Audit of the Department of Public Works Residential Street Paving Program

W. MARTIN MORICS
City Comptroller
City of Milwaukee, Wisconsin

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City of Milwaukee

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W Martin Morics, C P A
Comptroller

Michael J Daun
Deputy Comptroller

John M Egan, C P.A
Special Deputy Comptroller

Craig D. Kammholz
Special Deputy Comptroller

December 8, 2008

To the Honorable
the Common Council
City of Milwaukee

Dear Council Members:

The attached report summarizes the results of our Audit of the Department of Public Works Residential Street Paving Program.

The audit indicates that Milwaukee residential streets are on average in fair condition but getting worse. Nearly 21 percent, or 214 residential street miles, are now in poor condition. The pace of pavement deterioration will likely accelerate should past levels of street maintenance and replacement continue. The audit makes five programmatic recommendations, including moving from the current worst-first street replacement strategy to a preserve-first pavement strategy. Based on current spending, an increase averaging at least $6 million over each of the next 25 years would be needed to halt further deterioration and improve the overall residential street network.

Audit results are discussed in the Audit Conclusions and Recommendations section and Appendixes, followed by responses from the Department of Public Works.

Appreciation is expressed to the Department of Public Works for the full cooperation extended to the auditors.

Sincerely,

W. MARTIN MORICS
Comptroller

I. Scope and Objectives

This is an Audit of the Department of Public Works (DPW) Residential Street Paving Program. The audit was requested by 5th District Alderman James Bohl.

The audit covers the City of Milwaukee (City) administrative activities involved in maintaining and replacing (reconstructing/rehabilitating) local residential streets, from project planning to completion. The audit also comments on the conditions of residential streets. The audit did not analyze nor comment on the condition, repair or maintenance of collector and arterial streets, or Federal, State or County highways within the City. In addition, the audit did not examine the public works bidding and contracting process, which was previously audited and reported on in the 2006 Audit of DPW Procurement Activities. The audit utilized the services of RW Block Consulting, Inc. (consultant), a national construction project consulting and auditing firm.

The objectives of the audit were to:

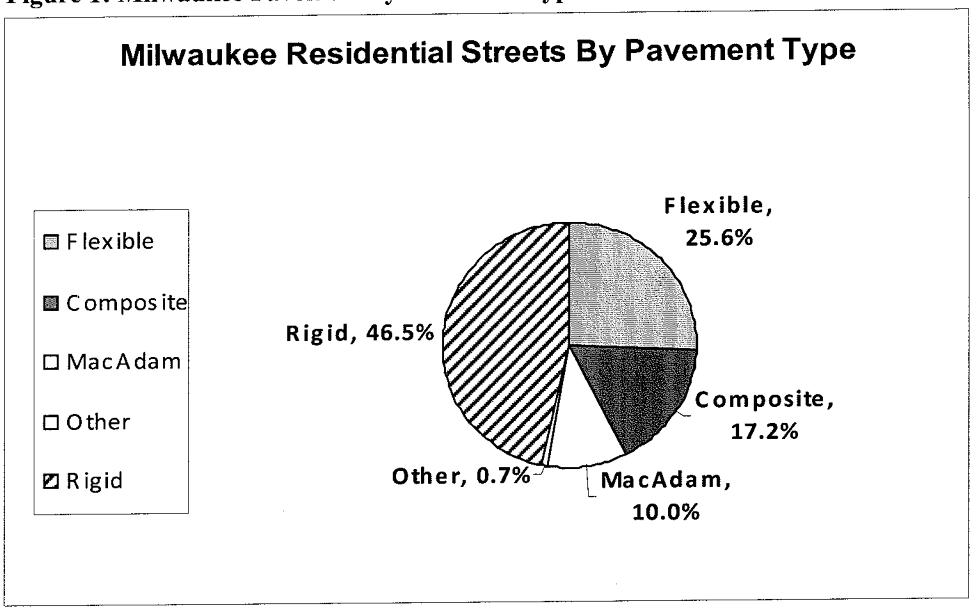
- Develop a descriptive inventory and profile on the condition of residential streets.
- Evaluate the DPW program for assessing residential street condition and determining maintenance, repair and replacement needs.
- Evaluate the DPW program for planning and scheduling work.
- Evaluate the City approval process for residential streets, particularly the impact of property owner special assessments.
- Evaluate the impact of City budgets on the preservation of residential streets and potential consequences of under funding.
- Identify possible cost-effective alternatives for managing and operating the City residential street paving program.

II. Background

There are approximately 1,415 miles of roads within the City of Milwaukee, including, streets, highways and freeways. Of these roads, other government units are responsible for replacing and maintaining roughly 122 miles, primarily highways and freeways. The City is responsible for replacing and maintaining the remaining 1,293 miles of roads, which includes residential, collector and arterial streets. DPW records indicate that there are between 969 to 1,024 miles of residential streets. The DPW Infrastructure Services Division is responsible for the design, construction and maintenance of these residential streets.

Figure 1 presents the breakdown by pavement type. Rigid pavement is full depth concrete pavement; Macadam pavement is a bituminous-penetrated stone base overlaid with asphalt and/or a surface treatment; Flexible pavement is full-depth asphalt over a granular base and/or sub-base; and Composite pavement is concrete overlaid with asphalt. Other pavement includes brick, gravel, and other miscellaneous pavements that are a small component of the City's residential streets.

Figure 1: Milwaukee Pavement by Pavement Type



The bulk of funding for residential streets comes from the City's capital budget. City capital funding includes both borrowed and tax levy funds. In addition, special assessments provided another capital funding source derived from charges to property owners whose properties abut the affected streets. The assessment rate for residential street reconstruction and structural rehabilitation projects was 60 percent of total project costs, including bid costs, project design costs, and engineering costs. This assessment rate was eliminated, effective April 2008, due to passage of the Municipal Vehicle Registration Fee (Wheel Tax). The 90 percent special assessment recovery rate for newly constructed streets will continue under the new Wheel Tax. The Wheel Tax is expected to generate about $6.6 million annually, more than twice the special assessment revenue it replaced, and is being applied to the current six-year City Capital Improvements Plan.

Augmenting the City's funding is the Wisconsin Department of Transportation's Local Road Improvement Program (LRIP), which provides 50 percent cost reimbursement for qualified projects. Table 1 below indicates the City and State funding from 2002 through 2008 that was available for residential street replacement and major (structural) rehabilitation.

Table 1: City and State Street Program Funding

Year	Non-Assessable Borrowing/Cash	Assessable	Total Capital	LRIP	Total Program
2002	$2,692,000	$1,125,000	$3,817,000	$2,134,892	$5,951,892
2003	3,640,000	2,460,000	6,100,000	0	6,100,000
2004	2,565,000	1,435,000	4,000,000	2,114,474	6,114,474
2005	4,184,000	1,968,700	6,152,700	0	6,152,700
2006	3,636,454	1,126,946	4,763,400	2,135,000	6,898,400
2007	4,954,556	1,387,494	6,342,050	0	6,342,050
2008	5,500,000	1,000,000	6,500,000	2,305,000	8,805,000

Source: DPW capital budgets

In addition to City street replacement, supported through the City's capital budget, the City also conducts street maintenance activities, supported primarily through the City operating budget. These maintenance efforts include temporary and permanent patching, crack filling, curb and gutter replacement and similar maintenance efforts. Although primarily funded through the City's operating budget, maintenance activities have also been supported through borrowing authority from the City's capital budget and from Community Development Block Grant (CDBG) funding. As maintenance efforts are funded in several accounts and funds, Table 2 shows City expenditures for maintenance activities from 2002 though 2007.

Table 2: City Street Maintenance Expenditures

Year	General Fund	CDBG	Borrowing	Total Program
2002	$1,002,098	$0	$12,152	$1,014,250
2003	638,009	3,168	11,969	653,146
2004	922,225	0	6,950	929,175
2005	1,333,504	0	323,976	1,657,480
2006	1,423,508	0	124,152	1,547,660
2007	1,247,089	0	424,008	1,671,097

DPW street maintenance records disclose that calls to the City about street potholes have increased in recent years, as shown in Table 3. Potholes are an indication of pavement failure. As pothole patching activity has increased, this "band-aid" or "reactive" maintenance absorbs funding that could otherwise be applied to more preventative maintenance efforts, such as crack filling.

Table 3: Potholes

Year	Calls
2004	8,500
2005	7,892
2006	9,339
2007	10,774
March 2008	5,570

III. Audit Conclusions and Recommendations

A. Summary Conclusions

The audit assesses the physical condition of local residential streets and evaluates street maintenance and replacement activities performed by the Department of Public Works (DPW). The audit also makes forward looking recommendations to address deficiencies. The following are the major findings of the audit.

Pavement Condition Assessment, Needs Determination and Budgeting

- Milwaukee residential streets are on average in fair condition but getting worse. This worsening condition is a longstanding trend, no doubt persisting over the past several years. The pace of future pavement deterioration can be expected to accelerate should current levels of street maintenance and replacement continue. The audit indicates that the residential street replacement cycle is currently 106 years, 2-3 times their useful lives. Nearly 21 percent, or 214 residential street miles, are in poor condition and in need of reconstruction.
- The audit also assessed pavement condition by comparing the age of residential streets to their engineered service lives. The audit found significant portions of the residential street network are nearing the end of their expected service life, indicating a general future decline in overall pavement condition over time[1].
- In addition to the existing backlog of streets in poor condition, increasing outlays will be required to prevent further deterioration. Excluding the 21 percent of streets currently in poor condition, the City needs to increase its street preservation spending by at least an average of $6 million over each of the next

[1] The service lives estimated by the audit are less than DPW standards, but similar to standards established by the former City Capital Improvements Committee and Capital Improvement Plans prior to 2003.

25 years to halt further deterioration and improve the overall residential street network.

- DPW lacks a Residential Street Preservation Plan to reduce and ultimately eliminate the streets in poor condition and to preserve the remaining streets in good condition. Without such a plan, meaningful reporting on the extent of progress toward a sustainable and functionally efficient residential street network is not possible.

- Various paving strategy options are available to the City of Milwaukee for achieving a sustainable, fully functional residential street network. The strategy chosen depends on the number of years taken to reduce or eliminate streets in poor condition, on future spending levels and financing methods, and on the street maintenance approaches that are utilized, etc. However, without clear recognition of the extent of the challenge and a plan to address this challenge, residential street conditions will continue to decline.

- DPW does not rely on its Pavement Management Application (PMA) and related Pavement Quality Index for determining street maintenance and replacement activities. DPW assesses pavement condition and develops paving priorities based on visual inspections of City streets. The audit found an insufficient link between pavement condition in the PMA and DPW's project priority list.

- The audit disclosed that the PMA's Pavement Quality Index is sufficiently accurate for establishing condition ratings based on the audit's sampling and verification of street condition.

- The audit also found both a lack of standards defining the true maintenance and replacement needs of the City's residential street network and a lack of reporting of accomplishments compared to these standards. This deficiency prevents policymakers from determining whether the network is being appropriately maintained and replaced.

- Ongoing paving needs of residential streets in the City regularly exceed the allotted budget. In addition, there is an existing sizable backlog of paving needs that also must be addressed to return the residential street replacement cycle to a value equal to the design life.

- The audit reviewed the per mile pavement cost for local residential streets in Milwaukee and determined that DPW is efficiently executing its projects with respect to costs. The weighted average cost for street replacement, rehabilitation and reconstruction was $910,000 in 2007.

- DPW does not have an accurate total of residential street miles. The two databases utilized by DPW in managing the system contain two different totals and DPW has not reconciled the differences. In addition, DPW has reported mileage totals different than what is reflected in these databases to the Budget Office, Comptroller's Office and Common Council.

Alternative Future Pavement Management Strategies

- The audit compared DPW's current funding and pavement strategy of "worst-streets-first" project prioritization to a "preserve-first" strategy. In contrast to a "worst-first" approach, a "preservation-first" strategy emphasizes the maintenance of better rated streets, preventing them from falling into the poor classification and allowing a "catch-up" toward eliminating the backlog of poor quality streets. The "preserve-first" strategy showed significant improvements over the existing strategy in terms of street condition, but requires greater funding to do so.
- DPW has a very limited number of maintenance treatment alternatives for City streets, limiting its ability to preserve City pavements. There is no formalized, effective mechanism for expanding the pavement treatment alternatives available or for implementing innovative pavement maintenance, rehabilitation or replacement techniques.
- Audit observations disclosed that utility cut patching in the City is not compatible with the surrounding pavement and in many cases is the primary cause of pavement distress (degraded condition), whether such distress takes place within the utility cut itself or in the surrounding pavement.

B. Residential Street Profile

Residential Street Databases

Data on the descriptive characteristics of all residential streets, including street length, are maintained in two separate DPW databases, which generally contain similar data but have some discrepancies.

The Road Life database is maintained by the DPW Construction Section and contains descriptive street data and construction history on all residential and arterial street segments and intersections. Road Life is the primary database used by DPW construction engineers. It does not contain any measures or data on the condition of residential streets. According to DPW, when the Road Life database was created in the 1970s, street length information was estimated based on hand-drawn quarter section maps. Intersection dimensions are coded in Road Life in a manner that allows DPW to add intersection length to street length for project purposes and for overall street network length. **Road Life reports 969 miles of local residential streets.**

The Pavement Management Application (PMA) is maintained by the DPW Planning Section and is a proprietary computer application from the vendor Stantec, Inc. The PMA is used to report to the State the inventory and condition of streets, required for LRIP grant funding and for long range planning projections. The PMA contains street dimensions from an earlier version of Road Life and does not contain data on street intersections. According to DPW, street lengths were increased in the PMA by 5 percent to approximate intersection lengths. **The PMA reports 1,024 miles of residential streets.** The PMA also contains data on the condition of every street, based on technical surveys conducted by Stantec, most recently in 2006 and 2007. The PMA generates a Pavement Quality Index (PQI) number for every street on a scale from 0 to 10, where a PQI of 10 indicates the best possible condition.

DPW has not reconciled the differences between the Road Life and PMA databases and does not appear to have an accurate overall total for residential street miles. An accurate total for street miles is needed to compute street replacement cycles for planning purposes. In 2007, DPW informed the Office of the Comptroller that there were 942 miles of residential streets, which was reported in the Comptroller's 2007 Expenditure Report. The 2008 City Plan and Budget Summary document states that there are 900 miles of residential streets, which are not eligible for grant funding. DPW has not explained why different street mileage totals are used and reported. The difference in mileage totals in the two databases, 1,024 in PMA and 969 in Road Life, may be the result of the different treatment of street intersections in each file and the recording in PMA of each lane length separately for divided streets. DPW indicates that changes made to Road Life by the Construction Section are communicated to the Planning Section so that the PMA can be updated, but there is no comparative reconciliation of these databases.

The Road Life database is probably the most accurate at 969 residential street miles, since it records intersection dimensions rather than approximating them. However, it could not be used for audit purposes because it does not include information on street condition. The audit used the PMA data because it correlates street descriptive data with street condition data. The audit recognizes that PMA street lengths are not precise.

Recommendation 1: Establish an accurate total for residential street miles

DPW should reconcile the differences between the Road Life and Pavement Management Application (PMA) databases to establish an accurate total of residential street miles. An accurate total for street miles is needed to accurately compute street replacement cycles for planning purposes. A more detailed discussion and recommendation related to the mileage discrepancy is provided in Appendix A.

Profile of Street Conditions and Pavement Types

The audit consultant substantiated the condition data in the PMA. The consultant drove and performed a detailed condition evaluation on a random stratified sample of 36 residential streets selected from the PMA database. The sample included a cross-section of major pavement types with different Pavement Quality Index (PQI) condition ratings. The consultant recorded and photographed pavement distress indicators such as cracking, then compared these audit observations with the condition data and PQI values in the PMA database.

The consultant recalculated PQIs for the sampled streets based on the audit observations, resulting in audit PQIs modestly lower than those in the PMA. The lower PQIs may be due in part to the elapsed time between the Stantec condition assessments and audit observations. The PMA vendor conducted its condition surveys in 2006 and 2007, while the audit consultant examined the streets after the intervening severe winter.

The consultant determined that DPW's PQI data is sufficiently accurate for establishing an overall condition rating as well as a street profile summarized into broad categories of good, fair and poor condition. As such, the audit determined that the PMA can be utilized to reliably forecast annual paving needs based on estimated street conditions.

The audit assigned PQI metrics to the following ranges, as summarized in Table 4 below:

- Good (PQI 7.21-10.0)
- Fair (PQI 4.51-7.20)
- Poor (PQI 0.0-4.50)

The audit indicates that City residential streets are in fair condition but continuing to deteriorate. The consultant estimated the average network condition Pavement Quality Index (PQI) to be 6.33, within the PQI range of fair streets of 4.51 to 7.2. However, the pace of pavement deterioration can be expected to accelerate should past levels of street maintenance and replacement continue. Nearly 21 percent, or 214 residential street miles, are in poor condition and in need of reconstruction or major rehabilitation. Table 4 summarizes the inventory of residential street miles by type of construction and pavement condition.

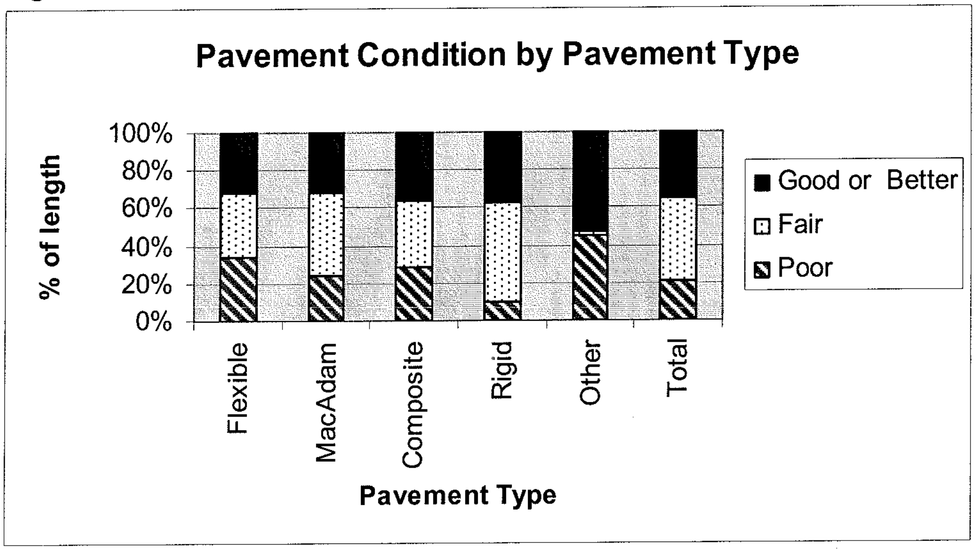
Table 4: Residential Street Profile

	Good	Fair	Poor	Total	Type %
Rigid	177.1	252.8	46.6	476.5	46.5%
Flexible	83.2	90.3	88.6	262.1	25.6%
Composite	64.2	60.9	50.6	175.7	17.2%
Macadam	32.7	44.4	25.2	102.3	10.0%
Other	3.9	0.1	3.4	7.4	0.7%
Total	361.1	448.5	**214.4**	1,024.0	100.0%
Condition %	35.3%	43.8%	20.9%	100.0%	

Due to funding constraints, DPW's reconstruction and major (structural) rehabilitation efforts have fallen far short of the effort needed to maintain the City's residential streets in good condition. **Based on expenditures reported in the Comptroller's 2008 Revenue and Expenditure Report, from 2002 to 2006, DPW averaged 5.9 miles of residential street replacement per year. At this rate, it would take more than 36 years to replace the 214 miles of residential streets that are currently in poor condition, without addressing any new and continuing deterioration.**

In addition to the overall average Pavement Quality Index (PQI), the PQI categories of good, fair and poor were applied to develop a cross-section of conditions for residential streets. The breakdown by pavement type is presented in Figure 2 and Table 5. As with the overall average PQI, the audit field verification suggests that further deterioration has taken place since the last data collection cycle.

Figure 2: Pavement Condition by Pavement Type



As Figure 2 shows, the percentage of Rigid (concrete) pavements in poor conditions is low compared to Flexible (asphalt), Macadam, and Composite pavements. However, as Table 5 shows, the number of miles of poor Rigid pavements (46.6 miles) is comparable to those of poor Composite pavements (50.6 miles), but less than those of Flexible pavements (88.6 miles). While Rigid pavements appear to have the least percentage of poor pavements, it is this pavement type for which the audit field review indicated that actual conditions are modestly lower than those forecasted by the PMA. The severity of pavement distresses for Rigid pavements is not as easily detected visually as with other pavement types and Rigid pavements are exposed to additional pavement deterioration at the joints, such as spalling and faulting.

Table 5: Residential Street Profile

	Good	**Fair**	**Poor**
Rigid	177.1	252.8	46.6
Flexible	83.2	90.3	88.6
Composite	64.2	60.9	50.6
Macadam	32.7	44.4	25.2
Other	3.9	0.1	3.4
Total	361.1	448.5	**214.4**

The significance of reporting Pavement Quality Index (PQI) metrics is that they provide guidance regarding the magnitude of the program needed to bring the residential street network back into a state of good repair. For instance, the total length of streets in poor condition is 214 miles, or the "average network condition" based on the length weighted average PQI is currently at 6.33. These system-wide metrics are essential for pavement management engineers in assessing accomplishments against program objectives, but they are not sufficient for reporting to policymakers or the public, as the average network PQI or total number of miles in poor condition are not representative of any one street segment and do not address the public's perceptions and experiences, which are most likely based only on streets in poorer conditions.

In addition to reporting system-wide PQI metrics, reporting pavement condition by pavement types and by aldermanic districts in the broad categories of good, fair and poor, allows for the development of a specific and localized paving program. For instance, residential streets classified in good condition are candidates for preservation strategies and/or routine maintenance. Residential streets with PQI ratings in the fair range generally require some degree of rehabilitation, while streets with poor PQI ratings require major rehabilitation or outright reconstruction. In essence, the specific treatment applied is dependent on the pavement type and PQI rating of specific street segments for a specific localized area.

Residential Streets Service Lives

In addition to reporting Pavement Quality Index (PQI) metrics, a second important measure is the age of the pavements. Pavement age relates to the expected service life of pavements and helps explain why the residential streets appear to be deteriorating all at once. Figures 3 and 4 present the frequency distribution of street age as measured by the "year of last rehabilitation" in the Pavement Management Application (PMA).

Figure 3: Age of Residential Streets All Pavement Types

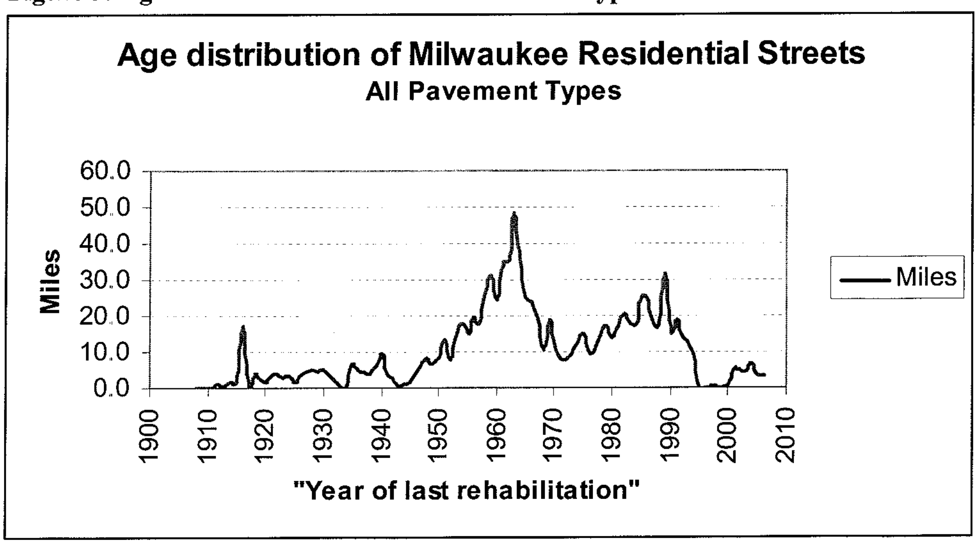


Figure 3, which includes all pavement types, shows two discernible peaks of street replacement activity. The first peak around the year 1960 corresponds to the very active construction period for Rigid (concrete) pavement. The second peak occurs around 1990 and consists of Flexible (asphalt) pavements and the conversion of Rigid pavements to Composite pavements through asphalt repairs and overlays.

Figure 4: Age of Residential Streets by Pavement Type

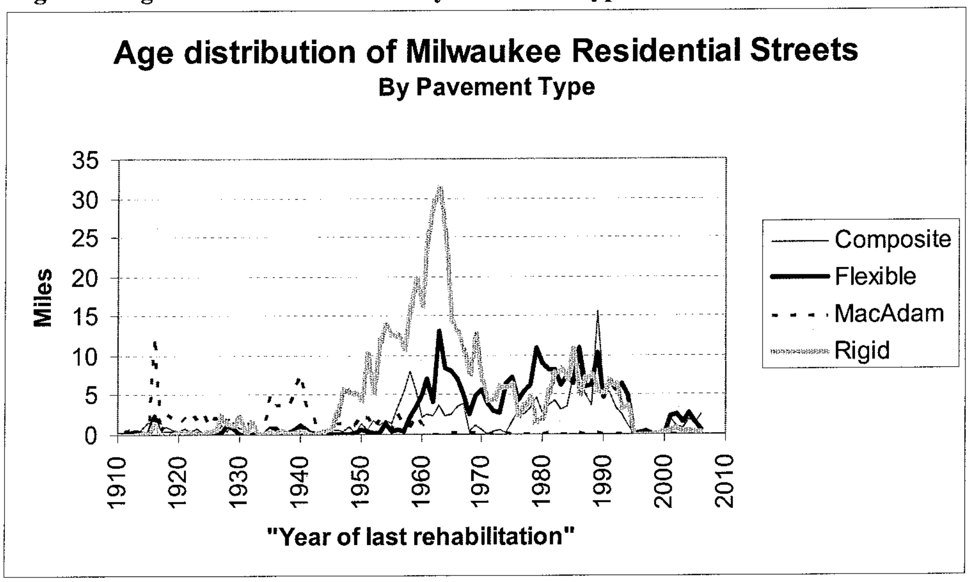


Figure 4 shows the age distribution of residential streets by pavement type, combining Flexible and Composite pavement types. One observation is the absence of a peak in rehabilitation activities around 2005. The service life of Rigid pavement is as much as 70 years, with rehabilitation occurring around year 45. This indicates that a peak in rehabilitation (conversion of Rigid pavements to Composite pavements) should have taken place around 2005, for Rigid pavements first constructed around 1960. In addition, with the expected life of the rehabilitation being 25 years, Rigid pavements converted to Composite pavements around 1990 would approach the end of their service life around 2015, if preservation is used. Without preservation efforts, failures begin to occur before the design life, as the audit observed for some streets.

Another observation is that while Macadam pavements were built prior to the peak in Rigid pavement construction around 1960, they have performed extremely well, particularly when they have remained relatively free of utility cuts or other disturbances. However, Macadam construction has been abandoned in part due to the labor intensiveness and quantity of bitumen required, which make them costly to construct.

Table 6 shows the average age of residential streets by pavement type along with DPW's current service life standards and consultant estimated service lives. The consultant estimated service lives were developed by the audit consultant based on structural design standards and field observations of City residential streets.

Table 6: Average Age of Residential Streets

Pavement Type	Average Years	DPW Service Life	Consultant Service Life
Rigid	42.5	70	50-60
Flexible	32.4	55	25-35
Composite	35.7	45	30-50
Macadam	72.2	100	85
Total Ave	41.7		

The overall weighted average age of the residential streets is 41.7 years. Since Rigid (concrete) pavement is the most common pavement type, its effect on the average age is greatest. Many of these streets were constructed in the 1960s and are approaching the end of their service lives. The average age of Flexible (asphalt) pavements is 32.4 years, near the end of the estimated service life of asphalt. Macadam pavements are by far the oldest with the longest estimated service lives, but make up only 10 percent of the City's residential streets.

Although the service lives estimated by the audit consultant are less than DPW's current standards, they are similar to the standards established under the former City Capital Improvements Committee, which was abolished in 1990. This Committee's 1988 to 1993 Capital Improvements Program report states the following:

> *"The [DPW] Bureau of Engineers' 1979 paving study estimated the expected average pavement life using Iowa survivor curves. Based on those estimates, the surface of a concrete pavement has an estimated service life of 40 to 50 years, asphalt 25 to 35 years."*

These Capital Improvement Committee standards were used as recently as 2002 when they were listed in the 2002-2007 City Capital Improvements Plan.

C. Residential Street Paving Program

DPW Paving Needs Assessment

The Pavement Management Application (PMA) vendor Stantec, Inc. conducted comprehensive condition surveys of all local residential streets in 2000-2001 and again in 2006-2007. Stantec drove the streets in specialized vehicles measuring and recording data on the various indicators of pavement deterioration. Survey data was loaded into the PMA to update its Pavement Quality Index (PQI) metrics. **Between these data update surveys, the PMA is able to generate projections on pavement condition based on pavement performance curves, so that for any given year a list of segments with condition values below a certain PQI threshold can be selected to initiate a six-year paving program.**

Rather than relying on the functionality of the PMA to assess street condition and generate project lists, DPW indicates that it tracks citizen complaints, aldermanic requests, maintenance information from DPW's Maintenance Section, and paving projects that have not been approved at public hearings. DPW then develops a four-year "target execution" plan and six-year residential paving program, based on this information. The timing of specific projects is determined by DPW staff based on their experience with paving project execution and available funding, subject to deletions and substitutions of projects.

The DPW Maintenance and Planning Sections do not rely on the PMA and its PQI for assessing street conditions and determining project lists. These sections assess pavement condition and develop paving priorities independently, based on their own visual inspections of City streets. **The audit could not substantiate DPW's independent street assessment and project selection process from reports and records provided by DPW.**

The PMA is a tool for managing the paving program at a system-wide level and is designed to maintain condition assessment data by street segment. It also provides reporting and analysis capabilities; in that it utilizes pavement performance models; identifies appropriate treatments, and estimates treatment costs. The PMA can be used to develop first-cut project lists, which may be supplemented with a project specific evaluation and design.

None of the DPW engineering and construction sections use the PMA as their primary data source. Information on pavement condition and paving activity is distributed throughout DPW's functional work locations, with each section maintaining its own data sources. This has resulted in multiple specialized data sources, redundant data, and a lack of data integration for efficient management and comprehensive planning and reporting. This distributed nature of DPW data was reported in the Comptroller's Inventory of DPW Infrastructure Databases report issued in 2004, which identified 22 infrastructure databases and 4 manual files.

DPW has not provided comprehensive reporting on the condition of residential streets and needed street work since the former City Capital Improvements Committee (CIC) was abolished in 1990. This former Committee's Capital Improvement Program report provided information on all capital assets, including streets, and reported the type, mileage and condition of the street inventory. Also reported were: the historical effort, estimated useful life, implied replacement cycle, preventative maintenance performed, street performance, and projects selected. This report also compared actual DPW accomplishments to stated goals, reporting the following:

> *"Since 1980, the City has accomplished about 95% of the street resurfacing and 91% of the street reconstruction called for in that study [1979 DPW Bureau of Engineers study]. Based on the needs identified in the study, at the end of 1987, the accumulated shortage of street resurfacing would be 177,253 square yards..."*

DPW's latest 2006 Annual Report provides limited information on paving program inputs and outputs, including the number of street projects approved, project estimates made, public hearings held and contracts awarded. The report does not contain information on the condition of City streets or whether paving needs are being adequately addressed. For the residential street program the DPW report simply states the following:

> *"In 2006 local paving work consisted of 14 contracts that totaled 5.87 miles of roads and 1.17 miles of alleys. The total local paving contract cost was $7.7 million. In addition, Street Maintenance resurface paving work consisted of one contract that totaled 1.8 miles of roads and private development paving work that totaled 0.2 miles of roads."*

Overall, the audit found an insufficient link between pavement conditions as measured in the PMA and DPW's candidate project list. The audit also found a lack of reporting of the true maintenance and replacement needs of the City's residential street network, as well as a lack of reporting on the basic elements necessary for policymakers to determine whether the network is being appropriately maintained and replaced.

Recommendation 2: Expand use of the Pavement Management Application (PMA) to develop a cost-effective paving strategy

DPW should expand its use of the PMA system to assist in developing a cost-effective strategy for improving local residential pavement conditions. Given that pavement conditions are less than desired, the PMA should be used to develop an optimized strategy for improving pavement conditions to acceptable levels. DPW should utilize the PMA's full functionality to identify street segments' relative need, the various treatments for those street segments as well as their associated treatment costs, and develop cost-benefit "packages" that produce strategies to maximize existing paving funding system-wide.

A fully utilized PMA should provide a long-term optimized strategy for the street network, contain options for interventions at all condition levels (preservation, minor rehabilitation, structural rehabilitation, and reconstruction), and be able to project policy and budget impacts on the street network into the future. A PMA derived strategy should be revisited and refined annually, as program actions and pavement deterioration impact network condition.

Full utilization of the PMA could expand the impact of budgeted capital funds for street replacement, producing a greater improvement in pavement condition than is now possible. Policy options are further described and analyzed under the Current Backlog of Conditions section of this report and Appendix D.

Recommendation 3: Implement a paving performance monitoring and reporting process

DPW should implement a Performance Monitoring process with a set of pavement condition goals and objectives based on need. Standards should be established to measure the extent that such physical condition goals/objectives are achieved. Goals could be adjusted where necessary based on actual funding allocated, with formal, periodic reporting of actual accomplishments against these stated goals. Reporting of performance should be addressed to DPW management, the Mayor and Common Council regarding street maintenance accomplishments and the resulting condition assessment.

Appendix B of this report includes 12 additional recommendations for assessing local street condition and determining maintenance and replacement needs.

Paving Project Development

Paving program effectiveness is dependent on proper selection of paving projects, the timeliness of project execution, adequacy of pavement engineering (design), and the quality of construction.

The audit disclosed the following DPW strengths in the residential street paving program.

- DPW handles all aspects of the paving program from project inception to final design and construction contractor oversight. DPW appears to have sufficient engineering resources and staff to manage projects through to completion.
- DPW has a robust and thorough process of recording information and data about City streets. Substantial information is available on street design, construction and repair, although information is decentralized throughout the department.
- DPW manages to implement some pavement preservation treatments, despite an inadequate budget.
- DPW's Pavement Management Application (PMA) is capable of providing the automated functionality needed to plan and manage a comprehensive paving program.
- DPW expressed willingness to evaluate and adopt new cost-effective and innovative paving techniques.

However, DPW does not have a clear and comprehensive plan for preserving residential streets. The audit did not uncover any DPW strategy to budget and direct paving work in order to maximize street conditions and minimize, sustain and stabilize overall street network costs. DPW applies a "worst-first" approach due to funding limitations that emphasizes replacement (street reconstruction or major rehabilitation) of pavements that have substantially deteriorated to poor conditions.

The current paving program focuses on structural rehabilitation and reconstruction of poor rated streets. The audit found that DPW's existing program development process, including timelines, is appropriate for these types of street projects. Currently, it takes 21 months to plan a residential street reconstruction project, from initiating the project to award of the construction contract, which usually runs from June of the initial year to April of year 2. However, this process is not well suited for preservation maintenance projects, where design work is much simpler and timing is more critical.

Table 7 is an audit summary of residential street reconstruction projects proposed and constructed during the last six years.

Table 7: Local Street Reconstruction Projects Proposed and Constructed

	2002	2003	2004	2005	2006	2007	Total	%
Priority projects on budget list	23	28	19	39	34	47	190	100%
Deleted at public hearings	8	9	4	13	5	4	43	23%
Paved in priority list year	10	5	8	10	4	2	39	21%
Paved in later years	4	13	4	11	7	n/a	39	20%
Listed again in later year	1	1	2	0	0	0	4	2%
Listed but not paved	0	0	1	5	18	41	65	34%
Total paved projects	28	16	43	23	31	28	169	100%
Paved in priority list year	10	5	8	10	4	2	39	23%
Paved from earlier priority list	n/a	0	17	4	9	10	40	24%
Paved but not on priority lists	18	11	18	9	18	16	90	53%

Table 7 was prepared from separate lists of projects proposed, deleted and completed. DPW did not provide any reports tracking the status of its project priorities over time. The 23 percent of proposed projects that were deleted at public hearings were dropped due to property owner objections to the associated special assessments. It is anticipated that the implementation of the Municipal Vehicle Registration Fee (Wheel Tax) and elimination of special assessments for repaving projects will address the issue of property owner objections to proposed street paving projects due to special assessments.

The audit noted that street projects that are paved using the Wisconsin LRIP funds received in even years were not on the lists of prioritized projects submitted to the Budget Office, despite the fact that LRIP funds reimburse the City for expenditures already incurred. These streets consist of 24 percent of the residential street paving program.

Although the projects are listed as priorities for the capital budget, the actual timing of construction does not appear to be critical in the current reconstruction program.

Delayed reconstruction projects may be impacted by changes in construction costs. However, maintenance and rehabilitation projects require a process where the lead time is much shorter and the approval process much more certain. Delays in maintenance and rehabilitation activities may result in an increased scope of work, where planned treatments are no longer feasible due to deteriorating street condition and more costly treatments are required.

In addition, the audit consultant observed certain deterioration in newer streets, indicating that DPW should reexamine its pavement designs. The consultant consistently found progressive edge cracking on newer Flexible (asphalt) pavement. Also, alligator cracking was noted around unsealed asphalt pavement cracks, which may indicate that pavement is too thin and water infiltration is weakening the pavement base. Some Rigid (concrete) pavement exhibited mid-slab cracks, spalled joints, cracked and depressed slabs, and some "D" cracking (see Glossary in Appendix G). Pavement design features that could mitigate this distress include improved water drainage, joint sealing, inclusion of sufficient expansion joints, and slab design with load-transfer devices such as dowels.

Audit observations disclosed that utility cut patching in City streets is not compatible with the surrounding pavement and in many cases is the primary cause of pavement distress.

DPW engineering design standards for streets need to be evaluated periodically against pavement performance data and observations. This is especially needed for Flexible (asphalt) pavement. Appendix E provides additional information and 7 recommendations regarding residential street design standards.

Paving Project Approval

The ability of DPW to actually construct the projects it identifies for paving is greatly affected by the current approval process. The current project-level, rather than program-level, approach for public hearings and approval limits DPW's ability to optimize project selection based on engineering factors, especially for scopes of work that are time-sensitive. The approval process yields a significant probability of project rejections at public hearings. As indicated above, there is a lengthy 21 month paving project development and approval process for street replacements.

The importance of timely project development and approvals is indicated in Table 8. In general, the higher the level of pavement condition at which a treatment is appropriate, the more timing becomes critical in order to stop further deterioration.

Table 8: Effect of Paving Project Delays

Proposed work scope submitted for approval	Impact on pavement condition	Impact of delay on City costs	Impact of delay on User costs	Criticality of timely approval
Preservation / Preventive Maintenance	Maintain at good condition	Major increase	Minor	High
Functional Rehabilitation	Improve fair to good	Major increase	Minor	High
Structural Rehabilitation	Improve poor or fair to good	Major increase	Major	Medium
Reconstruction / Replacement	Improve poor to good	Minor or no increase	Major	Low unless unsafe
Band-aid Fix	Maintain at poor or improve to fair	Minor increase	Major	Low unless unsafe

As indicated in Table 8, preservation preventative-maintenance includes permanent patching, crack filling, curb and gutter repair and similar efforts. Functional rehabilitation restores the functional condition of streets, improving ride quality. These treatments help to preserve the street against further deterioration. Structural rehabilitation restores the structural condition and capacity of streets without a complete replacement. This includes concrete repairs and resurfacing, thick overlays, deep mill-and-fill operations, and full depth patching. Band-aid fixes or reactive maintenance maintains a minimum condition level by treating severe deterioration on a temporary basis. This includes thin overlays on badly distressed pavement, surface patching, spot paving for large potholes, depressed pavement, or severe alligator cracking. Reconstruction / replacement activities involve a complete reconstruct of an existing street segment.

Pavement Preservation

The U.S. Department of Transportation – Federal Highway Administration reported the following in January 2000:[2]

> *"To meet the growing travel demand and the public's expectations for safety, ride quality, and traffic flow, highway agencies are redefining their objectives to focus on activities and strategies to preserve and maintain existing highway systems, instead of the typical strategy of fixing the worst first. Doing that without busting budgetary limits requires a change of philosophy from reactive maintenance to preventive maintenance."*

TRIP, a nonprofit national transportation research group, reported the following in March 2008:[3]

- *"Nearly a quarter of the nation's major urban roads are rated in substandard or poor condition, providing motorists with a rough ride, which increases the cost of operating a vehicle."*
- *"A 2006 U.S. Department of Transportation (DOT) study prepared for Congress found that urban road and highway pavement conditions are likely to worsen at current funding levels... The DOT study found that keeping urban roadways in their current condition would require a 56 percent increase in annual funding. Improving the physical condition of urban roadways would require a 126 percent increase in funding."*
- *"Transportation agencies, particularly at the state level, are adopting a pavement preservation approach that emphasizes making early initial repairs to pavement surfaces while they are still in good condition and the use of higher-quality paving materials to reduce the cost of keeping roads smooth by delaying the need for costly reconstruction."*

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[2] Report by U.S. DOT entitled; Optimizing Highway Performance: Pavement Preservation, January 2000.
[3] Report by TRIP of Washington, DC entitled; Keep Both Hands on the Wheel: Metro Areas with the Roughest Rides and Strategies to Make our Roads Smoother, March 2008.

- *"A preventive maintenance approach to keeping pavements in good condition has been found to reduce overall pavement life cycle costs by approximately one-third over a 25-year period."*
- The TRIP report includes an analysis of 2006 data from the Federal Highway Administration on the condition of major urban roads for each large American City. TRIP reports that 25 percent of major Milwaukee roads and highways were in poor condition in 2006, similar to the audit finding of nearly 21 percent of Milwaukee residential streets in poor condition.

The audit confirms that the City can realize significant benefits in terms of pavement condition and return on pavement investment by redirecting its paving program from the current worst-first reconstruction orientation to a preserve-first strategy. **The audit estimates that preserving one mile of asphalt streets for 40 years using aggressive maintenance would cost the City $150,000 less in current dollars than doing no maintenance before the streets are reconstructed in 30 years. That amounts to a total current dollar life cycle savings of $39.3 million for the 262 miles of City asphalt residential streets.**

Paving Program Budgeting

Capital funding for residential street replacement has been under funded in City budgets for nearly two decades. Funding decisions appear to have been driven more by budget considerations than by infrastructure needs. Typically, City budget appropriations for residential streets appear to be based on prior years funding, without clear disclosure on the funding level impact. Without a thorough assessment of residential street paving needs and a clearly communicated needs assessment and preservation plan, there is little likelihood of implementing a sustainable funding strategy, necessary to upgrade and preserve the City's residential street network.

In conjunction with the elimination in 1990 of the former City Capital Improvements Committee and its comprehensive reporting, the prior Mayor also began significant budget reductions in infrastructure funding that continued until recently. These budget reductions were publicly challenged by the former City Comptroller.

The Milwaukee Journal reported the following on October 20, 1989:

"Will Milwaukee go to pot if its streets and sidewalks aren't replaced quite so often? So City Comptroller James McCann seems to fear... McCann worries about Norquist's plan to lengthen the replacement cycle [for streets] to 43 years, as compared to 38 in 1986-88. But the stretched-out schedule is still faster than the 51-year replacement cycle in former Mayor Henry Maier's last 10 budgets."

The Milwaukee Sentinel reported the following on July 20, 1991:

"City Comptroller James A. McCann on Friday called for a major rewrite of a document outlining the city's 1991-'96 capital improvements program... McCann said... the capital improvements document requires substantial revision because it is missing details...and information about past performance necessary to determine the adequacy of the city's 1990 capital improvement effort..."

The audit found that the cumulative affect of this under funding has resulted in a replacement cycle of 106 years for residential streets.

A Milwaukee Journal Sentinel article dated March 20, 2008 cited the TRIP study reported above, as well as the following:

"The gaping potholes in southeastern Wisconsin streets are exposing even larger holes in funding road maintenance over the years, authorities say. After deteriorating for years, miles of roads were vulnerable... The potholes are the jolting consequence of infrastructure neglect... In Milwaukee, years of cutting budgets and delaying road work left city streets particularly vulnerable to the attack of winter, Public Works Commissioner Jeff Mantes said.... Mantes said the problem dated back to 1993, when former Mayor John O. Norquist's administration cut the paving budget for the city's neighborhood streets from about $10 million a year to about $5 million a year. The paving budget stayed at that level until Mayor Tom Barrett took office in 2004, meaning the city fell $55 million behind on street work, not counting inflation, Mantes said."

The City is now phasing-in increased funding for street work. However, the true impact of these increases cannot be properly evaluated without a comprehensive infrastructure needs study and pavement preservation plan.

Establishing funding requirements for residential streets requires the comparison of residential street service life to the actual replacement of residential streets. Ideally, the replacement cycle for residential streets should match the service life, which would mean that residential streets are being replaced at the end of their engineered life spans before they degrade to street conditions that are more costly to replace. A replacement cycle that is significantly longer than the service life may indicate an insufficient level of construction effort and/or the need for additional funding. Extended replacement cycles may also indicate more streets in poor condition, with a corresponding increase in vehicle maintenance costs and safety risks.

The audit consultant computed the network length-weighted useful life of residential street pavements based on the midpoint of the consultant's estimated service life in Table 6 (page 15). Based on the consultant's service life, the length-weighted average service life for all residential street pavements is 50 years. This compares to a length weighted average service life of 64 years, based on DPW assumed service life for residential street pavement types. These values are stated in Table 9.

Table 9: Useful Life Assumptions for Residential Streets

Pavement Type	DPW Service Life Assumption	Consultant Service Life Assumption*
Flexible	55	30
Macadam	100	85
Composite	45	40
Rigid	70	55
Weighted Average (yrs)	64	50

* Midpoint of the consultant estimated service life range in Table 6

In order to estimate the funding necessary to reduce the replacement cycle and align it with the service life of residential streets, it is necessary to determine the replacement cost of all pavement treatments. The audit consultant reviewed typical cost per mile data to benchmark the City of Milwaukee's costs for pavement replacement, rehabilitation, and reconstruction. Comparison of costs from one region of the country to another is not advised without analyzing the detailed factors that drive cost such as the hauling distance of aggregate, labor cost variances, and other factors. Fortunately, however, the State of Wisconsin publishes the costs per mile for various treatments to guide municipalities. These values are presented in Table 10 and were compared with Milwaukee costs. These costs include utility relocation, real estate acquisition and construction.

Table 10: 2005 State of Wisconsin DOT Guidelines for Costs Per Mile for Pavement Treatments

Treatment	Cost Per Mile
Resurfacing, urban, 2-lane	$ 480,000
Resurfacing, urban, multilane	$ 725,000
Recondition, urban, 2-lane, minor (major)	$ 690,000 ($ 975,000)
Recondition, urban, multilane, minor (major)	$ 1,420,000 ($ 3,250,000)
Pavement Replacement, urban, 2-lane	$ 720,000
Pavement Replacement, urban, multilane	$ 1,000,000
Reconstruction, urban, 2-lane	$ 2,100,000
Reconstruction, urban, multilane	$ 4,000,000

The audit reviewed the per mile cost of the same treatments in Milwaukee and determined that the City is efficiently executing its projects with respect to costs, as the City's costs are in-line with these State of Wisconsin guidelines and industry standards. **The audit also disclosed that the weighted average cost per mile for these treatments was $910,000 in 2007, weighting the service life of each pavement type by the replacement cost.**

Assuming a 50 year service life and 2008 budgeted capital funds of $8.8, the current one-year replacement cycle is 105.9 years, as shown in Table 11. The ratio of replacement cycle to service life is 2.1, indicating that the current replacement cycle is approximately twice as long as the assumed service life. Capital funding would have to be more than doubled from the 2008 level of $8.8 million to bring the replacement cycle in line with the 50 year service life of residential streets.

Table 11: Street Replacement Cycle and Ratio of Replacement to Service Life4

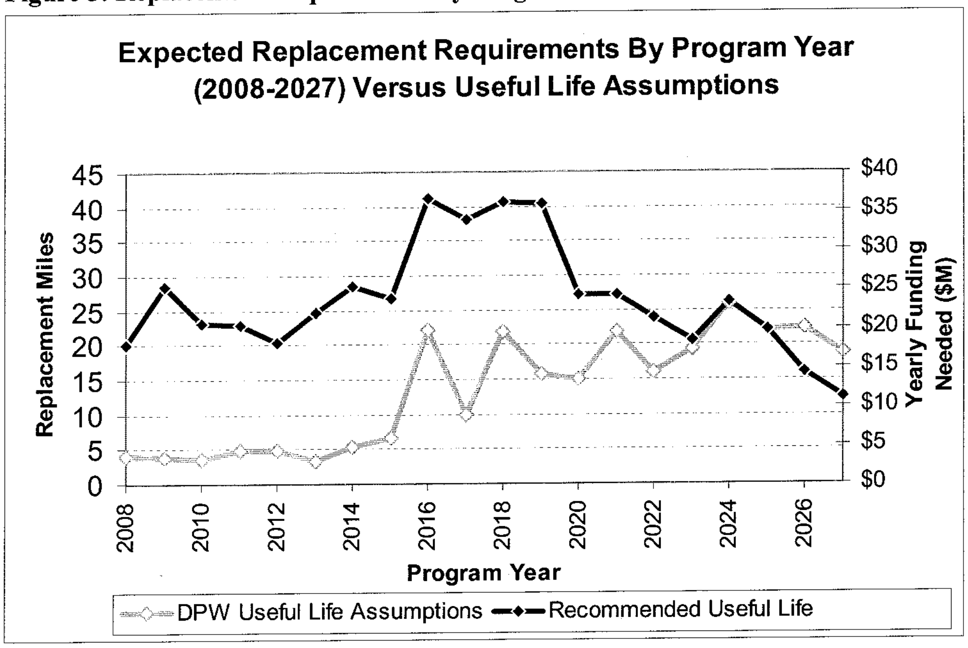
Consultant Service Life Assumption	Residential Street Miles	Current Street Replacement Cycle	Replacement Cycle to Service Life Ratio	Replacement Miles Required	Annual Funding Required
50	1024.5	105.9	2.1	20.5	$18,655,000

Dividing the total number of miles in the residential street network (1,024 miles) by the weighted average service life (50 years) results in a replacement requirement of 20.5 miles per year. Multiplying this annual mileage requirement by the average cost of all replacement activities for reconstruction and major structural rehabilitation of $910,000 per mile, results in an annual funding requirement of $18.6 million.

[4] Assumed $910,000 weighted average per mile cost for replacement and $8.8 million in funding in 2008 per Table 1 on page 4.

In addition to calculating the replacement cycle for residential streets, based on the weighted average service life of all pavement types, the audit consultant calculated residential street replacement needs through two alternative approaches. The first was to evaluate each pavement type separately and calculate the length of each pavement type that is reaching the end of its service life for each program year. The length required should be equal to the length "expiring" in each program year. The results are presented in Figure 5 for the consultant recommended service life, and for comparative purposes, DPW's existing service life assumptions.

Figure 5: Replacement Requirements by Program Year versus Useful Life Assumptions



This approach to calculating residential street paving needs has the advantage of determining the specific years when the replacement requirements increase or decrease based on the age of the existing pavement. Using the consultant recommended service life assumptions; a marked increase in replacement requirements can be observed beginning in 2016. In comparison, using DPW's existing service life assumptions, the total mileage required each year is much lower with the peak requirement occurring later. In both instances, the peak requirements are estimated to take place sometime in the future, either around 2015 to 2019 in the case of the consultant recommended service life assumptions, or from 2015 to 2027 or later in the case of DPW's existing service life assumptions.

A second approach to calculating residential street paving needs involves evaluating the actual performance of the pavements. This requires that the current pavement condition be measured and pavement performance estimated. This approach utilizes the Pavement Management Application (PMA) by evaluating the required miles of pavement to be replaced each year in order to maintain some standard level of condition for the street network as a whole. The audit consultant conducted this analysis for a period of four years and determined an average mileage replacement requirement of 28 miles per year, for an annual funding need of $25.5 million, based on the $910,000 per mile replacement cost. This approach is most representative of actual paving needs, as streets require replacement based on condition and not necessarily based on age.

The replacement of 28 miles is neither a permanent need, which would result in a replacement cycle of approximately 36 years, nor does it include the existing backlog of 214 miles already in poor condition. It does, however, reflect that the City's pavement replacement program has not been adequate in size to keep up with pavement deterioration and aging, resulting in a significant percentage of pavements approaching the end of their service life.

Regardless of the methodology used to support a pavement investment strategy, two major points must be considered when drawing conclusions about replacement needs. First, yearly replacement miles are not constant over time. Figure 5 above shows considerable fluctuations in replacement needs over a 20 year period. This reflects that miles of pavement constructed each year have not been constant and pavement performance has not been exactly uniform. Secondly, the calculation of a replacement cycle should account for the yearly fluctuation in replacement needs. Replacement cycle figures should be complemented with condition breakdowns, backlog calculations and long-term street network condition analysis, preferably using the PMA.

Current backlog of conditions

The two alternative approaches above evaluated residential street replacement requirements, excluding the existing backlogs. For the first approach, the current residential street condition is assumed to be in a steady state, and for the second, existing residential street condition is assumed to be acceptable.

Under the first approach, a backlog simply cannot be estimated, as the calculation relies only on mileage, irrespective of condition. For the second approach, a backlog estimate can be developed based on all pavement segments that need replacement prior to and including the current year. This backlog is simply the mileage of residential streets in "poor" condition, or 214 miles as reflected in Tables 4 and 5.

Based on the all of these calculations for determining on-going and backlog residential street replacement needs, **the audit consultant concludes that the most accurate and realistic approach is the condition based approach. This approach indicates an ongoing replacement need of 28 miles per year with an existing backlog of 214 miles.**[5]

If DPW continued its current worst-first paving strategy, the audit consultant estimates that annual funding for the residential street paving program would initially need to increase to between $42 million to $51.6 million in order to both eliminate the present backlog and improve the entire network of residential streets to good condition.

Delaying implementation of a paving program that is adequately sized to address pavement condition will only result in a more expensive and larger program later. If current funding levels continue over the next four years, another 81 miles of poor quality streets would be added to the present backlog of 214 miles, resulting in nearly 29 percent of City residential streets in poor condition. This deferral would amount to $73.7 million at the current street replacement cost of $910,000 per mile.

As the funding required to address the present backlog and ongoing residential street replacement is staggering, the audit consultant developed alternative funding scenarios for a City paving program that moves DPW from a worst-first pavement strategy to a preserve-first pavement strategy.

Appendix D is the audit consultant's full report which provides nine policy alternatives for consideration, including a "baseline" option of maintaining the current funding and pavement strategy. Policy alternatives other than the "baseline" scenario seek to accomplish, to varying degrees, the following four objectives:

- Provide adequate funding over the long term.
- Move from replacement (reconstruction and structural rehabilitation) to a more

[5] The audit consultant's analysis excluded the "other" pavement category due a scarcity of data and was based on the 211 miles of poor quality streets in the four major pavement types (Rigid, Flexible, Composite and Macadam)

cost-effective preservation driven strategy by including additional rehabilitation and preservation elements.

- Move from a worst-first approach to a preserve-first approach based on the Pavement Management Application (PMA).
- Increase utilization of innovative paving maintenance and rehabilitation treatments.

The first objective recognizes the obvious fact that improving the condition of residential streets in Milwaukee is going to require a significant long-term funding commitment from the City. The maintenance deferral developed over the long-term and is going to require a long-term strategy to remediate.

The second objective seeks to move away from DPW's worst-first pavement strategy, which is expensive given existing available resources, to a preserve-first strategy with the goal of maintaining streets before they fall into the poor quality classification. This objective seeks to realize significant benefits in terms of both pavement condition and return on pavement investment, using a pavement preservation strategy resulting in better streets at lower life-cycle costs.

The preserve-first approach may seem counter intuitive as treatments are applied to higher condition rated streets before they fall into the poor condition ratings, rather than streets that are already rated as poor. However, as stated earlier, aggressive preservation and maintenance efforts cost approximately $150,000 less per mile than reconstructing streets every 30 years with no maintenance.

The third objective is reflective of the fact that DPW's Pavement Management Application (PMA) has the potential to provide the decision-support information required to further refine and modify each of these nine policy options. Since the PMA is currently not set-up to incorporate pavement-preservation strategies, audit analysis was used instead to develop the nine policy options.

The fourth objective recognizes that the worst-first strategy misses significant opportunities to extend pavement life through innovative preservation treatments, which are currently underutilized. Emerging pavement technology could play an important role in containing the cost of replacement. For example, Rigid pavement rubblization, which has been used successfully elsewhere, can provide significant savings opportunities over reconstruction in certain circumstances. Also, full-depth reclamation for Flexible pavements can provide a viable alternative to reconstruction.

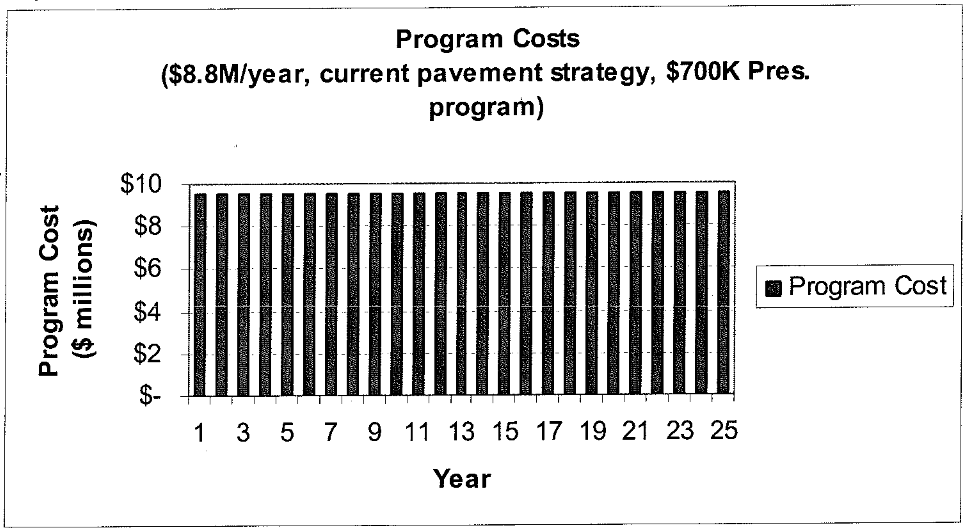
Table 12 summarizes the program costs and associated changes in residential street network conditions for the nine policy options in Appendix D.

Table 12: Policy Options in Appendix D

Policy Options	**Program Costs**	**Network Condition Change Network % Yr 1 → Yr 25**
1. Current strategy and capital funding; maintenance budget for band-aid work only	Yearly $8.8M 25 yrs $220M PV $130M	Good 35% → 14% Fair 44% → 24% Poor 21% → 62%
2a. Current strategy; eliminate backlog in 10 years	Ave yrly $41.8M 25 yrs $1B PV $639M	Good 35% → 50% Fair 44% → 50% Poor 21% → 0%
2b. Current strategy; eliminate backlog in 20 years	Ave yrly $40.4M 25 yrs $1B PV $590M	Good 35% → 51% Fair 44% → 49% Poor 21% → 0%
3. Pavement preservation strategy at current capital and maintenance funding	Ave yrly $9.5M 25 yrs $238M PV $141M	Good 35% → 22% Fair 44% → 31% Poor 21% → 47%
4a. Preservation with Rehab-Then-Preserve strategy; eliminate backlog in 10 years	Ave yrly $25.7M 25 yrs $641M PV $453M	Good 35% → 95% Fair 44% → 5% Poor 21% → 0%
4b. Preservation with RTP strategy; eliminate backlog in 20 years	Ave yrly $25.3M 25 yrs $633M PV $418M	Good 35% → 95% Fair 44% → 5% Poor 21% → 0%
5. Preservation with RTP strategy; eliminate backlog with constant budget	Ave yrly $25.2M 25 yrs $630M PV $394M	Good 35% → 95% Fair 44% → 5% Poor 21% → 0%
6. Preservation with RTP strategy into lower condition levels and structural repair	Ave yrly $21.9M 25 yrs $548M PV $372M	Good 35% → 96% Fair 44% → 4% Poor 21% → 0%
7. Preservation with RTP strategy without backlog elimination	Ave yrly $15.4M 25 yrs $384M PV $265M	Good 35% → 75% Fair 44% → 5% Poor 21% → 20%
8. Optimized limited budget	Ave yrly $10M 25 yrs $250M PV $150M	Good 35% → 61% Fair 44% → 5% Poor 21% → 34%
9. Structural rehab for poor streets	Ave yrly $29.1M 25 yrs $728M PV $454M	Good 35% → 54% Fair 44% → 26% Poor 21% → 20%

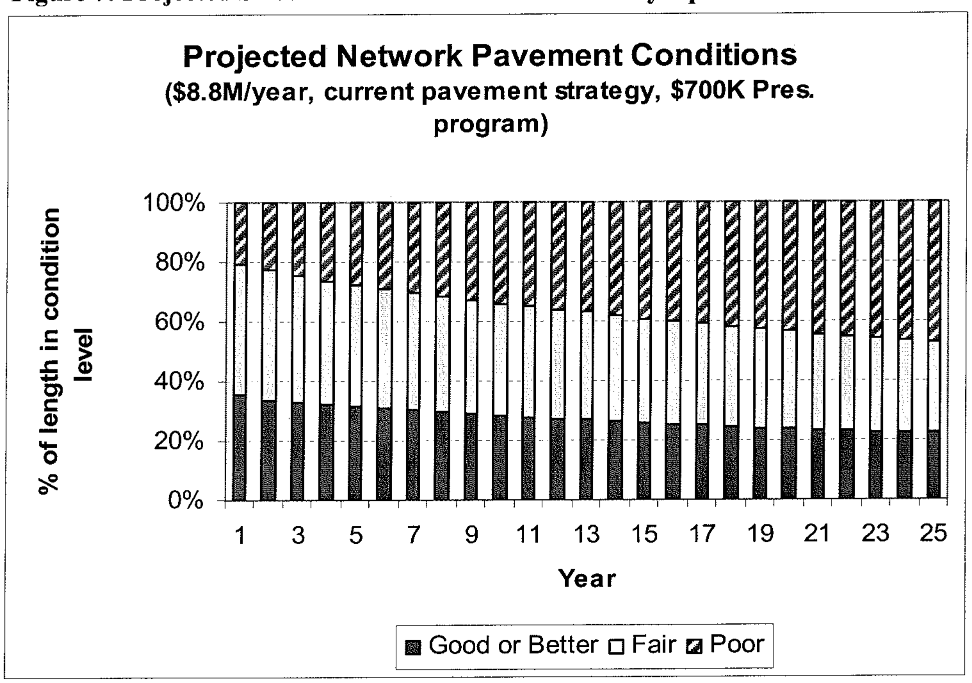
The audit consultant developed Policy Option 3, to reflect current funding levels of $9.5 million - $8.8 million in capital funding for structural rehabilitation and reconstruction, and $700,000 for maintenance activities, or $237.5 million over 25 years. Figure 6 shows the funding levels graphically.

Figure 6: Annual Funding for Policy Option 3



The projected results of this policy option are reflected in Figure 7, which shows an increase in poor rated streets from 21 percent in year one to approximately 47 percent in year 25. Correspondingly, the fair rated streets decline from 44 percent to 31 percent and good rated streets decline from 35 percent to 22 percent. Essentially, a continuation of the current funding and pavement strategy would result in an overall decline in the condition of the City residential streets.

Figure 7: Projected Street Network Conditions for Policy Option 3



In addition to Policy Option 3, the audit consultant developed Policy Option 8, to illustrate the impact of a program that optimizes limited resources. Policy Option 8 optimizes $250 million over 25 years. Figure 8 shows the funding levels graphically and Figure 9 shows the projected impact on the condition of residential streets.

Figure 8: Annual Funding for Policy Option 8

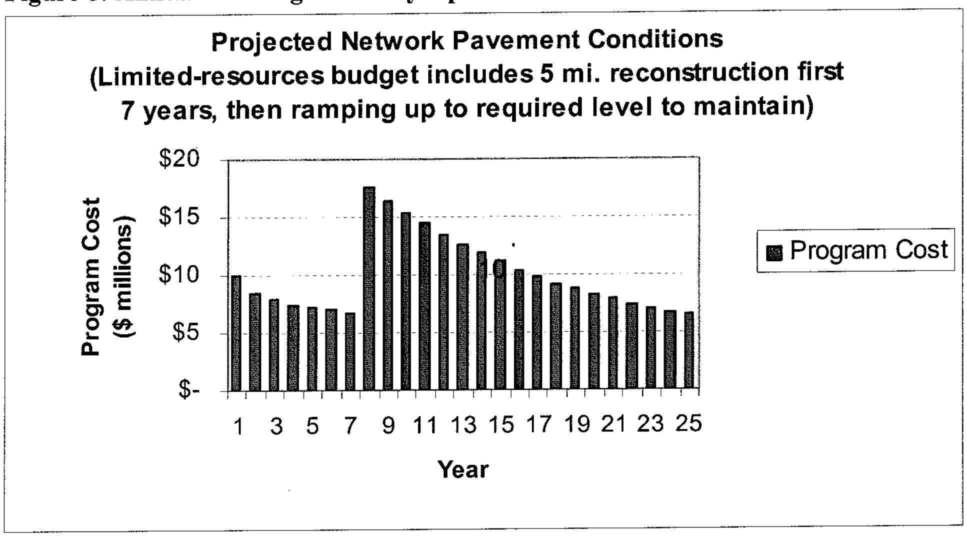
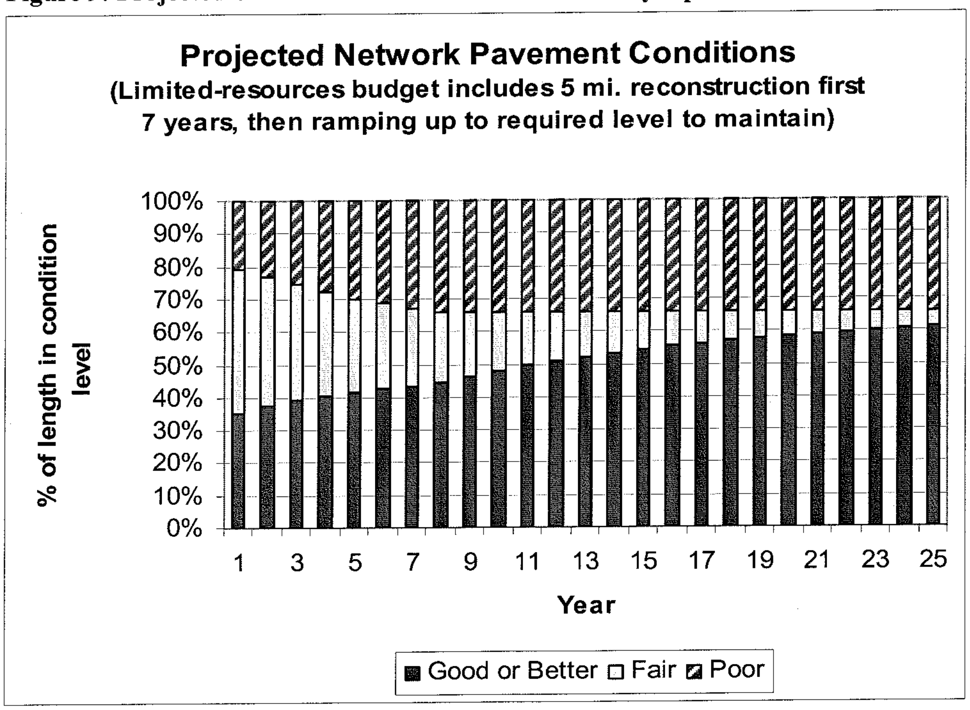


Figure 9: Projected Street Network Conditions for Policy Option 8



Unlike most of the policy options developed, Policy Option 8 targets 61 percent of residential streets as rated good in year 25, since this is the best that can be achieved with similar funding. Most of the other policy options set a target of 95 percent of streets as rated good in year 25. Policy Option 8 is suboptimal in terms of the overall quality of the streets, but its advantage is its lower relative cost.

Figure 9 shows an increase in poor rated streets from 21 percent in year one to 34 percent in year 25 for Policy Option 8. Correspondingly, the fair rated streets decline from 44 percent to 5 percent and good rated streets increase from 35 percent to 61 percent. Essentially, given modestly more funding compared to Policy Option 3 ($250 million versus $217.5 million), Policy Option 8 improves street conditions by moving towards a preserve-first strategy aimed at maximizing yield on infrastructure investment, compared to the worst-first approach currently applied.

Appendix D shows that based on current spending, an increase averaging at least $6 million over each of the next 25 years would be needed to halt further deterioration and improve the residential street network, as shown by Policy Option 7. Further improvements in street conditions could be achieved through additional funding, as indicated in the other policy options in Appendix D.

Regardless of the funding level selected, pavement preservation remains essential to minimizing the program cost. With any other option there is significant additional cost for repairs to streets at lower condition levels. Given this situation, it is difficult or impossible to achieve a cost-effective solution at lower condition levels with more streets in the "fair" category. Once the preservation threshold is passed, the cost of rehabilitation does not provide the same cost-benefit ratio and yields sub-optimal programs. Therefore, policy options at reduced funding levels like Policy Options 8 contemplate allowing a certain percentage of roads to move into the "poor" condition. Policy options at the lower funding levels defer backlog elimination and therefore cost more over the long-term. Policy options at higher funding levels are more cost-effective for a desired street condition standard.

Appendix D presents all nine policy options developed by the audit consultant in greater detail, a more dynamic array of policy options for consideration than presented here. Given the unlimited combination of funding commitments, paving strategies and pavement condition objectives, as well as significant financial resources and time horizon required to address the ongoing and backlog residential street needs, an entity of policymakers could provide oversight to assess the current condition of the residential street network, develop maintenance standards, establish priority setting criteria, and monitor DPW's performance against those criteria.

Recommendation 4: Develop and fund a revised "Preserve-First" pavement management strategy

DPW should develop a robust paving strategy to maintain the higher quality streets and eliminate the backlog of "poor" rated streets. This new pavement strategy should shift from the current worst-first project prioritization toward a preserve-first strategy. A preserve-first strategy facilitates the maintenance of better rated streets, to prevent them from falling into the poor classification and thereby allowing a "catch-up" on eliminating the backlog of poor quality streets. Paving program funding should be increased at least $6 million per year to halt further deterioration and substantially improve the residential street network. See Appendix D for a complete analysis of pavement strategy options.

Recommendation 5: Establish ongoing paving program oversight

The Mayor and Common Council should formalize ongoing paving program reporting and oversight to monitor the implementation of the audit recommendations and subsequently provide oversight for the proper maintenance of residential streets (and potentially other infrastructure components such as sewers, bridges, major streets and sidewalks). Entities which could provide such oversight include the Budget Office under the Mayor's Accountability in Management (AIM) Initiative, the Common Council Public Works Committee or a reconstituted Capital Improvements Committee (CIC). Depending on the scope of its responsibilities, a reconstituted Capital Improvements Committee could include representatives of the DPW, Budget Office, Comptroller and Common Council.

Maintenance Needs

Current maintenance activities are limited by the DPW Infrastructure Division's budget of approximately $700,000, with the majority of the funds being spent on repairs to streets in poor condition. There are some routine maintenance activities on flexible and composite pavement streets such as crack filling, and preservation activities such as routing-and-sealing cracks early in the pavement life, and a surface treatment, such as slurry seals with expected service life of 5 to 8 years and average cost of $50,000 per mile.

However, actual street maintenance needs go well beyond those currently deployed by DPW. The application of a surface treatment as a preservation treatment should take place while the road is still in good condition, but not so soon that the life extension is "wasted." A Pavement Quality Index (PQI) range of 7.5 to 7.2 was used as a starting point for proper timing of slurry sealing. This yielded a need for 16.7 miles, for an estimated total of $830,000. In addition, crack routing-and-sealing and crack filling continue to be required. Rigid pavement joints also need to be cleaned and sealed. Table 13 summarizes the need for these existing treatments. As discussed previously in this report, the set of treatments available for use is limited and should be expanded.

Table 13: Maintenance Needs Under Existing Conditions

Treatment	**Pavement Type**	**Criterion**	**Miles Needed Per Year (2008 used to estimate)**
Slurry Seal	Flexible, Composite	PQI 7.5 – 7.2	16.7
Routing and Sealing Cracks	Flexible, Composite	5 years after surface placed	5.7
Crack Filling (independent of surface treatment)	Flexible, Composite, Macadam	Top 2/3 of streets in fair condition; bottom 1/3 in good condition, every 5 years (composite, flexible, macadam)	38.1
Cleaning and Sealing Joints and Cracks [6]	Rigid	Every 10 years; poor condition streets excluded if distress is mostly joint-related	0 miles dating from 10 years ago; program could handle multiple years, 10-15 years old (1993-1997) add up to 14 miles.

The benefits of preservation maintenance are illustrated with the Pavement Performance Curves in Appendix F. Pavement can be maintained in good condition over an extended service life with timely and adequate preservation maintenance. Withholding such maintenance leads to quicker deterioration and pavement rehabilitation and reconstruction work at higher cost.

[6] This could be started with 20-year old pavements as well. 10-15 year-old pavements were selected to follow preservation principles.

The audit found a discrepancy in the total miles of residential streets from three different data sources – DPW's Road Life (969) and Pavement Management Application (PMA) (1024) databases and the Comptroller's Expenditure Report (942.1). These discrepancies have an impact on the absolute mileage totals reported in the audit depending on the data source selected, but no material impact on the nature of the report findings or any relative results, such as breakdowns by percentage, etc.

The mileage discrepancies appear when different data sources are used to calculate the total length of residential streets in the City of Milwaukee. Although these discrepancies can be disconcerting at first glance, the effect on the findings in this report are not of sufficient magnitude to impact the nature of the recommendations. However, there are impacts in terms of the absolute number of miles reported (about 5.7 percent higher if they are based on the 1,024 PMA total miles versus the 969 Road Life miles). DPW staff ascribed the higher 1,024 PMA miles to the fact that the PMA approximates street intersection lengths and that divided streets are counted separately in the PMA

All data analysis for the audit was conducted on the Pavement Management Application data set. For audit purposes the 100 percent length was 1,024 miles. In order to understand the magnitude of each number reported if the residential street network actually totals 969 miles, reported numbers would be multiplied by 0.946.

When examining relative numbers (percentages, breakdown of mileage, etc.) there is virtually no adjustment required. This conclusion was borne out in weighted age queries where the Road Life and the PMA databases were queried separately, as well as by taking a quasi-random sample out of the PMA database and querying the average network condition. In conducting these queries, the total mileage remained unchanged from the complete data set to at least two decimal points.

Accurate inventories of length of roadway for larger networks, such as the City of Milwaukee residential street network, are a challenge for any agency. Pavement management professionals as well as personnel closely involved with data collection are generally aware of these issues and typically find that these variations do not have a major effect on the nature of the information being presented, unless there is a large bias in the way the lengths are computed in the first place. Nevertheless, there is great value in having an "official" length for the system being maintained.

Recommendation A1: Select one length measurement as the "official length" for each segment. This could be the PMA or the Road Life database. Add a field to the PMA database for "official segment length." This length will differ from the length measured with the data-collection equipment, but will remain unchanged over time unless the physical dimensions of the street segment change. Then, when queries are run, the official segment length can be used to report conditions, for subsets and totals. This will provide stability over the long term as well as a solid accounting measure regardless of variances in measurement with data-collection equipment.

Appendix B provides a list of recommendations to produce a systematic improvement to the decision-support mechanism necessary to underpin a comprehensive pavement-management program for the City of Milwaukee. The underlying observations and the recommendations are discussed in greater detail in consultant memoranda submitted in the course of the audit.

Recommendation B1: Initiate the formation of any project list with Pavement Management Application (PMA) output, selecting an appropriate threshold level for rehabilitation (Pavement Quality Index 5.5 or less is suggested as a starting point). Supplement this initial candidate list with other current information sources.

Recommendation B2: Implement a procedure to "calibrate" pavement condition data projected by the PMA between data collection cycles, to reduce the risk of PMA "data drift" from uncontrolled factors such as extreme climatic cycles or changes in construction material properties. Procedures should include an independent verification of condition index estimations through a field evaluation of a representative sample of pavement segments, increasing the frequency of data collection, and/or allowing for a special data collection cycle after an extreme change.

Recommendation B3: Develop a methodology for combining PMA segments into meaningful project segments, and compute the Pavement Quality Index (PQI) for these units of analysis. This new layer of segments should be based on homogeneity of performance and composition, but could also include heterogeneous data collection segments.

Recommendation B4: Examine PQI values of individual PMA segments to identify opportunities for localized maintenance intervention that can increase the homogeneity of pavement performance.

Recommendation B5: Use the individual indices that compose the PQI to extract useful information about distress drivers that can be useful in prioritizing projects, alerting to possible scope change needs, and other engineering analyses.

Recommendation B6: Incorporate preservation treatments into the PMA treatment toolbox. The current PMA has a maintenance module that should be utilized.

Recommendation B7: Use high PQI values as a "reverse threshold" to trigger preventive maintenance treatment candidate projects, using PMA data. A range in the bottom of the "good or better" range (7.2 – 8.2) is suggested as a starting point, and can be subsequently calibrated so that the proper range of projects is being considered.

Recommendation B8: Complement PMA data with a time based schedule for programming certain maintenance treatments.

Recommendation B9: Increase the robustness of the PMA quality assurance program, especially with regard to acceptance of data. Formalize the program, documenting components, roles, and responsibilities so that it can be reviewed and adapted periodically and so that a proper assessment of system performance and/or reliability can be conducted in a straightforward manner.

Recommendation B10: Adopt a rating system for use by maintenance personnel in evaluating the condition of the segments they are considering. The PASER system provided by the DPW's maintenance staff could be useful in this regard. Provide the PASER rating along with the segment referral to DPW's Local Streets section.

Recommendation B11: Adopt a plan to integrate data collection that is captured and/or repeated in several DPW units. A suggested starting point is to compile soil-classification results currently available for City sewers. Use the DPW's GIS to develop a spatial profile of soil conditions. This will provide a salutary example for other data integration and streamlining efforts not only with the PMA as a client but also as a data source for supporting other programs.

Recommendation B12: Implement a formalized process for evaluating emerging pavement technology, products, and processes. This process should include condition evaluation performed on discrete "test segments" at frequent, periodic intervals, and a feedback mechanism for evaluation and development of adequate performance models.

Appendix C provides recommendations for Pavement Management Application integration into the paving program. The audit consultant provided more detailed information and analysis for these recommendations and the underlying observations that produced them.

Recommendation C1: Strengthen the data collection quality assurance program, with a focus on Rigid (Concrete) pavements.

Recommendation C2: Increase the frequency of data collection to help avoid "data drift" due to differences in actual and forecasted pavement performance. Pavement Management Application (PMA) data should be updated no later than every four years to maintain current conditions in the database.

Recommendation C3: Reduce time between data collection measurements. With long intervals between data collection measurements, there is increased likelihood for certain pavement improvements in the intervening time interval to modify distress conditions. This may be especially true of wide, longitudinal utility patching that replaces distressed pavement. In theory, the impact of this type of utility patching should improve condition levels for lower condition level streets.

Recommendation C4: Adjust pavement performance curves, especially after a third data collection cycle. There is sufficient data to refine both the basis of the curve family development (soil type, pavement thickness, and traffic volume) as well as to adjust to local pavement performance.

Recommendation C5: Incorporate maintenance treatments and analysis of those treatments into the PMA. This should include the calculation of remaining service life, or the forecasted time between current condition and minimum acceptable condition.

Recommendation C6: Integrate project history, condition history, and pavement related data into a single database. There are very comprehensive sets of project and construction history data in Milwaukee, but there is a corresponding significant opportunity for data integration and avoidance of having to enter and/or maintain data in separate locations. This will likely be an ongoing process conducted on an incremental basis once the framework for data storage has been defined.

Recommendation C7: Provide sufficient resources to accomplish all of the above tasks. Currently, there is only one engineer dedicated to these activities. The scope of work required is substantially more than can be accomplished by a single individual.

Recommendation C8: With material and energy costs undergoing significant price increases, rapid and accurate feedback of price changes and trends is essential to maintaining credibility of the program needs assessment, especially at the higher budget levels recommended by this audit. This will result in greater scrutiny of program effectiveness, since other competing city service needs or funding sources will be affected.

Appendix D presents an analysis of various pavement policy options in terms of the funding levels required (in 2007 dollars) and their impacts on the pavement condition of the residential street network.

Regardless of the funding level selected, pavement preservation remains essential to minimizing the program cost. With any other approach there is significant additional cost because repairs at lower condition levels require much more effort and cost. Given this situation, it is difficult if not impossible to achieve a stable condition at lower condition levels (with more streets in the "fair" category) that is at the same time more cost-effective. Once the preservation threshold is passed, the cost of rehabilitation does not provide the same cost-benefit ratio and yields sub-optimal programs. Therefore, policy options at reduced funding levels contemplate allowing a certain percentage of roads to move into the "poor" condition, in effect "reducing" the size of the network that must be managed. In effect the best approach at reduced funding levels is to defer the backlog-elimination program until such time as that program is financially feasible.

Also, in the first four years of the program the miles of roadway falling into the "poor" category is higher than in subsequent years. This is because deterioration over the first four years was produced from Pavement Management Application (PMA) data and subsequent forecasts have been derived from more generic deterioration assumptions (years to transition from one condition state to another). Both data sets are only estimates of actual deterioration. As part of an implementation plan to follow through on the recommendations of this audit, one of the first tasks should be to use the City's PMA to produce more refined results. This should be done once pavement preservation has been incorporated into the PMA.

This analysis conveys a range of strategies that can be implemented at various funding levels, including those that provide policymakers with options that are fiscally feasible in the shorter term. The following nine Policy Options are presented.

Policy Option 1: Maintain current capital funding and pavement strategy (capital improvement program, worst-first project selection).

Policy Option 2: Maintain current pavement strategy (capital improvement program) and eliminate the pavement-condition backlog.

Policy Option 3: Take into account contribution of pavement-preservation strategy but at current capital and maintenance funding levels.

Policy Option 4: Incorporate a pavement-preservation and Rehab-Then-Preserve (RTP) strategy and eliminate the pavement-condition backlog.

Policy Option 5: Incorporate a pavement-preservation and RTP strategy and maintain the current pavement-condition backlog, then gradually address the backlog.

Policy Option 6: Expand pavement-preservation into lower condition levels, perhaps combined with minor repair of structural conditions, and expand the RTP strategy into lower condition levels, and eliminate the backlog.

Policy Option 7: Defer (postpone) the backlog-elimination program until a propitious time when fiscal resources are available.

Policy Option 8: Optimize a program with limited resources at $250 million over 25 years.

Policy Option 9: Include a new treatment consisting of effecting structural rehabilitation on sections that need reconstruction in order to reduce the number of "poor" streets.

In terms of pavement-intervention type, the components of the policy options analyzed are defined as follows:

Pavement Preservation: The Federal Highway Administration (FHWA) Pavement Preservation Expert Task Group defines pavement preservation as,

> *"...a program employing a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety and meet motorist expectations."*

Pavement preservation treatments in this analysis consist of those treatments designed to maintain good roads in good condition. (Note: Policy Option 6 contemplates including minor spot preparatory work along with the preservation treatment to bring some "high-fair" streets in good general structural condition back to the "good" category). The list of potential treatments is extensive, and can include thin surface treatments (slurry seal, fog seal, microsurfacing, rubberized chip seal), preventively routing and sealing cracks, cleaning and sealing concrete-slab joints, and diamond-grinding Portland Cement-Concrete pavements, among others.

Rehab-Then-Preserve (RTP): A strategy consisting of minor, or functional, rehabilitation treatments (as defined in Appendix G, and usually consisting of resurfacing) designed to correct non-structural distress that if left untreated would lead to premature failure, or non-structural distress that is negatively impacting the condition of the roadway. (Note: Policy Option 6 contemplates including minor spot preparatory work along with the minor, functional rehabilitation treatment (usually resurfacing) to allow some "fair" roads in adequate general structural condition to be upgraded to the "good" category.

Structural Rehabilitation: Pavement treatments that address deficiencies in the ability of the roadway facility to support traffic loading (and some environmental loading). Structural rehabilitation treatments usually consist of significant repairs to the existing pavement, followed by reinforcement of the pavement structure. When extensive and severe structural distress is present, the cost of structural rehabilitation begins to approach that of reconstruction and becomes economically inefficient.

Reconstruction: The complete replacement of the pavement structure, at least in the bound layers (those with some cementing agent). For the purposes of this audit, the term is interchangeable with "pavement replacement."

Table D1: Policy Option Summary

Policy Option	Total Program Cost	Present Value (Cost rank – least to most)	Comments
1. Maintain current strategy (reconstruction; structural rehab) and capital funding level ($8.8M/year).	$220M	$130M (1)	Least expensive; results in declining conditions.
2. Maintain current strategy (reconstruction; structural rehab), implement backlog elimination program [10 years, 20 years].	a. $1B (10 year program) b. $1B (20 year program)	a. $639M [10-year program] (11) b. $590M [20-year program] (10)	10-year program provides quick condition turnaround; lower present value of 20-year program reflects deferment of some capital investments.
3. Implement pavement preservation strategy (limited preservation funds; reconstruction; structural rehab) at current capital ($8.8M/year) and maintenance ($0.7M/year) funding.	$238M	$141M (2)	Significant condition improvement over Option 1 (although still declining over time) at a minimally higher cost.

Note: Discount rate used for this analysis was 5%

Table D1: Policy Option Summary (Continued)

Policy Option	Total Program Cost	Present Value (Cost rank – least to most)	Comments
4. Implement preservation and "Rehab, Then Preserve" (RTP) strategy (preservation; minor rehab with subsequent preservation; reconstruction), implement backlog elimination program [10, 20 years].	a. $641M (10 year program) b. $633M (20 year program)	a. $453M [10 year program] (8) b. $418M [20 year program] (7)	10-year program provides quick condition turnaround; 20-year program is less expensive because more expenses are deferred farther into future. More cost-effective than Option 2.
5. Implement preservation and RTP strategy (preservation; minor rehab with subsequent preservation; reconstruction), phase in backlog elimination program to maintain "constant" budget.	$630M	$394M (6)	Provides for a slower turnaround versus Option 4 but may be easier to manage. Lower cost reflects deferment of some capital investments.
6. Implement preservation and RTP strategy (preservation; minor rehab with subsequent preservation; reconstruction); expand into lower condition levels combined with minor structural repair.	$548M	$372M (5)	Success depends on accurate project selection; condition levels are somewhat lower than in Option 5.
7. Implement preservation and RTP strategy (preservation; minor rehab with subsequent preservation; reconstruction); omit backlog elimination program.	$384M	$265M (4)	Allows for deferment of backlog elimination program while optimizing investment in remainder of network. Maintains roughly 20% of streets in "poor" condition.
8. Optimize limited budget of $250M over 25 years (preservation strategy; minor rehab with subsequent preservation; reconstruction).	$250M	$150M (3)	Optimizes limited budget; percentage of network in poor condition increases over time (backlog grows)
9. Apply structural rehab to poor segments to limit their number; maintain current level of poor streets (preservation; minor rehab with subsequent preservation; 20% reconstruction, 80% improvement).	$728M	$454M (9)	This option is presented to simulate loss of cost-effectiveness due to project selection and treatment that are inadequate.

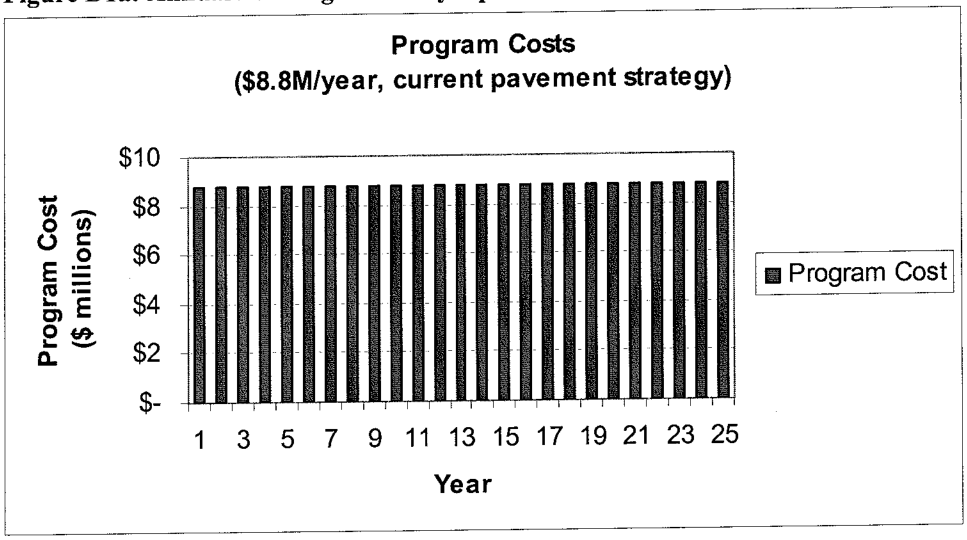
Note: Discount rate used for this analysis was 5%.

Each of these options carries effects on funding and pavement condition. The audit model reflects impact on pavement condition through graphical examination of annual funding levels and pavement-condition breakdowns (good vs. fair vs. poor.) The analysis is carried out over a 25-year analysis period.

The graphical representation of the model results below is a brief "user's guide" to the model. The model used is not intended to replace the PMA, but rather to provide sufficient information as part of the audit to support the recommendations and conclusions laid out in the report. On a continuing basis, the PMA should be used to provide the required information.

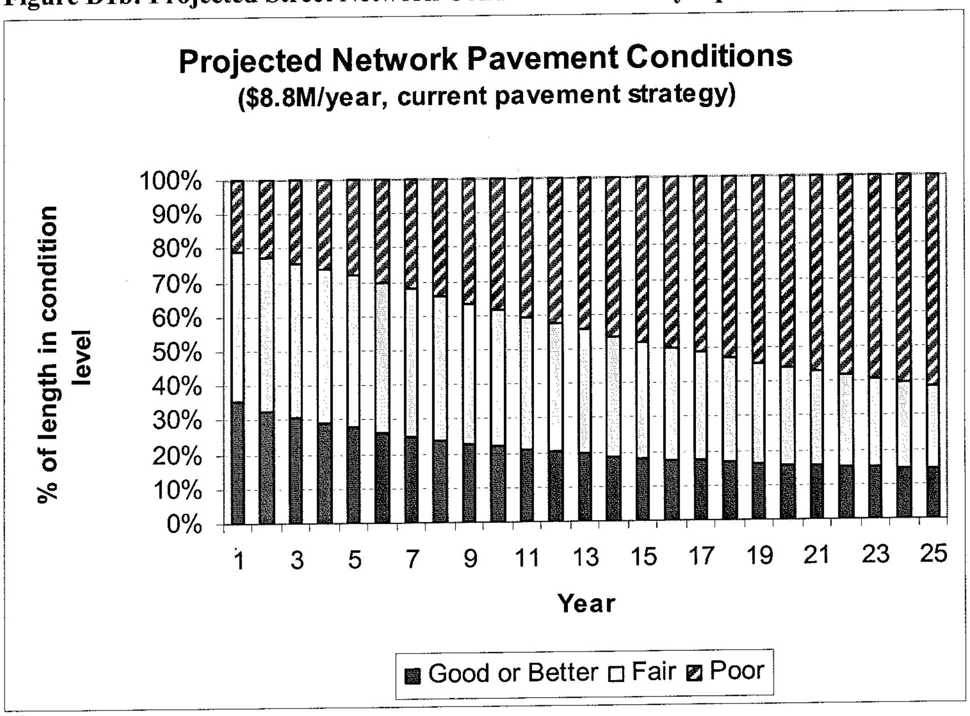
Policy Option 1: Maintain current funding level and pavement strategy.

Figure D1a: Annual Funding for Policy Option 1



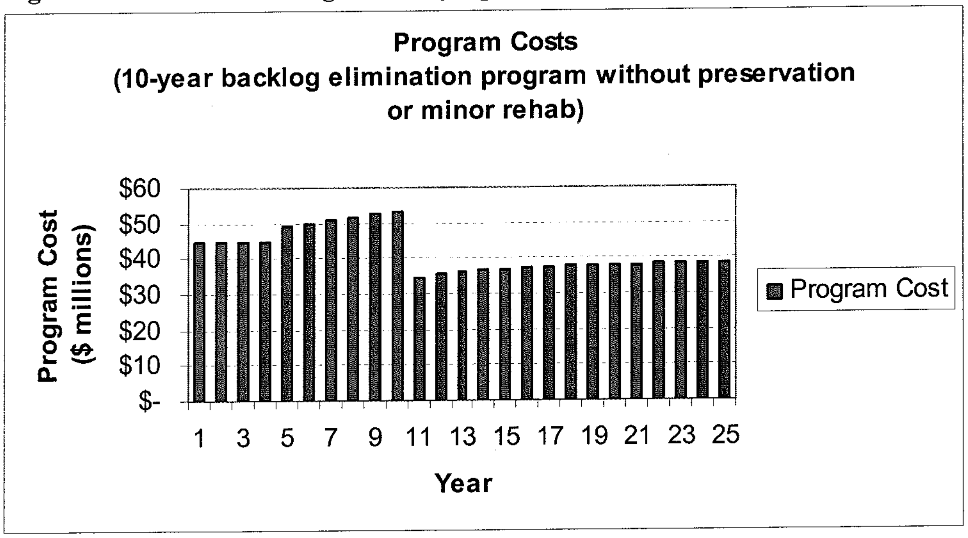
25-year total cost $220M (w/o preservation)

Figure D1b: Projected Street Network Conditions for Policy Option 1



Policy Option 2: Maintain current pavement strategy (capital improvement program) and eliminate the pavement-condition backlog (10 and 20 year backlog elimination programs).

Figure D2a: Annual Funding for Policy Option 2 (10 year backlog elimination)



25-year total cost w/10-year backlog elimination program: $1B

Figure D2b: Projected Street Network Conditions for Policy Option 2 (10 year backlog elimination)

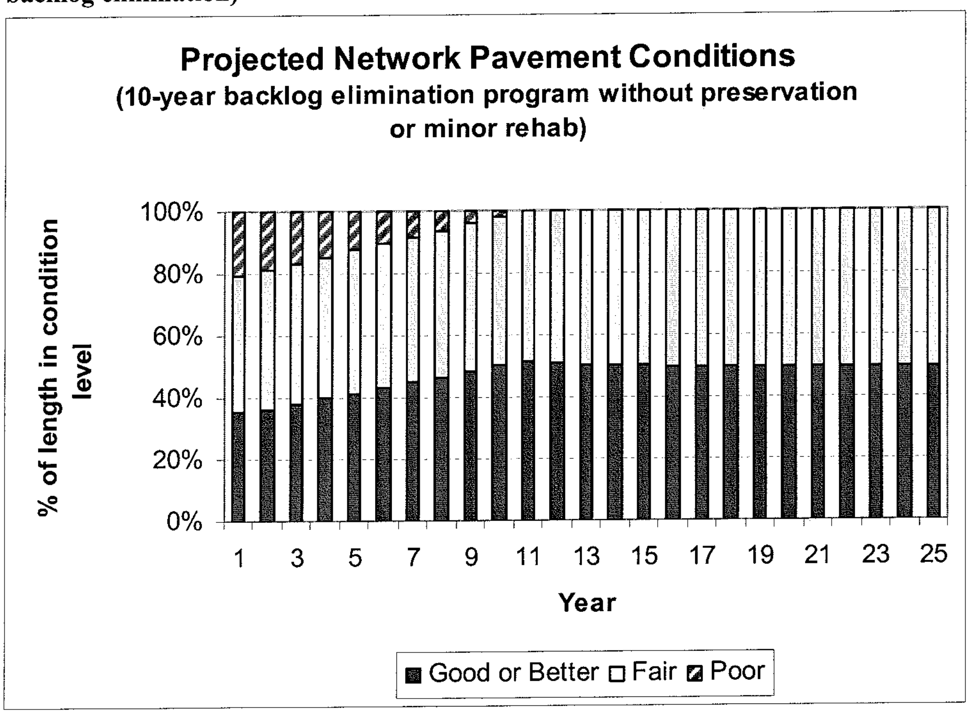
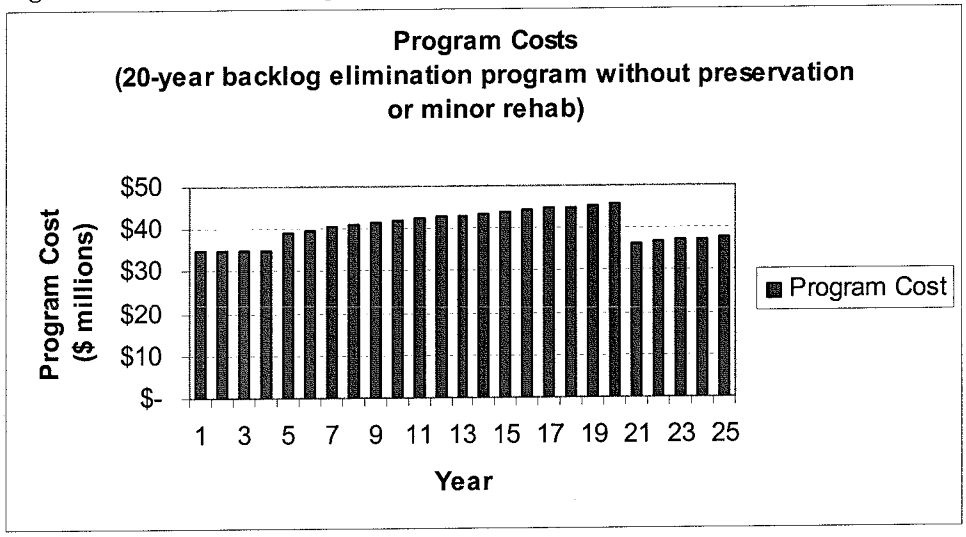
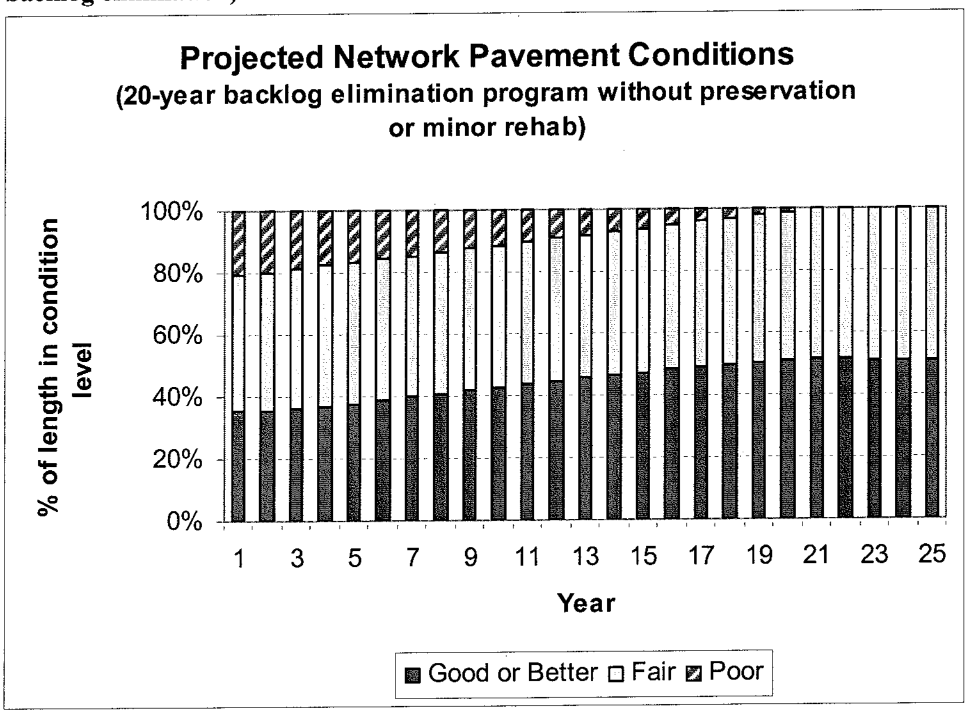


Figure D2c: Annual Funding for Policy Option 2 (20 year backlog elimination)



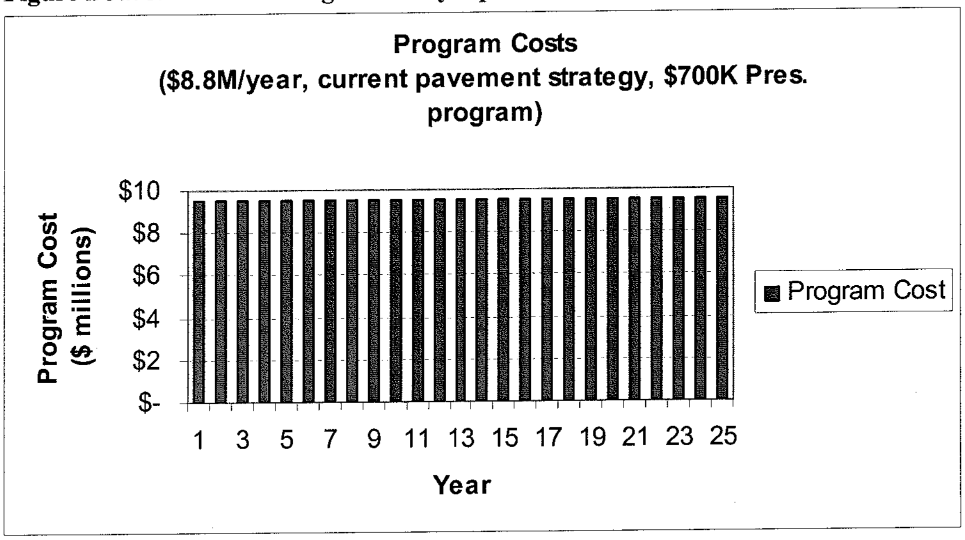
25-year total cost w/20-year backlog elimination program: $ 1B

Figure D2d Projected Street Network Conditions for Policy Option 2 (20 year backlog elimination)



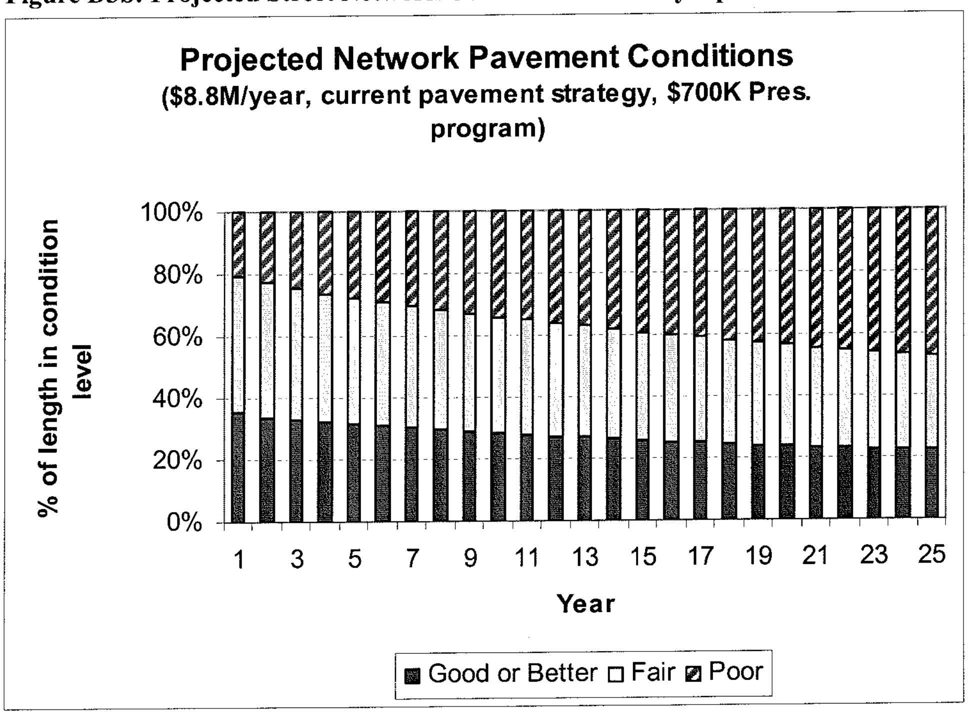
Policy Option 3: Take into account contribution of pavement-preservation strategy at current capital and maintenance funding levels.

Figure D3a: Annual Funding for Policy Option 3



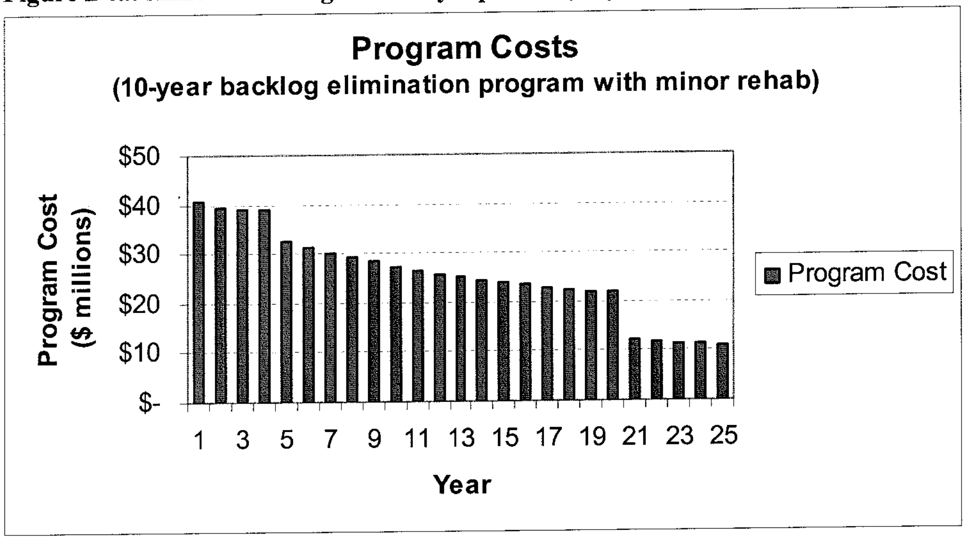
25-year total program cost $238M

Figure D3b: Projected Street Network Conditions for Policy Option 3



Policy Option 4: Incorporate a pavement-preservation and Rehab-Then-Preserve (RTP) strategy and eliminate the pavement-condition backlog (10 and 20 year backlog elimination programs).

Figure D4a: Annual Funding for Policy Option 4 (10 year backlog elimination)



25-year total cost with 10-year program: $641M

Figure D4b: Projected Street Network Conditions for Policy Option 4 (10 year backlog elimination)

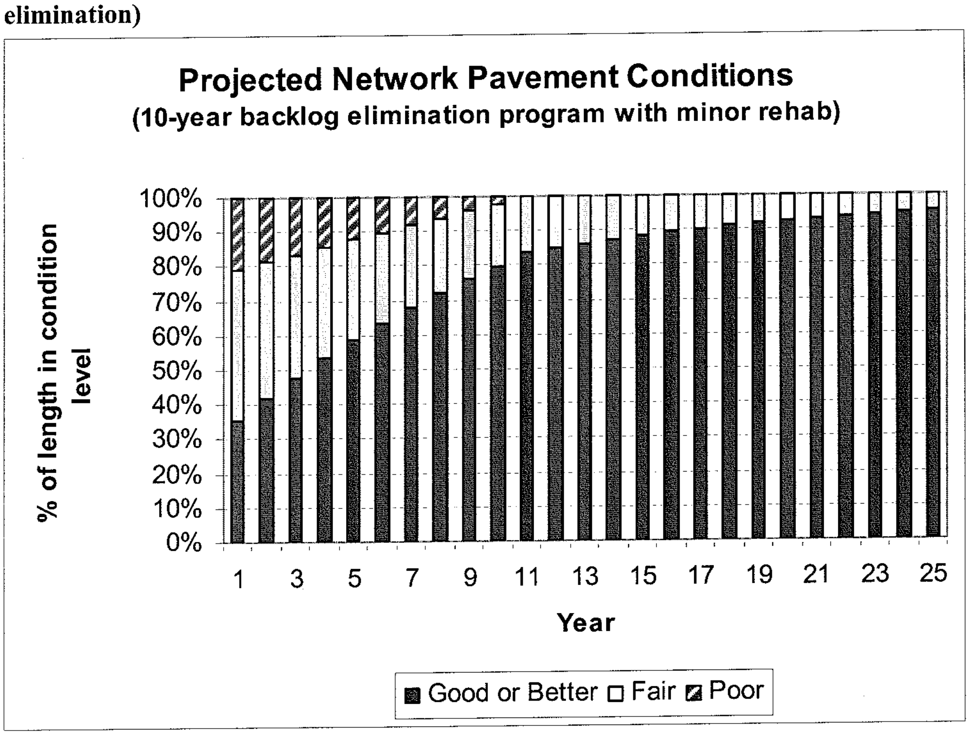
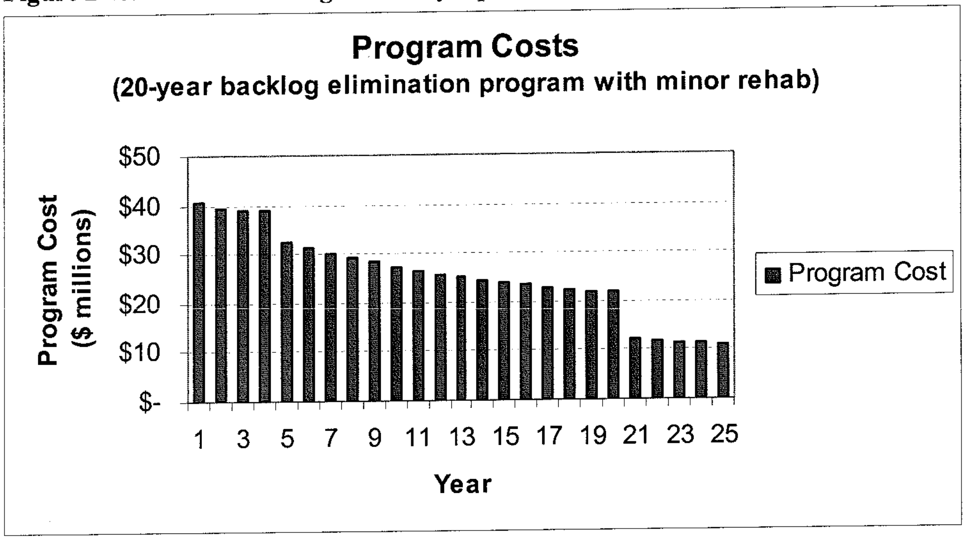
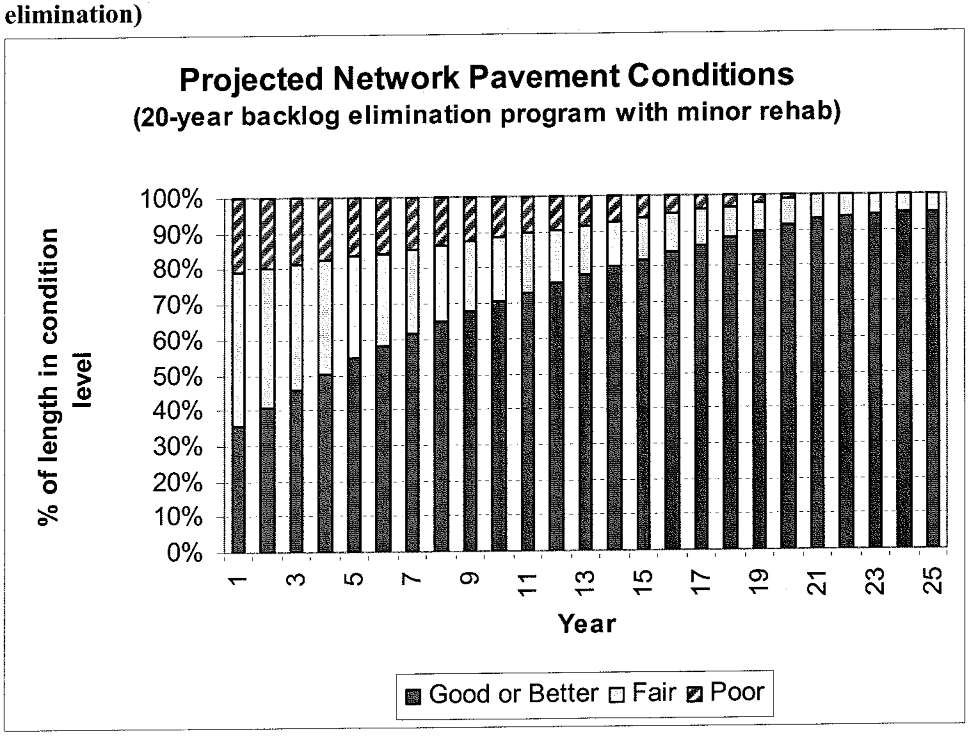


Figure D4c: Annual Funding for Policy Option 4 (20 year backlog elimination)



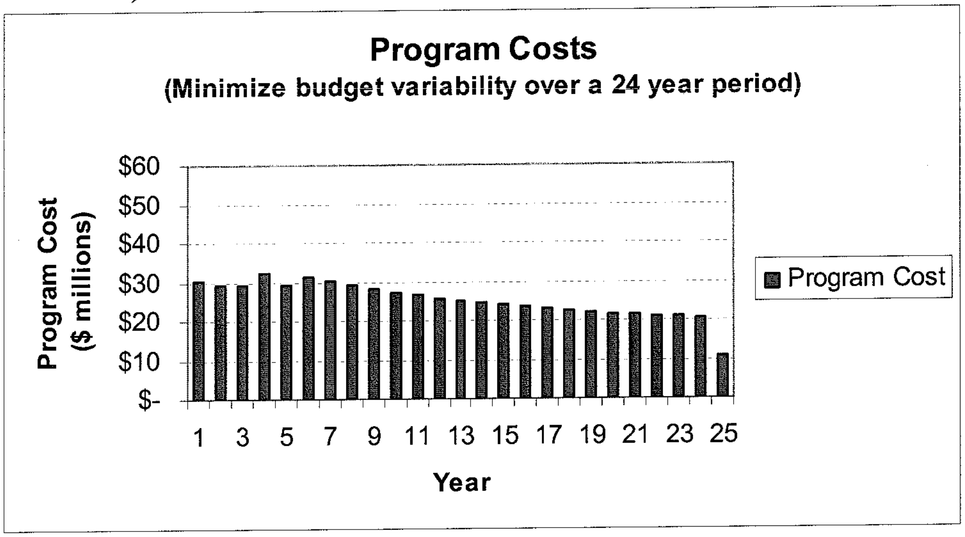
25-year total cost with 20-year program $633M

Figure D4d: Projected Street Network Conditions for Policy Option 4 (20 year backlog elimination)



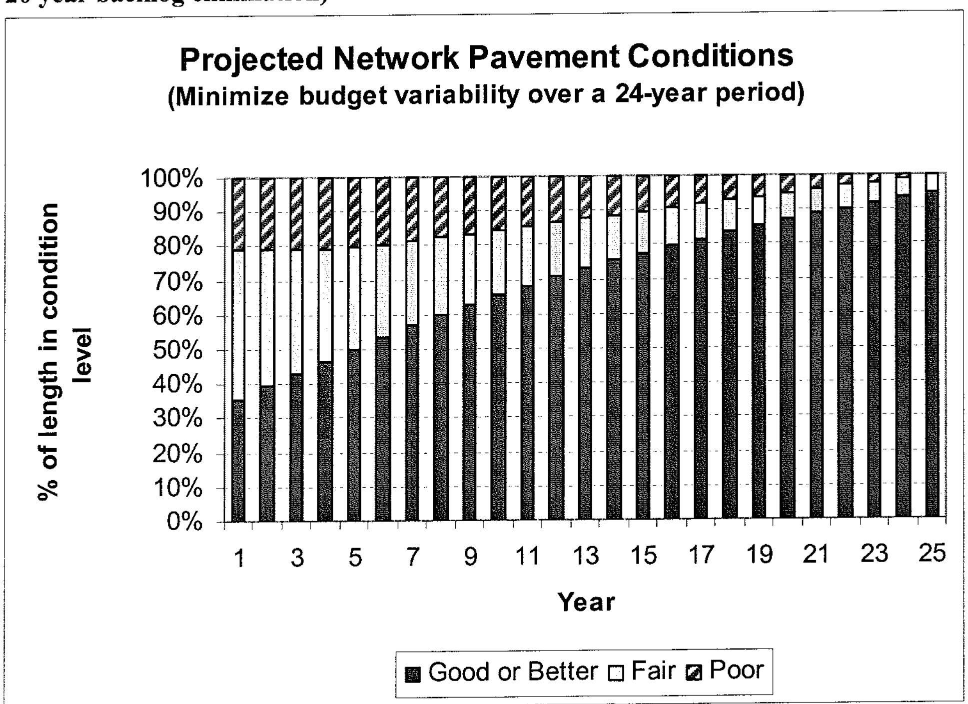
Policy Option 5: Incorporate a pavement-preservation and RTP strategy and maintain the current pavement-condition backlog, then gradually address the condition backlog (5-year delay, 20-year backlog elimination program).

Figure D5a: Annual Funding for Policy Option 5 (5 year delay, 20 year backlog elimination)



25-year total cost $630M

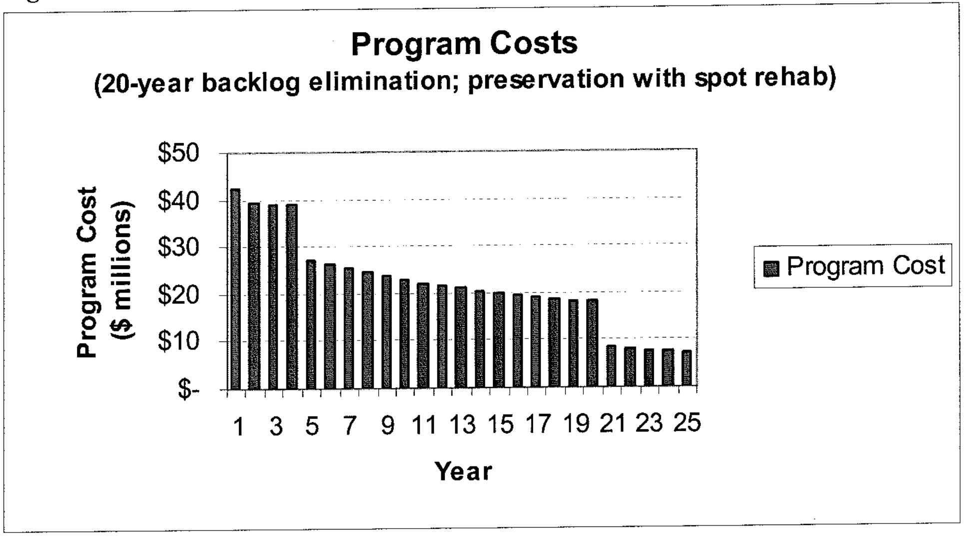
Figure D5b: Projected Street Network Conditions for Policy Option 5 (5 year delay, 20 year backlog elimination)



Policy Option 6: Expand pavement-preservation into lower condition levels, perhaps combined with minor repair of structural conditions, and expand the RTP strategy into lower condition levels, and eliminate the backlog.

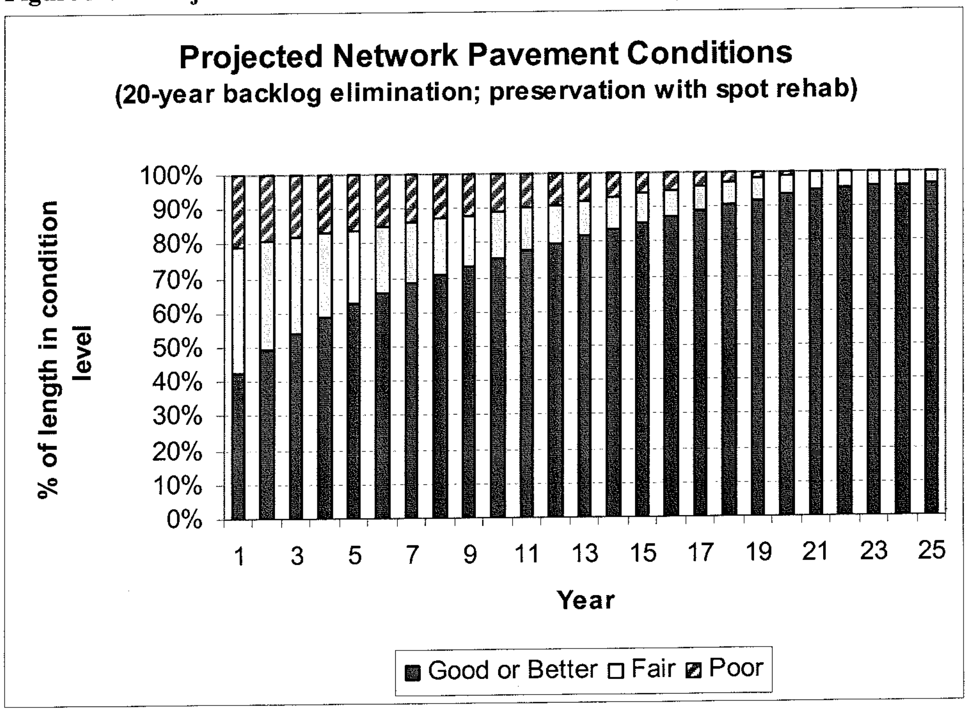
Policy Option 6 results in "extended life" for pavements at the range at which they can be addressed without capital improvement. The service life is correspondingly longer, and the "sustainable budget" is correspondingly lower (see funding required at year 25, once the backlog has been eliminated).

Figure D6a: Annual Funding for Policy Option 6



25-year total cost $548M

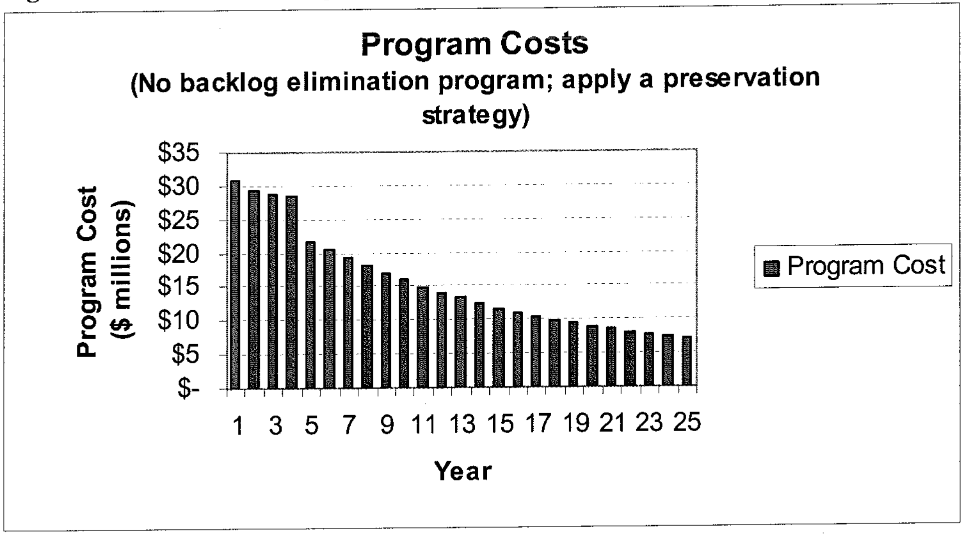
Figure D6b: Projected Street Network Conditions for Policy Option 6



Policy Option 7: Defer (postpone) the backlog-elimination program until a propitious time when fiscal resources are available.

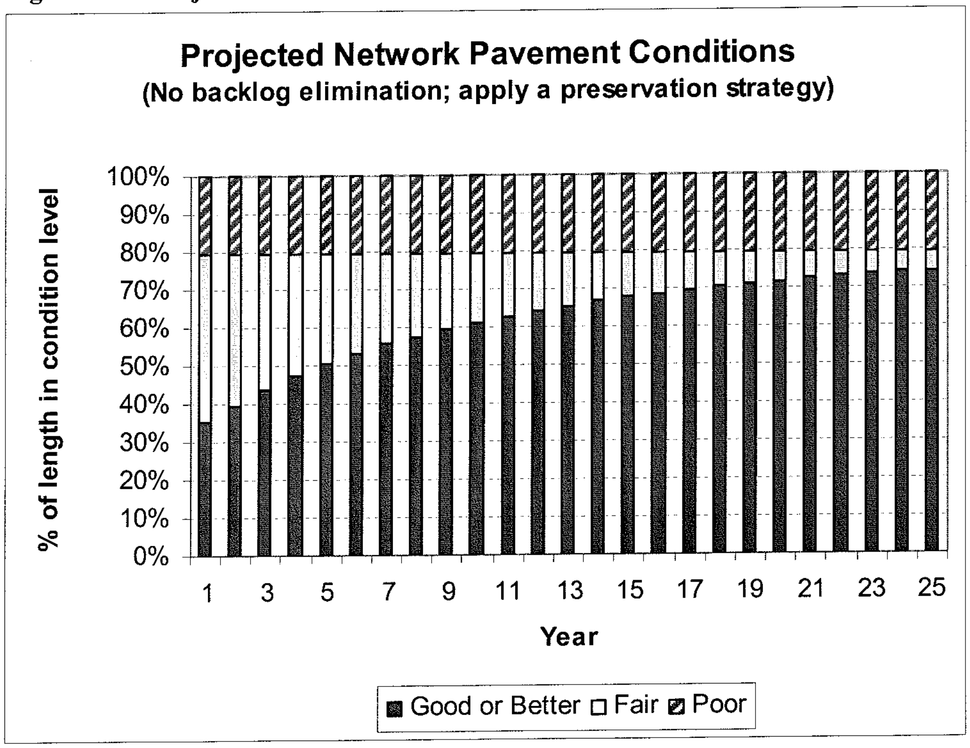
Since 21 percent of the current network is in poor condition, the effective size of the network that is proactively managed is reduced. This results in the lower ongoing yearly cost as observed in Figure D7a. The remaining pavements are maintained in the good-or-better range, at lower cost. It is not cost-effective to maintain more "fair" streets.

Figure D7a: Annual Funding for Policy Option 7



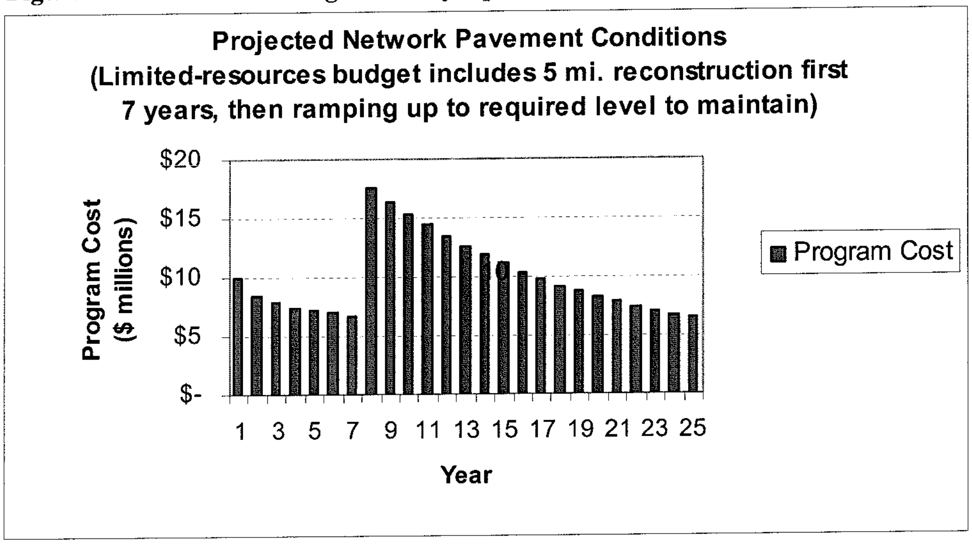
25-year total cost $384M

Figure D7b: Projected Street Network Conditions for Policy Option 7



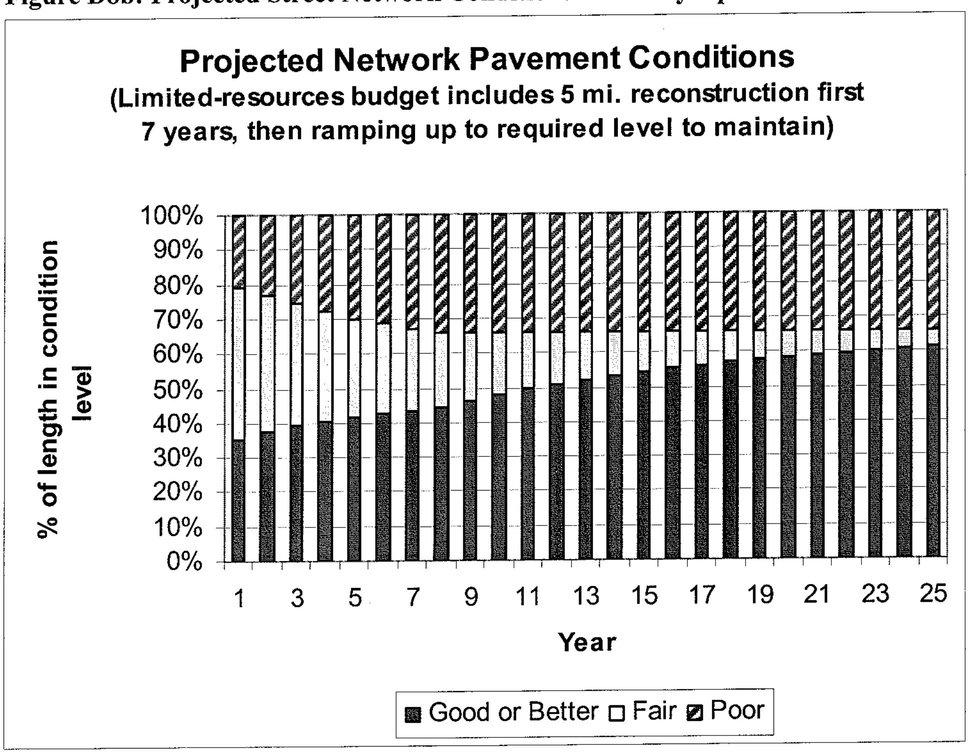
Policy Option 8: Optimize a program with limited resources at $250M over 25 years.

Figure D8a: Annual Funding for Policy Option 8



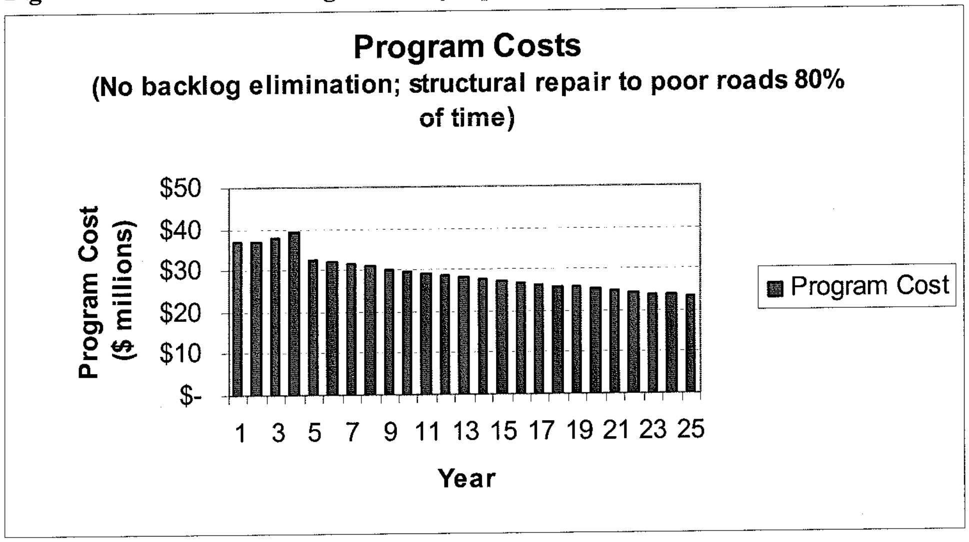
25-year program cost $250M

Figure D8b: Projected Street Network Conditions for Policy Option 8



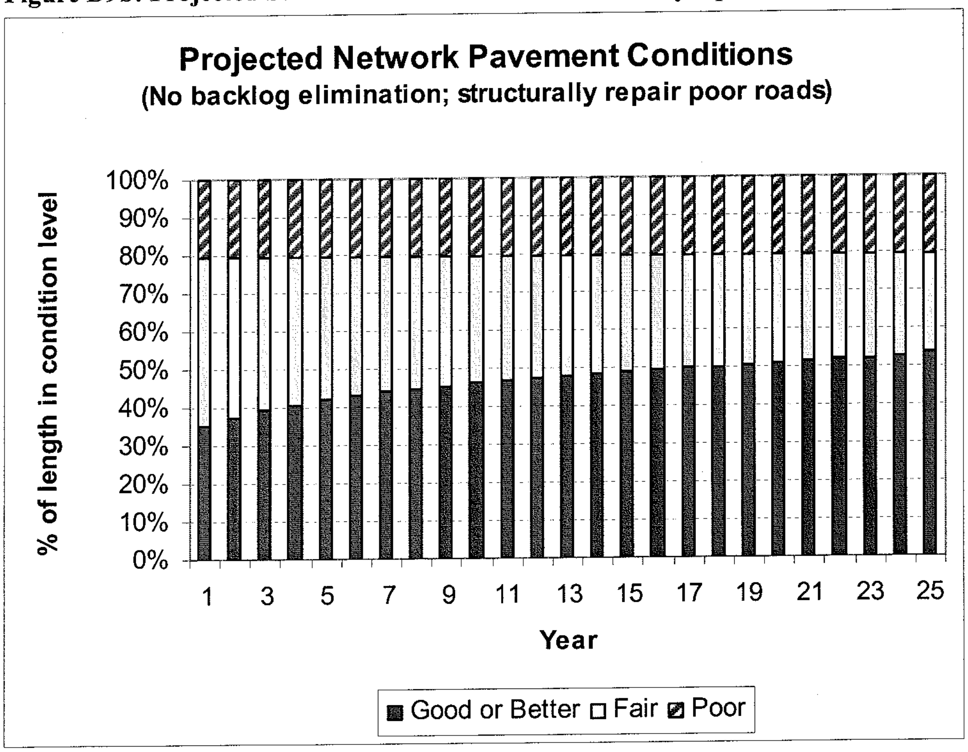
Policy Option 9: Include a new treatment consisting of structural rehabilitation on segments that require reconstruction in order to reduce the number of "poor" streets.

Figure D9a: Annual Funding for Policy Option 9



25-year program cost $728M

Figure D9b: Projected Street Network Conditions for Policy Option 9



Please note the difference in cost between Policy Options 7 and 9. Both result in the same percentage of poor streets, but Policy Option 9 contemplates more streets in "fair" condition at an additional program cost of approximately $344M over 25 years. Policy Option 9 demonstrates the effect of not following the most cost-effective strategies. It also shows the long-term effect of attempting to take shortcuts to the appropriate treatment in order to increase the number of miles treated.

Policy Scenario Assumptions

Initial condition breakdown as follows with required inputs for Policy Option 6 in [brackets]:

- Good or better pavements, Pavement Quality Index PQI: 7.2 – 10.0.
- Preservation candidates, PQI 7.2 – 7.39 [PQI 6.8 – 7.19]
- Rehab-Then-Preserve (RTP) candidates, PQI 6.8 – 7.19 [PQI 6.2 – 6.79]
- Fair pavements beyond RTP, PQI 4.5 – 6.79 [PQI 4.5 – 6.19]
- Poor pavements, PQI 1 – 4.49 [PQI 1 – 4.49]

Cost per mile used for each treatment type with Policy Option 6 in [brackets]:

- Pavement preservation: $50,000 / mile [$50,000 / mile]
- Rehab-then-preserve (minor functional rehabilitation, usually resurfacing): $210,000 / mile [$250,000 / mile]
- Structural rehabilitation: $455,000 / mile
- Reconstruction (replacement): $ 910,000 / mile

Additional Assumptions for Policy Options 1-5, 7-9

- The expected time from point of rehabilitation to the point beyond where the pavement can be preserved (PQI < 7.2) is 12 years.
- The expected time from the point when a pavement falls into the RTP category until it can no longer be a candidate for minor rehab (PQI < 6.8) is 8 years.
- The expected time from the point when a street is just beyond the scope of minor rehab (RTP) to poor condition is 12 years.
- The expected life of a preservation treatment is 6 years.
- Pavements which are preservation candidates can continue to be preserved over the duration of the analysis period because when the pavement structure is properly designed and constructed, the traffic loading is not material – it is the environmental loads that govern the behavior as long as the structure is not compromised.

Additional Assumptions for Policy Option 6

- The expected time from point of rehabilitation to the point beyond where the pavement can be preserved (PQI < 6.8) is 16 years
- The expected time from the point when a pavement falls into the RTP category until it can no longer be a candidate for minor rehab (PQI < 6.2) is 8 years.
- The expected time from the point when a road is just beyond the scope of minor rehab (RTP) to poor condition is 12 years.
- The expected life of a preservation treatment is 10 years, which is the time between consecutive treatments.
- Pavements which are preservation candidates can continue to be preserved over the duration of the analysis period, because when the pavement structure is properly designed and constructed, the traffic loading is not material – it is the environmental loads that govern the behavior as long as the structure is not compromised)
- The increase in cost for preparatory work for preservation treatments is 10 percent of the treatment cost.
- The increase in cost for preparatory (spot rehab) work for minor rehabilitation treatments is 20 percent of the treatment cost (as distress is allowed to progress, the additional cost of spot/minor repairs increases as well).

Model Assumptions

- Each year, a constant fraction of the pavements in each category falls into the next lower category. This fraction is equal to the inverse of the expected time it takes for a pavement to go from the top of the category to the next lower category. Example, for Policy Options 1-5, the expected time for a street to require preservation after initial rehabilitation is 12 years. Therefore, 1/12 of the mileage in that category can be expected to fall into the next lower category each year unless a treatment appropriate for that category is applied.
- Segments with pavement type "Other" (neither Rigid, Composite, Flexible, nor Macadam) were eliminated from the analysis, as were segments with a PQI = 0.0. This resulted in the total length calculated as 1,016.7 miles.

Appendix E is a summary of observations and recommendations regarding pavement design practices at the City of Milwaukee. The information was compiled from field evaluations conducted by the audit consultant RW Block Consulting, Inc. on April 8 and 9, 2008 in Milwaukee:

Observations on Flexible Pavement (Asphalt) Distress

A salient observation during field visits to Milwaukee residential-streets was the presence of "progressive edge cracking" (see Glossary of Terms in Appendix G), to varying extents, consistently on newer flexible-pavements (asphalt). Although there are a number of possible causes for this distress, an effort needs to be made to mitigate the formation of this distress type. A study of edge cracking in Colorado residential street Hot Mix Asphalt (HMA) pavements may provide insight into the issue. This study indicated that use of full-depth asphalt (without a substantial granular base), combined with potentially expansive, clayey soils, excess moisture at the location, and/or lack of density, could be related to the edge cracking and merits investigation. A related observation was the presence of fatigue (alligator) cracking around cracks that had formed in flexible-pavement segments that were otherwise structurally sound. The formation of alligator cracking around the existing unsealed cracks suggests that the pavement is thin. The repair strategy would involve a full-depth patch, with controlled procedures, including re-compaction of the granular base, careful saw-cutting at the edges, placement of high-quality Hot Mix Asphalt material, and placing some sealing material (tack coat or crack sealant) at the edges, etc. Given the low residential traffic, the structural failure is likely due to water infiltration, resulting in weakened support at the granular-base layer through freeze-thaw action and/or modulus reduction because of saturation.

Taken together, these pavement distress types merit further investigation and a review of design standards for Hot Mix Asphalt pavements used for residential streets in the City of Milwaukee.

Design (Engineering) Recommendations:

Recommendation E1: Review flexible design standards for new construction or reconstruction. Early, progressive edge failures were observed consistently on newer flexible pavements. In addition, alligator cracking has often developed around transverse or longitudinal cracks (see images of distress presented in Appendix G). This failure mechanism is indicative of structural weakness at these locations and suggests that the pavement section may be too thin altogether.

Recommendation E2: Review design procedures for placement of concrete curb. One possible cause of this early edge distress is difficulty in compacting the mix in a constrained area.

Recommendation E3: Current DPW standards for utility-cuts should result in a high quality patch. However, the standards should include requirements for compaction of the replacement material (in the case of granular layers, a percent compaction from a Proctor test; in the cast of Hot Mix Asphalt layers, a percent compaction from maximum theoretical compaction). DPW could also consider "controlled low-strength material" (CLSM or "flowable fill") for rapid, self-leveling fill material in some applications. Permit inspectors should periodically receive refresher training so that all aspects of utility-cut patching are adhered to in the field.

Recommendation E4: Review pavement design standards periodically. This should be done every time a new design practice is incorporated or at least every five years. Review does not necessarily mean change, but changes in any of the design assumptions (material properties, vehicle characteristics, etc.) should be considered.

Recommendation E5: Incorporate innovative reconstruction technology. This includes concrete rubblization (which has to include consideration of curb height issues, so it must be adjusted accordingly) for concrete pavements and full-depth reclamation for flexible pavements. Evaluate best practices and run pilot projects as part of a new-technique evaluation process.

Recommendation E6: Establish a formalized process for new product and technique evaluation, in conjunction with the DPW Maintenance Section. This should include a list of approved products and construction techniques and a process for evaluating the performance and feasibility of each treatment. This process should also contain an idea-solicitation feature, which could be both internal via official communication or focus groups, as well as external through an internet interface or other means. The Maintenance Section needs to be involved because of the principal role it is likely to play in implementing pavement-preservation techniques.

Observation on Rigid (Portland Cement-Concrete) Pavement Distress

Rigid pavements in the City of Milwaukee exhibited distress in the form of mid-slab cracks, spalled joints (older pavements), spalling that was not joint-related (surface potholes in older pavements), faulting, cracked and depressed slabs (in cases), and, occasionally, D-cracking (see Glossary in Appendix G).

Recommendation E7: A general review of existing distress forms and design features that help prevent or mitigate them should be conducted to ensure that existing standards and practices are adequate and/or that revisions are made to accommodate the distress observed in the field. By way of example, design features that can help prevent some of this distress include, but are not limited to, adequate drainage of water away from the pavement structure; sealing of joints; inclusion of sufficient expansion joints; slab design that includes load-transfer devices (dowels; this will require minimum slab thickness to be at least seven inches in thickness). These procedures, along with flexible-pavement (asphalt) design standards, should be revised on a regular basis. The audit consultant RW Block Consulting, Inc. provided the auditors with additional information on a comprehensive approach to revising or formalizing procedures with respect to design, construction inspection, and materials acceptance and testing.

Appendix F illustrates the benefits of preservation maintenance. Pavement can be maintained in good condition over an extended service life with timely and adequate preservation maintenance. Withholding such maintenance leads to quicker deterioration and pavement rehabilitation and reconstruction work at higher cost.

Figure F1: Flexible (Asphalt) Performance Curve

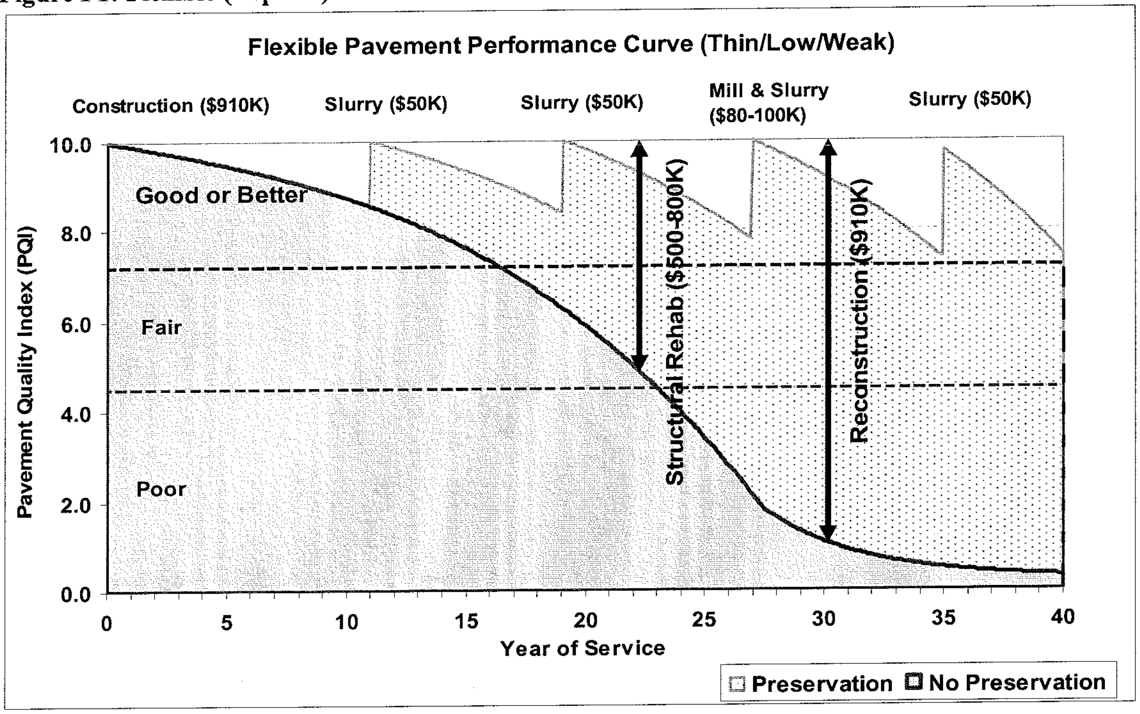
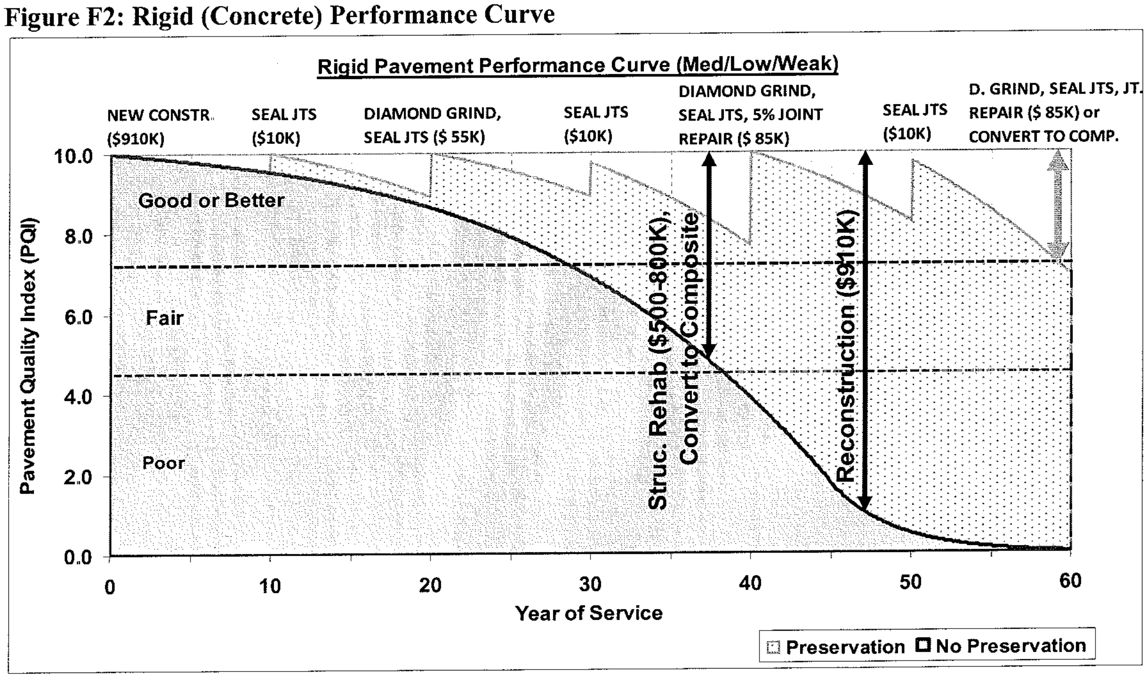


Figure F2: Rigid (Concrete) Performance Curve



Appendix G is a Glossary reference to the terminology used in the audit report.

Aggregate: The rock (coarse aggregate) and sand (fine aggregate) that are mixed with a binder (cement or asphalt) to produce a pavement mixture.

Alligator (Fatigue) Cracking: A form of structural distress consisting of interconnected cracks with one predominant direction (typically in the direction of traffic, but also found across the pavement when the structural distress is around a transverse crack, joint, or patch). Alligator cracking is normally concentrated around the wheel-paths, but it can also occur around wide cracks, at the roadway edge (in which case it is also called "edge cracking") and even outside a Portland-Cement-Concrete slab in a widened pavement.

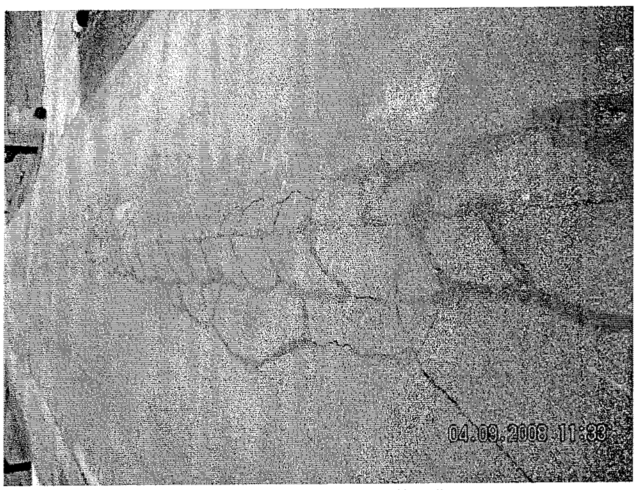


Photo of Alligator cracking (longitudinal)

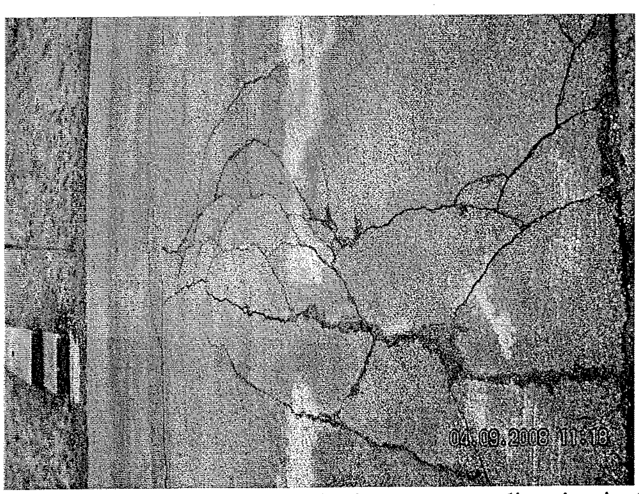


Photo of Alligator Cracking (in the transverse direction in this case)

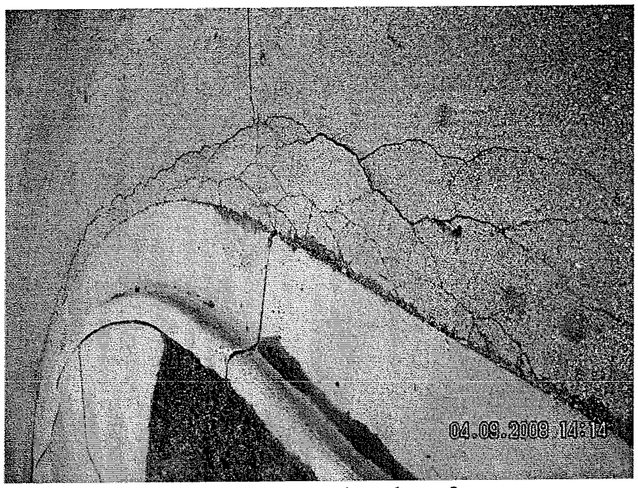


Photo of Alligator Cracking at the edge of pavement

Analysis Units: Synonymous with "pavement segments." In Pavement Management System terminology, a pavement network is composed of a number of homogeneous analysis units.

Composite Pavement: A pavement structure composed of a Portland Cement-Concrete slab which is overlaid with Hot-Mix Asphalt (HMA). Composite pavements are primarily the product of pavement rehabilitation; however, there are exceptional cases in which composite pavements may be constructed that way.

Construction (Paving) Joint: A joint created by two laterally-adjacent paving passes of Hot-Mix Asphalt (or thin surface treatment). In HMA pavements, this is often the location of the first distress, since it is difficult to obtain compaction at this joint on the first pass.

Photo of a longitudinal construction joint

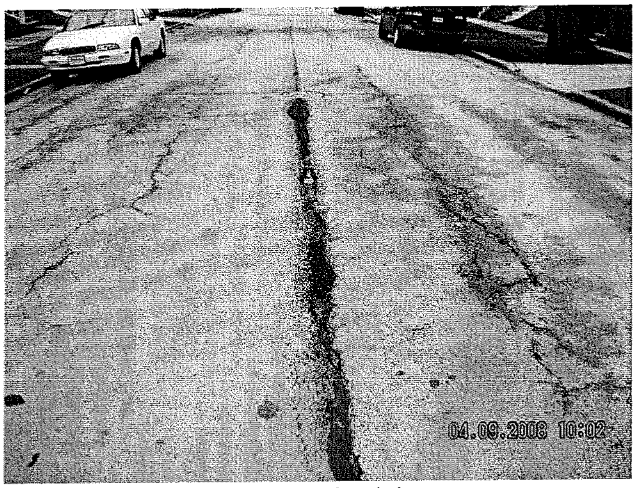


Photo of deteriorated construction joint

Block Cracking: Interconnected transverse and longitudinal cracks creating blocks of roughly equal dimensions, which are generally caused by aging and consequent shrinkage of a Hot-Mix Asphalt.

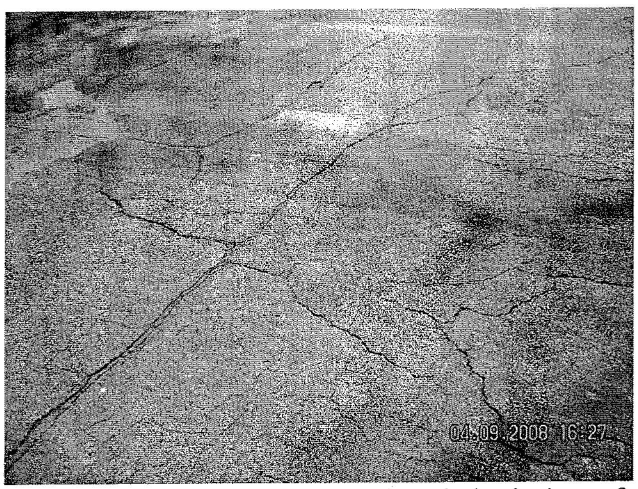


Photo of transverse and longitudinal cracks beginning to form blocks:

Crack Filling: The repair of wide cracks (more than one inch) with insertion of either Hot or Cold-Mix Asphalt or a low-modulus, non-expansive crack-filling material.

Crack Sealing: The introduction of a sealing material in cracks, typically ¼” to ¾” in width.

Data Collection Cycle: A completed pavement-condition assessment.

Data Collection Interval: The span of time (usually years) between two data collection cycles.

D-cracking: Multiple cracking centered around a Portland-Cement-Concrete (PCC) slab corner; typically caused by trapped moisture in the pavement structure and its base.

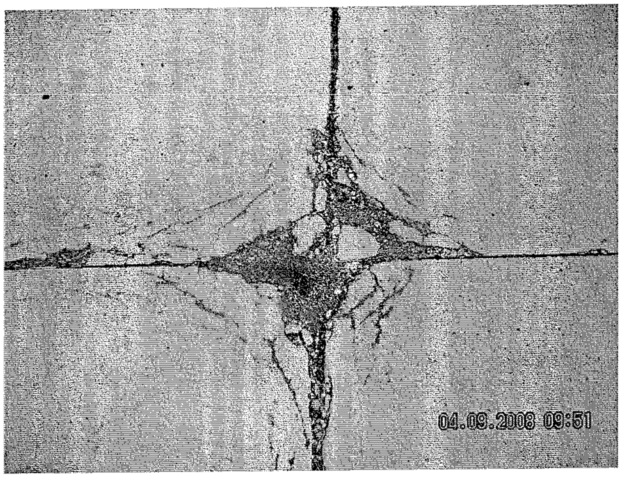


Photo of D-cracking

Delamination (Peeling): Debonding of a thin layer of Hot-Mix Asphalt from the underlying layer.

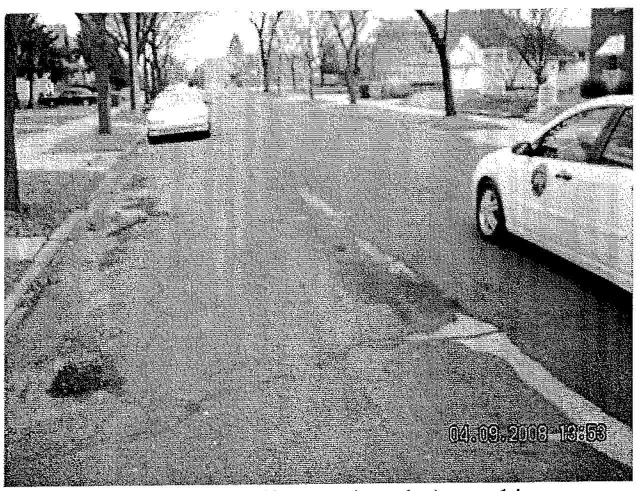


Photo of peeling (see difference in color), cracking.

Diamond Grinding: A specialized, high-accuracy texturing and re-profiling technique for Portland-Cement-Concrete (rigid) pavements; it reduces pavement noise, can eliminate faulting and significantly increases smoothness in these pavements, thus reducing the dynamic loads caused by uneven pavement.

Doweling: A typical load-transfer device (see definition below) in Portland-Cement-Concrete (rigid) pavement.

Faulting: A Portland-Cement Concrete distress consisting of a vertical differential at the transverse joint between two slabs (it is much less frequent in longitudinal joints). Often caused by a lack of load-transfer devices at the joints, but can also be caused by curling (warping) of the concrete slab.

Photo of faulting

Flexible Pavement: A pavement structure composed of a layer of Hot-Mix Asphalt (HMA) over an unbound granular base, which in turn is placed over a "sub-base" or directly over the subgrade (prepared native soil).

Hot-Mix Asphalt (HMA): A pavement mixture composed mainly of stone and sand, bound together by asphalt. It may contain additives such as mineral filler, polymers, or anti-strip agents (to improve adhesion between the asphalt and the aggregate).

Intervention: The act of applying some treatment to a pavement. Interventions consist of specific treatments.

Load-Transfer Device: A mechanism for transferring traffic load from one slab to the next. This is specific to Portland Cement-Concrete (rigid) pavements.

Longitudinal Crack (Joint): A crack generally oriented along the direction of travel.

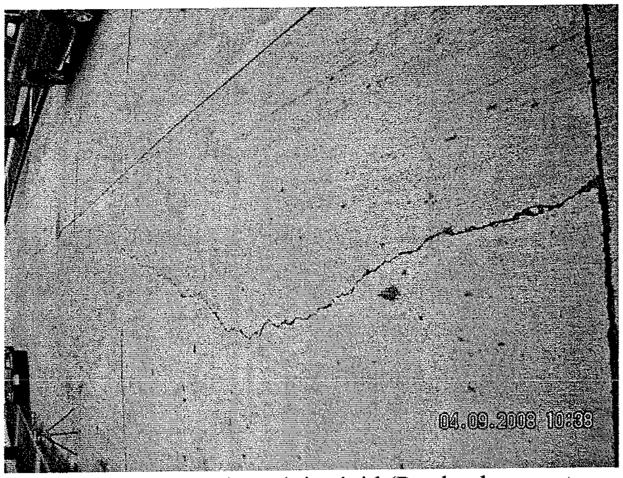


Photo of longitudinal crack in rigid (Portland-cement-concrete) pavement

Macadam Pavement: A pavement structure composed of a layer of interlocking crushed stone, generally bound together with bitumen (asphalt), and surfaced with either hot-mix asphalt or an asphaltic surface treatment.

Microsurfacing: A thin surface treatment consisting of a polymerized asphalt emulsion (including an emulsifier that can cure chemically) and a specific aggregate gradation. It is in essence the next generation of Slurry-Seal (see definition), providing faster cure times so that traffic can be allowed sooner, and improved durability in many instances. Microsurfacing can be used for some rut-filling operations by applying a first layer in the ruts and a second layer over the entire surface.

Minor, or Functional, Rehabilitation Treatment: A pavement treatment designed to correct non-structural distress that if left untreated would lead to premature failure, or non-structural distress that is negatively impacting the condition of the roadway.

Network Level Pavement Management: Pavement Management analysis to address system-wide questions such as: a) determination of preservation and rehabilitation needs; b) determination of funds required to address these needs; c) determining the impact of funding decisions on the health of the pavement system as a whole.

Pavement Management Application: The Pavement Management Application is the core of the Milwaukee Pavement Management System. It is a computer application that contains a database with an inventory of all street segments in the system, pavement performance models, treatment costs and expected lives, and pavement condition and history information. The PMA is capable of: a) providing reports on pavement condition for the pavement network; b) developing a long-term, optimized strategy for addressing pavement condition at the network level given a budget level; and c) determining the budget required to achieve certain pavement condition goals over the long term.

Pavement Management System: The American Association of State Highway and Transportation Officials (AASHTO) defines a Pavement Management System as,

> *"...a set of tools or methods that assist decision-makers in finding optimum strategies for providing, evaluating, and maintaining pavements in a serviceable condition over a period of time."*

Pavement Preservation: The Federal Highway Administration Pavement Preservation Expert Task Group defines pavement preservation as,

> *"...a program employing a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety and meet motorist expectations."*

Pavement Quality Index (PQI): An index ranging from 10 to 0 that is used to characterize pavement condition for a pavement segment. It can be aggregated to represent the condition of the entire pavement network. The aggregation should be done on either a length or area basis. A PQI of 10 denotes a road in perfect condition. The index was developed by Stantec, Inc., the vendor of Milwaukee's Pavement Management Application and consultant for implementation and data collection.

Pavement Reconstruction: Similar to pavement replacement and used interchangeably in this audit.

Pavement Replacement: The complete replacement of the pavement structure, at least in the bound layers (those with some cementing agent).

Pavement Segments: Stretches of street pavement that is considered as single units for analysis. In Milwaukee's PMA, pavement segments are street segments for which condition data are summarized and reported. However, pavement projects are seldom executed on a data-collection basis; the criterion for "projects" (pavement segments for construction purposes) typically includes such additional variables as reasonable length to obtain competitive prices, uniform or homogeneous pavement condition, and other factors.

Pitting: The loss of coarse aggregate (rock), especially in Hot-Mix Asphalt pavements. The space vacated by the large aggregate often progresses to raveling and/or potholes if left untreated because new material is exposed to the elements. Often caused by stripping but also can be caused by poor-quality aggregate or breakdown of aggregate during compaction.

Photo of Pitting

Portland Cement-Concrete (PCC): A mixture composed mainly of stone and sand, bound together by cement. It may contain mineral filler or one of a number of admixtures.

Preservation Strategy: A Pavement Management strategy that consists of prioritizing the preservation of pavements in good or excellent condition so that they do not fall into lower condition levels. The basic premise is that preservation treatments are much more cost-effective than rehabilitation or reconstruction treatments so that many more pavements can be preserved at the higher condition levels than can be replaced or rehabilitated.

Preservation Treatment: A pavement treatment designed to extend pavement life through prevention of the formation of specific distress types.

Project Approval Process: The procedure utilized to approve or deny a project that has been developed (or is being developed) by the public-works agency. Project approval processes range from a program-based approach where a funding level is provided and the agency has significant discretion over project selection, to ones where the public-works agency has little control over the approval decision, such as a project-specific public-hearing process.

Project Development and Scheduling Process: The actions of the public-works agency to take a candidate project (one with the need for a treatment) all the way through project execution.

Project Level Pavement Management: Pavement management activities conducted for each pavement section in the street network; issues include: a) assessment of the cause of deterioration leading to the need for some kind of pavement intervention; b) analysis of the cost-effectiveness of feasible alternatives or treatments; c) definition of imposed constraints such as minimum condition level, etc.; d) selection of the most cost-effective strategy given constraints.

Project Scope: The magnitude of work (and cost) that is required to complete the pavement aspects of a construction project. Project scope is a dynamic value until the scope is pavement replacement or reconstruction, which is the largest scope possible. Project scopes vary from pavement preservation to rehabilitation, to reconstruction.

Project Selection Process: The methodology used to develop a list of candidate projects for treatment. In a Pavement Management System, project selection begins as the result of a network-level analysis and selected strategy. The PMS is used to generate a list of "ranked" or "prioritized" candidate projects, consistent with the selected pavement-management strategy. This list of candidate projects is then adjusted to account for constraints on the ability of the agency to execute these projects. Constraints include planned utility work, the project-approval process, changes in budget level or changes in project scope that decrease available funds.

Popout: See "Spalling."

Punchout (Blowout): The destruction of a transverse Portland-Cement-Concrete pavement joint because of thermal expansion (often combined with the presence of incompressible solids within the joint).

Raveling: Disintegration of the pavement layer, typically Hot-Mix Asphalt. Causes may include inadequate compaction, stripping of the asphalt binder from the aggregate, or particle segregation in the mix. Raveling is common at the construction joint between two adjacent paving passes, because during the first paving pass the edge is unconfined and therefore difficult to compact.

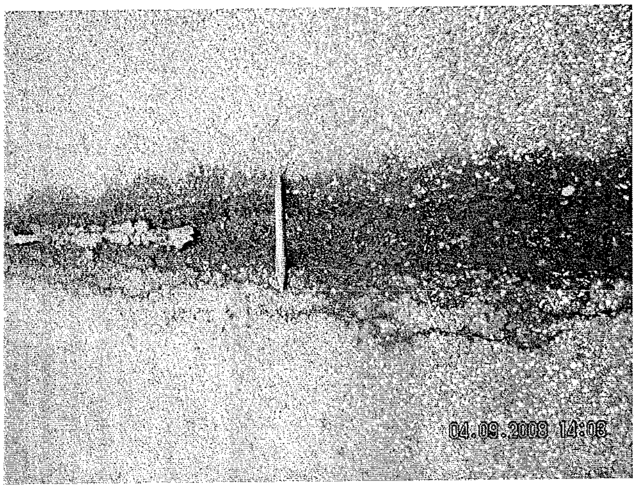


Photo of raveling at construction joint

Rehab-Then-Preserve (RTP): A strategy consisting of Minor, or Functional, Rehabilitation Treatments (as defined in this Glossary, and usually consisting of resurfacing), designed to correct non-structural distress that if left untreated would lead to premature failure, or non-structural distress that is negatively impacting the condition of the roadway.

Rigid Pavement: A pavement structure composed of a Portland Cement-Concrete slab placed over an unbound granular base or directly on the subgrade (prepared native soil).

Routing and Sealing: A method of Crack Sealing (see definition) that includes crack preparation by routing neat edges and thus creating a reservoir for the sealing material.

Rubberized Chip Seal: A particular type of chip seal that involves pre-coating the aggregate with asphalt, mixing it at a hot temperature, and spreading it over a rubberized asphalt layer sprayed onto an existing pavement surface. The rubberized asphalt layer is very effective at sealing minor cracks and at maintaining adherence to the pre-coated stone. Rubberized Chip Seal uses rubber-tire rollers for compaction and is followed by sweeping of excess aggregate.

Slurry Seal: A thin surface treatment consisting of an asphalt emulsion and aggregate of a specified gradation. Its intent is to retard the aging of a Hot Mix Asphalt pavement surface and thus prevent or slow down the formation of cracks due to environmental effects. Slurry Sealing can also mitigate environmental distress caused by minor raveling, segregation, and light stripping or pitting.

Spalling: Deterioration around a crack or joint consisting of small pothole-like features. In Portland Cement-Concrete pavement, Spalling can also occur at the surface, outside joints or cracks, and is also called "Popout."

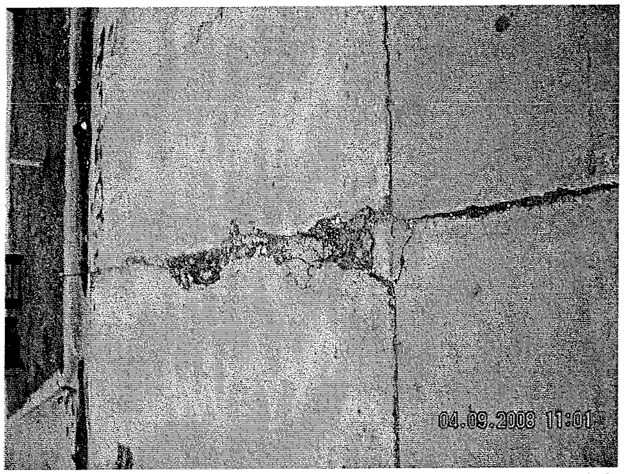


Photo of spalling at a rigid (Portland Cement-Concrete) joint

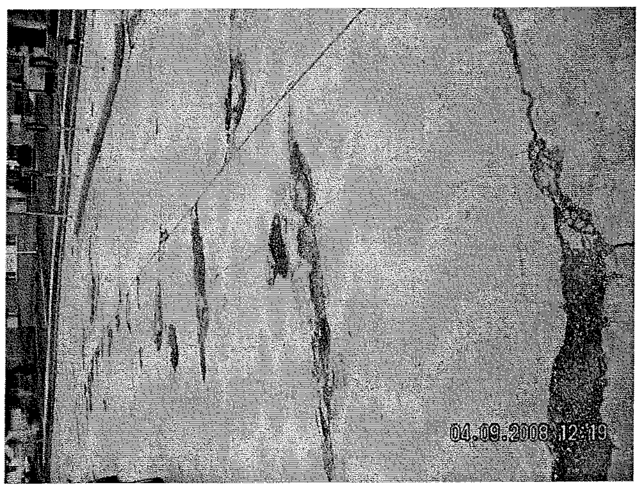


Photo of spalling

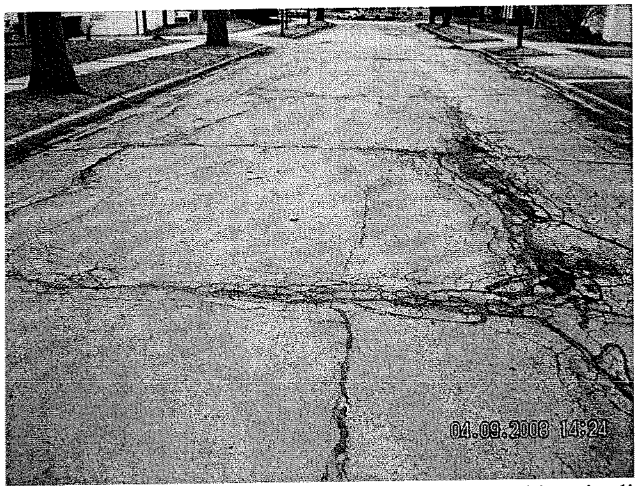


Photo of severe spalling mixed with alligator and longitudinal cracking, and potholes

Stripping: In a pavement mixture (especially Hot-Mix Asphalt), the de-bonding of the binder agent from the aggregate particles. Typically this indicates a chemical incompatibility between the binder and aggregate, but has other causes.

Photo of Stripping / raveling

Photo of Stripping

Structural Rehabilitation Treatment: A pavement treatment that addresses deficiencies in the ability of the roadway facility to support traffic loading (and some environmental loading). Structural rehabilitation treatments usually consist of significant repairs to the existing pavement, followed by reinforcement of the pavement structure.

Thermal Crack: See Transverse Crack.

Transverse Crack (Joint): A crack oriented across the pavement (full-width, edge-to-edge cracking in Hot Mix Asphalt pavement is also called a "Thermal Crack").

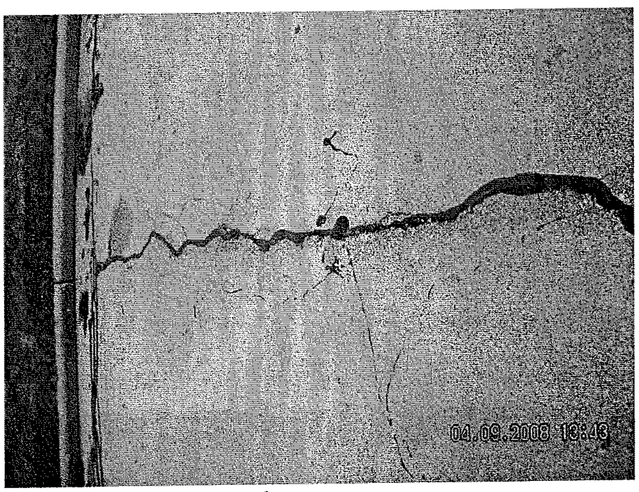


Photo of transverse crack

Treatment: An action designed to improve or preserve the condition of a pavement. Treatments are specific activities (such as Slurry Seal, Hot Mix Asphalt overlay, reconstruction) that in Pavement Management Systems are categorized by the scope of the activity (preservation, rehabilitation, replacement/reconstruction).

Utility Patch: The patch placed after a pavement is sawed and excavated for utility work. It typically has straight, sawed edges.

Worst-First Strategy: A Pavement management strategy that consists of prioritizing the repair of those pavement segments in the worst condition. Worst-First Strategies generally lead to deteriorating network pavement conditions, especially when funding levels are not sufficient to address all pavement needs.

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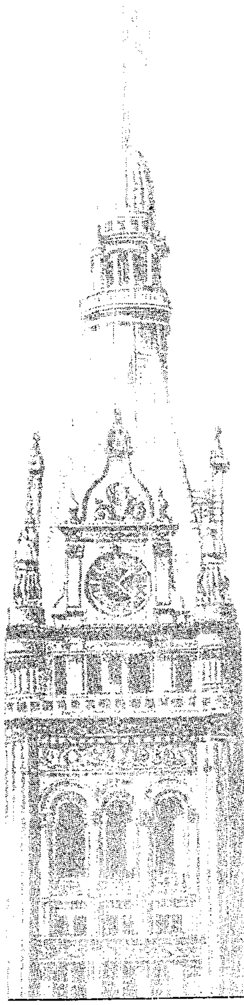
2007 SEP 14 AM 8: 18

JAMES A. BOHL JR.
Alderman, 5th District



September 12, 2007

W. Martin Morics, Comptroller
City of Milwaukee, Room 401
200 East Wells Street
Milwaukee, WI 53202

RE: AUDIT OF STREET RECONSTRUCTION AND RESURFACING

Dear Comptroller Morics:

The Comparative Revenue and Expenditure Report you conducted showed that the replacement cycle (3-year average) for local streets from 2003 to 2005 was 162 years. As indicated in the report, Department of Public Works noted that repaving and resurfacing is now being done with asphalt rather concrete, life expectancy for streets which are repaved or resurfaced with asphalt is likely to be in the range of 25 to 35 years.

The replacement cycle of 162 years for local street replacement is not acceptable. This cycle is the result of the combination of the decrease in residential street reconstruction projects resulting from objections by the affected property owners, and the reduction in the City's preventive street maintenance and repair work.

Since, it is imperative that City of Milwaukee streets be adequately maintained and replaced in a timely manner. I am hereby requesting that your office conduct a financial and operational audit of the Department of Public Works, Street Maintenance and Replacement Programs. A thorough, impartial review of the Department of Public Works done by your office is essential in assisting the members of the Common Council in making informed decisions regarding the future of the way the City maintains and replaces its streets.

Thank you for your assistance in this matter. Please feel free to contact me to discuss this request.

Sincerely,

Jim Bohl, Alderman
5th Aldermanic District

JB:so

City Hall • Room 205 • 200 East Wells Street • Milwaukee, WI 53202-3570
PHONE (414) 286-3870 • **FAX** (414) 286-3456 • **E-MAIL** jbohl@milwaukee.gov • **WEBSITE** www.milwaukee.gov/district5

City of Milwaukee

Department of Public Works
Infrastructure Services Division

Jeffrey J. Mantes
Commissioner of Public Works

James P. Purko
Director of Operations

Jeffrey S. Polenske
City Engineer

October 23, 2008

Mr. W. Martin Morics
City Comptroller
Office of the City Comptroller
Room 404, City Hall

Subject: Audit, Residential Street Paving Program

Dear Mr. Morics:

We have reviewed the findings of the subject audit and are generally in agreement with them. Some of the recommended changes have already been implemented as a result of prior audits, including increased funding levels for street maintenance and capital paving. As the audit points out, the data collected for the audit was done after the intervening severe winter. Specific to the report's recommendations, we offer the following:

1. Accurate number of miles: It was explained that the total reported is attributable to how the data was extracted. In the case of the Pavement Management Application (PMA), lengths for streets were used and a percentage was added to account for intersections. Other factors that would influence the total miles reported include adjusting for boundary streets, inclusion of rural roadways and lengths of unimproved rights of way. We agree that the total from the PMA should be used for purposes of the condition report in the audit. We also agree that the more accurate figure would be the road life summary at roughly 970 miles. We will use this figure in future correspondence when we relate to the replacement cycle for local streets. For example, the report indicates the replacement cycle is nearly 106 years. This would be nearly 100 years using the 970 mile figure. In relative terms, both show a need for additional funding.

2. Expand use of PMA: The program is currently used as a budget tool and identifies potential paving projects. We are developing ways to use this data within our maintenance area, along with our existing maintenance data base system, to help identify potential maintenance strategies to prolong segments of pavement before a more costly improvement is necessary. Recommendations B1, B2 and B3 are already being done.

Mr. W. Martin Morics
October 24, 2008
Page 2

3. Implement a paving performance monitoring and reporting process: We will look into what can be done in this regard. Note our permit process does include a provision based on the age of the adjacent pavement. This had not been conveyed to the consultant until recently.

4. Develop a "preserve-first" strategy: Our maintenance personnel do implement this strategy. The consultant focused more on staff within the project scheduling area than with maintenance personnel and may have missed this. Projects that can be maintained are not recommended for paving. Once they pass the threshold of maintenance, they are recommended for paving. When a project is scheduled for paving, our first option is to resurface the pavement. With the previous assessment process, projects would be deleted by the property owners and rescheduled 5 years later. Sometimes during this timeframe, the projects deteriorated to the extent that a reconstruct would then be necessary. With the implementation of the Motor Vehicle Registration Fee, more projects would be approved through the public hearing process as resurface projects.

5. Establish a paving program oversight committee: If the Capital Improvements Committee were recreated, we would support any reporting necessary and would welcome the opportunity to be represented on the committee.

We agree with the analysis that improving the condition of residential streets is going to require "a significant long term funding commitment". Additional funding will be needed to eliminate the backlog of poor streets and also upgrade the pavement. We will continue to work with policy makers to determine what resources need to be dedicated to the local street program.

Very truly yours,

Jeffrey S. Polenske
City Engineer

Jeffrey J. Mantes
Commissioner of Public Works

CAW:sdp

City of Milwaukee

Department of Public Works
Infrastructure Services Division

Jeffrey J. Mantes
Commissioner of Public Works

James P. Purko
Director of Operations

Jeffrey S. Polenske
City Engineer

December 1, 2008

Mr. Wally M. Morics
Comptroller
841 North Broadway, 4th Floor
Milwaukee, WI 53202

Subject: Residential Street Paving Audit – Your Letter dated November 19, 2008

Dear Mr. Morics:

The subject letter requests input relative to service lives associated with different pavement types and a large perceived discrepancy between general city service lives, the auditor's service lives and those listed in a document prepared by us dated January 25, 2007.

The January 25, 2007 document was developed to spur discussion with the budget office on the need for added funding to the local paving program. As the local street paving program had been drastically under-funded in the past, the chart reflected a high-end service life to emphasize, even if pavements lasted that long, how much funding would be needed for the local paving program. We continued to use our normal service lives with our budget submittals in 2008 and 2009. These are in line with those provided by the consultant and we are not in disagreement to use their range of service lives at this time.

Caution should be exercised when using these or any estimated service lives. The problem of identifying true service lives comes from insufficient data available to determine the estimated useful life. In an ideal world, we would have several full life cycles for the entire local street network used to determine the overall estimated useful life of the various types of pavements. Unfortunately, much of our data does not include one full life cycle of results. This does not allow for an accurate estimate of useful lives.

As reported by the consultant, changes in maintenance strategies can impact these service lives. We have been doing such things as crack filling, patching and sealing roadways for years. Some of these were reduced in past years. Recently, our maintenance program budgets for local streets have increased. Future service lives should expect to increase as we enhance our maintenance programs.

As there is so much uncertainty to pavement life cycles, going with the consultants reported values gives us a picture of what might be happening and a framework from which to work. Attached are several charts using the high, mid and low ranges of data from the consultant to compare with the January 25, 2007 document. Basically, using our high end service life would require $11.5 M in annual funding and the consultant's high end would require $13.8 M, the mid range would be $15.9 M and the low end would be $18.9 M.

Mr. Wally M. Morics
December 1, 2008
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To summarize, we agree with the consultants analysis of pavement service lives as a ball park tool used to determine potential future needs within the local street paving program. Improving the condition of residential streets is going to require "a significant long term funding commitment". We will continue to work with policy makers to determine what resources need to be dedicated to the local street program for both maintenance and capital improvements.

Very truly yours,

Jeffrey S. Polenske, P.E.
City Engineer

CAW: ns

c: Mayor Tom Barrett
Mr. Jeffery J. Mantes
Mr. Mark Nicolini

Attachments

2007 Service Life Estimate

Existing pavements of Local streets :

Type:	Miles	% of total	Assumed life (years)	Assumed * Replacement rate	Replacement pavement	Cost per mile	Amount needed per year
Composite (asphalt over concrete):	70	8%	45	1.6	asphalt recon.	$ 1,450,000	$ 2,255,556
Composite (asphalt over concrete):	70	8%	45	1.6	asphalt	$ 725,000	$ 1,127,778
Flexible (asphalt)	240	27%	55	4.36	asphalt	$ 725,000	$ 3,163,636
Macadam	90	10%	100	0.90	asphalt	$ 750,000	$ 675,000
Rigid (concrete)	430	48%	70	6.14	asphalt	$ 700,000	$ 4,300,000
Totals	900	100%		**14.52**			**$ 11,521,970**

* = number of miles/assumed life

1/25/07 MLD
Updated by CAW 11/26/08

Highest Consultant Service Life Estimate

Existing pavements of Local streets :

Type:	Miles	% of total	Assumed life (years)	Assumed * Replacement rate	Replacement pavement	Cost per mile	Amount needed per year
Composite (asphalt over concrete):	70	8%	50	1.4	asphalt recon.	$ 1,450,000	$ 2,030,000
Composite (asphalt over concrete):	70	8%	50	1.4	asphalt	$ 725,000	$ 1,015,000
Flexible (asphalt)	240	27%	35	6.86	asphalt	$ 725,000	$ 4,971,429
Macadam	90	10%	85	1.06	asphalt	$ 750,000	$ 794,118
Rigid (concrete)	430	48%	60	7.17	asphalt	$ 700,000	$ 5,016,667
Totals	900	100%		**17.88**			**$ 13,827,213**

* = number of miles/assumed life

11/26/08 CAW

Mid Range Consultant Service Life Estimate

Existing pavements of Local streets :

Type:	Miles	% of total	Assumed life (years)	Assumed * Replacement rate	Replacement pavement	Cost per mile	Amount needed per year
Composite (asphalt over concrete):	70	8%	40	1.8	asphalt recon.	$ 1,450,000	$ 2,537,500
Composite (asphalt over concrete):	70	8%	40	1.8	asphalt	$ 725,000	$ 1,268,750
Flexibie (asphalt)	240	27%	30	8.00	asphalt	$ 725,000	$ 5,800,000
Macadam	90	10%	85	1.06	asphalt	$ 750,000	$ 794,118
Rigid (concrete)	430	48%	55	7.82	asphalt	$ 700,000	$ 5,472,727
Totals	900	100%		**20.38**			**$ 15,873,095**

* = number of miles/assumed life

11/26/08 CAW

Lowest Consultant Service Life Estimate

Existing pavements of Local streets :

Type:	Miles	% of total	Assumed life (years)	Assumed * Replacement rate	Replacement pavement	Cost per mile	Amount needed per year
Composite (asphalt over concrete):	70	8%	30	2.3	asphalt recon.	$ 1,450,000	$ 3,383,333
Composite (asphalt over concrete):	70	8%	30	2.3	asphalt	$ 725,000	$ 1,691,667
Flexible (asphalt)	240	27%	25	9.60	asphalt	$ 725,000	$ 6,960,000
Macadam	90	10%	85	1.06	asphalt	$ 750,000	$ 794,118
Rigid (concrete)	430	48%	50	8.60	asphalt	$ 700,000	$ 6,020,000
Totals	900	100%		**23.93**			**$ 18,849,118**

* = number of miles/assumed life

11/26/08 CAW