropriate level of staffing for this measurement tool. Specifically, the 2009 budget continues the elimination of the GIS Analyst position in the Public Works Department. This budget reduction is necessary because of limited resources available to the Department. We are using temporary staff and other resources to respond to this important responsibility. We will continue to seek to provide adequate staffing to maintain our pavement condition measurement tools.

Similarly, your second recommendation focuses on documenting the database for the pavement condition measurements. We agree with this recommendation. The same staffing issues which challenge our upkeep of the pavement condition tool also challenge our ability to prepare the "how-to" manual for our system. We recognize the importance of documenting our pavement condition system and will put the necessary resources toward this project. I believe it is appropriate to note that we have focused on what we believe to be the top priority: inspecting and documenting our street conditions and putting our limited resources where we can best use them **prior** to using those same resources to prepare the "how-to" manual.

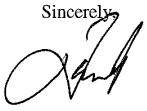
The third recommendation recommends that a written data back up policy be adopted for the pavement measurement data. We agree with this recommendation. On a daily basis the City backs up numerous data operations. We believe this recommendation will be addressed in a more comprehensive fashion through our already existing business continuity planning efforts.

Your final recommendation focuses on City Code requirements concerning excavation permits. We agree with the recommendation to review our entire right-of-way management tools. Your audit did not examine or document particular issues with excavation, and we believe that we have successfully worked with franchised utilities (gas, electric, phone, cable, etc.) on this issue in the majority of circumstances. Because of the physical location of utilities in Lawrence, much pavement excavation involves City water and wastewater facilities which coordinates their work with other City departments. We should balance a complete review of our right-of-way management tools (excavation ordinance, other new ordinances) with our ability to staff enforcement of such laws, any likely City benefit in actual pavement condition, and any burden placed on either private or public utilities.

We believe we can respond to the recommendations in a timely manner, likely by the first half of next year.

Again, thank you for your work and your results confirming our pavement condition measurement tools.

Sincerely,



David L. Corliss
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