PAVEMENT MANAGEMENT SYSTEMS

IMPLEMENTATION POLICY

September 2021

EXECUTIVE SUMMARY

Systematic management of pavements has become increasingly important as pavements continue to age and deteriorate and funding levels have decreased due to reduced funding or increased competition for funds. The use of a pavement management system (PMS) is intended to provide the Town of Stallings with a systematic process for generating answers to many of their pavement management questions.

Pavement management can be simply defined as the process of maintaining the pavement infrastructure cost-effectively. The American Public Works Association (APWA) defines pavement management in the following way (1993):

> *Pavement management is a systematic method for routinely collecting, storing, and retrieving the kind of decision-making information needed to make maximum use of limited maintenance (and construction) dollars.*

Pavement management is, in essence, a process that includes a series of steps that will help the user analyze work plan alternatives. Combined with practical judgment and local knowledge, the pavement management recommendations can be used to help make final roadway investment decisions.

COST AND BENEFITS

It is important to understand the benefits and associated costs of any investment in pavement management before starting the process. Therefore, the types of benefits that can be realized by implementing a pavement management process include:

- Providing a centralized location for pavement inventory condition information, construction, maintenance, and rehabilitation records.
- Providing a method to analyze the consequences of various funding levels on pavement conditions.
- Improving scheduling of pavement works; assisting as a decision making tool in optimizing rehabilitation, maintenance, and trade-off options.
- Providing the information needed to analyze the cost-effectiveness of treatment repairs.
- Allowing the Town to answer “what-if” type questions regarding pavement repair programs and funding levels.
- Justifying budget needs to elected officials and other stakeholders.

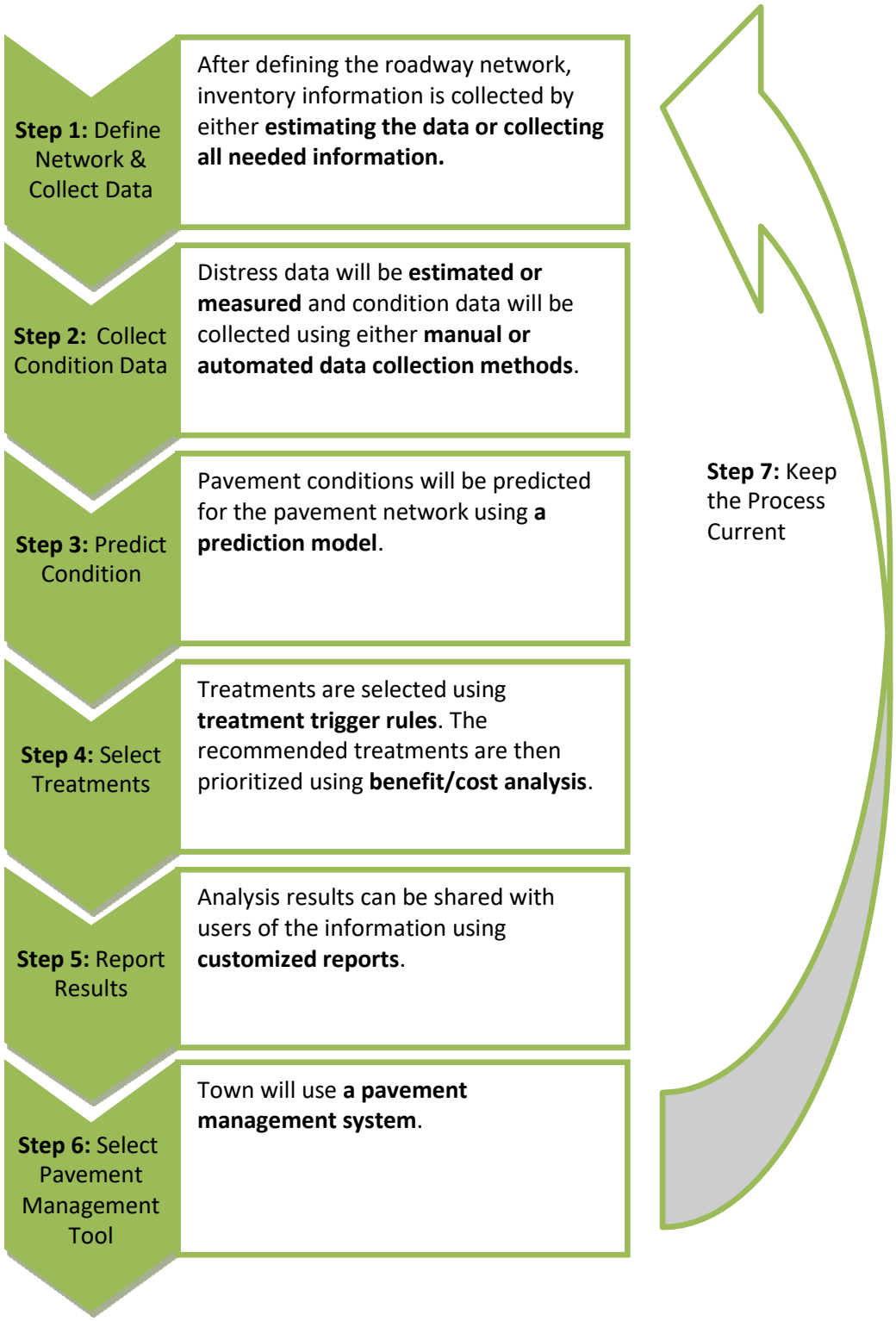
The costs associated with pavement management can include software acquisition and installation, personnel training, data collection, database building, and system maintenance and updates.

WHY INVEST IN PAVEMENT MANAGEMENT?

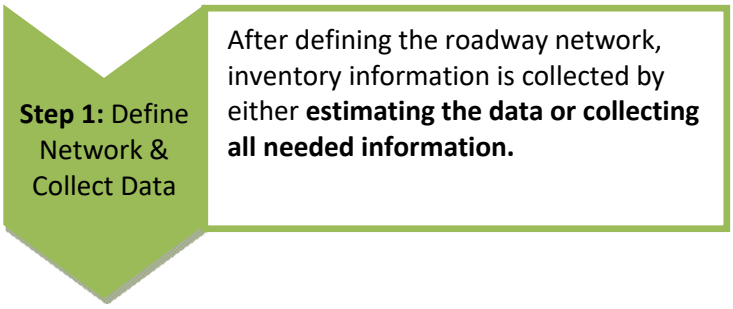
Many agencies are constrained by limited budgets and personnel resources. Even with those constraints, many agencies have a variety of reasons for investing in pavement management. They reported that the investment was worthwhile because pavement management provides the tools the Town needs to address management challenges and to provide a consistent and rational management method that helps in rational resource allocation, optimal use of funds, pavement rehabilitation cost reductions, pavement treatment selection, pavement life extensions, and increased credibility with stakeholders. The pavement management process described in this policy is to be implemented by **the Town of Stallings Engineer or other qualified staff appointed by the Town Manager**.

TOWN OF STALLINGS PAVEMENT MANAGENT PROCESS

The development of a systematic and repeatable pavement management process is a key component in the effective planning and management of a pavement network. The steps outlined below serve as a guide for the Town of Stallings pavement management process.



Step 1: Define the Roadway Network and Collect Inventory Data



The first step in designing a pavement management process is to define the roadway network. A roadway network is comprised of an inventory of the physical characteristics of the roadways being managed by the Town. The inventories are typically built by dividing the network roadways into manageable segments. These segments are divided based on similar characteristics, and they are of specific importance since they will serve as the basis for planning future maintenance and rehabilitation projects. Factors that may define the boundary between roadway segments include changes in the following attributes:

- Pavement surface type (e.g., hot-mix asphalt or portland cement concrete).
- Pavement structure (e.g., pavement materials or thickness).
- Construction history (e.g., different construction periods, different contractors, or different materials and techniques).
- Roadway geometry (e.g., number of traffic lanes).
- Traffic (e.g., volume or patterns).
- Pavement condition (e.g., significant variation in condition that is not simply an isolated area).
- Geographic boundaries (e.g., intersections, bridges, waterways, jurisdiction limits, railroad crossings).

After segments are defined in a manner that best fits the needs of the Town, the inventory information for each segment is collected. Typical inventory data collected for a pavement management system includes:

- Roadway Name – A written description of the roadway name and any corresponding numeric references.
- Pavement Location – Physical reference to the location, including “beginning location” and “ending location” designations.
- Pavement Dimensions – Values including length, width, and/or area.
- Pavement Type – The material that comprises, at a minimum, the pavement surface.
- Construction History – Details of the latest maintenance and rehabilitation treatments and construction date, and, if possible, original construction dates and additional maintenance and rehabilitation records.

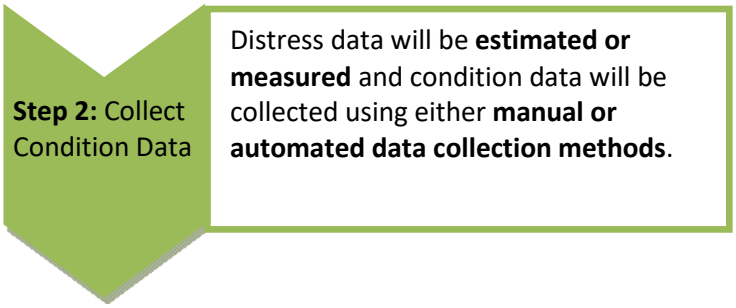
The data outlined above serves as the minimum amount of data needed to complete the segment inventory. Additional data that may be beneficial to the Town to support the pavement management processes includes, but is not limited to:

- Functional Classifications – Type of service the roadway was intended to provide (e.g., arterial, collector, or local/residential).
- Layer Thicknesses – All the thicknesses of the layers above subgrade.
- Subgrade Information – Type and material classification.
- Drainage Characteristics – Occurrence of curb and gutter or ditches and related details.
- Shoulder Data – Shoulder type and width.
- Traffic Information – Details on average daily traffic (ADT) and truck traffic if available.

The desired inventory data is summarized for each pavement segment defined in the network. While some inventory data require updates with time, information such as names, location, and dimensions do not normally require modifications unless changes have been made to the network. Compiled inventory information can be stored a variety of ways:

- Electronic spreadsheets.
- Databases (e.g., either stand-alone database or a database as part of pavement management software).
- Maps (e.g., GIS-based maps).

Step 2: Collect Condition Data



Pavement condition data are a major factor in any data-driven, decision-making pavement management process. Within the pavement management process, the condition data can be used to help identify current maintenance and rehabilitation needs, to predict future needs, and to assess the overall impact on the network.

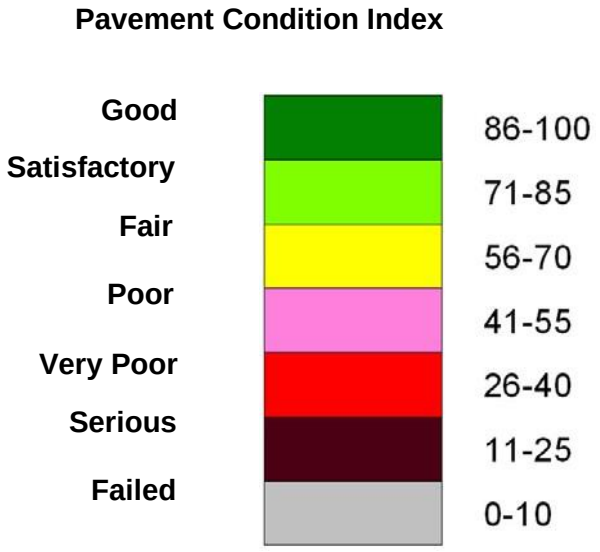
Condition data that are not used to support decisions or are not needed for specific reporting purposes should not be considered essential to the pavement management process as it may be difficult to keep the data current. Special attention must be given to balancing the level of desired data and the resources available to collect and maintain the data into the future.

Pavement Condition Index

The pavement condition index (PCI) survey is a detailed survey method that will be used by the Town in assessing pavement condition. It was developed by the U.S. Army Corps of Engineers, adopted by the American Public Works Association and ASTM International (formerly the American Society for Testing and Materials), and documented in ASTM D6433, Standard Test Method for Roads and Parking Lots Pavement Condition Index Surveys (ASTM 2009). The PCI methodology is a rating system that measures the pavement integrity and surface operational condition based on a 100-point rating scale, as shown in figure 4 (ASTM 2009). According to this methodology, the pavement network is first divided into branches (e.g., individual road), sections

(e.g., segments with consistent work history), and sample units.

Pavement surveys are conducted on sample units. A sample unit is a small segment of pavement of required size, which is then inspected in detail. For example, sample units in asphalt-surfaced pavements are each approximately 2,500 square feet, plus or minus 1,000 square feet (ASTM 2009). A representative percentage of sample units are randomly selected and inspected. Since the inspected sample units are used to characterize the condition of the entire section, it is important that they are representative of that condition. Detailed pavement condition surveys are conducted by identifying the type, severity, and amount of each distress in representative sample units selected according to systematic sampling procedures.



A total of thirty-nine distress types (twenty types for asphalt pavements and nineteen for concrete pavements) are defined with three levels of severity (i.e., high, medium, or low) (ASTM 2009). Each combination of distress type, severity, and extent has a deduct value associated with it, which is determined by using available graphs for different types of distresses.

Distresses that are considered to be more damaging to the pavement (such as fatigue cracking) have higher deduct points associated with them than distresses that are less critical (such as transverse cracks). Once each distress's deduct value is determined, they are added together to get the total deduct value for that sample unit. This value is then adjusted depending on how many distresses were used. The deduct values are subtracted from a perfect score of 100 to determine the PCI for that sample unit. A weighted average of all the PCIs for the inspected sample units within a single section are then used to represent the condition of that section. Many pavement management systems calculate the PCI based on the distress inputs entered into the software.

Manual Surveys

Manual surveys are generally considered to be visual assessments of field conditions conducted by one or more individuals who view the pavement through the windshield of a vehicle or as they walk the pavement. Data from a manual survey may be recorded on a sheet of paper, into a handheld tool, or in a computer.

Automated Distress Survey Collection Method

Automated surveys are conducted using vehicles equipped with specialized cameras and sensing devices that record images and data related to the pavement being evaluated. An example data collection vehicle is shown in the figure below.

The data collected with the automated equipment must be processed to convert it into a usable format using fully or semi-automated means. “Fully automated” data collection and processing uses computers to interpret, reduce, and analyze the images and sensor data collected in the field without human intervention. Alternatively, “semi-automated” data processing is also used to convert the data collected using automated collection means, but images will be viewed by people who interpret the images to identify distress information.

Selecting Appropriate Methodology

With a range of levels of sophistication and required resources (time and money) to complete condition data collection, a significant amount of consideration must be given to this choice of survey procedures.

The choice between using manual or automated surveys can be determined by evaluating the advantages and disadvantages associated with each procedure listed in the table below.

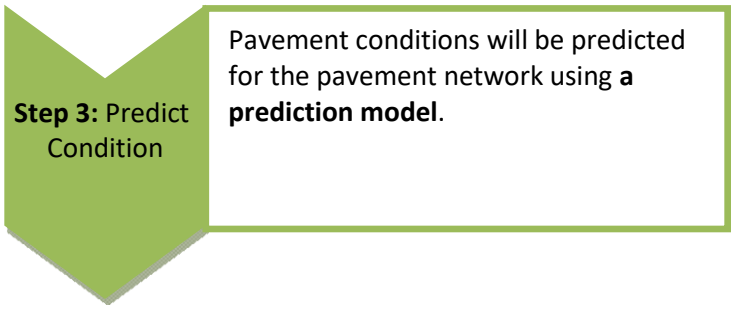
Frequency

The Town should perform a condition assessment for each segment of road every three (3) years.

Advantages and disadvantages of manual and automated surveys

Survey Methodology	Advantages	Disadvantages
Manual	• Detailed distress information can be collected • Simple to conduct • No capital expenditures required	• Resource intensive • High safety risk • Potential for high variability in the data without strong training programs and quality control checks
Automated	• Lends itself to capturing large quantities of data • Multiple types of data can be collected at the same time • Data can be collected at traffic speeds • Images are stored and available for other uses	• May require a large capital investment or contracting fees • Data must be viewable from the pavement lanes • Some distress characteristics are difficult to capture (e.g. weathering and raveling of the pavement surface)

Step 3: Predict Condition



With current pavement condition assessed, the Town is equipped with the information needed to predict the future condition of a segment. In pavement management, conditions are predicted in terms of a performance model that estimates the average rate of pavement deterioration each year. In addition to forecasting future conditions, the performance model will assist with the following activities:

- Identifying the appropriate timing for pavement maintenance and rehabilitation for each segment.
- Identifying the most cost-effective treatment strategy for pavement segments in the network.
- Estimating pavement needs and associated budgets required to address specified goals, objectives, and constraints.
- Demonstrating the consequences of different pavement investment strategies.

For the Town to develop a multi-year pavement maintenance and repair program, it needs to

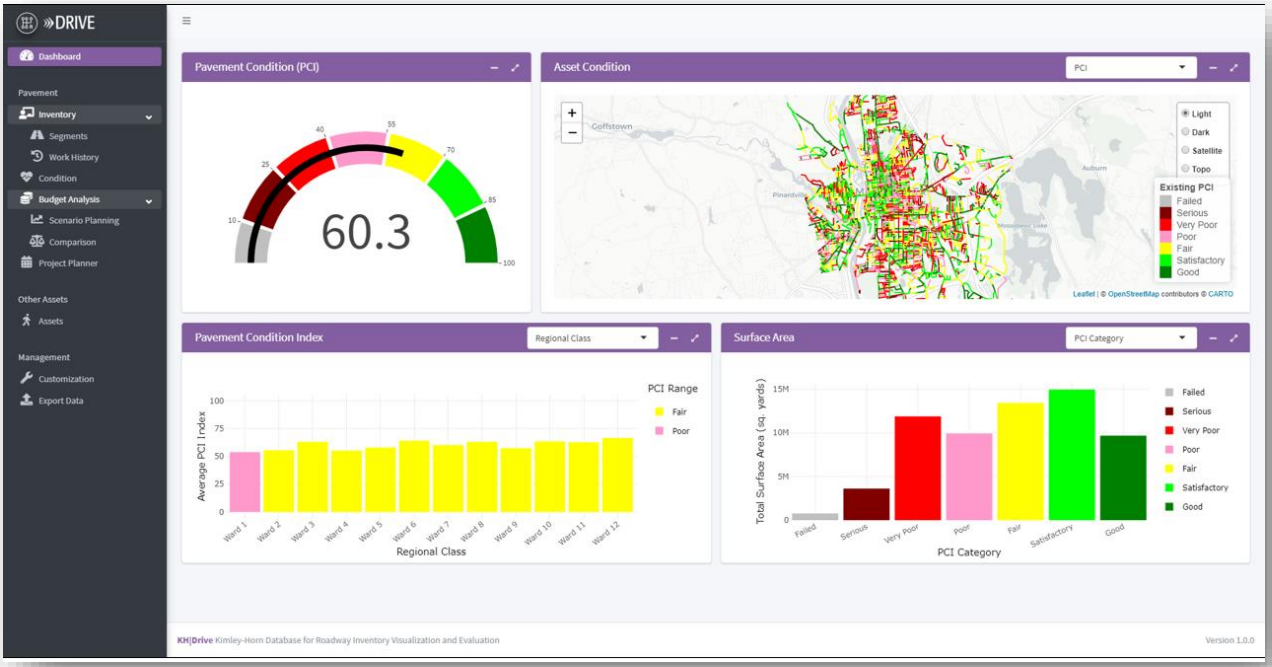
project pavement condition into the future. A prediction model will be used to determine the future condition of a pavement segment. A performance curve is calculated by evaluating past historical data often in terms of pavement age and condition. The models can be produced for any measure of condition according the Town's needs. Pavement conditions will predicted for the pavement network using a performance prediction model.

Performance Based Prediction Model

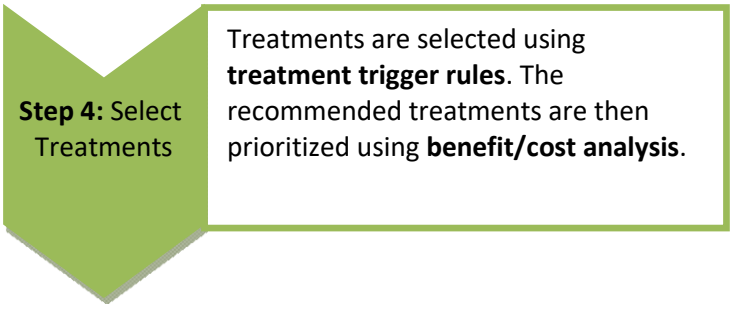
The development of a prediction model using statistical analysis is a more complex activity than creating average rates of deterioration. The Town can accomplish the creation of a model within the pavement management software that is uses.

The Town will use a performance based prediction model to:

- Store and manage pavement inventory data
- Record, track and understand the performance of pavement maintenance and repair treatments
- View current and historical asset condition data in tables, figures, and maps
- Query data by inventory attributes (functional class, age condition)
- Forecast future pavement conditions using customized performance models
- Maintain a library of repair treatments and unit costs
- Develop budget analyses and what-if scenarios at various funding levels



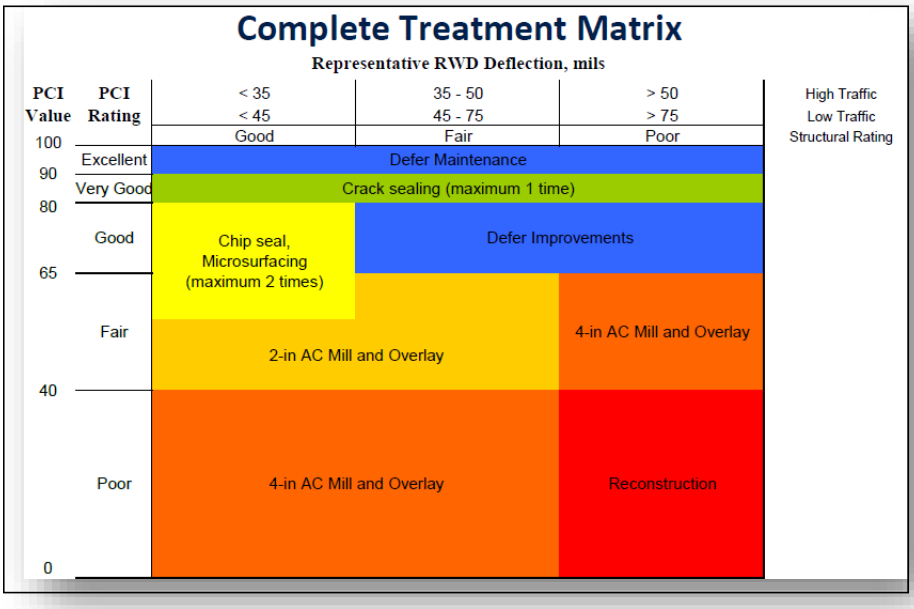
Step 4: Select Treatments



The fourth step in designing the pavement management process is to select appropriate treatments for the roadway network. The selection of treatments is based on the Town's defined maintenance and rehabilitation strategy, which is created by selecting trigger values to identify segments needing repair. Trigger values are thresholds that can be used to signify the need for various treatments to be applied to pavement segments. For example, pavement age, pavement surface condition, or traffic can be used as a factor to determine the eligibility of a pavement for repair. The selection of a treatment can be based on either a cyclical selection or the creation of treatment rules.

Treatment Triggers

The creation of cyclical treatment triggers is a method of treatment selection that uses treatment rules that are developed into a matrix or a decision tree. To develop treatment rules, the Town needs to define its treatment strategy. That is, select treatments that will be applied at specific condition levels for pavements with specific inventories. An example treatment matrix is shown to the right.



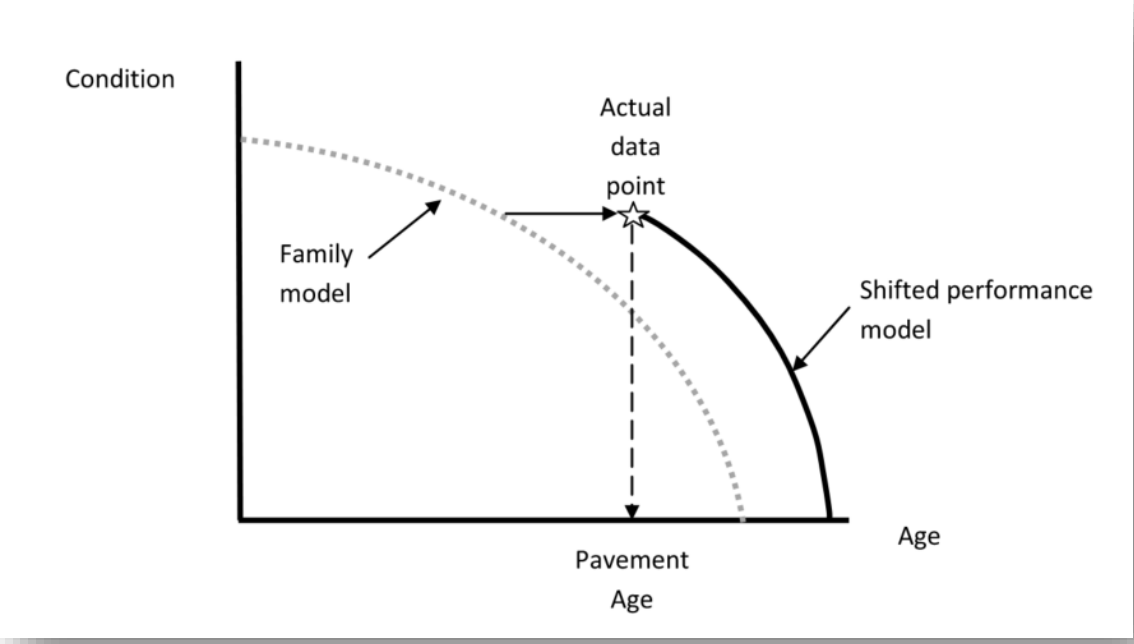
Other forms of treatment rules can be developed, including decision trees for selecting treatments for the roadway segments. A decision tree contains a strategy for each branch of the tree, generating specific treatment options for various categories defined by the Town.

With treatment selection rules established, recommended projects must be selected to match Town funding levels.

Benefit/Cost Analysis

A benefit/cost analysis allows the Town to work at prioritizing, or even optimizing, the choice of treatments on a multi-year period. This approach is preferred over a ranking approach because multiple treatments are considered, consequences of delaying or accelerating a treatment are evaluated, and the cost-effectiveness of a treatment is taken into account in developing the program recommendations.

The benefits of the treatment, which are normally represented as the increase in pavement condition, are divided by the construction cost to determine the benefit/cost ratios, as shown in the figure below. Therefore, the longer the pavement stays in good condition, the more benefit will be accrued by the user and the higher the benefit/cost ratio. Those projects which provide the greatest benefit for the funds expended are considered the best choices.



Selecting Appropriate Methodology

To help identify the most appropriate treatment for each project, the Town will use treatment rules. Treatment rules are easily created within pavement management software.

After treatments are determined they then must determine the prioritization of the projects since the Town has more needs than available funding. The Town can choose to prioritize projects based on ranking or through benefit/cost analysis. Benefit/cost analysis is best conducted inside a PMS. The results of the treatment selection step provide final work plan recommendations for the Town.

Step 5: Report Results

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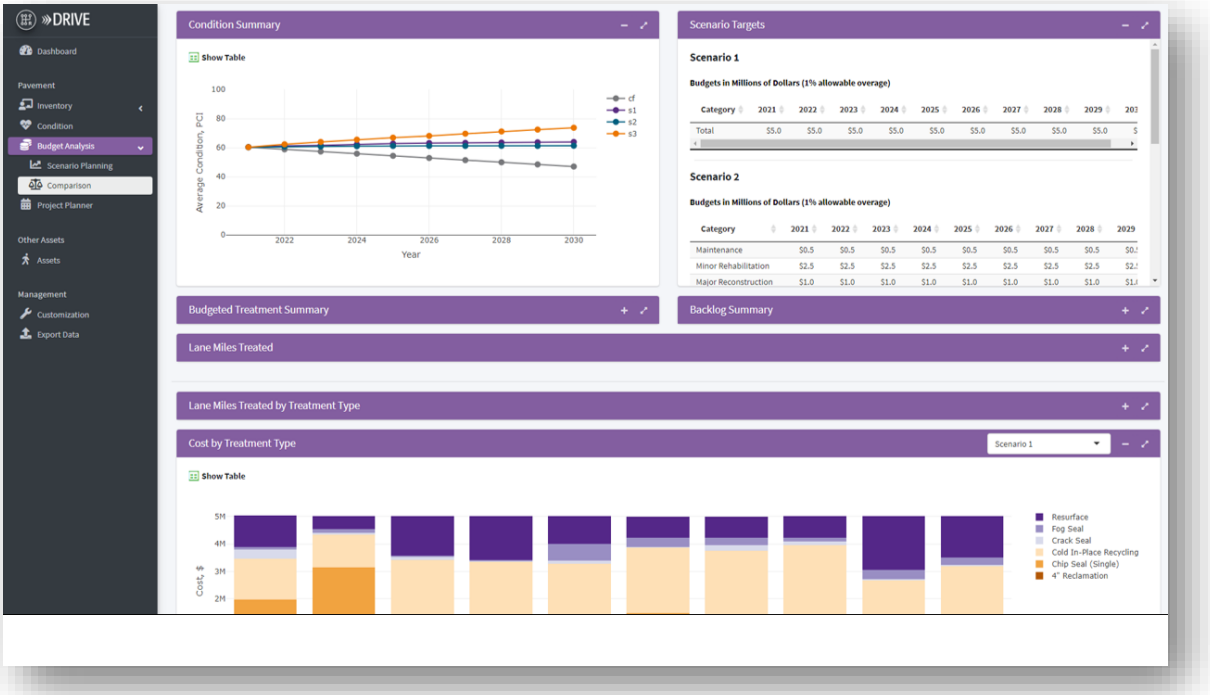
Analysis results can be shared with users of the information using **standard or customized reports**.

The reporting of project results is the fifth step in the implementation process, in which the results of data analysis are presented. The findings can be reported using different methods to highlight important factors, which will assist decision makers in making various decisions. Data reporting is an effective method of communicating not only the recommendations of the pavement management process but also transferring related information to strategic decision makers. The data can be used to generate summaries of relevant information pertaining to any segments under consideration. In general, the results can be presented either by using standard reports or customized summaries.

Standard Reports

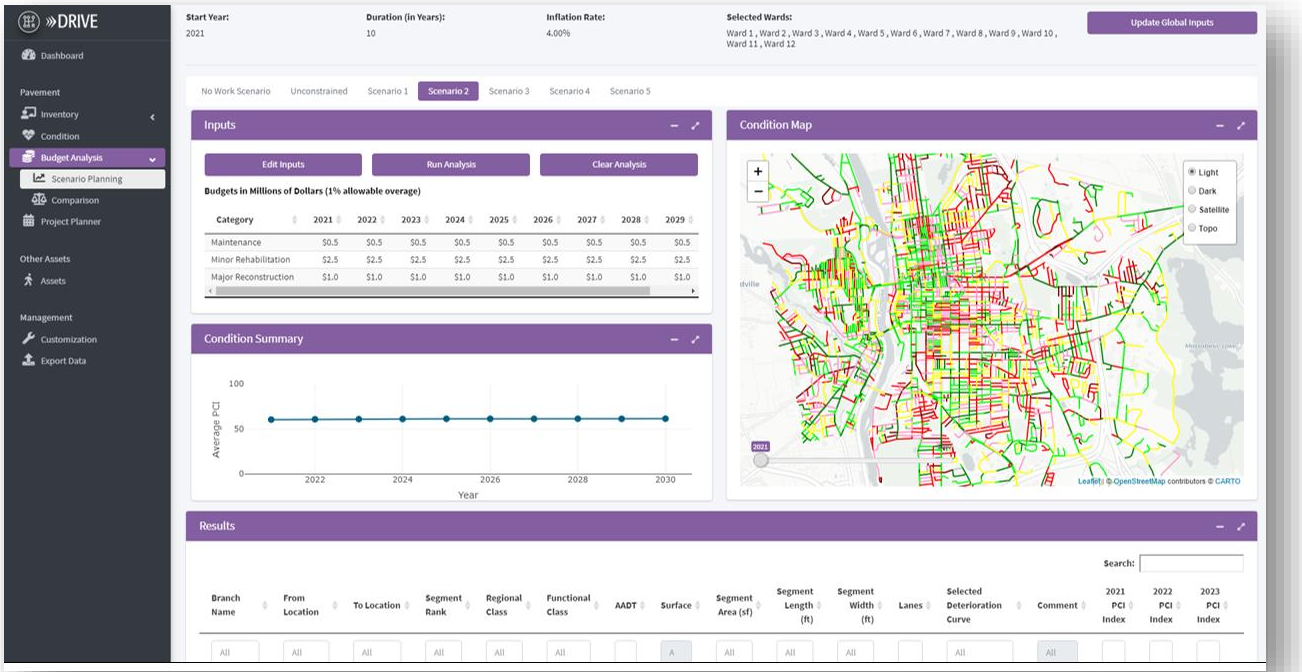
Typically, analyzed data can be represented in the form of standard reports and charts that are available from various pavement management software programs or from spreadsheets. The pavement management process tool provides a platform to utilize the results of an analysis and generate different types of reports, such as work history information, section information, and pavement condition information.

Standard graphics are often used to display percent of pavement mileage in various condition categories.



Customized Summaries

One advantage to implementing pavement management software is the ability to use the available data to generate user-defined reports that can be modified to suit the requirements of the Town.. The pavement management software used by the Town must facilitate the generation of reports linked to the GIS component of the database or separately-managed GIS software. An example of a summarized work plan that is linked to the GIS map is shown below.



The results of the pavement management analysis can also be used to generate summaries for presentations to decision makers. The effect of budget changes on the network condition, often referred to as “what if” scenarios, are often very effective at showing decision makers the need for continued and/or increase levels of funding for the road networks.

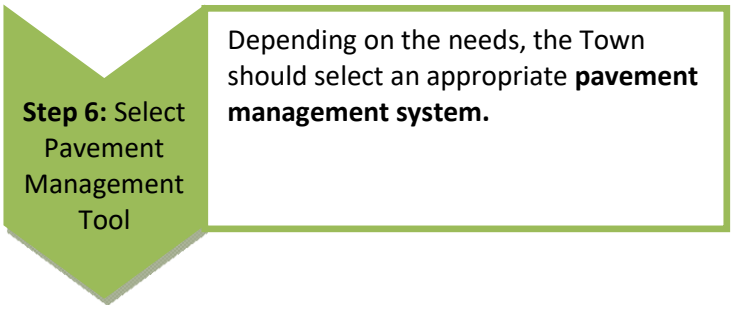
Selecting Appropriate Methodology

General guidance on the types of visual aids that work best for sharing data with various users of pavement management information and examples of each is summarized below.

Visual Aid	When to Use	Examples
Tables	• Incorporate into a report or document for detailed-oriented user (engineers, planners, etc.) • Display extensive amount of detailed information • Support detailed analysis and provide technical information	• Inventory listing (e.g., segment location and name, surface type, age, traffic) • Condition listing (e.g., segment name, condition indices) • Maintenance listing (e.g., segment name, year of maintenance activity, maintenance type and cost) • Budget listing (e.g., money proposed for repairs for each segment or for various functional classifications)

Visual Aid	When to Use	Examples
Charts	• Present information to nontechnical audiences, such as elected officials and the public • Emphasize points to be made (easy method to convey simple summaries)	• Pie chart (shows size of each part as a percentage of the whole) – figure 12 • Column chart (show how items change with time or compare to one another) – figure 13 • Line chart (shows how items change over time and can compare "what if" budget scenarios) – figure 15
Maps	• Display single type of information on a geographical basis • Present information to nontechnical audiences, such as elected officials and the public	• Segment surface type • Color-coded current condition • Color-coded projects by year • Future condition for a funding scenario • Deferred projects

Step 6: Select Pavement Management Tool



The selection of a pavement management tool is influenced by the requirements of the Town's needs. The tool provides a platform to store the pavement management information and to perform different types of analysis.

A pavement management software is the ideal tool for them, the software should be able to:

- Store and manage pavement inventory data
- Record, track and understand the performance of pavement maintenance and repair treatments
- View current and historical asset condition data in tables, figures, and maps
- Query data by inventory attributes (functional class, age condition)
- Forecast future pavement conditions using customized performance models
- Maintain a library of repair treatments and unit costs
- Develop budget analyses and what-if scenarios at various funding levels
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- Create 5-year pavement maintenance and repair plans driven by segment cost-benefit values (CBVs)

- Adjust work plans to revise repair treatment and timing using the Project Planner tool
- Update work history with completed roadway improvements from a finalized annual maintenance and repair plan
- Generate reports that include maps, table, and figures

Step 7: Keep the Process Current

Pavement management is a dynamic process that requires regular updates. Pavement management is not a one-time activity, so the Town must make an effort to update the information incorporated in the pavement management process. Data management is a key component to maintaining the database and keeping the information current.

The required updates needed to keep the overall pavement management process current are outlined for the first five pavement management process steps:

1. Define Network and Collect Data – Inventory information related to pavement segments are relatively constant components of a database. These elements need to be updated only in the case of major changes to the pavement network. Work history details, however, should be updated on an annual basis to keep proper track of maintenance and rehabilitation activities on the pavement sections.
2. Collect Condition Data – General pavement management practices recommend that condition information is collected on a minimum 3-year cycle on pavement segments. Therefore, this data should be collected and updated in the pavement management spreadsheet or software on the same cycle.
3. Predict Condition – Average deterioration rates can be updated with each data collection cycle. If prediction models are utilized, they should be updated every three (3) years.
4. Select Treatments – As agencies use the results of recommended treatments based on treatment selection processes, the rules and priorities should be updated to ensure that the process continues to improve in the future.
5. Report Results – Report results will be used by the Town with each new pavement management plan, which ideally should be conducted each year or on a maximum 3-year cycle to correspond with the 3-year data collection cycle.

SUMMARY

The details for implementing a pavement management program in the Town are outlined in this document. Recommendations are provided for how to develop a process that best meets the given needs of the Town. Overall, the implementation of a pavement management process will help the Town manage roadway networks to make more effective management decisions.