Treasure State Acres
Road Maintenance Plan

DRAFT 2015 REPORT

Prepared for:
Lewis & Clark County
Public Works Department
and
Treasure State Acres Homeowners Assoc.

Helena, Montana

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Abbreviations and Acronyms

AC	asphaltic concrete
DTM	digital terrain model
FHWA	Federal Highway Administration
GIS	geographic information system
LCC	Lewis & Clark County
MCA	Montana Code Annotated
MDT	Montana Department of Transportation
MPWSS	Montana Public Works Standard Specifications
N/A	Not Applicable
O&M	Operation and Maintenance
RID	Rural Improvement District
RPA	Robert Peccia and Associates
TSA	Treasure State Acres

Section 1 – Introduction

The intent of this Maintenance Plan is two-fold:

- Evaluate asphalt roadways within the Treasure State Acres (TSA) Rural Improvement District (RID) using the PASER rating methodology to document roadway conditions and provide a 20-year horizon maintenance plan for TSA.

- To assess the existing drainage system/facilities and recommend improvements.

The Maintenance Plan is a plan developed to assist with roadway management within Treasure State Acres RID. The Plan is designed to ensure that Lewis & Clark County (LCC) and TSA can better meet the expectations of the homeowners and traveling public when it comes to managing and maintaining the TSA interior roads. By this tool, LCC and TSA can therefore provide the best treatments in a timely manner by planning for road maintenance. By documenting the actual conditions of the roads, both entities can set realistic budgets and set up cost-effective maintenance procedures. Developing a maintenance plan for the roadway system allows for both entities to make informed decisions based on sound reasoning, to ensure they are able to budget and plan for current needs. When detailed information is available, local officials and the TSA Homeowners Association officers can respond more effectively to questions from the subdivision residents whom fund the RID. A planned approach for roadway management is easier to explain and receives greater homeowner support. LCC and TSA have undertaken numerous roadway maintenance projects over the course of the RID. This plan is not intended to supersede protocol but supplement processes as an additional tool in the toolbox by means of providing a plan re-evaluation of road status for the next 20-year cycle.

The overall objectives of the Maintenance Plan are to:

- Design a maintenance plan update to be carried out for TSA roads.
- Provide a systematic way to budget for the maintenance and improvements of roads in TSA.
- Prepare a priority schedule of maintenance for TSA roads that is reasonable and justifiable to LCC and the citizens of TSA.
- Provide preliminary information for improving storm drainage within TSA.

The Maintenance Plan is not intended to be a static document. The Plan will need to be reviewed on a regular basis and amended to meet the changing needs of TSA. The Maintenance Plan will develop a baseline for the allocation of funding and resources for roadway maintenance within TSA. The Plan is designed to ensure that LCC and TSA can better meet the expectations of the homeowners when it comes to maintaining roads by establishing a long-term outlook.

To rate and evaluate roadways, LCC chose the PASER Manuals developed by the Transportation Information Center at the University of Wisconsin – Madison[1&2]. The rating process is a point assignment basis, with 10 (highest) as a new constructed road with no visible distresses, and 1 (lowest) being a road that has severe distress and is structurally failed, needing reconstruction. PASER process manuals are contained in this report's appendices as reference. Using the PASER system, Robert Peccia and Associates' (RPA) staff evaluated the roadways within TSA and assigned a rating to them. The ratings for paved roadways will change slowly, decreasing as the pavement condition slowly deteriorates due to aging and environmental factors or rapidly increasing due to maintenance treatments being applied.

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Section 2 – Evaluation of Roadway Conditions

2.1 Preservation vs. Reconstruction[3]

There is an ongoing debate for many local jurisdictions as to what roadway management method is the most effective. Historically, most local jurisdictions have implemented "worst first" roadway management philosophy. Pavements with the worst ride quality generate the most complaints and get moved up the repair priority list. The "worst first" management method allocates resources to the worst roads, trying to maintain roads that are in need of complete reconstruction. However, the maintenance dollars used to repair these roads provide only temporary band-aid solutions for roadways that are already "too far gone". Shortly after repairs are made, the original underlying road base problems reflect through to the surface and the maintenance efforts that were made are shown to be in vain. Or, issues may be a result of pavement aging deterioration due to loss of ductility, layer delamination, severe raveling, etc. Even after repeated applications of maintenance attempts, the inevitable will occur and the road will fail. At this point the only remedy for the roadway is to administer a costly complete reconstruction of the roadway. However, if the "too far gone" roadway was originally allowed to fail, extra costs associated with ineffective maintenance treatments could have been avoided.

As more research is conducted on proper roadway management methods, light is being shed on new effective management alternatives. The more cost effective option for local jurisdictions is to adopt the "best first" roadway management philosophy, in which resources are allocated to preserve the roadways that are already in good condition in order to prevent irreparable damage to the road. This philosophy is one in which preventative measures are taken in order to protect the public's investment. ***"The number one fault of agencies is that they wait until a problem develops before they address it,"*** said Larry Galehouse, P.E., executive director of the National Center for Pavement Preservation (NCPP) at Michigan State University. This is not to say that LCC and TSA have not done the upmost to maintain the roads in the most appropriate manners. These entities have and will continue to do so. We wish to only point out the reasoning that can be presented, if it comes about, to homeowners who may demand that their particular street be included in an overlay, crack seal or chip seal project, when in fact the road deterioration may be so great that it is beyond what, as an example, these treatments can provide.

This method of roadway management can, however, be hard to implement due to being misunderstood by the public. It is hard for many individuals to understand why good roads would receive maintenance while others in worse shape would be allowed to fail. In spite of this, an effort needs to be made in order to understand that the roadways within a jurisdiction need to be thought of as a system and not as individual roads. Meaning that, in order to maintain good working order on the greatest number of roads for the least amount of cost, a well thought out management plan must be used to determine where resources will be most effectively allocated.

If roadway management is thought of as a vehicle, it makes perfect sense that the best way to ensure that the vehicle has a long service life is to conduct routine maintenance. Everyone knows that the small upfront costs associated with changing the oil on a vehicle will prevent engine damage that would later result in costly repairs. Even a brand new vehicle will soon develop problems if not properly maintained. If this mindset is adopted for roadway management, the equivalent to a car's oil change is a roadway chip seal. Even though the vehicle or road may be in perfect working order, the preventative measures taken now will be recovered in the long term investment.

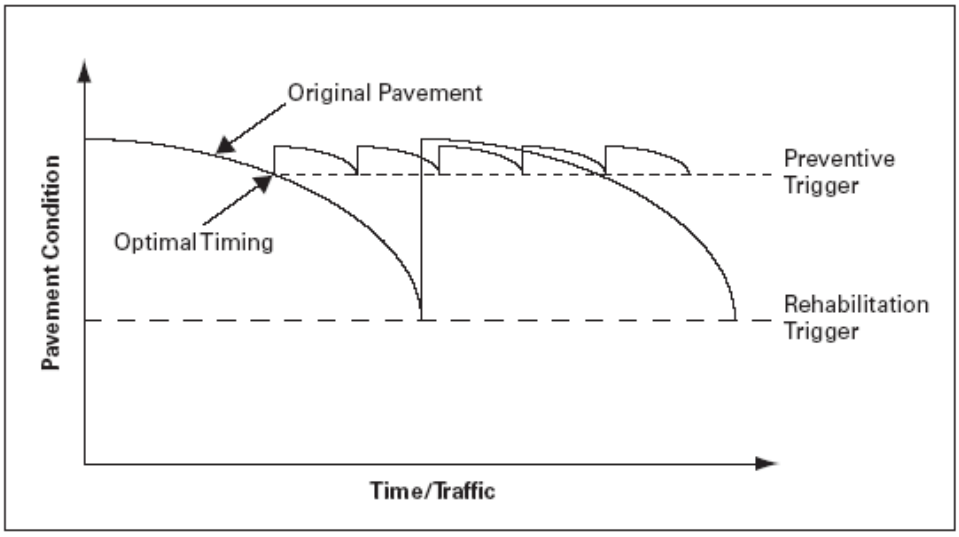
Roadway Preservations

Traditionally, roadways deteriorate to "fair" or "poor" structural condition and ride quality before steps are implemented to rehabilitate the road. However, this type management system is both costly and time consuming. The most cost effective way to manage roadways is to implement a series of low-cost preventative maintenance treatments in order to preserve roadways and avoid continual rehabilitation.

The AASHTO definition of roadway preservation is: ***"…The planned strategy of cost effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system without increasing structural capacity."*** In essence, roadway preservation is a system of planned roadway treatments that are implemented at the optimum time to enhance roadway longevity and maximize the useful life of a roadway while minimizing costs.

The purpose of roadway preservation is **not** to improve traffic flow or increase the level of service of a roadway; it is designed to be the most cost effective way to maintain the current working order of a healthy roadway. Roadway preservation is intended to address minor deficiencies in a roadway and implement low cost solutions that extend the service life of the roadway by preventing minor deficiencies from becoming major problems. **Figure 2-1** below shows the concept behind roadway preservation and the emphasis of "Optimal Timing".

Figure 2-1: Pavement Condition vs. Time/Traffic



Pavement preservation concept[3]

The example compares two paved roadways starting at the same condition. One of which is managed under the approach of rehabilitating the roadway and its subsequent deterioration to a state of failure by applying no or very little maintenance during the course of the road's life cycle. Failure occurs when the road is in fair to poor condition shown by the rehabilitation trigger line. At this line, irreversible structural damage has occurred, resulting in the need for costly rehabilitation of the entire roadway. The second road implements regular roadway preservation techniques. These preservation techniques are low-cost preventative maintenance treatments that are implemented when the roadway reaches a predetermined level. The timing of treatment implementation is crucial for the success of the preservation plan. If the preservation techniques are implemented after the optimal time, the roadway will be deteriorating at a rate from which it cannot recover from and the investment in maintenance will

be wasted. However, if the preventative maintenance is implemented at the optimal time, the roadway will be restored to near original condition, and if routine maintenance continues it will result in much greater intervals between roadway rehabilitations.

Minimizing the need for costly rehabilitations of roadways by implementing preventative maintenance is at the forefront of this plan. It is the intent of this Maintenance Plan to utilize roadway preservation as a long-term strategy for enhancing functional roadway performance by using integrated, cost-effective practices that extend roadway life, improve safety (e.g. skid resistance) and motorist satisfaction while achieving sustainable conditions for TSA roads.

Roadway Reconstruction

Roadway reconstruction is an action that must be utilized when preservation techniques are no longer a cost-effective solution to extend the service life for a specific roadway. If any road is left to the elements without routine maintenance, it will encounter a point in its life when it rapidly deteriorates to a state of failure. Failure of a roadway occurs when the road experiences structural damage. Structural damage takes place when a roadway loses its ability to resist and recover from repeated load applications and sustains permanent deformations.

In order to restore the structural integrity, load capacity, and rideability of a roadway, different treatment options are available depending on the condition of the roadway. Roads that have failed can be reconstructed, rehabilitated, or resurfaced. Complete roadway reconstruction is the most drastic treatment option, but must be implemented when structural damage has occurred throughout the road strata. Reconstruction of a roadway replaces an existing road structure with an equivalent or improved new road structure. Rehabilitation involves improving the structural integrity of the existing road strata, and resurfacing restores the surface course of a roadway to like-new condition. Typically with resurfacing, underlying spot issues, if any, need to first be addressed since resurfacing in itself does not address the whole road strata from the pavement, down through the aggregate base and subbase, and beyond down through the native soil subgrade. That is, localized failure areas as a result of under-the-pavement issues need to be addressed prior to capping with an overlay. If underlying issues are not spot issues, but extend through the majority of the road, then the road may be more of a candidate for reconstruction than resurfacing.

Structural restoration of roadways is a very costly and time consuming part of roadway management. However, it is a crucial part of a well-structured roadway management plan. Roadway preservation is the best treatment option for roadways that still have structural integrity. Though there comes a certain point when low-cost preventative maintenance treatments only offer a short term superficial fix.

Roadways must be closely monitored and rated to determine what treatment option is best for that roadway. Large sums of money can be wasted by reconstructing roads that still have service life, or by applying preventative treatments to roads that have sustained structural damage. Roadway reconstruction is the only option for some roads, but not the only option for every road.

Cost/Benefit Analysis

The benefits of roadway preservation are not instantaneous nor are they dramatic. The key to the success of this plan is longevity. Roadways that are generally in good condition and receive preventative treatments at the optimal time do not typically show marked improvements, even after multiple applications. Where the benefits become apparent are in the roadways' ability to stand up to long term

use, and avoid permanent structural damage. When compared to roads that are left to the elements, roadways that receive preventative treatments have a longer service life and are in better condition.

Roadways, and particularly paved roadways, perform well and resist the wear and tear subjected to them by traffic and weather until a certain point in their life. After which they begin to deteriorate precipitously and rapidly to a point of failure. This is shown in previous **Figure 2-1** with the nose of the curve continuing to dip down, and more steeply as time progresses. However, if preservation efforts are made early in the roads' life, significant gains can be made to protect the longevity of the road. Low-cost preventative maintenance treatments have been shown to not only extend the service life of roads, they also provide for a better ride quality while the road is in service. Reconstructing old roads or constructing new roads is the number one expense for most local governments; therefore, it makes economic sense to make every effort possible to preserve the taxpayer's investment. A study conducted by the Federal Highway Administration (FHWA) found that when pavement preservation techniques were implemented at the optimal time they resulted in a significant long-term economic savings.

In September 2006 the FHWA published a compilation of articles titled "Pavement Preservation Compendium II[3]". One of the articles published conducted a case study in which it compared the life-cycle cost of two identical pavement sections - one with and one without pavement preservation treatments. This article is included as **Appendix E** to this Maintenance Plan. The data in the article was reviewed and replicated herein to portray the described concepts for a typical roadway project in the TSA area. For this example, a theoretical one-thousand foot section of roadway is considered in terms of the *reconstruction approach* versus utilizing a *preservation approach*. Costs shown in **Table 2-1** and **Table 2-2** are based on those values computed for maintenance treatments as contained in **Appendix D**.

Table 2-1: 1-Thousand Foot of Road Example - Reconstruction Alternative (Project Life Cycle Cost)

Activity	Age	Life Extended (Years)	Remaining Service Life (Years)	Cost
Initial New Construction	0		25	$228,000
Subsequent Reconstruction	25		25	$228,000
Total				**$456,000**

Table 2-2: 1-Thousand Foot of Road Example - Preservation Alternative (Project Life Cycle Cost)

Activity	Age	Life Extended (Years)	Remaining Service Life (Years)	Cost
Initial New Construction	0		25	$228,000
Chip Seal & Crack Seal	5	2	22	$18,000
Non-Structural Overlay	10	8	25	$52,000
Chip Seal & Crack Seal	14	1	22	$18,000
Structural Overlay	20	5	21	$79,000
Chip Seal & Crack Seal	25	2	18	$18,000
Total				**$413,000**

The examples in the tables above show the cost savings and increase in service life gained by using pavement preservation treatments[3]. In the example, a thousand feet of road was constructed for $228,000 and designed to last 25 years without any routine maintenance. Implementing the reconstruction approach of roadway management shown in **Table 2-1**, the roadway was in need of reconstruction after 25 years at a cost of $228,000. The second example implements roadway preservation techniques on that thousand feet of road through the use of multiple preservation treatments shown in **Table 2-2**. After 5 years of use, the first short-term preservation treatment was initiated at a cost of $18,000 and extended the life of the roadway 2 years. After 10 years a second preservation treatment was applied at a cost of $52,000 that extended the life of the road 8 years. In years 14, 20, and 25 addition treatments were applied. At the end of the 25-year period a total of 5 short term preservation treatments would be applied for a total of $185,000, and at this point the road still had 18 years of remaining service life.

The preventative techniques shown in **Table 2-2** are based on a 32-foot wide asphalt width roadway with curb and gutter and accordance with the estimates depicted in **Appendix D**.

This example shows that money spent developing a plan, monitoring roadway conditions, determining optimal timing and investing in pavement preservation; thus extending pavement life, will more than pay for the up-front investment.

The ultimate goal of this Maintenance Plan is to improve roadway conditions, extend roadway life, and enhance roadway performance for TSA residents. In the past, many roadway management practices around the country have not been successful due to the fact that they are implemented without a definitive long-term plan being in place. By making timely decisions that employ proper treatments there will be marked improvements of the overall success of roadway management within TSA.

2.2 Roadway Treatments

Key steps are necessary to develop a meaningful roadway management plan. The first is to inventory the existing conditions of the roadways and rank them in accordance with the ***Local Road Assessment and Improvement Drainage Manual,*** *and* the ***PASER Manual for Asphalt Roads,*** **Appendix A** and **Appendix B, respectively**. Once the roadways are ranked, the appropriate treatment can be determined.

However, roadway treatments should only be recommended in conjunction with drainage treatment assessment, since lack of appropriate road drainage can be considered a primary cause for road surfacing deterioration. The other primary cause can be attributed to structural overload, such as heavy multi-axle commercial truck traffic on a under designed road with inadequate surfacing thicknesses. TSA is not likely experiencing this latter issue of significant road overloading, as the predominant vehicle makeup is light duty passenger sized vehicles reflective of residential neighborhood traffic.

Drainage Improvements

The Importance of Drainage: Inadequate drainage greatly contributes to road failure. Proper drainage is vital, as standing water penetrates through road layers to affect road serviceability. To maintain a healthy roadway network, TSA must keep water away from it, and that is by keeping it flowing to its final discharge location.

A drainage system reduces water damage by effectively expediting surface water off of the road. This in turn saves money. The major elements to a drainage system are:

- Traveled Way
- Shoulders
- Curb & Gutter/Ditches
- Culverts/Conveyance Pipes
- Inlets
- Discharge

These elements work together to prevent water from passing through the road surface. The roadway and shoulder move water to the side and carry it away. Even properly designed roads could flood, washout, and develop potholes if drainage is neglected. Damaged shoulders, curb & gutter, ditches, and culverts result in poor drainage. They allow water to stand on the road or seep back into the base, which saturates and weakens the base/road. **It is important to fix problems immediately**.

Ensuring that roads have adequate crowns, cross slopes, curbs & gutters, and ditches is critical. This allows the road to shed water to the curb & gutter and/or ditches and away from the roadway. Once off the roadway, the water needs to be disposed of. For TSA, most of this is accomplished by subsurface infiltration via perforated manholes. Many of these appear to have heavy sedimentation and maybe inadequately sized to discharge the required volume of water into the underlying soil before ponding occurs.

Below is a summary of drainage ratings and treatments for each:

A. Major Improvements Required (Poor Rating)

A roadway with a poor rating for drainage is essentially a roadway that has no crown, shoulders create a secondary ditch, and frequent ponding is observed on the roadway. The roadway will typically exhibit erosion with surface distresses or failure.

Roadways showing these distresses require major improvements to the drainage system. This will include reshaping the roadway to restore adequate crown and cross slopes, major culvert/inlet replacement and/or improvements, and significant ditching/curb and gutter improvements on more than 50% of the roadway.

B. Several Improvements Necessary (Fair Rating)

A roadway with a fair rating for drainage is essentially a roadway that has minimal crown, needs some shoulder slope improvements, has localized flooding or ponding and needs some culvert cleaning or minor repairs.

Roadways showing these distresses need to have several improvements to the drainage system. This will include ditching/curb and gutter improvements and/or cleaning on up to 50% of ditches/curb and gutter, shoulder slope improvements and some cleaning and minor repairs of culverts/inlets.

C. Minor or Localized Repairs (Good Rating)

A roadway with a good rating is essentially a roadway that has an adequate roadway crown and shoulder slope and is showing no signs of drainage related surface damage.

Roadways showing no signs of surface distresses may need localized cleaning of ditches/curb and gutter and culverts/inlets to ensure the rating.

D. No Improvements Necessary (Excellent Rating)

A roadway with an excellent rating has wide adequate ditches, like-new curb, functional storm sewer system, good roadway crown and shoulder slope. All culverts/inlets are clean and sound. No improvements are necessary.

Roadway Drainage shall be reviewed with reference to ***Local Road Assessment and Improvement Drainage Manual*** prepared by the Transportation Information Center, University of Wisconsin-Madison **(Appendix A).**

Once drainage assessments are taken into account, paved roadway treatments can be better analyzed with more cost effective approaches taken.

Paved Roadway Treatments

Pavement Management + Pavement Maintenance = Pavement Preservation: Classic pavement preservation starts with a pavement inventory and condition database. Paved Roadways should be reviewed with reference to ***PASER Manual Asphalt Roads*** **(Appendix B**) and recommended ***Montana Department of Transportation's Crack Sealing Manual and Chip Seal Manual***.

Assessment is used to determine which road surfaces are near the point where they will begin to fail rapidly. Those pavements — not the worst (already failing) pavements — are the ones that should be targeted with whatever funds are available, to prolong their service life. This is addressing the 'preventative trigger' at the 'optimal timing' as shown in previous **Figure 2-1**.

The problem that LCC and TSA face is determining which roads need to be improved and how to optimize the budget. Pavements that are falling apart and below a determinable preventative trigger threshold should not receive substantial maintenance dollars, but should be allowed to fail and then be rebuilt. That's why adhering to a pavement preservation program may be in conflict with homeowners, particularly those that live on the failing street, who may demand quick fixes for failing pavements.

At that point, the roadway inventories and roadway management plan can be exhibited to show that LCC and TSA are making the informed and calculated decisions based on the recommendations contained herein.

"The worst way of responding to complaints is the policy of worst-first," said John O'Doherty, P.E., training coordinator, National Center for Pavement Preservation. "It's a suboptimal strategy and, if you continue to follow it, you'll eventually bankrupt your agency. When you wait for worst-first, you've waited until structural damage is being done to the road and you have to do major rehabilitation. Worst-first waits until serious damage is done, and every road in your system will have to descend to that level, making it the most expensive strategy you can think of."

"Pavement Preservation involves a paradigm shift from worst-first to optimum timing. Preservation programs must focus on selecting the right treatment for the right pavement at the right time."

Those preventive maintenance treatments include:

- crack sealing

- chip seals
- hot-mix asphalt thin overlays (non-structural) w/ spot improvements for localized failures prior to overlaying

Through planned, early application of preventive maintenance treatments, good roads are kept in good condition, validating the motto of pavement preservation being "the right treatment for the right road at the right time."

Below is a summary of paved roadway rating classifications and recommended treatments. These are applied to TSA roads and the specifics to each individual road assessment are discussed later in the report under **Section 2.5 Roadway Assessment of Treasure State Acres.**

A. Reconstruct (PASER Manual Rating of 1 or 2)

A paved roadway with a ranking of 1 is essentially a roadway that is failing and typically showing signs of severe distress with extensive loss of surface integrity.

A paved roadway with a ranking of 2 is essentially a roadway that is in very poor condition. The roadway will typically have alligator cracking (over 25% of surface), severe distortions (over 2" deep), and extensive patching with potholes.

Roadways showing these distresses have severe deterioration. These roadways need a complete reconstruction with extensive base repair.

The roadways are to be redesigned to the Lewis and Clark County Public Works specifications. Additionally, when reconstructing existing roadways, alternative approaches such as Full Depth Recycling (FDR), which includes a Cement Treated Base (CTB) or other engineering solutions that could reduce the costs, should be explored. Pulverization of old pavement is also an effective way to reduce costs.

B. Structural Improvement and Leveling (PASER Manual Rating of 3 or 4)

A paved roadway with a ranking of 3 is essentially a roadway that is in poor condition. The roadway will typically have closely spaced longitudinal and transverse cracks often showing raveling and crack erosion, severe block cracking, some alligator cracking (less than 25% of surface), patches in fair to poor condition, moderate rutting or distortion (1" or 2" deep) and occasional potholes.

A paved roadway with a ranking of 4 is essentially a roadway that is in fair condition. The roadway will typically show severe surface raveling, multiple longitudinal and transverse cracking with slight raveling, longitudinal cracking in wheel paths, block cracking (over 50% of surface), patching in fair condition, and slight rutting or distortions (1/2" deep or less).

Roadways showing these distresses are showing significant signs of aging and severe deterioration. These roadways need to be milled (for severely deteriorated portions) and/or patched and repaired prior to overlay. These roadways would benefit from a structural overlay of approximately 3" in depth.

C. Preservative Treatments (PASER Manual Rating of 5 or 6)

A paved roadway with a ranking of 5 is essentially a roadway that is in fair condition. The roadway will typically show moderate to severe raveling (loss of fine and coarse aggregate), longitudinal and transverse cracks (open ½") show first signs of slight raveling and secondary cracks, first signs of longitudinal cracks near pavement edge, block cracking up to 50% of surface area, extensive to severe flushing or polishing with some patching or edge wedging in good condition.

A paved roadway with a ranking of 6 is essentially a roadway that is in good condition. The roadway will typically show slight raveling (loss of fines) and traffic wear, longitudinal cracks (open ¼ - ½"), some spaced less than 10', first signs of block cracking, slight to moderate flushing or polishing with occasional patching in good condition.

Roadways showing these distresses are showing signs of surface aging and are in sound structural condition. These roadways would benefit from a crack seal and chip seal (PASER Rating of 6) or a thin non-structural overlay of approximately 2" in depth (PASER Rating of 5).

D. Routine Maintenance, Crack Sealing and Minor Patching (PASER Manual Rating of 7)

A paved roadway with a ranking of 7 is a roadway in good condition. The roadway will typically show very slight or no raveling, surface shows some traffic wear, have longitudinal cracks (open 1/4") due to reflection or paving joints, have transverse cracks (open 1/4") spaced 10' or more apart with little or slight crack raveling with no patching or very few patches in excellent condition.

Roadways showing these distresses are showing the first signs of aging. These roadways would benefit from routine crack sealing.

E. Little or No Maintenance (PASER Manual Rating of 8)

A paved roadway with a ranking of 8 is a roadway in very good condition. The roadway will show virtually no longitudinal cracks except reflection of paving joints and an occasional transverse cracks, widely spaced (40'or greater). All cracks sealed or tight (open less than 1/4").

Roadways showing these distresses require little or no maintenance at the time of the assessment and would not benefit greatly from any treatment. Continue to monitor.

F. No Maintenance Required (PASER Manual Rating of 9 or 10)

A paved roadway with rankings of 9 or 10 is a roadway in excellent condition that has received a recent overlay or is newly constructed. Continue to monitor.

The key to success of the Maintenance Plan is implementing the right treatment to the right road at the right time. If any one of these three elements is not correctly decided upon, the Maintenance Plan will have a reduced chance for success. Section 3 will discuss the different treatment options available to keep the TSA roads in optimal condition, and the estimated costs associated with each treatment option.

Before a specific treatment option can be decided upon, a line needs to be drawn and it needs to be decided whether the road should be maintained or improved (reconstruction or otherwise rehabilitated). This is critical to determine what the most cost-effective treatment option will be. An in-depth analysis of both the roadway ranking process and treatment options are included later in this document. Through the subsequent analysis, it is recommended that asphalt roadways having a PASER rating of 5 or better require maintenance treatments, with the exception of rankings of 9 or 10 at the time of the rating which should continue to be monitored. Roadways falling below these levels will require improvement treatments (i.e. non-maintenance work).

2.3 Roadway Maintenance

There are many different preventative maintenance techniques that can be implemented to a roadway that will increase its service life. The following maintenance treatment options are available for asphalt roads. Other options are available, but can require more specialty contractor work (e.g. slurry seals).

Asphalt Roadway Maintenance Options

- culvert/pipe and inlet inspections/maintenance
- ditch/curb and gutter maintenance
- crack sealing
- chip seals
- hot-mix asphalt thin overlays (non-structural)

Table 2-3: Typical Expected Life of Pavement Maintenance Treatments

TREATMENT	EXPECTED LIFE OF TREATMENT* (YEARS)		
	Min.	*Average*	Max
Non-Structural Overlay	2	*7*	12
Chip Seals	3	*5*	7
Crack Seal	2	*3*	5

** Life is Dependent on Traffic Volumes and Environmental Conditions*

Each of these pavement treatment options identified above will be most effective when implemented at the optimal time. Determination of the optimal application time for each roadway treatment is established by utilizing the roadways PASER rating and field verification.

Below is a summary of roadway PASER ratings, the recommended treatment option, and estimated cost associated with each treatment option on a per thousand foot basis. Cost estimates are based on an assumed 32-foot wide asphalt width and curb and gutter.

Table 2-4: Asphalt Roadways Maintenance Cost Summary

ASPHALT ROADWAYS MAINTENANCE COST SUMMARY		
PASER Rating	Treatment Option	Estimate Cost Per Thousand Feet*
10	None Needed	$0
9	None Needed	$0
8	None Needed	$0
7	Crack Sealing	$2,000
6	Chip Seal & Crack Seal	$18,000
5	Non-Structural Overlay	$52,000

** Cost estimates are current dollars.*

2.4 Roadway Improvements

Table 2-4 above summarizes estimated maintenance costs for roadways currently rated 5 and above. Similarly, this section summarizes options for roadway improvements. Roadway improvements are treatments that must be utilized when a roadway has sustained structural damage. The severity of structural damage and methods to reverse this damage can vary greatly from road to road. Roadway improvement options include the following.

Asphalt Roadway Improvement Treatment Options

- culvert/inlet improvements
- ditch/curb and gutter drainage improvements
- excavation
- pulverization/milling of old asphalt
- full depth recycling (FDR)
- separation/stabilization fabric installation
- addition of select sub-base gravel
- addition of base gravel
- new asphalt
- structural overlays

Table 2-5: Asphalt Roadways Improvements Cost Summary

ASPHALT ROADWAYS IMPROVEMENTS COST SUMMARY		
PASER Rating	Treatment Option	Estimated Cost Per Thousand Feet*
4	**Minor Structural Improvement** (3" structural overlay)	$79,000
3	**Structural Improvement** (keep existing curb and gutter, Full Depth Recycling, 3" asphalt)	$116,000**
2	**Reconstruct (Minor)** (keep existing curb and gutter, excavation, new sub-base, base course, 3" asphalt)	$159,000**
1	**Total Reconstruct** (excavation, ditch/curb improvements, new culverts, sub-base, base course, 3" asphalt)	$228,000**

** Cost estimates were derived from recent bid tabulations and experience. Cost estimates are current dollars.*
*** Costs are only for roadway reconstruction, any drainage improvements or infiltration chambers would be additional.*

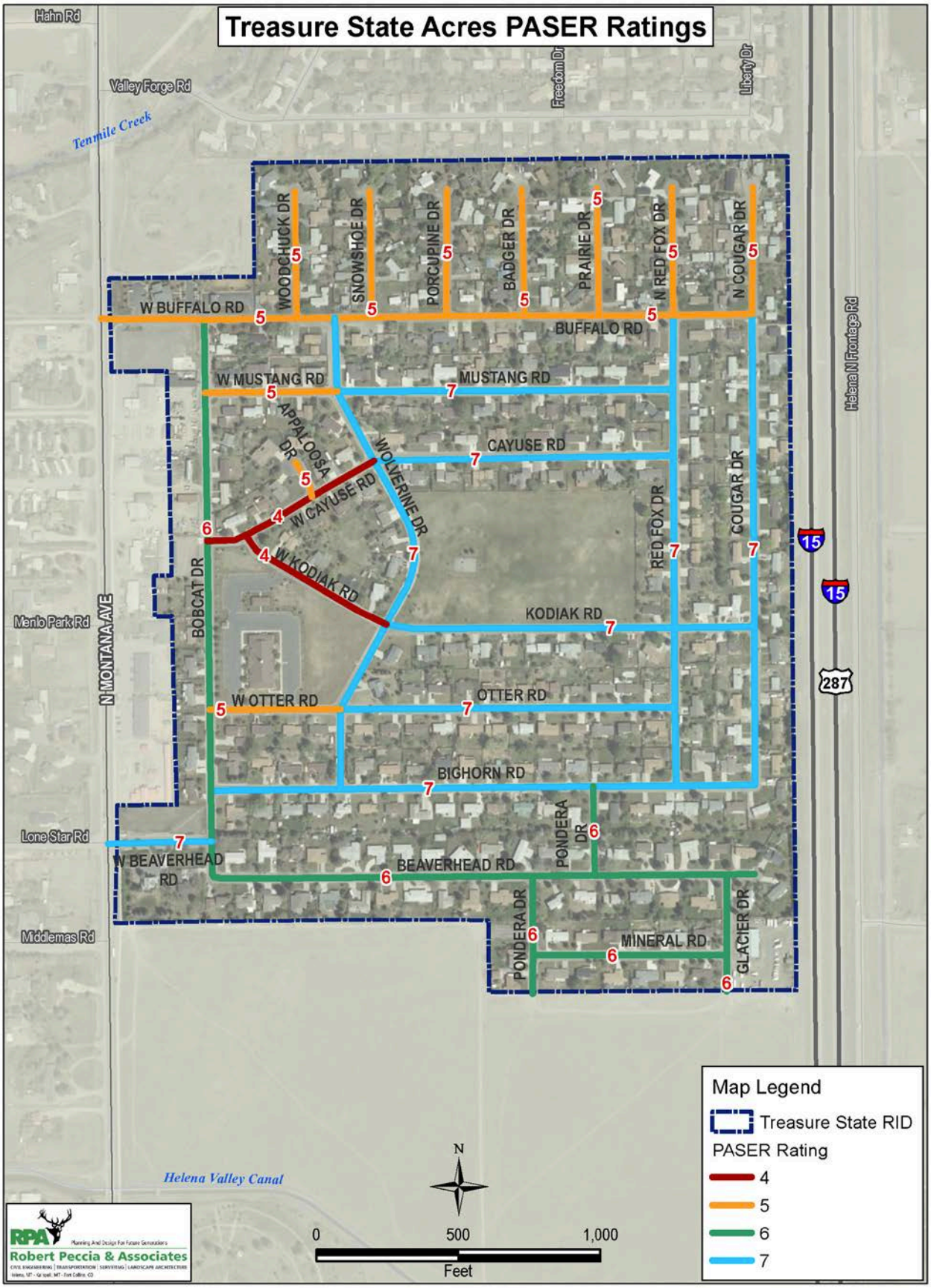
2.5 Roadway Assessment of Treasure State Acres

RPA conducted a roadway surface assessment in April 2015 using PASER methodology for the TSA roadways as listed in **Table 2-6** and as shown in the following **Figure 2-2**. Detailed results of the Roadway Assessment are presented in **Appendix C**.

Table 2-6: Selected Roadways for Assessment

Roadway	Limits	Length (feet)
Mineral	Pondera to Glacier	690
Beaverhead Entrance	Montana Ave to Bobcat	350
Beaverhead	Bobcat to Cul-De-Sac	2,030
Bighorn	Bobcat to Cougar	1,950
Otter	Bobcat to Wolverine	460
Otter	Wolverine to Red Fox	1,200
Kodiak	Cayuse to Wolverine	600
Kodiak	Wolverine to Red Fox	1,055
Kodiak	Red Fox to Cougar	275
Cayuse	Bobcat to Wolverine	660
Cayuse	Wolverine to Red Fox	1,055
Mustang	Bobcat to Wolverine	465
Mustang	Wolverine to Red Fox	1,180
Buffalo	Montana Ave to Bobcat*	365
Buffalo	Bobcat to Wolverine*	460
Buffalo	Wolverine to Porcupine*	390
Buffalo	Porcupine to Cougar*	1,080
Bobcat	Beaverhead to Buffalo	1,835
Appaloosa	Cayuse to Cul-De-Sac	85
Appaloosa	Cul-De-Sac	75
Wolverine	Bighorn to Buffalo	1,790
Pondera	S End to Beaverhead	420
Pondera	Beaverhead to Bighorn	310
Red Fox	Bighorn to Buffalo	1,660
Red Fox	Buffalo to Cul-De-Sac*	405
Red Fox	Cul-De-Sac*	60
Glacier	S End to Beaverhead	410
Cougar	Bighorn to Buffalo	1,660
Cougar	Buffalo to Cul-De-Sac*	405
Cougar	Cul-De-Sac*	60
Woodchuck	Buffalo to Cul-De-Sac*	405
Woodchuck	Cul-De-Sac*	60
Snowshoe	Buffalo to Cul-De-Sac*	405
Snowshoe	Cul-De-Sac*	60
Porcupine	Buffalo to Cul-De-Sac*	405
Porcupine	Cul-De-Sac*	60
Badger	Buffalo to Cul-De-Sac*	405
Badger	Cul-De-Sac*	60
Prairie	Buffalo to Cul-De-Sac*	405
Prairie	Cul-De-Sac*	60
*These Streets do not have curb and gutter.		
TOTAL		**25,765**

Figure 2-2: 2015 PASER Ratings of Paved Roads Assessed



2.6 Results of Roadway Assessments

Roadway ratings are summarized in **Table 2-7**. The paved roads were rated on a scale of 1 to 10, with 1 being "failed" and 10 being "excellent" per the PASER rating process (appendices). See **Appendix C** for more information on each TSA road rating.

Table 2-7: Pavement Condition Summary

Pavement Surface Condition	PASER Rating	Feet
Failed	1	0
Very Poor	2	0
Poor	3	0
Fair	4	1,420
Fair	5	6,475
Good	6	5,695
Good	7	12,175
Very Good	8	0
Excellent	9 and 10	0
TOTAL LENGTH INVENTORIED		**25,765**

As shown in **Table 2-7**, the roadways rated during this project are currently in fair to good condition. This indicates that the majority of roadways are reasonably structurally sound, lending those to a maintenance program to improve the roadway surface and maintain the integrity of the roadway section. Roadways rated 4 or less will however require structural improvements and are beyond applying maintenance techniques.

The first step in developing a road management plan, after rating each road, is to establish the acceptance level for roadways within TSA. The acceptance rating for roadway within TSA needs to be considered with available budgets and funding. LCC should develop a priority of roadways to be improved, in an effort to improve those roadways that are below the desired rating. Many factors, including traffic volumes, will play into deciding which roadways receive treatments. Once this is completed, LCC can focus on bringing existing roadways up to the acceptable levels and maintaining other roadways to ensure that they don't deteriorate below the acceptable levels.

The following **Section 3** discusses treatment categories for each rating, and applications to increase each rating to an acceptable level. Again, the final acceptance level will depend on the threshold that TSA can comfort (not all roads are or will likely be perfect). For the basis of this report, the "target" level is a rating of 8 or better.

Section 3 – Evaluation of Roadway Treatments

3.1 Surface Treatments Categories

Surface treatments are categorized based upon the PASER ratings for the selected roadways. Surface treatments are summarized in **Table 3-1** below.

Table 3-1: Required Surface Treatments

PASER Rating	Required Treatment
1 or 2	Complete Reconstruction including base-course
3	Milling and structural overlay
4	Structural overlay
5	Chip Seal or non-structural (<2") overlay
6	Chip Seal with crack sealing
7	Crack sealing
8, 9, and 10	No maintenance required, continue to monitor

Cost estimating spreadsheets have been prepared for the various treatments listed in **Table 3-1**. The spreadsheets allow LCC and TSA to input the current unit prices for materials and length of roadway improvements to calculate the total project cost for the proposed roadway treatments. Copies of the spreadsheets are presented in **Appendix D**.

Table 3-2 below shows the costs associated with constructing/maintaining the TSA roads to satisfactory levels (being a PASER rating of 8 or better for asphalt roads).

Table 3-2: Cost to Achieve Satisfactory PASER Ratings (8 or better)

PAVED ROAD MAINTENANCE & IMPROVEMENTS COSTS					
Treatment Needed	**Cost/1,000 Feet To Repair**	**PASER Rating**	**Feet of Road**	**% of Roads**	**Total Cost**
Reconstruct (Major)	$228,000	1	0	0.00%	$0
Reconstruct (Minor)	$159,000	2	0	0.00%	$0
Leveling & Overlay (Structural)	$116,000	3	0	0.00%	$0
Overlay (Structural)	$79,000	4	1,420	5.51%	$112,180
Overlay (Non-Structural)	$52,000	5	6,475	25.13%	$336,700
Chip Seal & Crack Seal	$18,000	6	5,695	22.10%	$102,510
Crack Seal	$2,000	7	12,175	47.25%	$24,350

PAVED ROAD MAINTENANCE & IMPROVEMENTS COSTS					
Treatment Needed	Cost/1,000 Feet To Repair	PASER Rating	Feet of Road	% of Roads	Total Cost
No Work Needed (Continue to Monitor)	$0	8, 9 & 10	0	0%	$0
Total Costs =			**25,765**	**100%**	**$575,740**

3.2 Annual Maintenance

Asphalt maintenance would include crack sealing, crack sealing followed by a chip seal, and non-structural overlays. These treatments are recommended for roads rating 5 and higher. This assumes that selected TSA roads with a PASER rating of 4 or less receive no maintenance improvements and all the funding was spent on just maintaining the existing paved roadway network. Roads rating 4 or less are beyond cost-effective maintenance and funding for those would be applied to structural improvements. Using the average expected life of typical pavement maintenance treatments as discussed earlier, it can be reasonably predicted when a roadway with a specific current PASER Rating would need a specific maintenance treatment. Using this information, and the estimated cost of each treatment, we can determine how many times of each maintenance treatment would be implemented over a specified timeframe and the cost of those treatments. **Table 3-3** summarizes the number of maintenance treatments that would be applied to each roadway rating from 2015 thru 2035.

Table 3-3: Estimated Number of Treatments from 2015 thru 2035

NO. OF TREATMENTS FROM 2015 THRU 2035				
PASER Rating	Feet (2015)	Crack Seals	Crack Seals & Chip Seals	Non-Structural Overlays
8, 9 &10	0	1	2	1
7	12,175	2	2	1
6	5,695	2	2	1
5	6,475	1	2	2
Total =	24,345			
Crack Seal ($/1,000 Feet) =	$2,000			
Crack Seal & Chip Seal ($/1,000 Feet) =	$18,000			
Non-Structural Overlay ($/1,000 Feet) =	$52,000			
Total Cost per Treatment =		$84,430	$876,420	$1,602,640
Total Cost of All Treatments =			$2,563,490	
Annual Cost of All Treatments (20 years) Current Value =			$128,175	

For TSA to maintain the paved roadways with a PASER rating of 5 or more, it would cost approximately $128,175 annually, or $5,265 per thousand feet per year for a paved roadway. Therefore, the RID

should be capable of funding at least $128,175 annually for road maintenance. Potential storm drainage improvements and roadway structural improvements are additional, and discussed later in the report.

Pavement Maintenance Recommendations

Paved roadways that have a surface condition rating of 5, 6, or 7 should be prioritized to receive the appropriate maintenance treatment.

Roads with a PASER Rating of 7 should be prioritized per the "best first" roadway management philosophy. These roads would benefit most from a crack sealing treatment. No detailed surveying or engineering design, other than measuring the actual length of cracks, is necessary to prepare a bid package and advertise for construction.

Next would be the roads that have a PASER rating of 6. These roads would benefit most from a crack seal and chip seal treatment. Again, no detailed surveying or engineering design, other than measuring the actual length of cracks, is necessary to prepare a bid package and advertise for construction.

Then, the roads with a PASER rating of 5 should receive treatments. These roads would benefit most from a non-structural overlay. Due to the fact that most of TSA has curb and gutter, it is recommended that detailed surveying and engineering design be completed to prepare construction drawings for the overlays. This will ensure that existing drainage patterns are identified and maintained and that adequate cross slopes are incorporated into the project.

Table 3-4 on the following pages shows the roads, estimated quantities and estimated costs of these maintenance treatments. It is estimated that the total project costs for all maintenance will be approximately $461,740 as they are currently measured and rated.

Table 3-4: Pavement Maintenance

Pavement Maintenance					
Crack Sealing (PASER Rating 7)					
Roadway Name	From - To	Length (feet)	Crack Sealing Cost/Foot		Cost
Beaverhead Entrance	Montana Ave to Bobcat	350	$2.00		$700
Bighorn	Bobcat to Cougar	1,950	$2.00		$3,900
Otter	Wolverine to Red Fox	1,200	$2.00		$2,400
Kodiak	Wolverine to Red Fox	1,055	$2.00		$2,110
Kodiak	Red Fox to Cougar	275	$2.00		$550
Cayuse	Wolverine to Red Fox	1,055	$2.00		$2,110
Mustang	Wolverine to Red Fox	1,180	$2.00		$2,360
Wolverine	Bighorn to Buffalo	1,790	$2.00		$3,580
Red Fox	Bighorn to Buffalo	1,660	$2.00		$3,320
Cougar	Bighorn to Buffalo	1,660	$2.00		$3,320
			Total Cost =		$24,350
Crack Sealing & Chip Sealing (PASER Rating 6)					
Roadway Name	From - To	Length (feet)	Crack Sealing Cost/Foot	Chip Sealing Cost/Foot	Cost
Mineral	Pondera to Glacier	690	$2.00	$16.00	$12,420
Beaverhead	Bobcat to Cul-De-Sac	2,030	$2.00	$16.00	$36,540
Bobcat	Beaverhead to Buffalo	1,835	$2.00	$16.00	$33,030
Pondera	S End to Beaverhead	420	$2.00	$16.00	$7,560
Pondera	Beaverhead to Big Horn	310	$2.00	$16.00	$5,580
Glacier	S End to Beaverhead	410	$2.00	$16.00	$7,380
				Total Cost =	$102,510

Pavement Maintenance

Non-Structural Overlays (PASER Rating 5)

Roadway Name	From - To	Length (feet)	Mill & Overlays Cost/Foot	Overlays Cost/Foot	Cost
Otter	Bobcat to Wolverine	460	$58		$18,860
Mustang	Bobcat to Wolverine	465	$58		$19,065
Buffalo	Montana Ave to Bobcat*	365		$49	$11,315
Buffalo	Bobcat to Wolverine*	460		$49	$14,260
Buffalo	Wolverine to Porcupine*	390		$49	$12,090
Buffalo	Porcupine to Cougar*	1,080		$49	$33,480
Appaloosa	Cayuse to Cul-De-Sac	85	$58		$3,485
Appaloosa	Cul-De-Sac	75	$58		$3,075
Red Fox	Buffalo to Cul-De-Sac*	405		$49	$12,555
Red Fox	Cul-De-Sac*	60		$49	$3,720
Cougar	Buffalo to Cul-De-Sac*	405		$49	$12,555
Cougar	Cul-De-Sac*	60		$49	$3,720
Woodchuck	Buffalo to Cul-De-Sac*	405		$49	$12,555
Woodchuck	Cul-De-Sac*	60		$49	$3,720
Snowshoe	Buffalo to Cul-De-Sac*	405		$49	$12,555
Snowshoe	Cul-De-Sac*	60		$49	$3,720
Porcupine	Buffalo to Cul-De-Sac*	405		$49	$12,555
Porcupine	Cul-De-Sac*	60		$49	$3,720
Badger	Buffalo to Cul-De-Sac*	405		$49	$12,555
Badger	Cul-De-Sac*	60		$49	$3,720
Prairie	Buffalo to Cul-De-Sac*	405		$49	$12,555
Prairie	Cul-De-Sac*	60		$49	$3,720
				Total Cost =	$334,880
				Total Cost of All Treatments =	**$461,740**

* Streets without curb and gutter

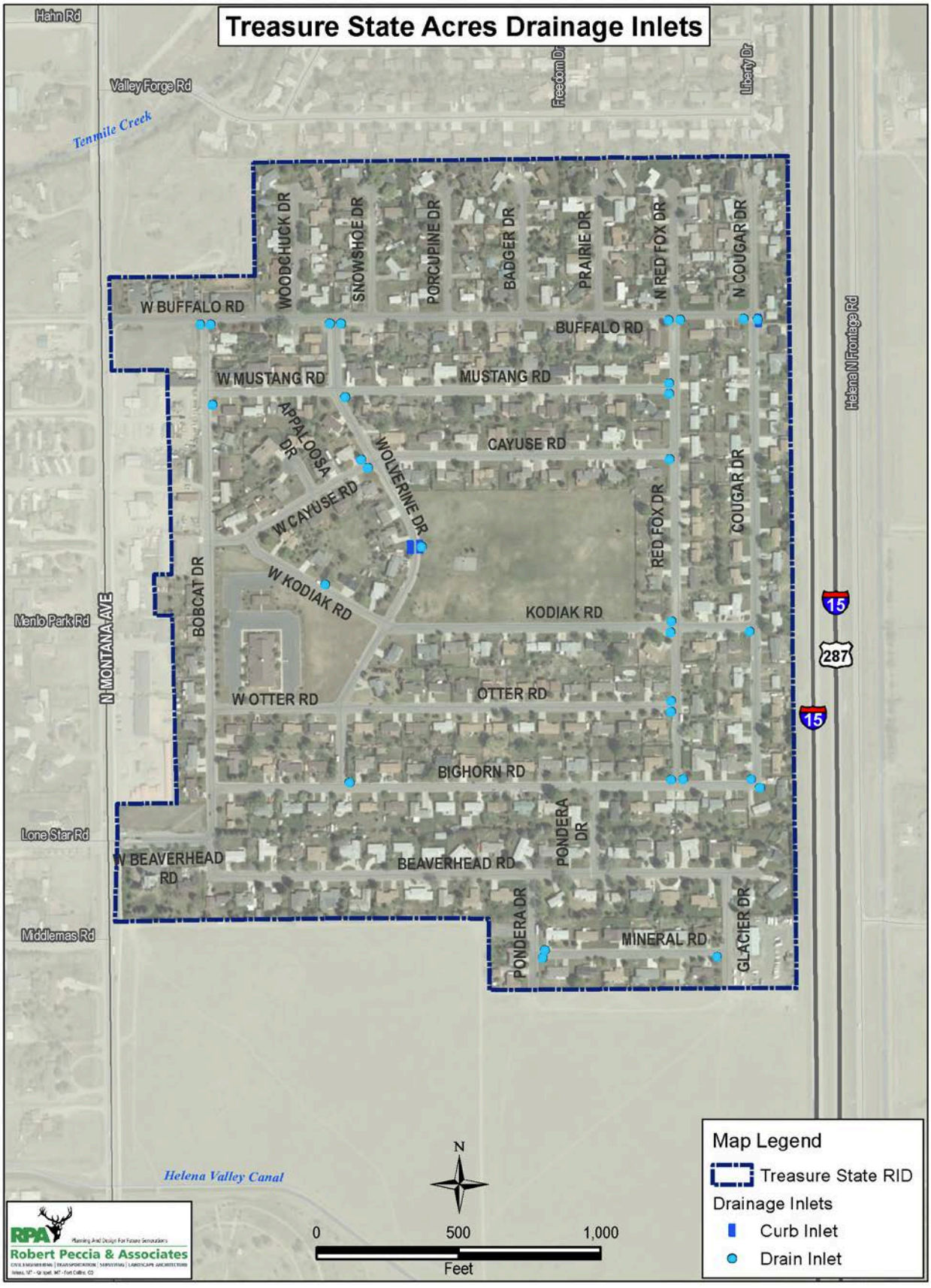
3.3 Drainage and Structural Road Improvements

Section 3.2 above discussed road maintenance and recommendations as it pertains to TSA. This Section 3.3 discusses roads rated 4 or below, that require a form of structural improvement, and the potential drainage improvements that should be considered. Drainage improvement projects could be stand alone, or completed in conjunction with roadway improvements. In most instances, adding drainage capacity to the existing TSA perforated manhole drains will require excavation through the existing road section, and therefore recommendations would be to complete improvements to the drainage system prior to undertaking a significant and costly roadway maintenance or improvement project.

Storm Drainage Improvements

The existing storm drainage system for TSA consists primarily of curb and gutter and infiltration inlets. There is no curb and gutter and minimal ditches for Buffalo Road and the roads north of Buffalo Road. **Figure 3-1** on the following page shows the location of drainage inlets.

Figure 3-1: Treasure State Acres Drainage Inlets

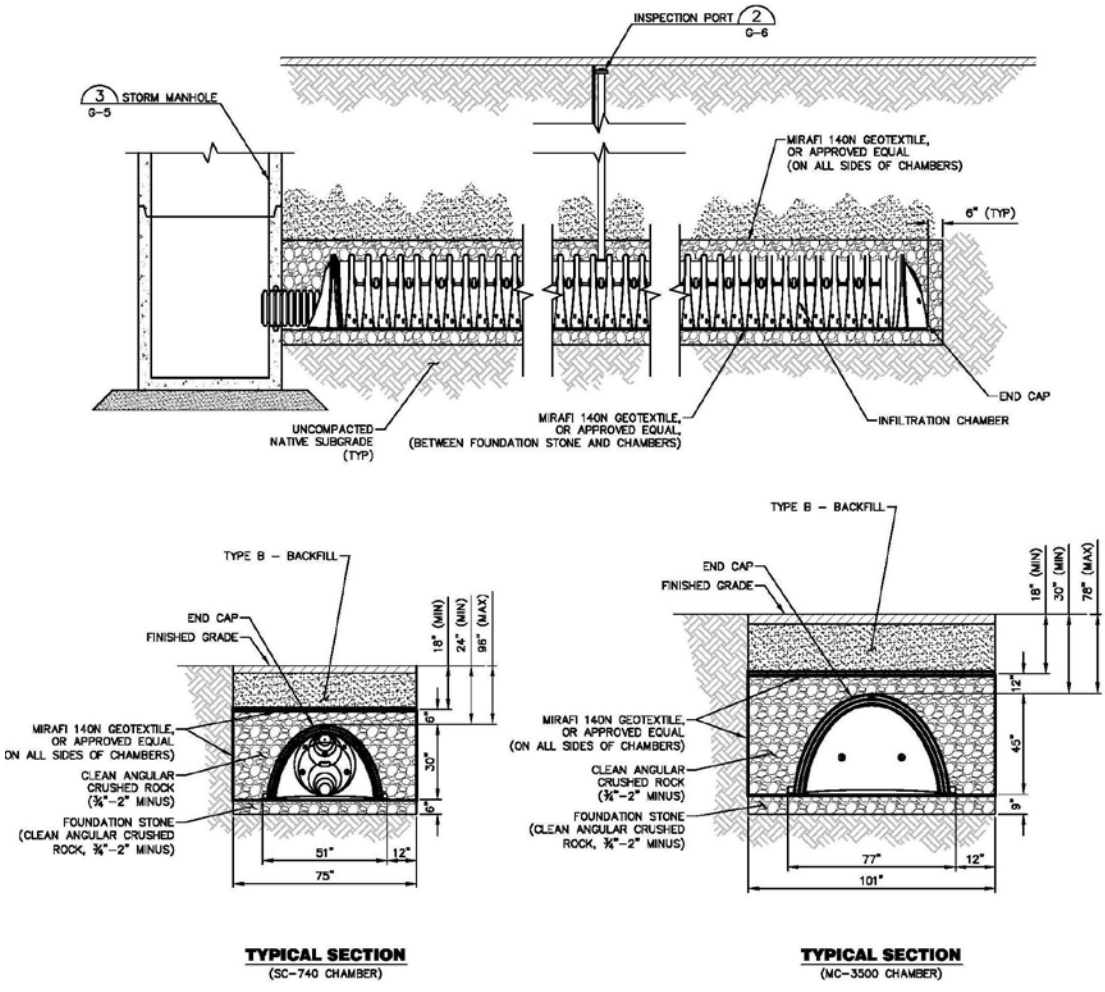


Many of the infiltration inlets pond during spring snow melt and/or significant precipitation events. This is likely caused because the inlets are undersized to handle the flows and the infiltration capacity of the inlets has diminished over time due to sedimentation and clogging.

There are many ways to improve the drainage system for TSA. More traditional, and costly improvements, would include a collection system of inlets, manholes and pipes that would collect storm runoff and convey it to a centralized infiltration facility or discharge point. These types of systems are effective, but costly due to the amount of inlets, manholes, pipes, deep excavations, and roadway reconstruction. Presently TSA does not have surface areas available for storm drainage outfall discharges.

An alternative, that is more cost effective, would be to continue using infiltration facilities but with modifications to increase capacity. This system would utilize the existing inlets and would add either infiltration pipes or infiltration chambers to the existing inlets. Below is a typical detail of an infiltration chamber.

Figure 3-2: Infiltration Chamber Typical Detail



Preliminary Storm Drainage Requirements

Infiltration chambers can be easily connected to the existing infiltration inlets to improve the infiltration rates and storage capacity. **Appendix F** includes product data on the StormTech® MC-3500 Chamber System, as a product example. This product has been specified by RPA on other recent similar projects.

Other proprietary products are available for TSA to consider. As the figure above depicts, besides increasing storm runoff capacity, the benefits of using a lateral also include the ability to elevate the chamber above the manhole inlet floor to reduce sediment build up in the chamber. The chamber becomes the primary infiltration gallery. As TSA's inlets are today, besides likely being undersized, consolidated sediment in the base of the inlet is the most limiting factor in allowing storm water to adequately discharge due to the sediment being directly in-line with the vertical infiltration. Other benefits of manufactured infiltration chambers are that they relatively light weight, constructed to be modular to vary chamber length installations as needed, and promote generally quick and efficient installations.

There are many variables associated with the design of infiltration chambers. The two most important variables are how much storm water runoff is generated for various storm events and how quickly can the runoff infiltrate into the soil. This information is usually calculated based on detailed surveying, soils investigations and testing, and engineering analysis. Without this information, we have completed a preliminary storm drainage analysis for the basis of this report, on a per lot analysis. For this preliminary analysis, we utilized only the 10 and 2-year storm events. Below is a table that illustrates the approximate lengths of chambers (storage and infiltration area) required per each lot for TSA. **Appendix F** includes preliminary calculations for this analysis.

Table 3-5: Preliminary Storm Drainage Requirements

Preliminary Storm Drainage Requirements		
Storm Event	**Estimated Storage Requirement per Lot**	**Length of Chambers per Lot**
10-Year	361 Cubic Feet	15.1 Feet
2-Year	109 Cubic Feet	4.6 Feet

It is important to mention that the values in the table above are preliminary and only calculated for the purposes of cost estimating. As mentioned, several site variables such as soil type, infiltration rates, topography, existing buried utilities, etc., may impact the placement and size of the chamber systems. Detailed surveying, soils investigations and testing and detailed engineering analysis are required prior to designing and installing a StormTech® MC-3500 Chamber System or similar.

The estimated costs for a StormTech® MC-3500 Chamber System is $230/Ft. With 4.6 feet of chamber needed per lot, for a 2-year storm event, TSA could spend approximately $1,060 per lot for storm drainage improvements. With a total of about 354 lots within the TSA RID, that would total about $375,240 for a storm drainage improvement project.

It is recommended that a detailed survey, soils investigation and testing, and engineering analysis be completed to verify storm drainage calculations. Infiltration chambers should be incorporated into any project that will improve the existing roadway with more than a non-structural overlay.

Structural Roadway Improvements

The report discussed road maintenance needs in **Section 3.2**. However asphalt surfaced roadways that have a surface condition rating of 4 or less should be planned for a structural or reconstructive improvement project. Roadways with these ratings are showing signs of significant aging and severe deterioration. These roadways would NOT benefit from maintenance treatments and need to have

either a structural improvement (PASER Rating of 3 or 4) or complete reconstruction (PASER Rating of 1 or 2) planned.

Roads with a PASER Rating of 4 should be prioritized over roads with a lesser PASER rating, per the "best first" roadway management philosophy. It is recommended that these roadways be improved with patches and repairs prior to a 3" structural overlay. Additionally, these roads should have storm drainage improvements incorporated into the design as necessary, or completed prior rehabilitating the road surfacing. Detailed surveying, soils investigations and testing, and engineering design should be completed for these roadways that require structural improvements. The following **Table 3-6** identifies the most severely deteriorated TSA roads as inventoried and rated under this report.

Table 3-6: Non-Maintenance Structural Roadway Improvements

Roadway Improvements				
Roadway Name	From – To	Length (feet)	Cost/Foot	Cost
W Kodiak	Cayuse to Wolverine	600	$79	$47,400
W Cayuse	Bobcat to Wolverine	660	$79	$52,140
Storm Drainage Improvements		~90	$230	$20,700
			Total =	$120,240

Section 4 – Summary

The purpose of this plan is to provide information to help establish an effective roadway management system that will be continuously reviewed and updated. LCC and TSA should use this plan and other reference material to assist them in managing the roads within TSA. The plan should be a living document for its 20-year term; referenced and updated based on the needs, final budgets and final TSA and LCC prioritization.

4.1 Recommendations Regarding Maintenance & Improvements

RPA recommends that the Pavement Maintenance outlined in **Section 3.2** be executed beginning calendar year 2016, or as soon as possible. This pavement maintenance responds to on-the-ground conditions for those roads that were analyzed. The pavement maintenance allows for preservation treatments on those roadways classified with PASER ratings of 5, 6 and 7.

RPA recommends that the necessary surveying, soil analysis and testing, and engineering design for the roads identified in **Table 3-6** be performed prior to their rehabilitation. Those improvements are for roadways with a PASER rating of 4 and should include storm drainage improvements as discussed.

As roadway treatments are applied, or as roadways deteriorate, the rating of these roads will change. TSA and LCC will need to re-survey the roadways and update the ratings on a periodic basis to keep a current list of road conditions as part of the living document.

RPA can provide the project's initial rating spreadsheet to the LCC Public Works Department, in MSEXCEL format (not contained in this report) that is flexible and can be modified as new data becomes available, and to supplement with the past PASER ratings completed by LCC.

4.2 Recommendations Regarding Preservation

The benefits of aggressive preservation activities versus traditional reconstruction are articulated in **Section 2.1** of this Maintenance Plan. The "worst first" management method allocates resources to the worst roads, trying to maintain roads that are in need of either improvements or complete reconstruction. The recommended method is for TSA is to adopt the "best first" roadway management philosophy, in which resources are allocated to preserve the roadways that are already in good condition in order to prevent irreparable damage to the road. This philosophy is one in which preventative measures are taken in order to protect the public's investment. Money spent developing a plan, monitoring roadway conditions, determining optimal timing and investing in pavement preservation; thus extending pavement life, will more than pay for the up-front investment. Although adopting the "best first" philosophy will allow for cost savings over the long-term, there will be reconstruction needs going forward both to mitigate past deferred maintenance and/or inadequate initial construction.

Therefore, RPA recommends that LCC and TSA strive for funding to cover the preservation costs for the next 20-years, which is anticipated to be about $128,000 per year (**Table 3-3**). Other near term needs should also be addressed for non-maintenance structural improvements as identified in one or more projects to address W Kodiak and W Cayuse as summarized in **Table 3-6**. It is understood that identified funding levels may not be fully achievable, however the "best first" method of road maintenance will significantly deter pavement aging and reduce maintenance costs for the entire TSA RID.

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Section 5 - References

1. Donald Walker, Lynn Entine, and Susan Kummer. *Pavement Surface Evaluation and Rating (PASER): Asphalt Roads Manual.* Transportation Information Center, University of Wisconsin-Madison, 2002.

2. Donald Walker, Lynn Entine, and Susan Kummer. *Pavement Surface Evaluation and Rating (PASER): Gravel Roads Manual.* Transportation Information Center, University of Wisconsin-Madison, 2002.

3. *Pavement Preservation Compendium II.* U.S. Department of Transportation, Federal Highway Administration, September 2006.

4. Gary Hicks, Stephen B. Seeds, and David G. Peshkin. *Selecting a Preventive Maintenance Treatment for Flexible Pavements.* Foundation for Pavement Preservation, June 2000.

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Appendix A

Local Road Assessment and Improvement Drainage Manual

RURAL URBAN

Local Road Assessment and Improvement

Drainage Manual

Transportation Information Center
University of Wisconsin–Madison

Contents

This manual is intended to assist local officials in understanding and rating pavement drainage. It complements PASERWARE, the computerized pavement management program developed and supported by the Wisconsin Transportation Information Center (T.I.C.).

It was produced by the T.I.C. with assistance from the Federal Highway Administration, the Wisconsin Department of Transportation, and the University of Wisconsin–Extension. The T.I.C., part of the nationwide Local Technical Assistance Program (LTAP), is a Center of the College of Engineering, Department of Engineering Professional Development, University of Wisconsin–Madison.

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Local Road Assessment and Improvement

Drainage Manual

Donald Walker, T.I.C. Director, *author*
Lynn Entine, Entine & Associates, *editor*
Susan Kummer, Artifax, *design*

Transportation Information Center
University of Wisconsin–Madison

Local Road Assessment and Improvement

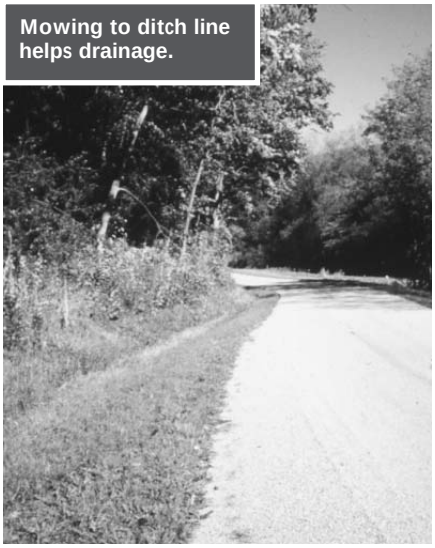
Drainage Manual

This manual is designed to help local officials evaluate drainage conditions along rural and urban roadways. It is part of the PASERWARE pavement management system. This manual can also be used to plan for road maintenance and improvements.

The manual includes background information on the importance of drainage and the impacts of poor drainage on roadway performance. It covers both rural roads with ditches and culverts and urban sections with curb and gutter and storm sewer. Drainage elements are explained and accompanied by representative photographs to aid field inspection.

Evaluation tools are a necessary part of pavement management systems. They aid in developing cost estimates and setting strategies for maintenance and improvement. This manual has a rating and evaluation section which you can use with PASERWARE, with another pavement management system, or simply as an inspection tool for your maintenance and improvement programs.

Most local officials can use visual inspection and common sense to evaluate and develop an effective roadway maintenance and improvement program. However, we strongly recommend using professional advice in redesigning and making major improvements in culvert sizes and in assessing the causes and solutions for flooding conditions. The cost and potential severity of problems caused by flooding and improper drainage design and construction make professional assistance a wise investment.



Mowing to ditch line helps drainage.

The state has regulations on erosion control and on constructing and maintaining local roads near wetlands and navigable streams. When you are planning work near navigable streams and wetlands and on larger projects that will uncover more than five acres of soil, you should contact the Department of Natural Resources (DNR) transportation liaison for your county. They welcome questions about the regulations and will help you meet state requirements. Sediment run-off and other non-point source pollution regulations are evolving. It is wise to keep abreast of these changes.

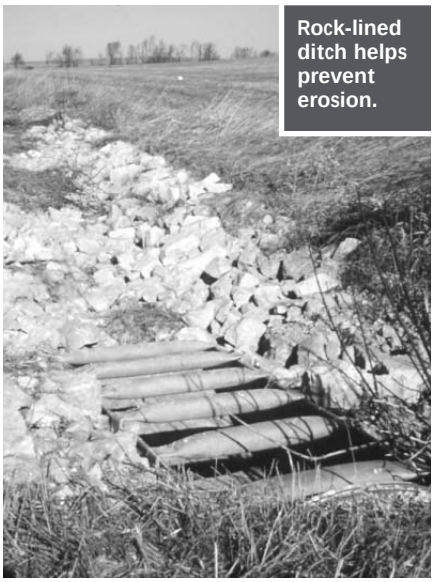
Good round-bottom ditch. Seed for erosion control.

Maintaining proper drainage

Even on roads built with all the proper drainage elements, neglecting maintenance is likely to result in flooding, washouts, and potholes. To keep a road in good condition, maintenance to the road surface and shoulder should retain and restore the original design as much as possible. On gravel roads, this involves smoothing and reshaping with a motor grader. Surfaced roads may need periodic patching or overlays.

Other conditions requiring maintenance to improve drainage include:

- Ditches clogged with debris or sediment need cleaning to avoid overflowing and washouts. Excavated sediments which are of the same quality as the aggregate mix on the road can be put back onto a gravel road and bladed into the surface. Well designed and built ditches have gentle side slopes which a grader can travel to clean the ditch bottom. Cleaning ditches with steep slopes requires a backhoe which is more expensive and time consuming to use than a grader.
- Vegetation and brush that obstruct water flow need to be mowed or cut. However, when removing sediment from ditches be careful to disturb vegetation as little as possible to limit erosion. It may be necessary to re-seed, mulch, or use other erosion protection methods on steep slopes or in areas sensitive to severe erosion. Sediments from eroding slopes can fill downstream road ditches and culverts or pollute streams and lakes.
- Culverts need to be kept free of sediment so water flows freely and doesn't wash out roads and flood adjacent property. Inspect periodically for sediment buildup and for cracks or corrosion that might lead to culvert failure. Clear clogged culverts with hand shovels or mechanized equipment. However, the best maintenance technique is to prevent sediment buildup in ditches so there is no material to run into and clog culverts.
- In urban areas, ponding behind curbs that saturates the street base needs to be corrected. Regrade soil in the terrace behind the curb to protect the street structure from localized ponding due to lawn watering or runoff. For more severe or persistent conditions, install underdrain behind the curbing. Repair or replace sunken inlets which collect standing water.



Rock-lined ditch helps prevent erosion.

Good urban drainage system.

The text and photos that follow describe each drainage component and depict inadequate drainage conditions that can lead to road damage. This manual should serve as a guide to help you locate, assess, rate, and improve drainage conditions on your roads.

Assessing drainage systems

A drainage system includes the pavement and the water handling system. They must be properly designed, built, and maintained. The water handling system includes: shoulders, ditches and culverts; curb, gutter and storm sewer. When a road fails, whether it's concrete, asphalt or gravel, inadequate drainage often is a major factor.

Shoulders and embankments damaged by heavy rain or floods can allow water to stand on the road or seep back into the base, saturating it. Surface cracks allow water to penetrate and weaken the base. Poor design can direct water back onto the road or keep it from draining away. Too much water remaining in the surface, base, and subgrade combine with traffic action to cause potholes, cracks and pavement failure.

The basics of drainage are similar in both rural and urban settings. Some issues specific to certain drainage elements are discussed separately.

Crown

The road surface should be crowned so water will run off to the shoulders. As a general rule, the center of the road on paved surfaces should be 2½ inches higher than the shoulder, 5 to 6 inches higher for gravel surfaces. Shoulders should slope as much or more than the road to keep water moving to the ditches. For example, a paved roadway with an 11 foot lane and 4 foot shoulder should have a total crown (from centerline to outside edge of shoulder) of not less than 4 inches.

Gravel roads need special attention because they are more susceptible to rain damage. They will need higher crowns than paved surfaces to prevent the surface from absorbing too much water, becoming saturated, and not drying out. Traffic action on a saturated surface causes potholes and ruts.

Poor crown allows pavement saturation.

A good quality gravel surface absorbs minimal amounts of water, sheds the rest, and dries out quickly. Poor drainage may be caused by gravel with a poor gradation of stones, sand and fines. You can partially compensate for poor quality gravel with a higher road crown.

Steep roads may also require higher crowns since the water will tend to flow down the road flooding traffic lanes, rather than across the crown.

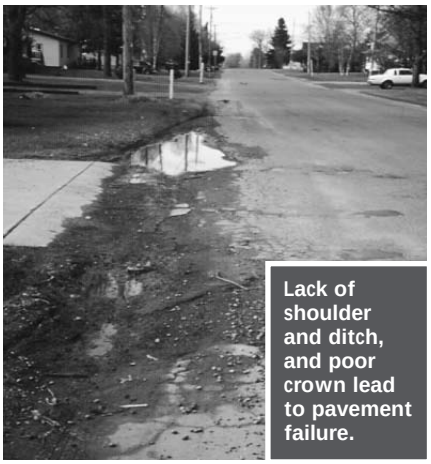
Shoulders

Shoulders extend the road surface, directing water flow to the ditches if they slope as much or more than the crown. If they slope less, water will build up during heavy rain at the join between shoulder and road, flooding traffic lanes. Make sure the shoulder continues the road crown smoothly.

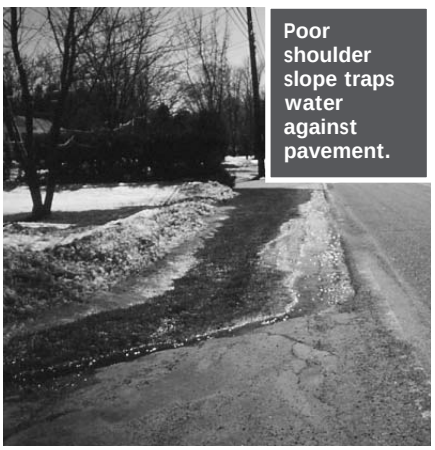
Springs or seepage areas will require special treatment. You can use french drains (rock filled trenches) or perforated pipes to drain this subsurface water into ditches or streams.

One common method for constructing gravel roads, the trench technique, causes poor drainage. It involves making a shallow excavation of just the intended road surface, then filling it with sub-base and base material. The shoulders are not fully excavated and the original soil is covered with a thin layer of gravel.

The problem with this method is that usually water can't penetrate beneath and through the shoulder's subsurface material. These impermeable shoulders keep water from draining out of the roadway's base. It is trapped and weakens the roadway.



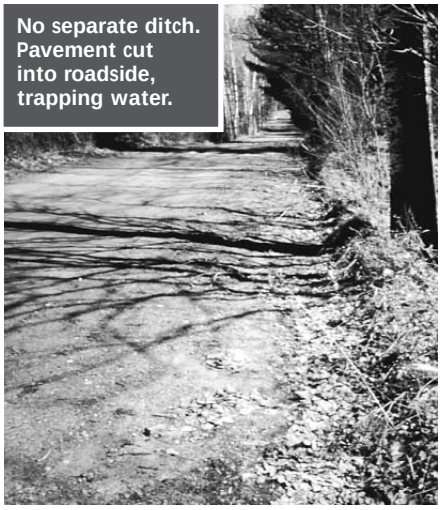
Lack of shoulder and ditch, and poor crown lead to pavement failure.



Poor shoulder slope traps water against pavement.

For proper drainage and longer roadway life, excavate the shoulders to the same depth as the roadway and use the same sub-base and base material. Use a gravel or crushed rock that drains well to remove any water which soaks through the surface or enters the subsurface.

High shoulder creates a secondary ditch and damages pavement.



No separate ditch. Pavement cut into roadside, trapping water.

Ditches

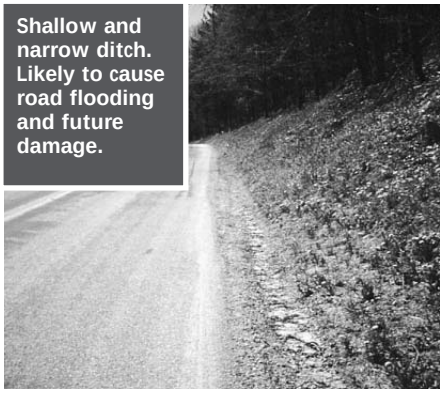
Ditches carry water away from the roadway and into streams or other natural waterways. To do this, ditches must be properly shaped for safety, maintenance, waterflow, and erosion control. The ditch should be at least one foot below the bottom of the gravel base in order to drain the pavement. Deeper ditches may be necessary to provide positive drainage patterns.

Use a smooth transition to the ditch. Sides that are too steep may cause errant vehicles to roll over. Side slopes of 4:1 are desirable while the maximum slope should be 2½:1. A gentle slope makes mowing and ditch cleaning easier, faster and cheaper, but, of course, they require a wider right of way.

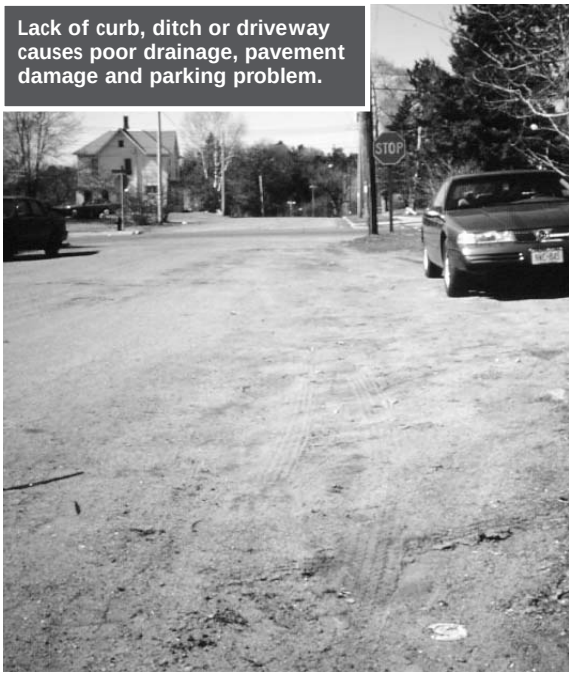
It's very important that water flow along ditches and not stand in them. Standing water may saturate the subsurface material beneath the roadway, preventing the road from draining during the next storm. Standing water also reduces the ditch's capacity to handle runoff. As a result, the next storm could wash out the roadway.

Ditches with 1% gradient are desirable (½% minimum) to insure proper flow. The flow of water in ditches should not erode the ditch itself or weaken the adjoining shoulder. Vegetation in ditches is necessary to help keep the soil in place and minimize erosion. Use rubble, riprap, or fabric to slow water flow on steep slopes, or pave them to prevent serious erosion. You may also consider installing a short section of storm sewer.

Poor ditch slope traps water.



Shallow and narrow ditch. Likely to cause road flooding and future damage.



Lack of curb, ditch or driveway causes poor drainage, pavement damage and parking problem.

No ditch or shoulder drainage can cause severe pavement damage.

Roadway culverts

Culverts channel water under the roadway from one side to the other. They help control water flow and slow it down to control erosion. In designing culverts consider loads and cover, durability and capacity, placement, and slope.

A culvert must be strong enough to support the fill material above it and the traffic that moves over it. Concrete culvert strength depends on its wall thickness and the amount of steel reinforcement it has. Steel culvert strength depends on the depth of corrugations, gauge of steel used, and, to a great extent, on the quality and compaction of backfill material on the sides and haunches of the pipe.

Culverts should be covered with at least 12 inches of soil from the top of the pipe to the top of the subgrade. Arched and elliptical pipes or shallow box culverts can be helpful where cover depth over the culvert is limited.

A culvert must be durable and have sufficient hydraulic capacity to carry away a predetermined quantity of water in a given time. Design charts are available for each type of culvert. A complete design involves reviewing the topography, predicting runoff, sizing the waterway and culvert, and comparing culvert cost to the risk of flood damage. For roadway cross culverts, the minimum recommended size is 18 inches. A professional designer with local experience can save you construction costs and damage claims.

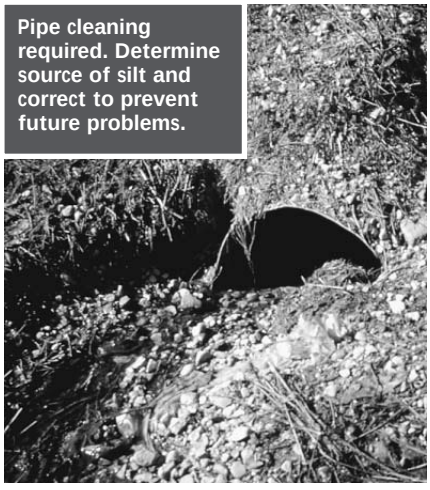
Altering the entrance configuration can significantly improve culvert capacity. Beveling the edge of the inlet or using side-tapers helps considerably.

Culverts should slope enough so water will flow at about 2½ feet per second. A minimum drop of 6 inches across the road is desirable. This will keep sediment from accumulating in the pipe but will not cause extensive erosion at the discharge end. Metal aprons or concrete headwalls improve the capacity, reduce erosion, and can shorten culvert length. For safety, headwalls should not project above the level of the roadway surface.

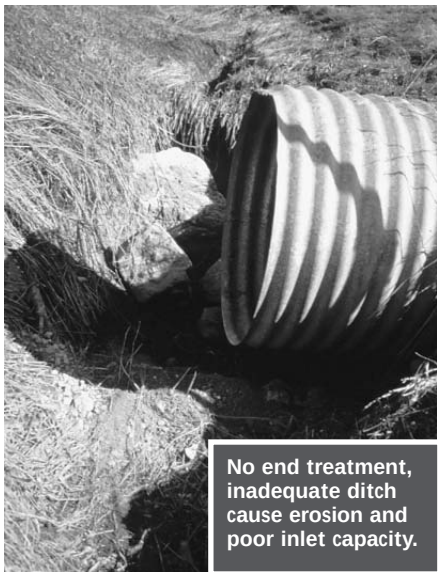
Culvert lacks proper cover. No end treatment. Ditch cleaning needed.

Place culverts so they match existing contours, or in the existing channel, if possible. Be extremely careful about changing culvert locations, capacities or drainage patterns. Section 88.87 of the Wisconsin Statutes requires that highways not impede the general flow of surface water. Drainage Districts must be notified if any changes or major maintenance work are being planned *(Wis. Stat. 86.075).* Before replacing culverts located in established flood plains you must also secure prior approval from the DNR.

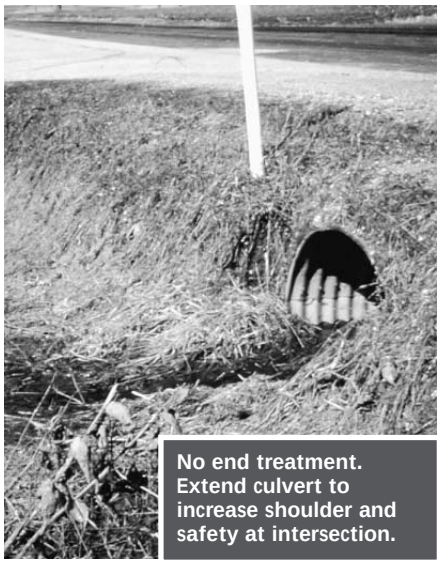
The state has regulations on erosion control and on constructing and maintaining local roads near wetlands and navigable streams. When you are planning work near navigable streams and wetlands and larger projects that will uncover more than five acres of soil, contact the county transportation liaison from the Wisconsin DNR.



Pipe cleaning required. Determine source of silt and correct to prevent future problems.



No end treatment, inadequate ditch cause erosion and poor inlet capacity.



No end treatment. Extend culvert to increase shoulder and safety at intersection.

Pipe too long. Discharge near top of side slope will cause erosion.

Driveway culverts

Driveways can block drainage and cause flooding. Culverts should be required to maintain normal ditch drainage. A minimum 15-inch diameter is recommended.

Driveways should be built so that they either slope away from the road or are graded with the low point over the culvert. This prevents water from washing onto the road from driveways.

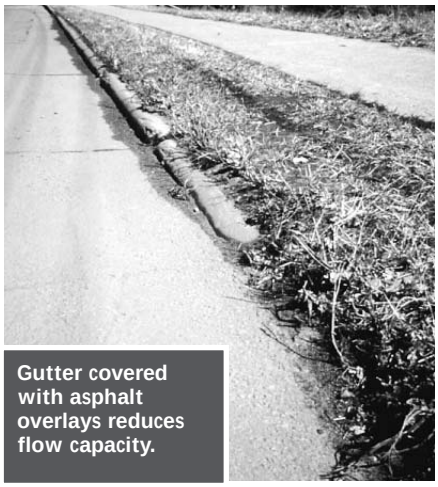
Drainage from improperly constructed driveway can cause road damage.

Cleaning and replacing driveway culverts is an ongoing priority.

Curb and gutter

Good drainage and maintenance practices are similar in both rural and urban areas. However, using curb and gutter and storm sewer raises additional considerations.

Curb and gutter may be preferable to an open ditch in areas with limited right-of-way or where open ditches are unacceptable. Short sections of curb and gutter may be used at spot locations without requiring storm sewer.

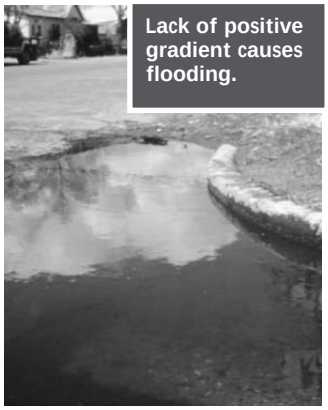


Gutter covered with asphalt overlays reduces flow capacity.

Curb settlement causes ponding and pavement damage.

Broken and failed curb.

Silt from adjacent property causes flooding.



Lack of positive gradient causes flooding.

Remove silt and debris to improve drainage.

Pavement settlement causes ponding.

Storm sewers and inlets

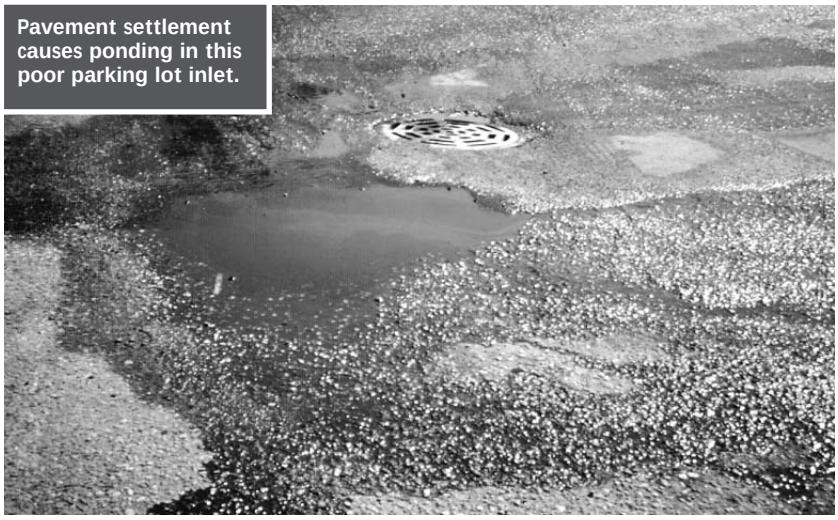
Storm sewer systems collect water from the street and adjoining property and deliver it to open surface waterways—streams, rivers, lakes. Short sections of storm sewer may be useful in rural areas with steep slopes where runoff is eroding open ditches, causing a problem. Storm sewer is also helpful at intersections and other locations.

It is important to maintain curb, gutter, inlets, and storm sewer systems. They should be inspected every five years. Inspecting storm sewer either visually or through TV remote systems is obviously more difficult and expensive than inspecting surface facilities. Consider scheduling this on a regular basis or in areas with visible surface problems. Catch basins, and manholes must be cleaned once or twice a year as part of maintaining an urban storm water system.

Storm water pollution is receiving increased attention nationally and in Wisconsin. Surface water collects a wide range of pollutants as it travels over a roadway surface, across lawns, and into ditches and storm sewer systems. Unfortunately, many of these pollutants are carried directly into waterways and ground water. Since control and monitoring of storm water quality is becoming more complex, local agencies must review their practices and be aware of controls, regulations, and effective pollution abatement practices.

In general it has been found that open drainage systems with vegetated ditches are helpful in reducing the pollutants in runoff from roadways. This suggests that open ditch sections, where possible, are preferable to storm sewers for pollution abatement. A more detailed discussion of this topic is beyond the scope of this publication.

Routine cleaning improves drainage.



Pavement settlement causes ponding in this poor parking lot inlet.

Clogged inlet causes flooding.

Rating and evaluating roadway drainage

Periodic inspection, rating and evaluation of roadway drainage is required as a part of pavement management. It is considered good practice even without a formal pavement management program. A regular inspection program allows managers to identify and schedule necessary improvements on a timely and cost-effective basis.

Routine maintenance can often avert more serious drainage-related problems. While casual observation is frequently used, a scheduled and organized evaluation system produces more consistent results.

These more formal evaluations also promote good recordkeeping which is very helpful in planning projects and reducing time and information loss due to staff turnover.

The basic rating system used in this manual is based on common sense and is intended to be easy to use. It describes four rating categories: excellent, good, fair, and poor. The ratings are described by the general condition, typical defects, and the recommended improvements.

Each category is illustrated by a series of photographs. It is unlikely that all defects will be present. There may be only one or two in a specific section of road. The extent of work required should help determine if the rating is poor, fair, or good. Annual costs associated with the necessary maintenance and improvements for each rating can be developed and used with a pavement management system for programming both short-range and long-range improvements.

Rating	*Condition*	*Improvement*
Excellent	Wide adequate ditches or like-new curb, gutter and storm sewer system. All culverts clean and sound.	No improvement necessary.
Good	Overall, pavement and shoulder have adequate crown, ditching or storm sewer on the majority of the section. May need localized cleaning of ditches, storm sewers and culverts; minor repairs to curbs, inlets and culverts. No drainage-related pavement damage.	Minor or localized repairs.
Fair	Minimal crown on pavement. Some areas need shoulder slope improvement. Ditching improvement or cleaning needed on up to 50% of ditches. Pavement distress from localized flooding or ponding indicates improvements are needed in some storm sewer, inlets or ditching. Some culverts need cleaning or minor repairs.	Several improvements necessary.
Poor	No pavement crown. Shoulders create secondary ditch. Frequent ponding. Significant ditching improvements needed on more than 50% of roadway. Frequent localized flooding or erosion with pavement distress or failure. Significant improvement in storm sewer, curb or inlets and/or major culvert replacement or improvement needed.	Major improvement in drainage required.

☑ Excellent

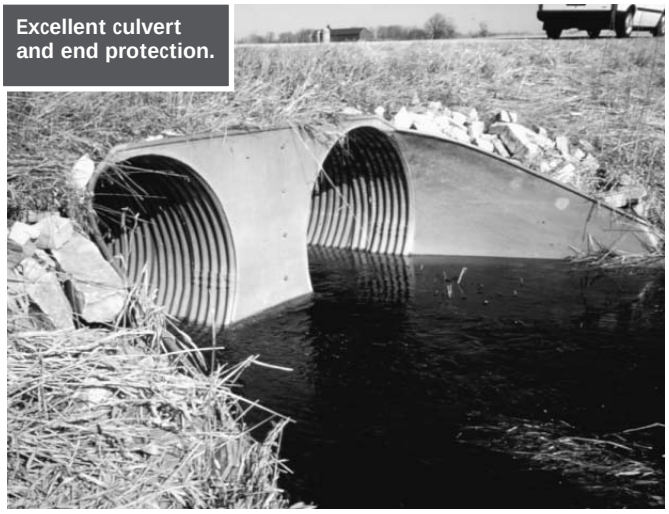
Wide adequate ditches or like-new curb, gutter and storm sewer system. All culverts clean and sound.

No improvement necessary.

Excellent urban drainage.

Excellent rural drainage.

Excellent culvert.



Excellent culvert and end protection.

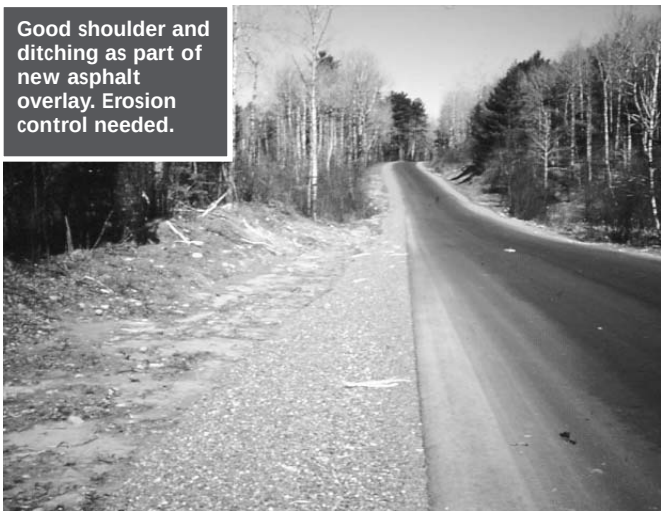
✔ Good

Overall, pavement and shoulder have adequate crown, ditching or storm sewer on the majority of the section. May need localized cleaning of ditches, storm sewers and culverts; minor repairs to curbs, inlets.

Minor or localized repairs. No pavement damage related to poor drainage.

Good urban drainage. Local curb failure needs replacement.

Good shoulder and ditching as part of new asphalt overlay. Erosion control needed.



Adequate ditch and good erosion control.

Good rural ditch and driveway culvert. Culvert end needs cleaning.

Good culvert with apron end walls.

☑ Fair

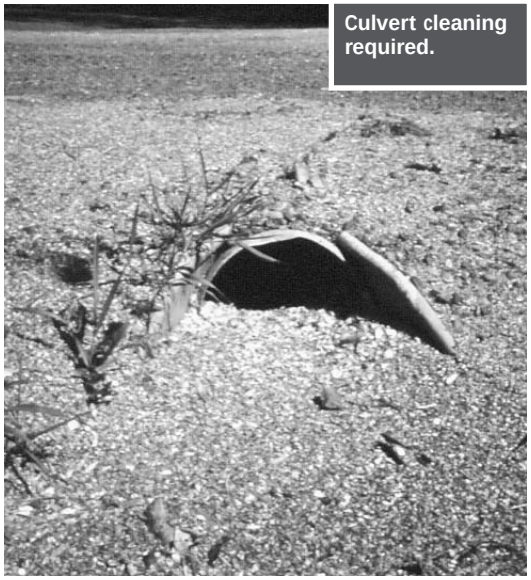
Minimal crown on pavement. Some areas need shoulder slope improvement. Ditching improvement or cleaning needed on up to 50% of ditches. Pavement distress from localized flooding or ponding indicates improvements are needed in some storm sewer, inlets or ditching. Some culverts need cleaning or minor repairs.

Several improvements necessary.

Localized ponding and deteriorating curb and gutter.

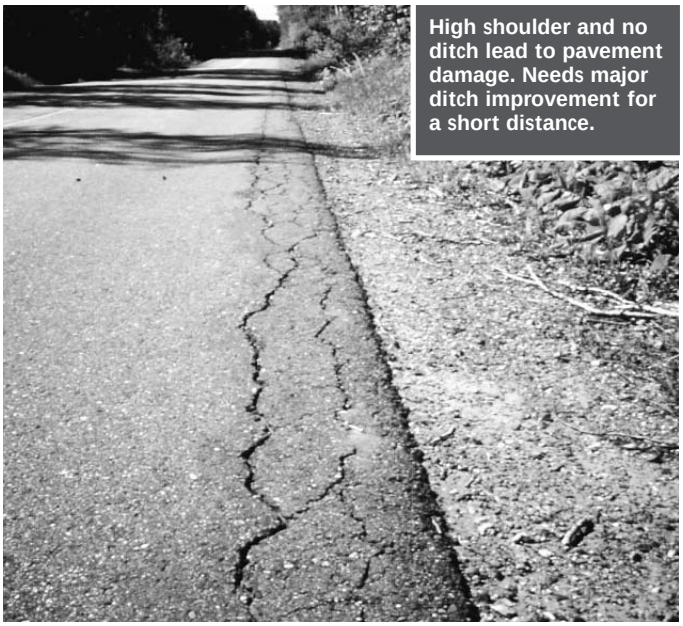
Clean drain and sewer to prevent localized flooding.

Needs localized curb repair.



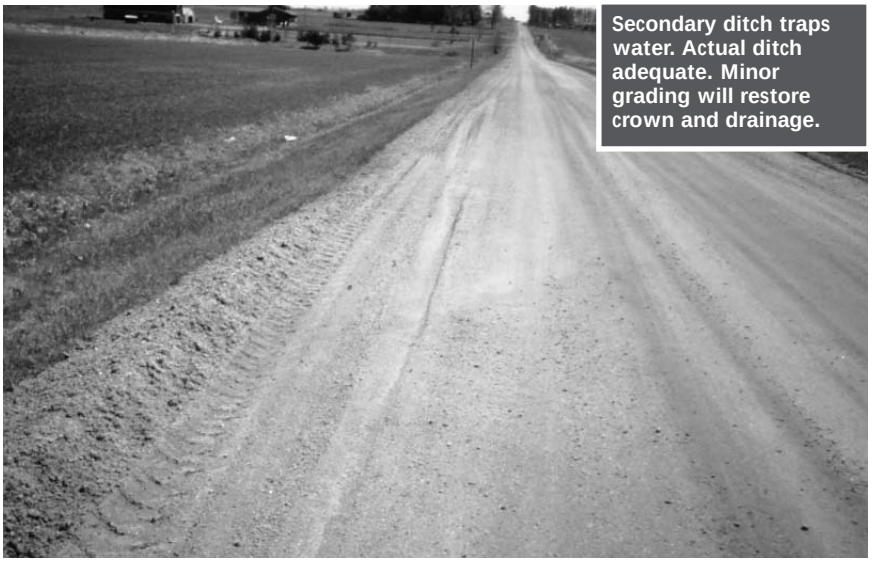
Culvert cleaning required.

Reshape terrace behind curb to restore drainage and prevent damage to curb and street.



High shoulder and no ditch lead to pavement damage. Needs major ditch improvement for a short distance.

Shallow ditch will not adequately drain pavement. Needs ditch cleaning.



Secondary ditch traps water. Actual ditch adequate. Minor grading will restore crown and drainage.

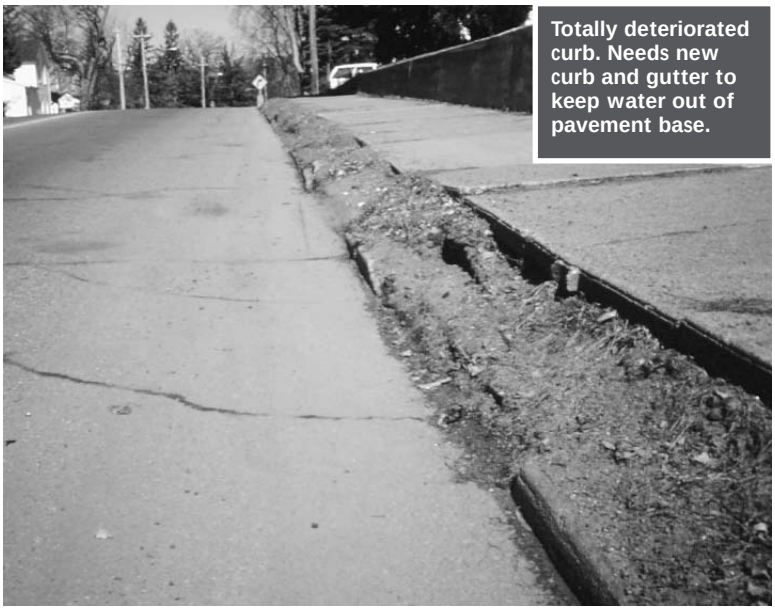
High water table and localized flooding cause premature pavement failure for a short distance.

Good culvert but ditch needs cleaning.

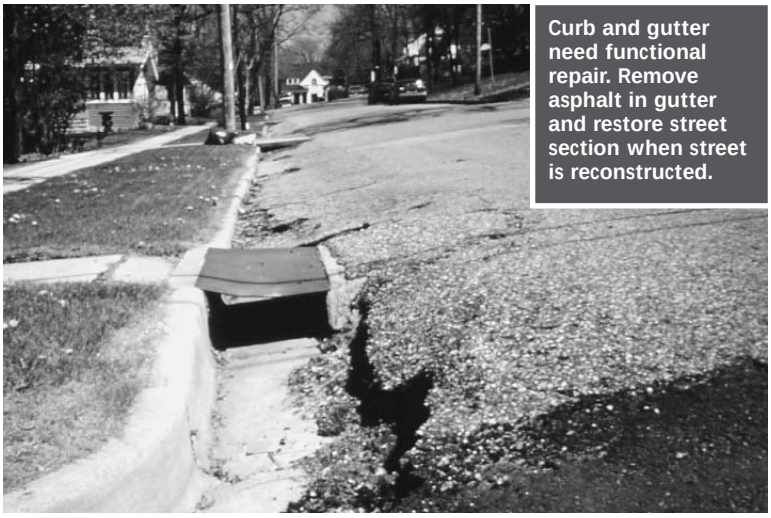
✔ Poor

No pavement crown. Shoulders create secondary ditch. Frequent ponding. Significant ditching improvements needed on more than 50% of roadway. Frequent localized flooding or erosion with pavement distress or failure. Significant improvement in storm sewer, curb or inlets, and/or major culvert replacement or improvement needed.

Major improvement in drainage required.



Totally deteriorated curb. Needs new curb and gutter to keep water out of pavement base.

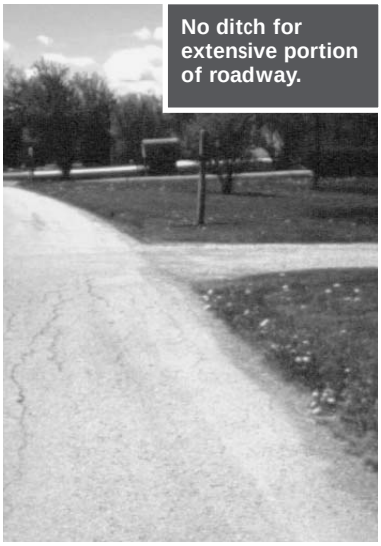


Curb and gutter need functional repair. Remove asphalt in gutter and restore street section when street is reconstructed.

Flooding. Curb and gutter need reconstruction.

Poor curb and gutter with damaged pavement. Need complete replacement.

No drainage leads to failed pavement.

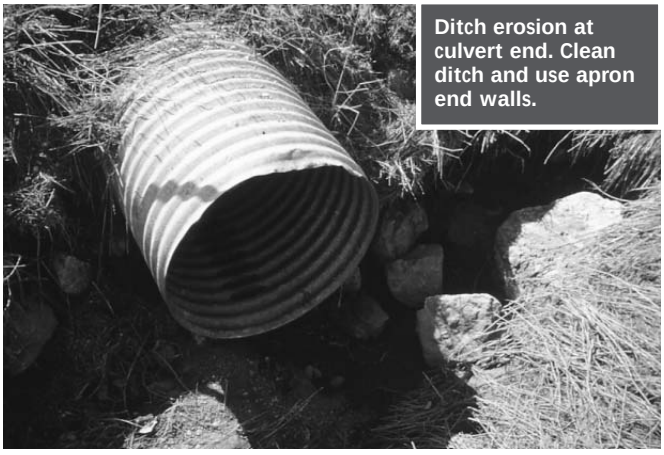


No ditch for extensive portion of roadway.

Inadequate drive-way culvert. Will cause local flooding.

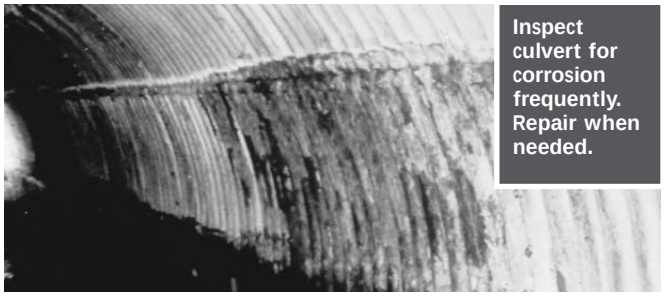
High water has damaged pavement.

No crown or ditching. Reconstruction required.



Ditch erosion at culvert end. Clean ditch and use apron end walls.

Severe roadside erosion causes silting downstream.



Inspect culvert for corrosion frequently. Repair when needed.

Summary

The value of proper drainage design and maintenance on roads cannot be over-emphasized. The drainage system includes the roadway; the shoulders, ditches, and culverts; and the curbs, gutters and storm sewer systems. These elements work together as a system to prevent water from infiltrating the road surface, remove it from the driving lanes to the side ditches or gutter, and carry it away from the roadway. Even roads with all the proper drainage design elements will flood, wash out, and develop cracks and potholes if maintenance is neglected.

- Build and maintain a roadway crown to drain water from the surface: ¼ inch per foot of width for paved roads, ½ inch per foot of width for gravel roads, more under certain conditions.
- Avoid the trench technique of construction. Extend the roadway base to the outer shoulder edge.
- Use ditches with gentle side slopes for vehicle safety, to minimize erosion, and to aid maintenance.
- Design culverts to handle soil and traffic loads with appropriate drainage capacity. Good design saves money. Professional help is recommended.
- Maintain the pavement and culverts to perform as originally intended.
- Keep ditches clean for efficient water flow.
- Inspect culverts regularly. Inspection after a heavy rain will give the most information on your drainage problems.
- Maintain natural surface water flow conditions and coordinate improvements with local drainage boards and with the DNR transportation liaison.
- Avoid placing asphalt overlays on concrete gutter. Mill so overlay matches gutter level.
- Inspect and clean storm sewer inlets and sewers.

Regular annual evaluation of drainage systems is an important part of maintaining and managing our roadways. Using the simple evaluation system outlined here will help local officials in their pavement management responsibilities. This can be incorporated into a formalized pavement management system such as PASERWARE or done manually to have a simple ongoing record of drainage maintenance needs. Before investing in pavement surface improvements, make drainage improvements. It is most economical and effective to plan and upgrade drainage as part of road surface improvements.

Transportation Information Center Publications

Asphalt PASER Manual
Pavement Surface Evaluation and Rating, 1987, 39 pp.

Gravel PASER Manual
Pavement Surface Evaluation and Rating, 1989, 32 pp.

Concrete PASER Manual
Pavement Surface Evaluation and Rating, 1989, 48 pp.

Sealcoat PASER Manual
Pavement Surface Evaluation and Rating, 2000, 16 pp.

Drainage Manual
Local Road Assessment and Improvement, 2000, 16 pp.

SAFER Manual
Safety Evaluation for Roadways, 1996, 40 pp.

Wisconsin Transportation Bulletins

#1 Understanding and Using Asphalt
#2 How Vehicle Loads Affect Pavement Performance
#3 LCC—Life Cycle Cost Analysis
#4 Road Drainage
#5 Gravel Roads
#6 Using Salt and Sand for Winter Road Maintenance
#7 Signing for Local Roads
#8 Using Weight Limits to Protect Local Roads
#9 Pavement Markings
#10 Seal Coating and Other Asphalt Surfaces
#11 Compaction Improves Pavement Performance
#12 Roadway Safety and Guardrail
#13 Dust Control on Unpaved Roadways
#14 Mailbox Safety
#15 Culverts-Proper Use and Installation
#16 Geotextiles in Road Construction/Maintenance and Erosion Control
#17 Managing Utility Cuts
#18 Roadway Management and Tort Liability in Wisconsin
#19 The Basics of a Good Road
#20 Using Recovered Materials in Highway Construction
#21 Setting Speed Limits

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Appendix B

PASER Manual for Asphalt Roads

Pavement Surface Evaluation and Rating

PASER Manual

Asphalt Roads

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Contents

This manual is intended to assist local officials in understanding and rating the surface condition of asphalt pavement. It describes types of defects and provides a simple system to visually rate pavement condition. The rating procedure can be used as condition data for the Wisconsin DOT local road inventory and as part of a computerized pavement management system like PASERWARE.

The PASER system described here and in other T.I.C. publications is based in part on a roadway management system originally developed by Phil Scherer, transportation planner, Northwest Wisconsin Regional Planning Commission.

Produced by the T.I.C. with support from the Federal Highway Administration, the Wisconsin Department of Transportation, and the University of Wisconsin-Extension. The T.I.C., part of the nationwide Local Technical Assistance Program (LTAP), is a Center of the College of Engineering, Department of Engineering Professional Development, University of Wisconsin–Madison.

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Pavement Surface Evaluation and Rating

PASER Manual

Asphalt Roads

Donald Walker, former T.I.C. Director, *author*
Lynn Entine, Entine & Associates, *editor*
Susan Kummer, Artifax, *designer*

Transportation Information Center
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Pavement Surface Evaluation and Rating

Asphalt PASER Manual

A local highway agency's major goal is to use public funds to provide a comfortable, safe and economical road surface—no simple task. It requires balancing priorities and making difficult decisions in order to manage pavements. Local rural and small city pavements are often managed informally, based on the staff's judgment and experience. While this process is both important and functional, using a slightly more formalized technique can make it easier to manage pavements effectively.

Experience has shown that there are three especially useful steps in managing local roads:

1. Inventory all local roads and streets.
2. Periodically evaluate the condition of all pavements.
3. Use the condition evaluations to set priorities for projects and select alternative treatments.

A comprehensive pavement management system involves collecting data and assessing several road characteristics: roughness (ride), surface distress (condition), surface skid characteristics, and structure (pavement strength and deflection). Planners can combine this condition data with economic analysis to develop short-range and long-range plans for a variety of budget levels. However, many local agencies lack the resources for such a full-scale system.

Since surface condition is the most vital element in any pavement management system, local agencies can use the simplified rating system presented in this ***Asphalt PASER Manual*** to evaluate their roads. The PASER ratings combined with other inventory data (width, length, shoulder, pavement type, etc.) from the WisDOT local roads inventory (WISLR) can be very helpful in planning future budgets and priorities.

WISLR inventory information and PASER ratings can be used in a computerized pavement management system, PASERWARE, developed by the T.I.C and WisDOT. Local officials can use PASERWARE to evaluate whether their annual road budgets are adequate to maintain or improve current road conditions and to select the most cost-effective strategies and priorities for annual projects.

PASER Manuals for gravel, concrete, and other road surfaces, with compatible rating systems are also available (page 29). Together they make a comprehensive condition rating method for all road types. PASER ratings are accepted for WISLR condition data.

Asphalt pavement distress

PASER uses visual inspection to evaluate pavement surface conditions. The key to a useful evaluation is identifying different types of pavement distress and linking them to a cause. Understanding the cause for current conditions is extremely important in selecting an appropriate maintenance or rehabilitation technique.

There are four major categories of common asphalt pavement surface distress:

Surface defects
Raveling, flushing, polishing.

Surface deformation
Rutting, distortion—rippling and shoving, settling, frost heave.

Cracks
Transverse, reflection, slippage, longitudinal, block, and alligator cracks.

Patches and potholes

Deterioration has two general causes: environmental due to weathering and aging, and structural caused by repeated traffic loadings.

Obviously, most pavement deterioration results from both environmental and structural causes. However, it is important to try to distinguish between the two in order to select the most effective rehabilitation techniques.

The rate at which pavement deteriorates depends on its environment, traffic loading conditions, original construction quality, and interim maintenance procedures. Poor quality materials or poor construction procedures can significantly reduce the life of a pavement. As a result, two pavements constructed at the same time may have significantly different lives, or certain portions of a pavement may deteriorate more rapidly than others. On the other hand, timely and effective maintenance can extend a pavement's life. Crack sealing and seal coating can reduce the effect of moisture in aging of asphalt pavement.

With all of these variables, it is easy to see why pavements deteriorate at various rates and why we find them in various stages of disrepair. Recognizing defects and understanding their causes helps us rate pavement condition and select cost-effective repairs. The pavement defects shown on the following pages provide a background for this process.

Periodic inspection is necessary to provide current and useful evaluation data. It is recommended that PASER ratings be updated every two years, and an annual update is even better.

SURFACE DEFECTS

Raveling

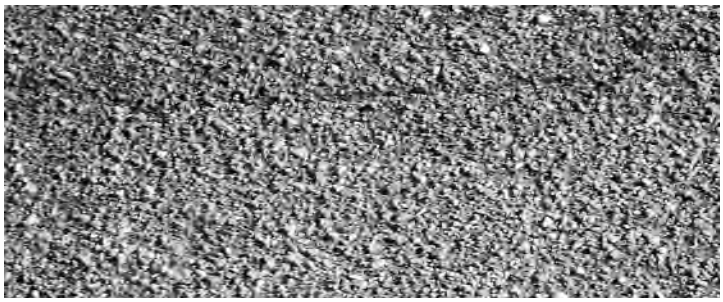
Raveling is progressive loss of pavement material from the surface downward, caused by: stripping of the bituminous film from the aggregate, asphalt hardening due to aging, poor compaction especially in cold weather construction, or insufficient asphalt content. Slight to moderate raveling has loss of fines. Severe raveling has loss of coarse aggregate. Raveling in the wheelpaths can be accelerated by traffic. Protect pavement surfaces from the environ - ment with a sealcoat or a thin overlay if additional strength is required.

Flushing

Flushing is excess asphalt on the surface caused by a poor initial asphalt mix design or by paving or sealcoating over a flushed surface. Repair by blotting with sand or by overlaying with properly designed asphalt mix.

Polishing

Polishing is a smooth slippery surface caused by traffic wearing off sharp edges of aggregates. Repair with sealcoat or thin bituminous overlay using skid-resistant aggregate.



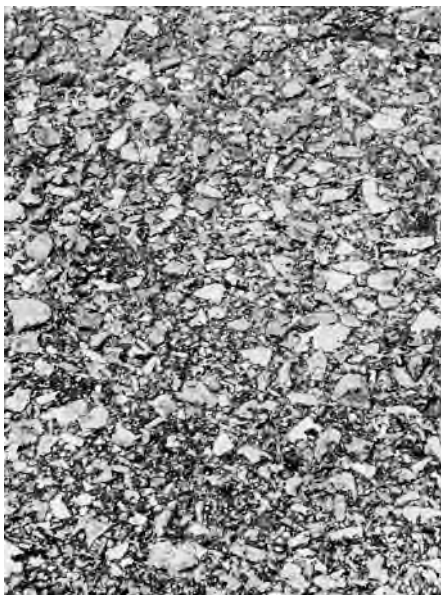
◄ **Slight raveling. Small aggregate particles have worn away exposing tops of large aggregate.**

◄ **Moderate to severe raveling. Erosion further exposes large aggregate.**

◄ **Severe raveling and loss of surface material.**

Polished, worn aggregate needs repair. ▼

► **Flushing. Dark patches show where asphalt has worked to surface.**



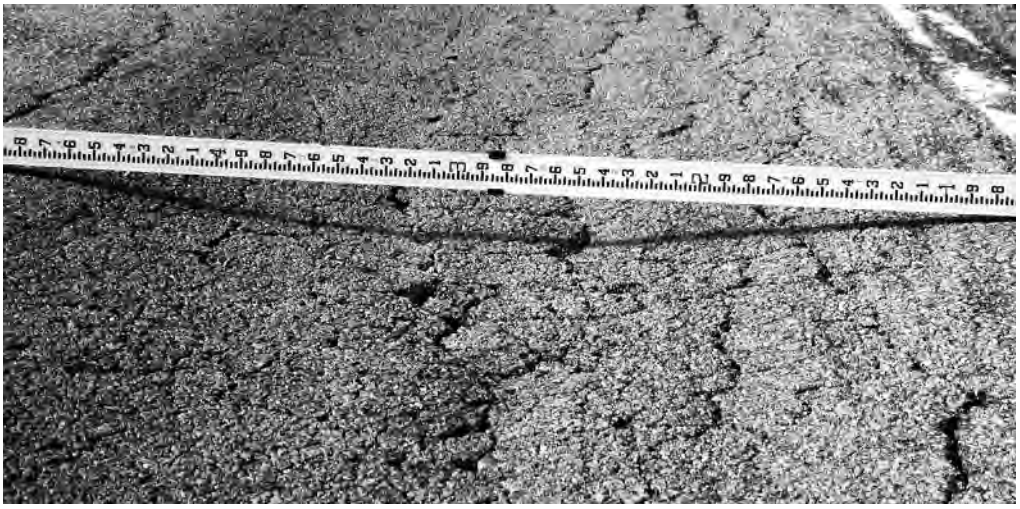
SURFACE DEFORMATION

Rutting

Rutting is displacement of material, creating channels in wheelpaths. It is caused by traffic compaction or displacement of unstable material. Rutting of any severity can cause safety concerns because water can collect in ruts increasing vehicle stopping distances and increasing the chances of hydroplaning. In freezing temperatures ice can form in ruts. Severe rutting (2 inches or more in depth) may be caused by base or subgrade consolidation. Repair minor rutting with microsurfacing or overlays. Severe rutting requires milling the old surface or reconstructing the roadbed before resurfacing.

◄
Even slight rutting is evident after a rain.

◄
Severe rutting over 2" caused by poor mix design.



◄
Severe rutting caused by poor base or subgrade.

Distortion

Shoving or rippling is surfacing material displaced crossways to the direction of traffic. It can develop into washboarding when the asphalt mixture is unstable because of poor quality aggregate or improper mix design. Repair by milling smooth and overlaying with stable asphalt mix.

Other pavement distortions may be caused by settling, frost heave, etc. Patching may provide temporary repair. Permanent correction usually involves removal of unsuitable

▼ **Heavy traffic has shoved pavement into washboard ripples and bumps.**

► **Severe settling from utility trench.**

► **Frost heave damage from spring break-up.**

▼ **Widely spaced, well-sealed cracks.**

subgrade material and reconstruction.

CRACKS

Transverse cracks

A crack at approximately right angles to the center line is a transverse crack. They are often regularly spaced. The cause is movement due to temperature changes and hardening of the asphalt with aging.

Transverse cracks will initially be widely spaced (over 50'). Additional cracking will occur with aging until they are closely spaced (within several feet). These usually begin as hairline or very narrow cracks; with aging they widen. If not properly sealed and maintained, secondary or multiple cracks develop parallel to the initial crack. The crack edges can further deteriorate by raveling and eroding the adjacent pavement.

Prevent water intrusion and damage by sealing cracks which are more than ¼" wide.

◄ **Sealed cracks, a few feet apart.**

▲ **Tight cracks less than ¼" in width.**

▲ **Open crack – ½" or more in width.**

▲ **Water enters unsealed cracks softening pavement and causing secondary cracks.**

▲ **Pavement ravels and erodes along open cracks causing deterioration.**

Reflection cracks

Cracks in overlays reflect the crack pattern in the pavement underneath. They are difficult to prevent and correct. Thick overlays or reconstruction is usually required.

► **Concrete joints reflected through bituminous overlay.**

Slippage cracks

Crescent or rounded cracks in the direction of traffic, caused by slippage between an overlay and an underlying pavement. Slippage is most likely to occur at intersections where traffic is stopping and starting. Repair by removing the top surface and resurfacing using a tack coat.

► **Crescent-shaped cracks characteristic of slippage.**

► **Loss of bond between pavement layers allows traffic to break loose pieces of surface.**

Centerline crack (still tight). ►

Edge cracking from weakened subbase and traffic loads. ▼

Longitudinal cracks

Cracks running in the direction of traffic are longitudinal cracks. Center line or lane cracks are caused by inadequate bonding during construction or reflect cracks in underlying pavement. Longi - tudinal cracks in the wheel path indicate fatigue failure from heavy vehicle loads. Cracks within one foot of the edge are caused by insufficient shoulder support, poor drainage, or frost action. Cracks usually start as hairline or vary narrow and widen and erode with age. Without crack filling, they can ravel, develop multiple cracks, and become wide enough to require patching.

Filling and sealing cracks will reduce moisture penetration and prevent further subgrade weakening. Multiple longitudinal cracks in the wheel path or pavement edge indicate a need for strengthening with an overlay or reconstruction.

► First stage of wheelpath cracking caused by heavy traffic loads.

Load-related cracks in wheel path. ▼

Multiple open, longitudinal cracks that are raveling. ▼

Block cracks

Block cracking is interconnected cracks forming large blocks. Cracks usually intersect at nearly right angles. Blocks may range from one foot to approximately 10′ or more across. The closer spacing indicates more advanced aging caused by shrinking and hardening of the asphalt over time. Repair with sealcoating during early stages to reduce weathering of the asphalt. Overlay or reconstruction required in the advanced stages.

► **Large blocks, approximately 10′ across.**

► **Intermediate-size block cracking, 1′-5′ across with open cracks.**

▲ **Extensive block cracking in an irregular pattern.**

► **Severe block cracking – 1′ or smaller blocks. Tight cracks with no raveling.**

Alligator cracks

Interconnected cracks forming small pieces ranging in size from about 1" to 6". This is caused by failure of the surfacing due to traffic loading (fatigue) and very often also due to inadequate base or subgrade support. Repair by excavating localized areas and replacing base and surface. Large areas require reconstruction. Improvements in drainage may often be required.

◄
Alligator crack pattern. Tight cracks and one patch.

◄
Characteristic "chicken wire" crack pattern shows smaller pavement pieces and patching.

◄
Open raveled alligator cracking with settlement along lane edge most likely due to very soft subgrade.

PATCHES AND POTHOLES

Patches

Original surface repaired with new asphalt patch material. This indicates a pavement defect or utility excavation which has been repaired. Patches with cracking, settlement or distortions indicate underlying causes still remain. Recycling or reconstruction are required when extensive patching shows distress.

► **Typical repair of utility excavation. Patch in fair to good condition.**

► **Edge wedging. Pavement edges strengthened with wedges of asphalt. Patch is in very good condition.**

► **Extensive patching in very poor condition.**

Potholes

Holes and loss of pavement material caused by traffic loading, fatigue and inadequate strength. Often combined with poor drainage. Repair by excavating or rebuilding localized potholes. Reconstruction required for extensive defects.

◄
Small pothole where top course has broken away.

◄
Multiple potholes show pavement failure, probably due to poor subgrade soils, frost heave, and bad drainage.

◄
Large, isolated potholes extend through base. Note adjacent alligator cracks which commonly deteriorate into potholes.

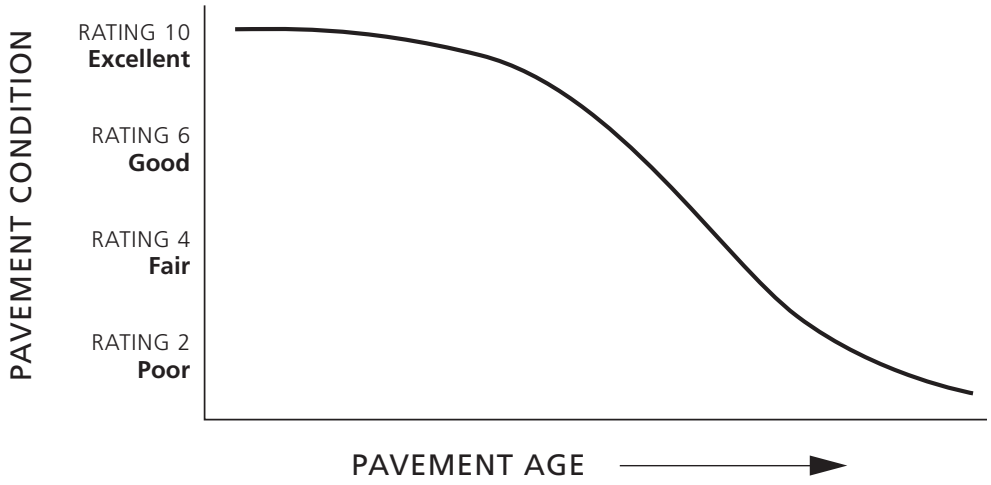
Rating pavement surface condition

With an understanding of surface distress, you can evaluate and rate asphalt pavement surfaces. The rating scale ranges from **10–excellent** condition to **1–failed**. Most pave - ments will deteriorate through the phases listed in the rating scale. The time it takes to go from excellent condition (10) to complete failure (1) depends largely on the quality of the original construction and the amount of heavy traffic loading.

Once significant deterioration begins, it is common to see pavement decline rapidly. This is usually due to a combination of loading and the effects of additional moisture. As a pavement ages and additional cracking develops, more moisture can enter the pavement and accelerate the rate of deterioration.

Look at the photographs in this section to become familiar with the descriptions of the individual rating categories. To evaluate an individual pavement segment, first determine its general condition. Is it relatively new, toward the top end of the scale? In very poor condition and at the bottom of the scale? Or somewhere in between? Next, think generally about the appropriate maintenance method. Use the rating categories outlined below.

Finally, review the individual pavement distress and select the appropriate surface rating. Individual pavements will ***not*** have all of the types of distress listed for any particular rating. They may have only one or two types.



In addition to indicating the surface condition of a road, a given rating also includes a recommendation for needed maintenance or repair. This feature of the rating system facilitates its use and enhances its value as a tool in ongoing road maintenance.

RATINGS ARE RELATED TO NEEDED MAINTENANCE OR REPAIR

Rating 9 & 10	No maintenance required
Rating 8	Little or no maintenance
Rating 7	Routine maintenance, cracksealing and minor patching
Rating 5 & 6	Preservative treatments (sealcoating)
Rating 3 & 4	Structural improvement and leveling (overlay or recycling)
Rating 1 & 2	Reconstruction

Rating system

Surface rating	*Visible distress**	*General condition/ treatment measures*
10 Excellent	None.	New construction.
9 Excellent	None.	Recent overlay. Like new.
8 Very Good	No longitudinal cracks except reflection of paving joints. Occasional transverse cracks, widely spaced (40′ or greater). All cracks sealed or tight (open less than ¼″).	Recent sealcoat or new cold mix. Little or no maintenance required.
7 Good	Very slight or no raveling, surface shows some traffic wear. Longitudinal cracks (open ¼″) due to reflection or paving joints. Transverse cracks (open ¼″) spaced 10′ or more apart, little or slight crack raveling. No patching or very few patches in excellent condition.	First signs of aging. Maintain with routine crack filling.
6 Good	Slight raveling (loss of fines) and traffic wear. Longitudinal cracks (open ¼″–½″). Transverse cracks (open ¼″–½″), some spaced less than 10′. First sign of block cracking. Sight to moderate flushing or polishing. Occasional patching in good condition.	Shows signs of aging. Sound structural condition. Could extend life with sealcoat.
5 Fair	Moderate to severe raveling (loss of fine and coarse aggregate). Longitudinal and transverse cracks (open ½″ or more) show first signs of slight raveling and secondary cracks. First signs of longitudinal cracks near pavement edge. Block cracking up to 50% of surface. Extensive to severe flushing or polishing. Some patching or edge wedging in good condition.	Surface aging. Sound structural condition. Needs sealcoat or thin non-structural overlay (less than 2″)
4 Fair	Severe surface raveling. Multiple longitudinal and transverse cracking with slight raveling. Longitudinal cracking in wheel path. Block cracking (over 50% of surface). Patching in fair condition. Slight rutting or distortions (½″ deep or less).	Significant aging and first signs of need for strengthening. Would benefit from a structural overlay (2″ or more).
3 Poor	Closely spaced longitudinal and transverse cracks often showing raveling and crack erosion. Severe block cracking. Some alligator cracking (less than 25% of surface). Patches in fair to poor condition. Moderate rutting or distortion (greater than ½″ but less than 2" deep). Occasional potholes.	Needs patching and repair prior to major overlay. Milling and removal of deterioration extends the life of overlay.
2 Very Poor	Alligator cracking (over 25% of surface). Severe rutting or distortions (2″ or more deep). Extensive patching in poor condition. Potholes.	Severe deterioration. Needs reconstruction with extensive base repair. Pulverization of old pavement is effective.
1 Failed	Severe distress with extensive loss of surface integrity.	Failed. Needs total reconstruction.

** Individual pavements will not have all of the types of distress listed for any particular rating. They may have only one or two types.*

RATING 10 & 9

EXCELLENT —
No maintenance required

Newly constructed or recently overlaid roads are in excellent condition and require no maintenance.

► **RATING 10**
New construction.

► **RATING 9**
Recent overlay, rural.

► **RATING 9**
Recent overlay, urban.

RATING 8

VERY GOOD —
Little or no maintenance required

This category includes roads which have been recently sealcoated or overlaid with new cold mix. It also includes recently constructed or overlaid roads which may show longitudinal or transverse cracks. All cracks are tight or sealed.

◄ **Recent chip seal.**

◄ **Recent slurry seal.**

▲ **New cold mix surface.**

▼ **Widely spaced, sealed cracks.**

RATING 7

GOOD —
Routine crack sealing recommended

Roads show first signs of aging, and they may have very slight raveling. Any longitudinal cracks are along paving joint. Transverse cracks may be approximately 10′ or more apart. All cracks are ¼″ or less, with little or no crack erosion. Few if any patches, all in very good condition. Maintain a crack sealing program.

► **Tight and sealed transverse and longitudinal cracks. Maintain crack sealing program.**

► **Tight longitudinal crack and sealed transverse cracks.**

► **Transverse cracks about 10′ or more apart. Maintain crack sealing program.**

RATING 6

GOOD —
Consider preservative treatment

Roads are in sound structural condition but show definite signs of aging. Seal-coating could extend their useful life. There may be slight surface raveling. Transverse cracks can be frequent, less than 10′ apart. Cracks may be ¼–½″ and sealed or open. Pavement is generally sound adjacent to cracks. First signs of block cracking may be evident. May have slight or moderate bleeding or polishing. Patches are in good condition.

◄ **Slight surface raveling with tight cracks, less than 10′ apart.**

◄ **Transverse cracks less than 10′ apart; cracks well-sealed.**

▼ **Large blocks, early signs of raveling and block cracking.**

▼ **Open crack, ½″ wide; adjoining pavement sound.**

▼ **Moderate flushing.**

RATING 5

FAIR —
Preservative maintenance treatment required

Roads are still in good structural condition but clearly need sealcoating or overlay. They may have moderate to severe surface raveling with significant loss of aggregate. First signs of longitudinal cracks near the edge. First signs of raveling along cracks. Block cracking up to 50% of surface. Extensive to severe flushing or polishing. Any patches or edge wedges are in good condition.

▼ **Block cracking with open cracks.**

► **Moderate to severe raveling in wheel paths.**

▼ **Severe flushing.**

▲ **Wedges and patches extensive but in good condition.**

RATING 4

FAIR —
Structural improvement required

Roads show first signs of needing strengthening by overlay. They have very severe surface raveling which should no longer be sealed. First longitudinal cracking in wheel path. Many transverse cracks and some may be raveling slightly. Over 50% of the surface may have block cracking. Patches are in fair condition. They may have rutting ½" deep or less, or slight distortion.

Severe raveling with ▼ extreme loss of aggregate.

Load cracking and slight ▼ rutting in wheel path.

◄ Longitudinal cracking; early load-related distress in wheel path. Strengthening needed.

▼ Slight rutting; patch in good condition.

▼ Extensive block cracking. Blocks tight and sound.

◄ Slight rutting in wheel path.

RATING 3

POOR—
Structural improvement required

Roads must be strengthened with a structural overlay (2" or more). Will benefit from milling and very likely will require pavement patching and repair beforehand. Cracking will likely be extensive. Raveling and erosion in cracks may be common. Surface may have severe block cracking and show first signs of alligator cracking. Patches are in fair to poor condition. There is moderate distortion or rutting (more than ½" and less than 2" in depth), and occasional potholes.

► **Many wide and raveled cracks indicate need for milling and overlay.**

► **Ruts need mill and overlay.**

► **Open and raveled block cracks.**

RATING 3

POOR — (continued)
Structural improvement required

◄ **Alligator cracking. Edge needs repair and drainage needs improvement prior to rehabilitation.**

▼ **Distortion with patches in poor condition. Repair and overlay.**

RATING 2

VERY POOR—
Reconstruction required

Roads are severely deteriorated and need reconstruction. Surface pulverization and additional base may be cost-effective. These roads have more than 25% alligator cracking, distortion or rutting 2 inches or more in depth, as well as potholes or extensive patches in poor condition.

► **Extensive alligator cracking. Pulverize and rebuild.**

▲ **Severe rutting. Strengthen base and reconstruct.**

▲ **Patches in poor condition, wheelpath rutting. Pulverize, strengthen and reconstruct.**

► **Severe frost damage. Reconstruct.**

RATING 1

FAILED —
Reconstruction required

Roads have failed, showing severe distress and extensive loss of surface integrity.

◄
Potholes from frost damage. Reconstruct.

◄
Potholes and severe alligator cracking. Failed pavement. Reconstruct.

◄
Extensive loss of surface. Rebuild.

Practical advice on rating roads

Inventory and field inspection

Most agencies routinely observe roadway conditions as a part of their normal work and travel. However, an actual inspection means looking at the entire roadway system as a whole and preparing a written summary of conditions. This inspection has many benefits over casual observations. It can be helpful to compare segments, and ratings decisions are likely to be more consistent because the roadway system is considered as a whole within a relatively short time.

An inspection also encourages a review of specific conditions important in roadway maintenance, such as drainage, adequate strength, and safety.

A simple written inventory is useful in making decisions where other people are involved. You do not have to trust your memory, and you can usually answer questions in more detail. Having a written record and objective information also improves your credi - bility with the public.

Finally, a written inventory is very useful in documenting changing roadway conditions. Without records over several years it is impossible to know if road conditions are improving, holding their own, or declining.

Annual budgets and long range planning are best done when based on actual needs as documented with a written inventory.

The Wisconsin DOT local road inventory (WISLR) is a valuable resource for managing your local roads. Adding PASER surface condition ratings is an important improvement.

Averaging and comparing sections

For evaluation, divide the local road system into individual segments which are similar in construction and condi - tion. Rural segments may vary from ½ mile to a mile long, while sections in urban areas will likely be 1-4 blocks long or more. If you are starting with the WISLR Inventory, the segments have already been established. You may want to review them for consistent road conditions.

Obviously, no roadway segment is entirely consistent. Also, surfaces in one section will not have all of the types of distress listed for any particular rating. They may have only one or two types. Therefore, some averaging is necessary.

The objective is to rate the condition that represents the majority of the roadway. Small or isolated conditions should not influence the rating. It is useful to note these special conditions on the inventory form so this information can be used in planning specific improvement projects. For example, some spot repairs may be required.

Occasionally surface conditions vary significantly within a segment. For example, short sections of good condition may be followed by sections of poor surface conditions. In these cases, it is best to rate the segment according to the worst conditions and note the variation on the form.

The overall purpose of condition rating is to be able to compare each segment relative to all the other segments in your roadway system. On completion you should be able to look at any two pavement segments and find that the better surface has a higher rating.

Within a given rating, say 6, not all pavements will be exactly the same. However, they should all be considered to be in better condition than those with lower ratings, say 5. Sometimes it is helpful in rating a difficult segment to compare it to other previously rated segments. For example, if it is better than one you rated 5 and worse than a typical 7, then a rating of 6 is appropriate. Having all pavement segments rated in the proper relative order is most important and useful.

Assessing drainage conditions

Moisture and poor pavement drainage are significant factors in pavement deterioration. Some assessment of drainage conditions during pavement rating is highly recommended. While you should review drainage in detail at the project level, at this stage simply include an overview drainage evaluation at the same time as you evaluate surface condition.

Urban drainage.

RATING: Excellent

Good rural ditch and driveway culvert. Culvert end needs cleaning.

RATING: Good

High shoulder and no ditch lead to pavement damage. Needs major ditch improvement for a short distance.

RATING: Fair

No drainage leads to failed pavement.

RATING: Poor

Consider both pavement surface drainage and lateral drainage (ditches or storm sewers). Pavement should be able to quickly shed water off the surface into the lateral ditches. Ditches should be large and deep enough to drain the pavement and remove the surface water efficiently into adjacent waterways.

Look at the roadway crown and check for low surface areas that permit ponding. Paved surfaces should have approximately a 2% cross slope or crown across the roadway. This will provide approximately 3" of fall on a 12' traffic lane. Shoulders should have a greater slope to improve surface drainage.

A pavement's ability to carry heavy traffic loads depends on both the pavement materials (asphalt surfacing and granular base) and the strength of the underlying soils. Most soils lose strength when they are very wet. Therefore, it is important to provide drainage to the top layer of the subgrade supporting the pavement structure.

In rural areas, drainage is provided most economically by open ditches that allow soil moisture to drain laterally. As a rule of thumb, the bottom of the ditch ought to be at least one foot below the base course of the pavement in order to drain the soils. This means that minimum ditch depth should be about 2' below the center of the pavement. Deeper ditches, of course, are required to accommodate roadway culverts and maintain the flow line to adjacent drainage channels or streams.

You should also check culverts and storm drain systems. Storm drainage systems that are silted in, have a large accumulation of debris, or are in poor structural condition will also degrade pavement performance.

The T.I.C. publication, ***Drainage Manual: Local Road Assessment and Improvement,*** describes the elements of drainage systems, depicts them in detailed photographs, and explains how to rate their condition. Copies are available from the Transportation Information Center.

Planning annual maintenance and repair budgets

We have found that relating a normal maintenance or rehabilitation proce - dure to the surface rating scheme helps local officials use the rating system. However, an individual surface rating should not automatically dictate the final maintenance or rehabilitation technique.

You should consider safety, future traffic projections, original construc - tion, and pavement strength since these may dictate a more comprehen- sive rehabilitation than the rating suggests. On the other hand, it may be appropriate under special condi- tions to do nothing and let the pavement fully deteriorate, then rebuild when funds are available.

Summary

Using local road funds most efficiently requires good planning and accurate identification of appropriate rehabili - tation projects. Assessing roadway conditions is an essential first step in this process. This asphalt pavement surface condition rating procedure has proved effective in improving decision making and using highway funds more efficiently. It can be used directly by local officials and staff. It may be combined with additional testing and data collection in a more comprehensive pavement manage- ment system.

Transportation Information Center Publications

Pavement Surface Evaluation and Rating (PASER) Manuals

- **Asphalt PASER Manual,** 28 pp.
- **Brick and Block PASER Manual,** 8 pp.
- **Concrete PASER Manual,** 28 pp.
- **Gravel PASER Manual,** 20 pp.
- **Sealcoat PASER Manual,** 16 pp.
- **Unimproved Roads PASER Manual,** 12 pp.

Drainage Manual
Local Road Assessment and Improvement, 6 pp.

SAFER Manual
Safety Evaluation for Roadways, 40 pp.

Flagger's Handbook (pocket-sized guide), 22 pp.

Work Zone Safety, Guidelines for Construction, Maintenance, and Utility Operations, (pocket-sized guide), 58 pp.

Wisconsin Transportation Bulletins

#1 Understanding and Using Asphalt
#2 How Vehicle Loads Affect Pavement Performance
#3 LCC—Life Cycle Cost Analysis
#4 Road Drainage
#5 Gravel Roads
#6 Using Salt and Sand for Winter Road Maintenance
#7 Signing for Local Roads
#8 Using Weight Limits to Protect Local Roads
#9 Pavement Markings
#10 Seal Coating and Other Asphalt Surface Treatments
#11 Compaction Improves Pavement Performance
#12 Roadway Safety and Guardrail
#13 Dust Control on Unpaved Roads
#14 Mailbox Safety
#15 Culverts-Proper Use and Installation
#16 Geotextiles in Road Construction/Maintenance and Erosion Control
#17 Managing Utility Cuts
#18 Roadway Management and Tort Liability in Wisconsin
#19 The Basics of a Good Road
#20 Using Recovered Materials in Highway Construction
#21 Setting Speed Limits on Local Roads
#22 Pre-wetting and Anti-icing
#23 Meeting Minimum Sign Retroreflectivity Standards

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PASER

Asphalt Roads

Transportation Information Center
University of Wisconsin–Madison

Appendix C

Roadway
Condition Survey
Results

Treasure State Acres
Roadway Assessments

Roadway Name: Appaloosa Dr

Start: Cayuse Road

Stop: Cul de sac

Roadway Width: 32'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 137'

Comments: Measured from GIS data (2015)

SSMH at #4304

Surface Rating:

1	2	3	4	5	6	7	8	9	10
				X					

Comments: Paser Rating of 7 in 2008
Chipped in 2006

transverse cracking and 25% block cracking, no patching

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Comments:

curb and gutter in good condition
asphalt valley gutter along intersection with Cayuse Road
some standing water visible at time of field inspection (May 29, 2015 - lots of rain recently)

Treasure State Acres
Roadway Assessments

Roadway Name: Badger Drive

Start: Buffalo Road

Stop: Cul de sac - (North)

Roadway Width: 30'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 405'

Comments: Measured from County Info (2008)

SSMH at #4507

Surface Rating:

1	2	3	4	5	6	7	8	9	10
				X					

Comments: Paser Rating of 4 in 2008

transverse and longitudinal cracking

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

no C&G - see drainage rating

Drainage Rating:

Excellent	Good	Fair	Poor
		X	

Comments:

culverts along east (buried, filled in)

Treasure State Acres
Roadway Assessments

Roadway Name: Beaverhead Road

Start: North Montana Ave (West)

Stop: Bobcat (East)

Roadway Width: 43.5'

Comments: Measured from GIS data (2015)

Roadway Length: 350'

Comments: Measured from GIS data (2015)

Big trees/shrubbery block sight distance at eastbound stop sign at Bobcat
Raised concrete median at North Montana stop light

Surface Rating:

1	2	3	4	5	6	7	8	9	10
						X			

Comments: Paser Rating of 7 in 2008
Chipped in 2002
Overlayed in 1999
only 2 block cracks
pullout on north side - paved

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Comments:
Curb and Gutter in good condition

Treasure State Acres
Roadway Assessments

Roadway Name: Beaverhead Road

Start: Bobcat (West)

Stop: Cul-De-Sac (east)

Roadway Width: 34'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 2030'

Comments: Measured from GIS data (2015)

SSMH at west end
SSMH at #1562
SSMH at #1525
SSMH at #1524
SSMH at #1440
SSMH at #1375
SSMH at #133

Surface Rating:

1	2	3	4	5	6	7	8	9	10
					X				

Comments: Paser Rating of 5 in 2008
Chipped in 2002
Overlayed in 1999
transverse and long cracking with some sealing
raveling along C&G edges

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Comments:
Curb and Gutter - a few spots have bad curb sections
Concrete valley gutter at south end of north section of Pondera Road

Treasure State Acres
Roadway Assessments

Roadway Name: Bighorn Road

Start: Bobcat Drive

Stop: Cougar Drive

Roadway Width: 32'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 1950'

Comments: Measured from County Info (2008); verified in field 2015

SSMH at #1263
SSMH at #1339
SSMH at #1393
SSMH at #1450
SSMH at Red Fox Drive

Surface Rating:

1	2	3	4	5	6	7	8	9	10
						X			

Comments: Paser Rating of 6 in 2008
Chipped in 2001
Overlayed in 2000
transverse cracks, far apart…

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Inlet at #1340
Inlet at Red Fox Drive (NW corner)
Inlet at Cougar Drive (NW & SE corners)
concrete fillets in curb line impeding flow

Treasure State Acres
Roadway Assessments

Roadway Name: Bobcat Drive

Start: Beaverhead Road

Stop: Buffalo Road

Roadway Width: 32'

Comments: Measured from County Info (2008); verified in field 2015

1835'? if not including small section of Bobcat???

Roadway Length: 1835'

Comments: Provided from County Info

SSMH at #4030
SSMH at #4090
SSMH at #4150
SSMH at Cayuse
SSMH at #4315

Surface Rating:

1	2	3	4	5	6	7	8	9	10
					X				

Comments: Paser Rating of 5 in 2008
Chipped in 2001
Overlayed in 1999
transverse and long cracking, some sealing
patching along curb

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Comments:

Inlet at Buffalo (SW & SE corners)
Inlet at Mustang (SE-sunken, behind curb and landscaping)

Treasure State Acres
Roadway Assessments

Roadway Name: Buffalo Road

Start: N Montana Ave

Stop: Porcupine Dr

Roadway Width: 31'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 1,215'

Comments: Provided from County Info

SSMH at Credit Union near N Montana
SSMH at Bobcat
SSMH at Woodchuck
SSMH at Snowshoe
SSMH at Porcupine

Surface Rating:

1	2	3	4	5	6	7	8	9	10
				X					

Comments: Paser Rating of 4 in 2008
Chipped in 2004

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

No C&G, no ditches

Drainage Rating:

Excellent	Good	Fair	Poor
			X

Comments:

Inlet at Bobcat (SE & SW corners)
Inlet at Wolverine (SE & SW corners)

Treasure State Acres
Roadway Assessments

Roadway Name: Buffalo Road

Start: Porcupine Dr

Stop: Cougar Dr

Roadway Width: 31'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 1,080'

Comments: Measured from GIS data (2015)

SSMH at Prairie

Surface Rating:

1	2	3	4	5	6	7	8	9	10
				X					

Comments: Paser Rating of 4 in 2008

transverse cracking and block cracking
potholes at #1469

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

no C&G - see drainage rating

Drainage Rating:

Excellent	Good	Fair	Poor
			X

Comments:

no ditches
Inlet at Red Fox (SW & SE corners)
Inlet at Cougar (SW corner) PLUS concrete valley gutter with curb and drop inlets

Treasure State Acres
Roadway Assessments

Roadway Name: West Cayuse Road

Start: Bobcat Dr

Stop: Wolverine Dr

Roadway Width: 32'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 660'

Comments: Measured from GIS data (2015)

SSMH at #1270 - paved over
SSMH at Appaloosa

Surface Rating:

1	2	3	4	5	6	7	8	9	10
			X						

Comments Paser Rating of 3 in 2008
Chipped in 2001
severe alligator cracking at #1250
Asphalt valley gutter at Appaloosa

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Comments:

curb and gutter in good condition
Inlet at Wolverine (SE & SW corners, SW sunken, behind curb)

Treasure State Acres
Roadway Assessments

Roadway Name: Cayuse Road

Start: Wolverine Dr

Stop: Red Fox Dr

Roadway Width: 32'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 1055'

Comments: Measured from GIS data (2015)

SSMH at #1375
SSMH at #1431

Surface Rating:

1	2	3	4	5	6	7	8	9	10
						X			

Comments: Paser Rating of 8 in 2008
Chipped in 2006
Overlayed in 2005
very few cracks
visible improvement over section to west…

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Comments:

curb and gutter in good condition
Inlet at Red Fox Dr (SW corner)

Treasure State Acres
Roadway Assessments

Roadway Name: Cougar Drive

Start: Bighorn Road

Stop: Buffalo Road

Roadway Width: 32'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 1660'

Comments: Measured from County Info (2008); verified in field 2015

SSMH at #4110
SSMH at Kodiak
SSMH at #4230
SSMH at #4310
SSMH at Buffalo

Surface Rating:

1	2	3	4	5	6	7	8	9	10
						X			

Comments: Paser Rating of 9 in 2008
Chipped in 2008
Overlayed in 2006
transverse cracks far apart

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Comments:

valley gutter at Buffalo with 2 Inlets - round and drop

Treasure State Acres
Roadway Assessments

Roadway Name: Cougar Drive

Start: Buffalo Road

Stop: Cul de Sac

Roadway Width: 30'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 405'

Comments: Measured from County Info (2008); verified in field 2015

Surface Rating:

1	2	3	4	5	6	7	8	9	10
				X					

Comments Paser Rating of 4 in 2008

lots of block cracking, sealing, patches
alligator cracking at poor drainage areas

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

no C&G or shoulders - see drainage rating

Drainage Rating:

Excellent	Good	Fair	Poor
			X

Comments:

Ditch along west, none along east

Treasure State Acres
Roadway Assessments

Roadway Name: Glacier Drive

Start: South End

Stop: Beaverhead Road

Roadway Width: 32'

Comments: Measured from County Info (2008)

Roadway Length: 410'

Comments: Measured from County Info (2008); verified in field 2015

SSMH at Mineral/Glacier intersection

Surface Rating:

1	2	3	4	5	6	7	8	9	10
					X				

Comments: Paser Rating of 6 in 2008
transverse cracking, some long cracking
excessive raveling along entire west side
some patching
recommend removal and replacement along curb @ raveling (about 3 feet wide)

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:
C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Comments:
one section has heaving damage

Treasure State Acres
Roadway Assessments

Roadway Name: Kodiak Road

Start: Cayuse Road

Stop: Wolverine Drive

Roadway Width: 32'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 600'

Comments: Measured from County Info (2008); verified in field 2015

Surface Rating:

1	2	3	4	5	6	7	8	9	10
			X						

Comments Paser Rating of 3 in 2008

block cracking up to 50%
alligator cracking at #1340

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

curb and gutter in good shape
Copncrete Valley Gutter with Inlet at #1320 (west side)

Treasure State Acres
Roadway Assessments

Roadway Name: Kodiak Road

Start: Wolverine Drive

Stop: Cougar Dr

Roadway Width: 32'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 1,330

Comments: Provided from County Info

SSMH at #1389
SSMH at #1441

Surface Rating:

1	2	3	4	5	6	7	8	9	10
						X			

Comments: Paser Rating of 8 in 2008
Chipped in 2006
Overlayed in 2005

transverse cracking more than 10' apart

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

several concrete fillets in C&G
Inlet at Red Fox (NW & SW corners)
Inlet at Cougar (SW corner)

Treasure State Acres
Roadway Assessments

Roadway Name: Mineral Road

Start: Pondera Road

Stop: Glacier Drive

Roadway Width: 32'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 690'

Comments: Provided from County Info

SSMH in front of #1520

Surface Rating:

1	2	3	4	5	6	7	8	9	10
					X				

Comments: Paser Rating of 6 in 2008
transverse cracking, block cracking up to 50%
some raveling
some crack sealing done

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Comments:
2 Inlets at west end of Pondera @ Mineral
1 Inlet at east end of Glacier @ Mineral
Curb and Gutter

Treasure State Acres
Roadway Assessments

Roadway Name: West Mustang Road

Start: Bobcat Dr

Stop: Wolverine Dr

Roadway Width: 32'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 465'

Comments: Measured from GIS data (2015)

Something...? at #1263

Surface Rating:

1	2	3	4	5	6	7	8	9	10
				X					

Comments Paser Rating of 6 in 2008

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Comments:

Inlet at Wolverine (SE Corner)

Treasure State Acres
Roadway Assessments

Roadway Name: Mustang Road

Start: Wolverine Dr

Stop: Red Fox Dri

Roadway Width: 32'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 1180'

Comments: Measured from GIS data (2015)

SSMH at #1385
SSMH at #1430

Surface Rating:

1	2	3	4	5	6	7	8	9	10
						X			

Comments: Paser Rating of 8 in 2008
Chipped in 2006
Overlayed in 2005
very few cracks
square patch at #1430-1461

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Comments:

Inlet at Mustang (NW & SW corners)

Treasure State Acres
Roadway Assessments

Roadway Name: W Otter Road

Start: Bobcat

Stop: Wolverine Drive

Roadway Width: 32'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 460'

Comments: Measured from GIS data (2015)

SSMH at Wolverine

Surface Rating:

1	2	3	4	5	6	7	8	9	10
				X					

Comments: Paser Rating of 6 in 2008

cracks

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

curb and gutter in good shape

Treasure State Acres
Roadway Assessments

Roadway Name: Otter Road

Start: Wolverine Drive

Stop: Red Fox Drive

Roadway Width: 32'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 1200'

Comments: Measured from County Info (2008); verified in field 2015

SSMH at Wolverine
SSMH at #1392
SSMH at #1440

Surface Rating:

1	2	3	4	5	6	7	8	9	10
						X			

Comments: Paser Rating of 8 in 2008
Chipped in 2006
Overlayed in 2005
some cracks, not many

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Comments:

lots of concrete fillets at driveways
Inlets at Red Fox (N & S)
curb and gutter in good shape

Treasure State Acres
Roadway Assessments

Roadway Name: Pondera Road

Start: South End

Stop: Beaverhead Road

Roadway Width: 32'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 420'

Comments: Measured from GIS data (2015)
SSMH at south end, center of street

Surface Rating:

1	2	3	4	5	6	7	8	9	10
					X				

Comments: Paser Rating of 6 in 2008
Laminating failure at north end
transverse cracking, block cracking u pto 50%
cracks are routed, some sealed

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Comments:
Curb and Gutter - some upheaving and settlement

Treasure State Acres
Roadway Assessments

Roadway Name: Pondera Road

Start: Beaverhead Road

Stop: Bighorn Road

Roadway Width: 34'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 310'

Comments: Measured from GIS data (2015)
SSMH at south end, center of street

Surface Rating:

1	2	3	4	5	6	7	8	9	10
					X				

Comments: Paser Rating of 6 in 2008
Laminating failure at north end
transverse cracking, block cracking u pto 50%
cracks are routed, some sealed

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Comments:
Curb and Gutter - some upheaving and settlement

Treasure State Acres
Roadway Assessments

Roadway Name: Porcupine Drive

Start: Buffalo Road

Stop: Cul de sac - (North)

Roadway Width: 30'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 405'

Comments: Measured from County Info (2008)

SSMH at Buffalo
SSMH at end of cul de sac

Surface Rating:

1	2	3	4	5	6	7	8	9	10
				X					

Comments: Paser Rating of 4 in 2008

transverse and longitudinal cracking

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

no C&G - see drainage rating

Drainage Rating:

Excellent	Good	Fair	Poor
			X

Comments:

no ditches, no culverts

Treasure State Acres
Roadway Assessments

Roadway Name: Prairie Drive

Start: Buffalo Road

Stop: Cul de sac (North)

Roadway Width: 30'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 405'

Comments: Measured from County Info (2008)

SSMH at Buffalo
SSMH at #4509 (cul de sac)

Surface Rating:

1	2	3	4	5	6	7	8	9	10
				X					

Comments: Paser Rating of 4 in 2008

transverse and long cracking
block cracking

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

no C&G - see drainage rating

Drainage Rating:

Excellent	Good	Fair	Poor
			X

Comments:

no ditches, no culverts

Treasure State Acres
Roadway Assessments

Roadway Name: Red Fox Drive

Start: Bighorn Road

Stop: Buffalo Road

Roadway Width: 32'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 1660'

Comments: Measured from GIS data (2015)

SSMH at Otter Road
SSMH at Kodiak Road
SSMH at #4220
SSMH at Mustang

Surface Rating:

1	2	3	4	5	6	7	8	9	10
						X			

Comments: Paser Rating of 9 in 2008
Chipped in 2008
Overlayed in 2006
transverse cracks, very little long cracking
some utility patches

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Comments:

Only one fillet along est side of C&G
Inlet at Bighorn/Red Fox on east (sunken)
Inlet at Otter Road (NW corner)
Inlet at Kodiak (NW & SW corners - NW paved over)
Inlet at Cayuse (SW corner)
Inlet at Mmustang (NW & SW corners)

Treasure State Acres
Roadway Assessments

Roadway Name: Red Fox Drive

Start: Buffalo Road

Stop: Cul de Sac

Roadway Width: 30'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 405'

Comments: Measured from GIS data (2015)

SSMH at #4510

Surface Rating:

1	2	3	4	5	6	7	8	9	10
				X					

Comments Paser Rating of 4 in 2008

cracks and potholes

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

no C&G or shoulders - see drainage rating

Drainage Rating:

Excellent	Good	Fair	Poor
			X

Comments:

no ditches or curb and gutter

Treasure State Acres
Roadway Assessments

Roadway Name: Snowshoe Drive

Start: Buffalo Road

Stop: Cul de sac (Northend)

Roadway Width: 30'

Comments: Measured from County Info (2008)

Roadway Length: 405'

Comments: Measured from County Info (2008)

SSMH at Buffalo
NO SSMH at cul de sac…?

Surface Rating:

1	2	3	4	5	6	7	8	9	10
				X					

Comments: Paser Rating of 4 in 2008

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

no C&G - see drainage rating

Drainage Rating:

Excellent	Good	Fair	Poor
		X	

Comments:

minimal ditches, no culverts

32'
Roadway Assessments

Roadway Name: Wolverine Drive

Start: Bighorn Road

Stop: Buffalo Road

Roadway Width: 32'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 1790'

Comments: Measured from GIS data (2015)

SSMH at Otter
Powerline trench at #4419 - #4155
SSMH at Mustang
Huge pothole at Mustang - west side of road

Surface Rating:

1	2	3	4	5	6	7	8	9	10
						X			

Comments: Paser Rating of 9 in 2008
Chipped in 2008
Overlayed in 2006
small surface defects

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

C&G - see Drainage Rating

Drainage Rating:

Excellent	Good	Fair	Poor
	X		

Comments:

curb inlets across road at #4230 plus drain inlet in park on west side (behind gutter)
Inlet at Mustang (SE corner)
Inlet at Buffalo (SE & SW corners)
Inlet at Cayuse (SW & NW corner, NW sunken)
curb and gutter in good shape

Treasure State Acres
Roadway Assessments

Roadway Name: Woodchuck Drive

Start: Buffalo Road

Stop: Cul de sac - (North)

Roadway Width: 30'

Comments: Measured from County Info (2008); verified in field 2015

Roadway Length: 405'

Comments: Measured from County Info (2008)

SSMH at Buffalo
SSMH at end of cul de sac

Surface Rating:

1	2	3	4	5	6	7	8	9	10
				X					

Comments: Paser Rating of 4 in 2008

cracking

Shoulder Rating:

1	2	3	4	5	6	7	8	9	10

Comments:

no C&G - see drainage rating

Drainage Rating:

Excellent	Good	Fair	Poor
			X

Comments:

minimal ditches, no culverts

Appendix D

Treatment Costs Spreadsheets

TREASURE STATE ACRES - COST ESTIMATES FOR TREATMENTS TO ALL ROADWAYS

Engineer's Estimate Date: May 5, 2015

Previous Work (Paved in 1981)																				
2008 Paser Rating	Chipped	Overlay	Road Name	2015 Paser Rating	Limits	Asphalt Width	Length	Asphalt Area	3" Asphalt Overlay	2" Asphalt Overlay	Chip Seal	Catch Basin	Clean Catch Basin	Raise Manholes	Remove & Replace Curb & Gutter	Complete Reconstruct	6 FT Wide Milling	Pothole	Crack Sealing**	Skin Patch	2015 Drainage Rating
						FEET	FEET	SY	TONS	TONS	SY	EA	EA	EA	LF	SY	SY	EA	LF	SY	
																					Good
6-2008			Mineral	6	Pondera to Glacier	32	690	2,453	0	0	2,453		3	0	0	0	0		517.5		Good
7-2008	2001	1999	W Beaverhead	7	Montana Ave to Bobcat	43.5	350	1,692	0	0	0		0	0	0	0	0		262.5		Good
5-2008	2002	1999	Beaverhead	6	Bobcat to Cul-De-Sac	34	2,030	7,669	0	0	7,669		0	0	0	0	0		1522.5		Good
6-2008	2001	2000	Bighorn	7	Bobcat to Cougar	32	1,950	6,933	0	0	0		5	0	0	0	0		1462.5		Good
6-2008			W Otter	5	Bobcat to Wolverine	32	460	1,636	0	180	0		0	1	0	0	307		0		Good
8-2008	2006	2005	Otter	7	Wolverine to Red Fox	32	1,200	4,267	0	0	0		2	0	0	0	0		900		Good
3-2008			W Kodiak	4	Cayuse to Wolverine	32	600	2,133	352	0	0		1	1	0	0	400		0		Good
8-2008	2006	2005	Kodiak	7	Wolverine to Cougar	32	1,330	4,729	0	0	0		3	0	0	0	0		997.5		Good
3-2008	2001		W Cayuse	4	Bobcat to Wolverine	32	660	2,347	387	0	0		0	2	0	0	440		0		Good
8-2008	2006	2005	Cayuse	7	Wolverine to Red Fox	32	1,055	3,751	0	0	0		1	0	0	0	0		791.25		Good
6-2008			W Mustang	5	Bobcat to Wolverine	32	465	1,653	0	182	0		0	0	0	0	310		0		Good
8-2008	2006	2005	Mustang	7	Wolverine to Red Fox	32	1,180	4,196	0	0	0		2	0	0	0	0		885		Good
4-2008	2004		W Buffalo	5	Montana Ave to Porcupine*	31	1,215	4,185	0	460	0		0	5	0	0			0		Poor
4-2008			Buffalo	5	Porcupine to Cougar*	31	1,080	3,720	0	409	0		0	4	0	0			0		Poor
5-2008	2001	1999	Bobcat	6	Beaverhead to Buffalo	32	1,835	6,524	0	0	6,524		3	0	0	0	0		1376.25		Good
7-2008	2006		Appaloosa	5	Cayuse to Cul-De-Sac	32	85	302	0	33	0			1	0	0	57		0		Good
7-2008	2006		Appaloosa	5	Cul-De-Sac*	75	75	491	0	54	0				0	0			0		Good
9-2008	2008	2006	Wolverine	7	Bighorn to Buffalo	32	1,790	6,364	0	0	0		7	0	0	0	0		1342.5		Good
6-2008			Pondera	6	S End to Beaverhead	32	420	1,493	0	0	1,493		0	0	0	0	0		315		Good
6-2008			Pondera	6	Beaverhead to Big Horn	34	310	1,171	0	0	1,171		0	0	0	0	0		232.5		Good
9-2008	2008	2006	Red Fox	7	Bighorn to Buffalo	32	1,660	5,902	0	0	0		2	0	0	0	0		1245		Good
4-2008			N Red Fox	5	Buffalo to Cul-De-Sac*	30	405	1,350	0	149	0		0	1		0			0		Poor
4-2008			N Red Fox	5	Cul-De-Sac*	60	60	314	0	35	0					0			0		Poor
6-2008			Glacier	6	S End to Beaverhead	32	410	1,458	0	0	1,458		0	0		0			307.5		Good
9-2008	2008	2006	Cougar	7	Bighorn to Buffalo	32	1,660	5,902	0	0	0		2	0		0			1245		Good
4-2008			N Cougar	5	Buffalo to Cul-De-Sac*	30	405	1,350	0	149	0		0	1		0			0		Poor
4-2008			N Cougar	5	Cul-De-Sac*	60	60	314	0	35	0					0			0		Poor
4-2008			Woodchuck	5	Buffalo to Cul-De-Sac*	30	405	1,350	0	149	0		0	1		0			0		Poor
4-2008			Woodchuck	5	Cul-De-Sac*	60	60	314	0	35	0					0			0		Poor
4-2008			Snowshoe	5	Buffalo to Cul-De-Sac*	30	405	1,350	0	149	0		0	1		0			0		Fair
4-2008			Snowshoe	5	Cul-De-Sac*	60	60	314	0	35	0					0			0		Fair
4-2008			Porcupine	5	Buffalo to Cul-De-Sac*	30	405	1,350	0	149	0		0	1		0			0		Poor
4-2008			Porcupine	5	Cul-De-Sac*	60	60	314	0	35	0					0			0		Poor
4-2008			Badger	5	Buffalo to Cul-De-Sac*	30	405	1,350	0	149	0		0	1		0			0		Fair
4-2008			Badger	5	Cul-De-Sac*	60	60	314	0	35	0					0			0		Fair
4-2008			Prairie	5	Buffalo to Cul-De-Sac*	30	405	1,350	0	149	0		0	1		0			0		Poor
4-2008			Prairie	5	Cul-De-Sac*	60	60	314	0	35	0					0			0		Poor
			TOTALS				25,765	92,619	739	2,606	20,768	0	31	21	0	0	1,514	0	13,403	0	

*These roads do not have curb & gutter

** It is estimated that there are 750 LF of cracks per 1,000 feet of roadway.

31

3" Asphalt Overlay	739	TONS	@	85.00	62,815.00
2" Asphalt Overlay	2,606	TONS	@	85.00	221,510.00
Chip Seal	20,768	SY	@	3.00	62,304.00
Catch Basin	0	EA	@	4,000.00	-
Clean Catch Basin	31	EA	@	150.00	4,650.00
Raise Manholes	21	EA	@	200.00	4,200.00
Remove & Replace Curb & Gutter	0	LF	@	40.00	-
Complete Reconstruct	0	SY	@	65.00	-
6 FT Wide Milling	1,514	SY	@	6.50	9,841.00
Pothole	0	EA	@	150.00	-
Crack Sealing**	13,403	LF	@	2.00	26,806.00
Skin Patch	0	SY	@	23.00	-
			CONSTRUCTION TOTAL		392,126.00
Contingency				10%	39,212.60
Subtotal					431,338.60
Mobilization, Bonding & Insurance				8%	34,507.09
Traffic Control				4%	17,253.54
Subtotal					483,099.23
Design & Construction Engineering				18%	86,957.86
			PROJECT TOTAL		**570,057.09**

TREASURE STATE ACRES - COST ESTIMATES FOR PASER RATINGS OF 1 OR 2

Previous Work (Paved in 1981)

Engineer's Estimate

Date: May 5, 2015

2008 Paser Rating	Chipped	Overlay	Road Name	2015 Paser Rating	Limits	Asphalt Width	Length	Asphalt Area	3" Asphalt	3" Crushed Base Course	6" Sub Base Course	Stabilization Fabric	New Curb & Gutter	12" Excavation						
						FEET	FEET	SY	TONS	CY	CY	SY	LF	CY						
			Road with Curb	2	Unknown	32	1,000	3,556	587	352	704	4,222	2,000	1,407						
			Road wthout Curb	1	Unknown	32	0	0	0	0	0	0		0						
			TOTALS				1,000	3,556	587	352	704	4,222	2,000	1,407	0	0	0	0	0	0

*These roads do not have curb & gutter

** It is estimated that there are 750 LF of cracks per 1,000 feet of roadway.

3" Asphalt	587	TONS	@	85.00	49,895.00
3" Crushed Base Course	352	CY	@	35.00	12,320.00
6" Sub Base Course	704	CY	@	30.00	21,120.00
Stabilization Fabric	4,222	SY	@	1.20	5,066.40
New Curb & Gutter	2,000	LF	@	20.00	40,000.00
12" Excavation	1,407	CY	@	20.00	28,140.00
		CONSTRUCTION TOTAL			156,541.40
Contingency				10%	15,654.14
Subtotal					172,195.54
Mobilization, Bonding & Insurance				8%	13,775.64
Traffic Control				4%	6,887.82
Subtotal					192,859.00
Design & Construction Engineering				18%	34,714.62
		PROJECT TOTAL			**227,573.62**

TREASURE STATE ACRES - COST ESTIMATES FOR PASER RATING OF 3

Previous Work (Paved in 1981)

Engineer's Estimate

Date: May 5, 2015

2008 Paser Rating	Chipped	Overlay	Road Name	2015 Paser Rating	Limits	Asphalt Width	Length	Asphalt Area	3" Asphalt	3" Crushed Base Course	Pulverization of Existing Asphalt	Full Depth Recycling	New Curb & Gutter	12" Excavation						
						FEET	FEET	SY	TONS	CY	SY	SY	LF	CY						
			Road with Curb	3	Unknown	32	1,000	3,556	587	352	3,556	3,556	0	0						
			Road wthout Curb	3	Unknown	32	0	0	0	0	0	0	0	0						
			TOTALS				1,000	3,556	587	352	3,556	3,556	0	0	0	0	0	0	0	0

*These roads do not have curb & gutter

** It is estimated that there are 750 LF of cracks per 1,000 feet of roadway.

3" Asphalt	587	TONS	@	85.00	49,895.00
3" Crushed Base Course	352	CY	@	35.00	12,320.00
Pulverization of Existing Asphalt	3,556	SY	@	1.00	3,556.00
Full Depth Recycling	3,556	SY	@	4.00	14,224.00
New Curb & Gutter	0	LF	@	20.00	-
12" Excavation	0	CY	@	20.00	-
			CONSTRUCTION TOTAL		79,995.00
Contingency				10%	7,999.50
Subtotal					87,994.50
Mobilization, Bonding & Insurance				8%	7,039.56
Traffic Control				4%	3,519.78
Subtotal					98,553.84
Design & Construction Engineering				18%	17,739.69
			PROJECT TOTAL		**116,293.53**

TREASURE STATE ACRES - COST ESTIMATES FOR PASER RATING OF 4

Previous Work (Paved in 1981)

Engineer's Estimate

Date: May 5, 2015

2008 Paser Rating	Chipped	Overlay	Road Name	2015 Paser Rating	Limits	Asphalt Width	Length	Asphalt Area	3" Asphalt Overlay	2" Asphalt Overlay	Chip Seal	Catch Basin	Clean Catch Basin	Raise Manholes	Remove & Replace Curb & Gutter	Complete Reconstruct	6 FT Wide Milling	Pothole	Seal Cracks**	Skin Patch
						FEET	FEET	SY	TONS	TONS	SY	EA	EA	EA	LF	SY	SY	EA	LF	SY
3-2008			W Kodiak	4	Cayuse to Wolverine	32	600	2,133	352	0	0		1	1	0	0	400		0	
3-2008	2001		W Cayuse	4	Bobcat to Wolverine	32	660	2,347	387	0	0		0	2	0	0	440		0	
			TOTALS				1,260	4,480	739	0	0	0	1	3	0	0	840	0	0	0

*These roads do not have curb & gutter

** It is estimated that there are 750 LF of cracks per 1,000 feet of roadway.

3" Asphalt Overlay	739	TONS	@	85.00	62,815.00
2" Asphalt Overlay	0	TONS	@	85.00	-
Chip Seal	0	SY	@	3.00	-
Catch Basin	0	EA	@	4,000.00	-
Clean Catch Basin	0	EA	@	150.00	-
Raise Manholes	3	EA	@	200.00	600.00
Remove & Replace Curb & Gutter	0	LF	@	40.00	-
Complete Reconstruct	0	SY	@	65.00	-
6 FT Wide Milling	840	SY	@	6.50	5,460.00
Pothole	0	EA	@	150.00	-
Seal Cracks**	0	LF	@	2.00	-
Skin Patch	0	SY	@	23.00	-
CONSTRUCTION TOTAL					68,875.00
Contingency				10%	6,887.50
Subtotal					75,762.50
Mobilization, Bonding & Insurance				8%	6,061.00
Traffic Control				4%	3,030.50
Subtotal					84,854.00
Design & Construction Engineering				18%	15,273.72
PROJECT TOTAL					**100,127.72**

TREASURE STATE ACRES - COST ESTIMATES FOR PASER RATING OF 5

Previous Work (Paved in 1981)

Engineer's Estimate

Date: May 5, 2015

2008 Paser Rating	Chipped	Overlay	Road Name	2015 Paser Rating	Limits	Asphalt Width	Length	Asphalt Area	3" Asphalt Overlay	2" Asphalt Overlay	Chip Seal	Catch Basin	Clean Catch Basin	Raise Manholes	Remove & Replace Curb & Gutter	Complete Reconstruct	6 FT Wide Milling	Pothole	Seal Cracks**	Skin Patch
						FEET	FEET	SY	TONS	TONS	SY	EA	EA	EA	LF	SY	SY	EA	LF	SY
6-2008			W Otter	5	Bobcat to Wolverine	32	460	1,636		180	0		0	1		0	307		0	
6-2008			W Mustang	5	Bobcat to Wolverine	32	465	1,653		182	0		0	0		0	310		0	
4-2008	2004		W Buffalo	5	Montana Ave to Porcupine*	31	1,215	4,185		460	0		0	5		0			0	
4-2008			Buffalo	5	Porcupine to Cougar*	31	1080	3,720		409	0		0	4		0			0	
7-2008	2006		Appaloosa	5	Cayuse to Cul-De-Sac	32	85	302	0	33	0			1		0	57		0	
7-2008	2006		Appaloosa	5	Cul-De-Sac	75	75	491	0	54	0					0	50		0	
4-2008			N Red Fox	5	Buffalo to Cul-De-Sac*	30	405	1,350		149	0		0	1		0			0	
4-2008			N Red Fox	5	Cul-De-Sac*	60	60	314		35	0					0			0	
4-2008			N Cougar	5	Buffalo to Cul-De-Sac*	30	405	1,350		149	0		0	1		0			0	
4-2008			N Cougar	5	Cul-De-Sac*	60	60	314		35	0					0			0	
4-2008			Woodchuck	5	Buffalo to Cul-De-Sac*	30	405	1,350		149	0		0	1		0			0	
4-2008			Woodchuck	5	Cul-De-Sac*	60	60	314		35	0					0			0	
4-2008			Snowshoe	5	Buffalo to Cul-De-Sac*	30	405	1,350		149	0		0	1		0			0	
4-2008			Snowshoe	5	Cul-De-Sac*	60	60	314		35	0					0			0	
4-2008			Porcupine	5	Buffalo to Cul-De-Sac*	30	405	1,350		149	0		0	1		0			0	
4-2008			Porcupine	5	Cul-De-Sac*	60	60	314		35	0					0			0	
4-2008			Badger	5	Buffalo to Cul-De-Sac*	30	405	1,350		149	0		0	1		0			0	
4-2008			Badger	5	Cul-De-Sac*	60	60	314		35	0					0			0	
4-2008			Prairie	5	Buffalo to Cul-De-Sac*	30	405	1,350		149	0		0	1		0			0	
4-2008			Prairie	5	Cul-De-Sac*	60	60	314		35	0					0			0	
			TOTALS				6,635	23,635	0	2,606	0	0	0	18	0	0	724	0	0	0

*These roads do not have curb & gutter

** It is estimated that there are 750 LF of cracks per 1,000 feet of roadway.

3" Asphalt Overlay	0	TONS	@	85.00	-
2" Asphalt Overlay	2,606	TONS	@	85.00	221,510.00
Chip Seal	0	SY	@	3.00	-
Catch Basin	0	EA	@	4,000.00	-
Clean Catch Basin	0	EA	@	150.00	-
Raise Manholes	18	EA	@	200.00	3,600.00
Remove & Replace Curb & Gutter	0	LF	@	40.00	-
Complete Reconstruct	0	SY	@	65.00	-
6 FT Wide Milling	724	SY	@	6.50	4,706.00
Pothole	0	EA	@	150.00	-
Seal Cracks**	0	LF	@	2.00	-
Skin Patch	0	SY	@	23.00	-
CONSTRUCTION TOTAL					229,816.00
Contingency				10%	22,981.60
Subtotal					252,797.60
Mobilization, Bonding & Insurance				8%	20,223.81
Traffic Control				4%	10,111.90
Subtotal					283,133.31
Design & Construction Engineering				18%	50,964.00
PROJECT TOTAL					**334,097.31**

TREASURE STATE ACRES - COST ESTIMATES FOR PASER RATING OF 6

Previous Work (Paved in 1981)

Engineer's Estimate

Date: May 5, 2015

2008 Paser Rating	Chipped	Overlay	Road Name	2015 Paser Rating	Limits	Asphalt Width	Length	Asphalt Area	3" Asphalt Overlay	2" Asphalt Overlay	Chip Seal	Catch Basin	Clean Catch Basin	Raise Manholes	Remove & Replace Curb & Gutter	Complete Reconstruct	6 FT Wide Milling	Pothole	Seal Cracks**	Skin Patch
						FEET	FEET	SY	TONS	TONS	SY	EA	EA	EA	LF	SY	SY	EA	LF	SY
6-2008			Mineral	6	Pondera to Glacier	32	690	2,453	0	0	2,453		3	0	0	0	0		517.5	
5-2008	2002	1999	Beaverhead	6	Bobcat to Cul-De-Sac	34	2,030	7,669	0	0	7,669		0	0	0	0	0		1522.5	
5-2008	2001	1999	Bobcat	6	Beaverhead to Buffalo	32	1835	6,524	0	0	6,524		2	0	0	0	0		1376.25	
6-2008			Pondera	6	S End to Beaverhead	32	420	1,493	0	0	1,493		0	0	0	0	0		315	
6-2008			Pondera	6	Beaverhead to Big Horn	34	310	1,171	0	0	1,171		0		0	0	0		232.5	
6-2008			Glacier	6	S End to Beaverhead	32	410	1,458	0	0	1,458		0	0		0			307.5	
			TOTALS				5,695	20,768	0	0	20,768	0	5	0	0	0	0	0	4,271	0

*These roads do not have curb & gutter

** It is estimated that there are 750 LF of cracks per 1,000 feet of roadway.

10.94

3" Asphalt Overlay	0	TONS	@	85.00	-
2" Asphalt Overlay	0	TONS	@	85.00	-
Chip Seal	20,768	SY	@	3.00	62,304.00
Catch Basin	0	EA	@	4,000.00	-
Clean Catch Basin	0	EA	@	150.00	-
Raise Manholes	0	EA	@	200.00	-
Remove & Replace Curb & Gutter	0	LF	@	40.00	-
Complete Reconstruct	0	SY	@	65.00	-
6 FT Wide Milling	0	SY	@	6.50	-
Pothole	0	EA	@	150.00	-
Seal Cracks**	4,271	LF	@	2.00	8,542.00
Skin Patch	0	SY	@	23.00	-
			CONSTRUCTION TOTAL		70,846.00
			Contingency	10%	7,084.60
			Subtotal		77,930.60
			Mobilization, Bonding & Insurance	8%	6,234.45
			Traffic Control	4%	3,117.22
			Subtotal		87,282.27
			Design & Construction Engineering	18%	15,710.81
			PROJECT TOTAL		**102,993.08**

TREASURE STATE ACRES - COST ESTIMATES FOR PASER RATING OF 7

Previous Work (Paved in 1981)

Engineer's Estimate

Date: May 5, 2015

2008 Paser Rating	Chipped	Overlay	Road Name	2015 Paser Rating	Limits	Asphalt Width	Length	Asphalt Area	3" Asphalt Overlay	2" Asphalt Overlay	Chip Seal	Catch Basin	Clean Catch Basin	Raise Manholes	Remove & Replace Curb & Gutter	Complete Reconstruct	6 FT Wide Milling	Pothole	Seal Cracks**	Skin Patch
						FEET	FEET	SY	TONS	TONS	SY	EA	EA	EA	LF	SY	SY	EA	LF	SY
7-2008	2001	1999	W Beaverhead	7	Montana Ave to Bobcat	43.5	350	1,692	0	0	0		0	0	0	0	0		263	
6-2008	2001	2000	Bighorn	7	Bobcat to Cougar	32	1,950	6,933	0	0	0		3	0	0	0	0		1463	
8-2008	2006	2005	Otter	7	Wolverine to Red Fox	32	1,200	4,267	0	0	0		2	0	0	0	0		900	
8-2008	2006	2005	Kodiak	7	Wolverine to Cougar	32	1,330	4,729	0	0	0		3	0	0	0	0		998	
8-2008	2006	2005	Cayuse	7	Wolverine to Red Fox	32	1,055	3,751	0	0	0		1	0	0	0	0		791	
8-2008	2006	2005	Mustang	7	Wolverine to Red Fox	32	1,180	4,196	0	0	0		1	0	0	0	0		885	
9-2008	2008	2006	Wolverine	7	Bighorn to Buffalo	32	1790	6,364	0	0	0		5	0	0	0	0		1343	
9-2008	2008	2006	Red Fox	7	Bighorn to Buffalo	32	1660	5,902	0	0	0		5	0	0	0	0		1245	
9-2008	2008	2006	Cougar	7	Bighorn to Buffalo	32	1660	5,902	0	0	0		2	0		0	0		1245	
			TOTALS				12,175	43,736	0	0	0	0	22	0	0	0	0	0	9,133	0

*These roads do not have curb & gutter

** It is estimated that there are 750 LF of cracks per 1,000 feet of roadway.

3" Asphalt Overlay	0	TONS	@	85.00	-
2" Asphalt Overlay	0	TONS	@	85.00	-
Chip Seal	0	SY	@	3.00	-
Catch Basin	0	EA	@	4,000.00	-
Clean Catch Basin	0	EA	@	150.00	-
Raise Manholes	0	EA	@	200.00	-
Remove & Replace Curb & Gutter	0	LF	@	40.00	-
Complete Reconstruct	0	SY	@	65.00	-
6 FT Wide Milling	0	SY	@	6.50	-
Pothole	0	EA	@	150.00	-
Seal Cracks**	9,133	LF	@	2.00	18,266.00
Skin Patch	0	SY	@	23.00	-
			CONSTRUCTION TOTAL		18,266.00
Contingency				10%	1,826.60
Subtotal					20,092.60
Mobilization, Bonding & Insurance				8%	1,607.41
Traffic Control				4%	803.70
Subtotal					22,503.71
Design & Construction Engineering				18%	4,050.67
PROJECT TOTAL					**26,554.38**

Appendix E

Article on Pavement Preservation from FHWA's *Pavement Preservation Compendium II*

Pavement Preservation Compendium II

SEPTEMBER 2006

U.S. Department of Transportation
Federal Highway Administration

Principles of Pavement Preservation

Definitions, Benefits, Issues, and Barriers

by Larry Galehouse, James S. Moulthrop, and R. Gary Hicks

Americans are accustomed to easy mobility on safe, smooth, and well-maintained roads. These same roads play a critical role in the nation's economy, bolstering agriculture, industry, commerce, and recreation.

During the 1990s, the nation's highways experienced a 29 percent increase in use, and growth is expected in the next 10 years. Large commercial truck traffic increased by nearly 40 percent, with growth projected to continue at more than 3 percent per year during the next 20 years. In addition, more than 95 percent of personal travel is by automobile.

Increasing the capacity of highways, therefore, is important in meeting the nation's needs. But can the United States finance future highway capacity while addressing the needs of the current system? Yes—by developing a strategic plan that includes pavement preservation.

Economical Alternative

Pavement preservation gives highway agencies an economical alternative for addressing pavement needs. Moreover, with pavement preservation, highway agencies gain the ability to improve pavement conditions and extend pavement life and performance without increasing expenditures. The focus is on preserving the pavement asset while maximizing the economic efficiency of the investment. Pavement preservation provides greater value to the highway system and improves the satisfaction of highway users.

Pavement preservation is not about a single treatment, nor is it a one-size-fits-all philosophy. Instead, pavement preservation must be tailored to each highway agency's system needs in the most cost-effective manner. This involves using a variety of treatments and pavement repairs to extend pavement life.

According to the Federal Highway Administration (FHWA), the United States maintains nearly 3.95 million miles of public roads.[1] Table 1 shows highway mileage by agency ownership. The problem facing highway agencies is that many roads are wearing out because of increased traffic, environment effects, and a lack of proper maintenance.

Every highway agency must deal with the effects of regional environments on pavement performance, in addition to the effects of traffic. Pavement sections originally projected to last many years can accumulate distress at an accelerated rate and fail prematurely. Most highway agencies experience and understand this problem but are daunted when budget allocations do not keep pace with the needs of highway pavement upkeep.

Toolbox Approach

In the past, many maintenance practices have not been effective, because they were applied reactively to roads in poor condition instead of proactively to roads still in good condition. Succinctly stated, the correct approach to preventive maintenance is to "place the right treatment on the right road at the right time."

Preservation became a topic in the early 1990s, when highway agencies examined effective mainte-

Table 1. Public highway ownership by miles.

Jurisdiction	Miles (Thousands)	Percentage
Federal	118	3.0
States	775	19.6
Local	3,055	77.4
Total	3,948	100.0

nance practices. The preservation concept—whether for pavements or for bridges—is a departure from traditional approaches, which wait until deficiencies are evident and until reconstruction or major rehabilitation are the only means to correct the problem.

Preservation, however, addresses minor deficiencies early, before the defects become major problems, and extends the life of the asset at a relatively low cost. A strong preservation program is essential to asset management.

Because preservation activities include so many kinds of treatments, agencies should build their own preservation toolboxes to serve their particular needs. Just as a mechanic's toolbox contains many different tools, each designed for a specific job, a preservation toolbox should include a host of treatments to address specific conditions.

No treatment will be suitable for every location. For example, a chip seal may be a long-lasting, cost-effective surface treatment in a rural area, but not in a large urban area. Conversely, concrete ultrathin whitetopping may be cost-effective in a large urban area, but not in a rural area. Similarly, performance and cost-effectiveness should be evaluated in the context of the areas in which the preservation treatments are applied.

Pavement preservation gives highway agencies an economical alternative for addressing pavement needs. Moreover, with pavement preservation, highway agencies gain the ability to improve pavement conditions and extend pavement life and performance without increasing expenditures.

Definition of Terms

A clear presentation of pavement preservation in the United States requires the development and adoption of standard definitions:

Asset Management

FHWA and the American Association of State Highway and Transportation Officials (AASHTO) define asset management as a systematic process of maintaining, upgrading, and operating physical assets cost-effectively.[2] Asset management combines engineering principles with sound business practices and economic theory and provides tools to facilitate an organized, logical approach to decision-making. Asset management provides a framework for both short- and long-range planning.

Asset management is important to state and local governments because of the Governmental Accounting Standards Board's (GASB) Policy Statement 34, "Basic Financial Statements for State and Local Governments," issued in June 1999. GASB 34 encourages government agencies to promote asset management practices and to report the value of capital assets such as utilities, roadways, and other infrastructure.[3]

The value and maintenance of these assets eventually affects the bond ratings of government agencies, which in turn affect the government's ability to borrow the money to repair and replace the investments. The objective of an asset management program, therefore, is to

- Consider various investment strategies,
- Provide a more rational decision process, and
- Improve the overall condition of the highway system at a lower cost.

Preventive Maintenance

According to AASHTO, preventive maintenance is a planned strategy of cost-effective treatments that preserves and maintains or improves a roadway system and its appurtenances and retards deterioration, but without substantially increasing structural capacity.[3] Preventive maintenance is a tool for pavement preservation—nonstructural treatments are applied early in the life of a pavement to prevent deterioration. In other words, preventive maintenance applies the right treatment to the right pavement at the right time.

Pavement Preservation

Pavement preservation is the sum of all the activities to provide and maintain serviceable roadways, including corrective and preventive maintenance, as well as minor rehabilitation. The strategy does not include new pavements or pavements that require major rehabilitation or reconstruction.

A pavement preservation program aims at preserving investment in the pavement network, extending pavement life, enhancing pavement performance, ensuring cost-effectiveness, and reducing user delays. In short, the goal is to meet customer needs.

Reactive Maintenance

Reactive maintenance comprises activities that respond to conditions beyond an agency's control—–activities such as pothole patching, rut filling, or unplugging drainage facilities. Reactive maintenance, therefore, is unscheduled; sometimes immediate response is necessary, to avoid serious consequences.

Emergency Maintenance

Extreme conditions, when life and property are at risk, require emergency maintenance. Examples include washouts, rigid pavement blowups (the shattering or upward buckling of concrete slabs along a joint), and rockslides or earthslides.

Establishing Values

Understanding the costs and benefits of pavement preservation is important because the nation's highway system has matured—that is, the system has begun to deteriorate. Preservation requires a customer-focused program to provide and maintain serviceable roadways cost-effectively, encompassing preventive and corrective maintenance, as well as minor rehabilitation (Figure 1).

The concept is gaining acceptance—initiatives in the business arena also are focusing on asset preservation, like the GASB policy emphasizing the preservation of infrastructure. GASB establishes requirements for the annual financial reports of state and local governments. Since June 1999, GASB 34 has required state and local agencies to provide more specific information in annual financial statements, following the model of the reports by private-sector companies and governmental utilities.

GASB recommends that state, county, and city government agencies apply historical costs to establish values for the transportation infrastructure. Agencies must identify the annual cost of maintaining and preserving the infrastructure assets at—or above—an established condition level. Pavement preservation, therefore, becomes integral to investment decision-making at highway agencies.

Describing the Benefits

The benefits of implementing a pavement preservation program are not immediate and dramatic but accrue over time. Roads that generally are in good condition do not register a major change in condition rating after a treatment is applied—the rating continues as good. What is important, however, is the condition rating several years later—roads that receive preservation treatments are in better condition than those left without treatments.

A comparison of the project life-cycle costs of identical pavement sections with and without treatments illustrates the benefits of pavement preservation. In the example of a traditional alternative, shown in Table 2, a highway is constructed for $508,000 per lane-mile to last 25 years without any

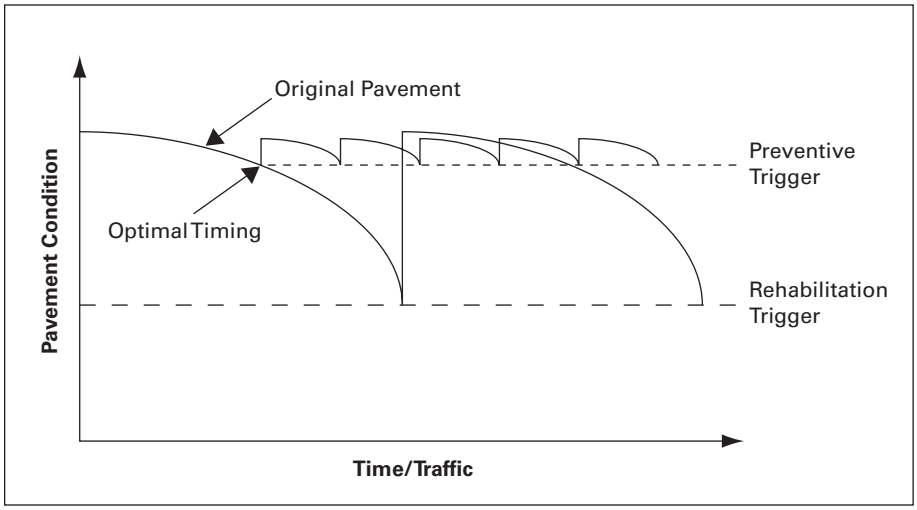

Figure 1. Pavement preservation concept.

Table 2. Traditional alternative: Project life cycle cost.

ACTIVITY	D.I. (Before)	D.I. (After)	AGE	LIFE EXTENDED (Years)	R.S.L. (Years)	COST (Lane-Mile)	COMMENTS
New Construction		0	0		25	$508,000 $ 21,000	Construction cost User cost
Major Construction	51	0	25		25	$490,000 $ 19,000	Construction cost User cost
Total						$998,000 $ 40,000	Construction cost User cost

D.I. = distress index, a measure of pavement condition. Scale values: 0 = no distress, 50 = reconstruction required.
R.S.L. = remaining service life, the remaining time in which a pavement can be preserved.

Table 3. Preservation alternative: Project life cycle cost.

ACTIVITY	D.I. (Before)	D.I. (After)	AGE	LIFE EXTENDED (Years)	R.S.L. (Years)	COST (Lane-Mile)	COMMENTS
New Construction		0	0		25	$508,000 $21,000	Construction cost User cost
First Preservation	11	6	5	2	22	$15,000 $350	Construction cost User cost
Second Preservation	21	0	10	8	25	$39,500 $350	Construction cost User cost
Third Preservation	16	8	14	1	22	$15,000 $350	Construction cost User cost
Fourth Preservation	33	0	20	5	21	$55,500 $700	Construction cost User cost
Fifth Preservation	14	7	25	2	18	$15,000 $350	Construction cost User cost
Total						$648,000 $23,100	Construction cost User cost

D.I. = distress index, a measure of pavement condition. Scale values: 0 = no distress, 50 = reconstruction required.
R.S.L. = remaining service life, the remaining time in which a pavement can be preserved.

preservation activity. After 25 years, the highway must be completely reconstructed at a cost of $490,000 per lane-mile.

In the preservation alternative, shown in Table 3, a highway is constructed with a 25-year design life, also at a cost of $508,000 per lane-mile. After 5 years, the first short-term preservation action is performed for $15,000 per lane-mile, extending the pavement life 2 years. A second preservation is applied 10 years after initial construction—a different treatment that costs $39,500 per lane-mile but that extends the pavement life an additional 8 years. A third preservation is applied in Year 14, a fourth in Year 20, and another in Year 25.

The preservation alternative offers potential savings in construction. In the traditional alternative, the pavement must be completely reconstructed after 25 years at a cost of $490,000 per lane-mile to extend the expected service life another 25 years. In contrast, preservation treatments cost $140,000 per lane-mile over 25 years and extend the expected service life another 18 years. Moreover, if the deterioration rate does not accelerate, pavement preservation can continue for more cycles, assuming that the pavement was designed and constructed properly.

Considering the user costs shown in the tables, additional savings will accrue. As shown in Figure 2, substantial savings can accrue with a well-planned pavement preservation program.

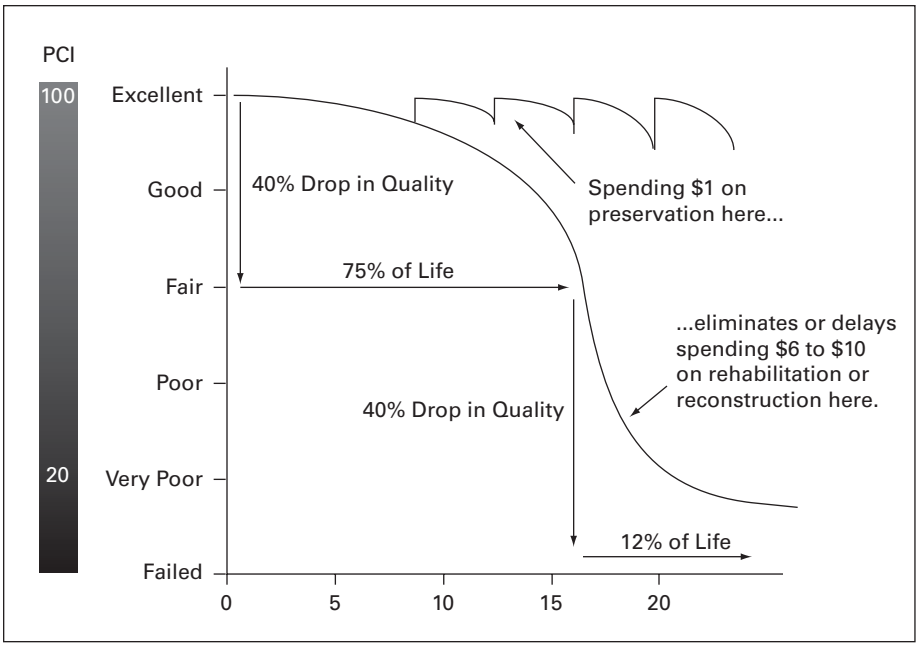

Figure 2. Pavement option curve (example). (PCI = Pavement Condition Index.)

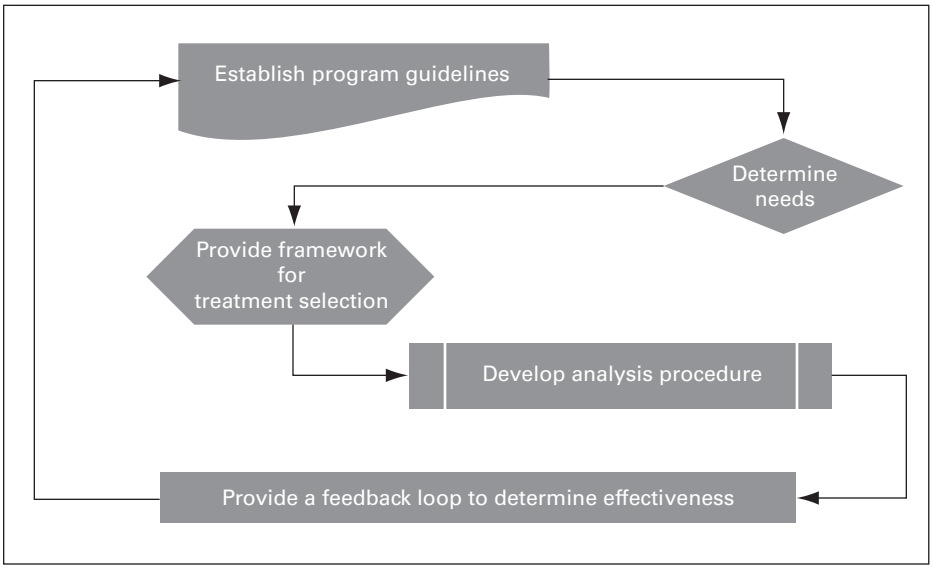

Figure 3. Pavement preservation process.

Essentials for Success

Pavement preservation is not a maintenance program, but an agency program. Almost every part of an agency should be involved. Success depends on support and input from staff in planning, finance, design, construction, materials, and maintenance. Two other essentials for an effective program are long-term commitment from agency leadership and a dedicated annual budget.

Agency personnel must address many critical issues before implementing a pavement preservation program. For example, terminology must be defined clearly and concepts such as cost-effectiveness, optimal timing, and pavement performance should be understood. Integrating pavement management with pavement preservation, to maximize the benefits to the highway network, also is imperative. In addition, agency personnel should be instructed about each preservation treatment and its appropriate use.

After preparing the groundwork, the next step is to tailor a program that meets agency needs. People with a thorough understanding of pavement engineering should develop preservation guidelines that relate to various pavement conditions, the purpose and limitations of each treatment, and the expected performance. The guidelines will assist in treatment selection and program assessment.

A good preservation program should establish continual monitoring to assure effective feedback for improvement of the guidelines. A process model is shown in Figure 3.

Issues and Barriers

Several issues and barriers may arise as an agency develops and implements a pavement preservation program. The issues and barriers, however, vary for each group involved.

Institutional Changes

Some of the issues and barriers from the transportation agency point of view may include the following:

- *Identifying a champion for the program.* Like any new effort or program within an agency, pavement preservation needs a champion. Without a champion to promote the importance and benefits, the new effort will not succeed.
- *Dealing with the paradigm shift from worst-first to best-first.* One of the biggest obstacles is convincing agency personnel to move from the tried-and-true practice of fixing the worst pavement problems first to fixing good pavements while the bad ones continue to deteriorate.
- *Gaining commitment from the top management.* The program's success requires top management commitment. This includes a commitment for dedicated funding and for the resources needed to collect information on the effectiveness of preventive maintenance treatments. Pavement preservation projects will not warrant ribbon-cutting ceremonies—unless the top management recognizes the program's importance.
- *Showing early benefits.* Pavement management systems that can show the early effects of the preventive maintenance treatments on extending life or on reducing life-cycle costs are essential.
- *Selecting the right treatment for the right pavement at the right time.* Failure can result if the correct treatment is not used. For a new program, a single failure can overshadow hundreds of successes. The right treatment must be applied to the pavement in a timely manner.

Marketplace Pressures

The issues and barriers for industry groups mostly involve reluctance to disturb the status quo and include the following:

- *Competition between the suppliers of maintenance and rehabilitation treatments.* With the shift from the traditional rehabilitation programs of pavement overlays applied every 10 to 20 years to pavement preservation programs using new or different treatments, resistance can be expected from the suppliers of traditional rehabilitation materials. For example, hot-mix suppliers will resist new cold-mix treatments because of the likely loss in market share.
- *Competition between various suppliers of maintenance treatments.* When markets have been established for certain types of treatments and a new treatment type is being introduced, industry often works to block the new products, whether for technical reasons or for business reasons, again to avoid loss of market share.
- *Political lobbying to prevent use of new maintenance treatments.* In some cases, industry will rely on political lobbying to prevent new technologies from entering the market. Again the reasons may be technical but more likely are related to the effect on the market if an agency adopts the new technology.
- *Establishing the benefits of new technologies or treatments.* Suppliers often introduce new technologies without adequate evidence of the benefits. The supplier must provide the agency with detailed documentation of the product's benefits and performance.

Convincing the Public

The introduction of preservation programs also affects the traveling public—the ultimate customer—raising a different set of issues and barriers:

- *Understanding the shift from repairing the worst pavements first to the best pavements first.* The public does not understand why agencies would be working on good roads but letting the bad roads deteriorate. Most of the public understands the importance of maintaining a car or a house to prevent major repairs. Pavement preservation engineers should be able to explain the value of preventive maintenance treatments now compared with the cost of major repairs later.
- *Understanding the effects of the various maintenance and rehabilitation strategies on delays and vehicle costs.* Primary benefits of pavement preservation include the potential for reducing traffic delays by using faster repair techniques and for reducing user costs by maintaining pavement networks in better condition. Although widely acclaimed, these benefits still lack the documentation of national studies.
- *Understanding safety issues.* Increased safety for the traveling public and for workers in the work zone are other potential benefits from keeping roads in good condition through pavement preservation treatments; these benefits also need to be documented and communicated.

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4. *Primer: GASB 34.* FHWA-IF-00-010, Office of Asset Management, Federal Highway Administration, U.S. Department of Transportation, November 2000.

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U.S. Department
of Transportation
**Federal Highway
Administration**

**Publication No.
FHWA-IF-06-049**

Appendix F

Storm Drainage Calculations and Information

StormTech®
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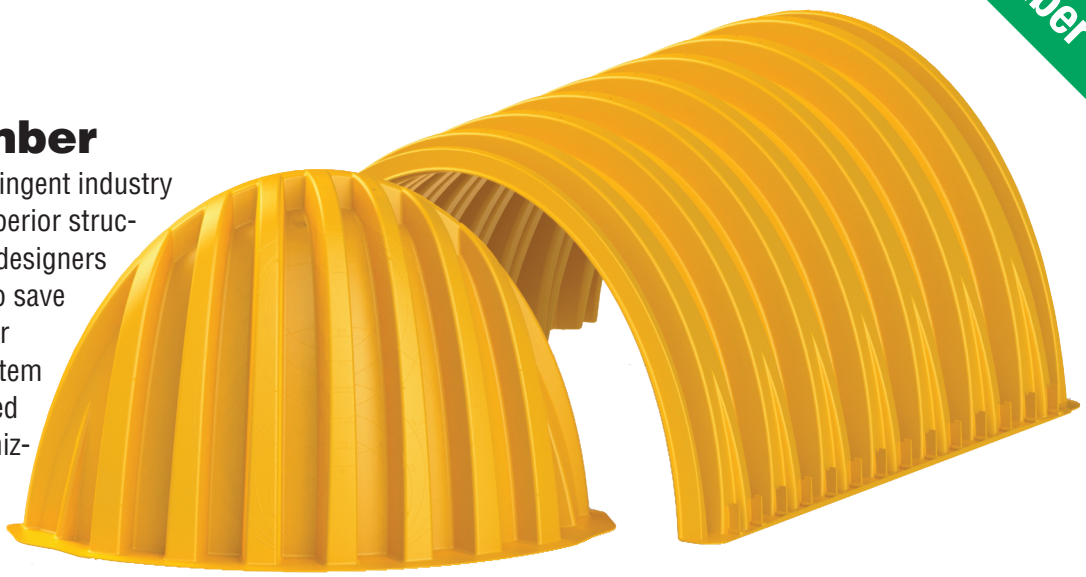
MC-3500 Chamber

StormTech MC-3500 Chamber

Designed to meet the most stringent industry performance standards for superior structural integrity while providing designers with a cost-effective method to save valuable land and protect water resources. The StormTech system is designed primarily to be used under parking lots thus maximizing land usage for commercial and municipal applications.



StormTech MC-3500 Chamber (not to scale)

Nominal Chamber Specifications

Size (L x W x H)	90" (2286 mm) x 77" (1956 mm) x 45" (1143 mm)
Chamber Storage	109.9 ft³ (3.11 m³)
Min. Installed Storage*	178.9 ft³ (5.06 m³)
Weight	134 lbs (60.8 kg)

* This assumes a minimum of 12" (305 mm) of stone above, 9" (229 mm) of stone below chambers, 9" (229 mm) of row spacing, and 40% stone porosity.

StormTech MC-3500 End Cap (not to scale)

Nominal End Cap Specifications

Size (L x W x H)	25.7" (653 mm) x 75" (1905 mm) x 45" (1143 mm)
End Cap Storage	14.9 ft³ (0.42 m³)
Min. Installed Storage*	46.0 ft³ (1.30 m³)
Weight	49 lbs (22.2 kg)

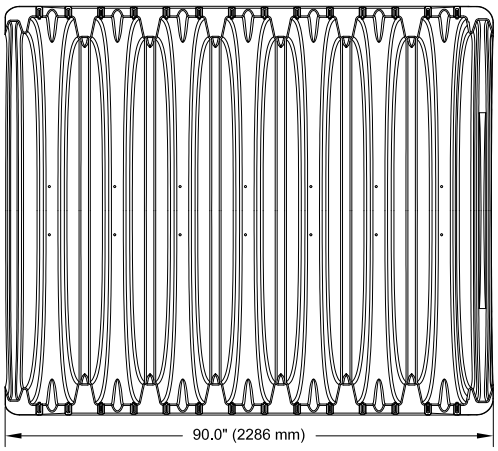
* This assumes a minimum of 12" (305mm) of stone above, 9" (229 mm) of stone below, 9" (229 mm) row spacing, 6" (152 mm) of stone perimeter, and 40% stone porosity.

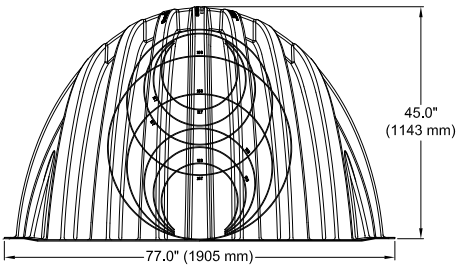
Shipping

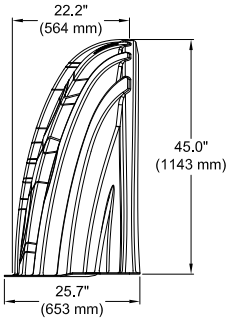
15 chambers/pallet

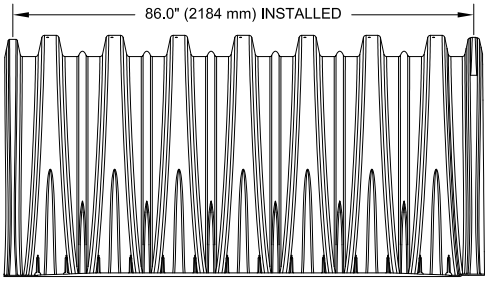
7 end caps/pallet

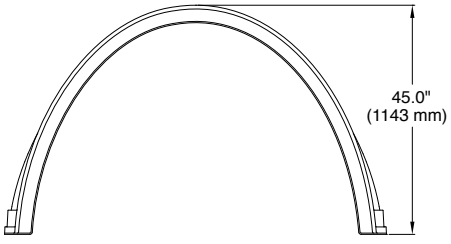
7 pallets/truck











Storage Volume Per Chamber/End Cap ft³ (m³)

	Bare Unit Storage	Chamber/End Cap and Stone Volume — Stone Foundation Depth in. (mm)			
	ft³ (m³)	9 (229)	12 (305)	15 (381)	18 (457)
MC-3500 Chamber	109.9 (3.11)	178.9 (5.06)	184.0 (5.21)	189.2 (5.36)	194.3 (5.5)
MC-3500 End Cap	14.9 (0.42)	46.0 (1.33)	47.7 (1.35)	49.4 (1.40)	51.1 (1.45)

NOTE: Assumes 40% porosity for the stone plus the chamber/end cap volume. End Cap volume assumes 6" (152mm) stone perimeter.

Volume of Excavation Per Chamber/End Cap in yd³ (m³)

	Stone Foundation Depth in. (mm)			
	9 (229)	12 (305)	15 (381)	18 (457)
MC-3500	12.4 (9.5)	12.8 (9.8)	13.3 (10.2)	13.8 (10.5)
End Cap	4.1 (3.1)	4.2 (3.2)	4.4 (3.3)	4.5 (3.5)

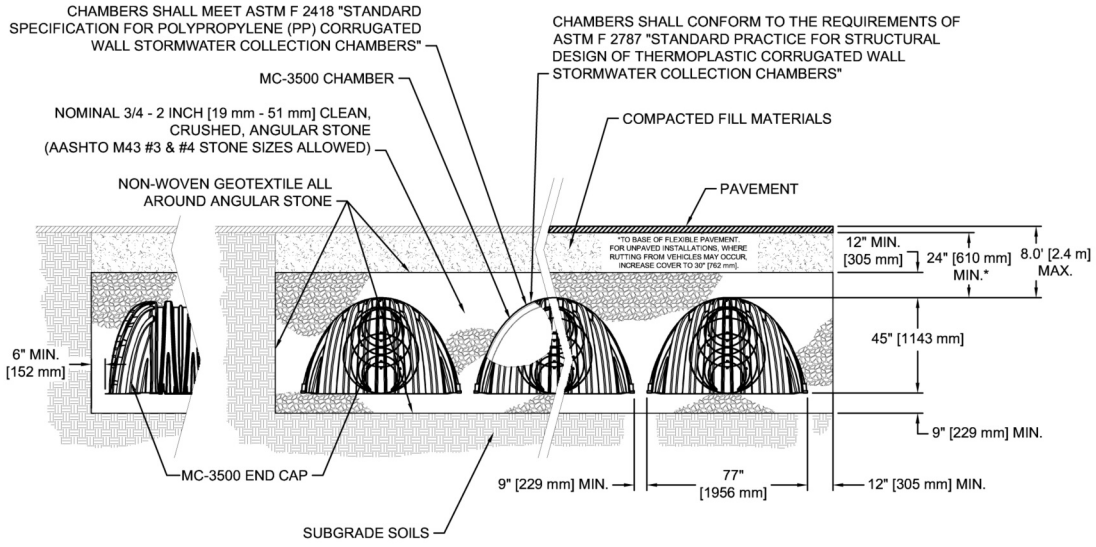
NOTE: Assumes 9" (229 mm) of separation between chamber rows, 6" (152 mm) of perimeter in front of end caps, and 24" (610 mm) of cover. The volume of excavation will vary as depth of cover increases.

Amount of Stone Per Chamber

ENGLISH tons (yd³)	Stone Foundation Depth			
	9 in.	12 in.	15 in.	18 in.
MC-3500	9.1 (6.4)	9.7 (6.9)	10.4 (7.3)	11.1 (7.8)
End Cap	4.1 (2.9)	4.3 (3.0)	4.5 (3.2)	4.7 (3.3)
METRIC kg (m³)	**229 mm**	**305 mm**	**381 mm**	**457 mm**
MC-3500	8220 (4.9)	8831 (5.3)	9443 (5.6)	10054 (6.0)
End Cap	3699 (2.2)	3900 (2.3)	4100 (2.4)	4301 (2.6)

NOTE: Assumes 12" (305 mm) of stone above, and 9" (229 mm) row spacing, and 6" (152mm) of perimeter stone in front of end caps.

General Cross Section



NOTES:
1. THIS CROSS SECTION PROVIDES GENERAL INFORMATION FOR THE MC-3500 CHAMBER. STORMTECH MC-3500 CHAMBERS MUST BE DESIGNED AND INSTALLED IN ACCORDANCE WITH THE MC-3500 DESIGN MANUAL AND MC-3500 CONSTRUCTION GUIDE.
2. PROPERLY INSTALLED MC-3500 CHAMBERS PROVIDE THE LOAD FACTORS SPECIFIED IN THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS FOR EARTH AND LIVE LOADS WITH CONSIDERATION FOR IMPACT AND MULTIPLE PRESENCES.
3. PERIMETER STONE MUST ALWAYS BE BROUGHT UP EVENLY WITH BACKFILL OF BED. PERIMETER STONE MUST EXTEND HORIZONTALLY TO THE EXCAVATION WALL FOR BOTH STRAIGHT OR SLOPED SIDEWALLS.

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Stormwater Storage Calculations

Average Lot Size (including ½ of ROW) = 130' x 100' = 13,000 SF = 0.30 Acres
Average Soil Group = B (USDA – Web Soil Survey)
Average Curve Number = 75 (Table 2-2a, ¼ Acre Lot, ARC II Condition, TR-55 Drainage Manual)

Storage per Lot (10 Year Storm Event – SCS Method, TR-55 Drainage Manual)

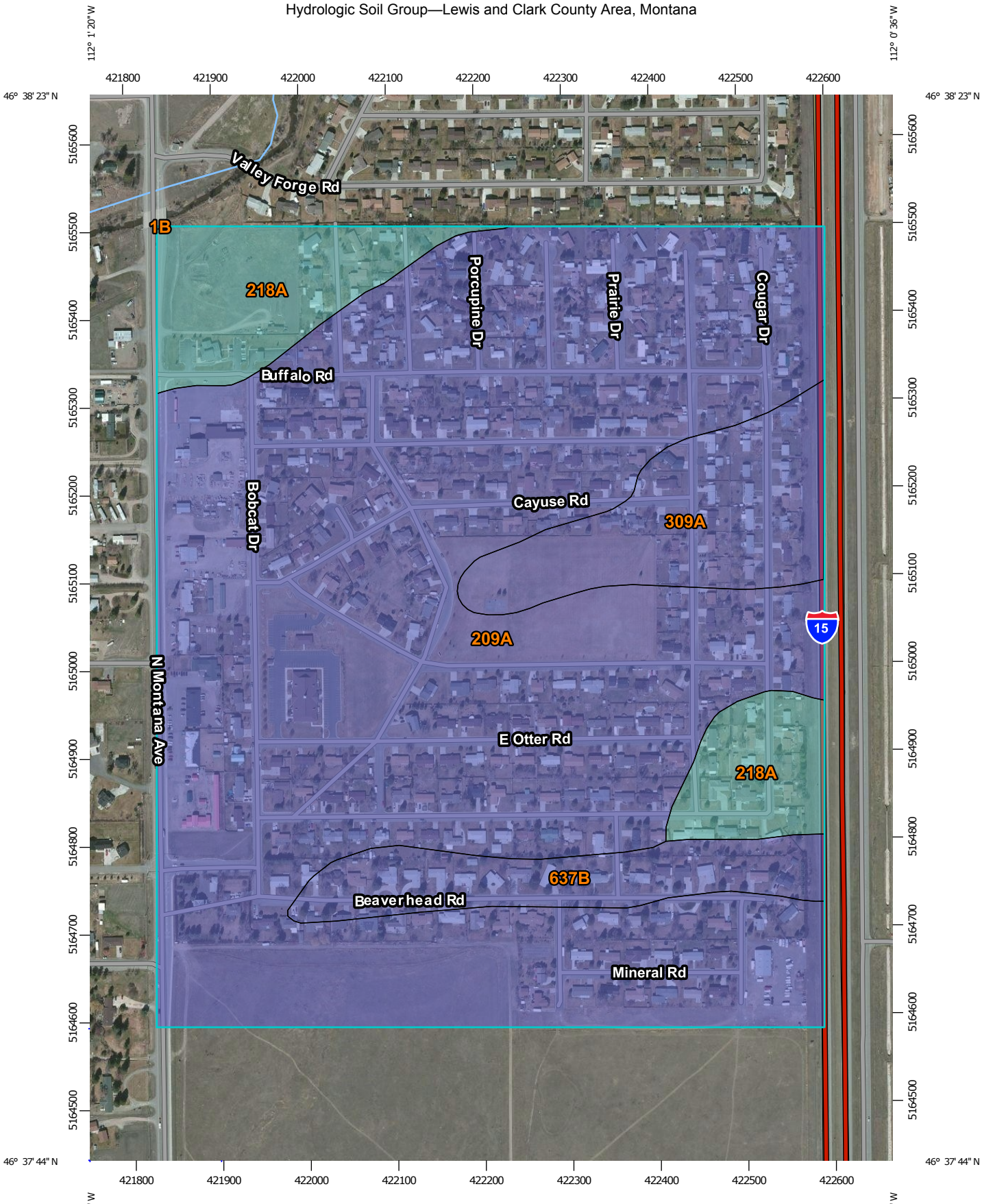
S = (1000/CN)-10 = (1000/75)-10 = 3.333
P = 1.9 Inches (10 year, 24 hour storm event for Helena, MT)
Q (runoff) = $\{P-0.2(S)\}^2/\{P+0.8(S)\}$ = $\{1.9-0.2(3.333)\}^2/\{1.9+0.8(3.333)\}$ = 0.334 In = 0.0278 Ft
V = QA = 0.0278 x 13,000 = **361 Ft^3/Lot**

Storage per Lot (2 Year Storm Event – SCS Method, TR-55 Drainage Manual)

S = (1000/CN)-10 = (1000/75)-10 = 3.333
P = 1.3 Inches (2 year, 24 hour storm event for Helena, MT)
Q (runoff) = $\{P-0.2(S)\}^2/\{P+0.8(S)\}$ = $\{1.3-0.2(3.333)\}^2/\{1.3+0.8(3.333)\}$ = 0.101 In = 0.0084 Ft
V = QA = 0.0084 x 13,000 = **109 Ft^3/Lot**

Storage – Subsurface Chambers (StormTech MC-3500 Chambers)

Size (L x W x H) = 90" x 77" x 45"
Stone Foundation Depth = 9 Inches
Volume per Chamber = 178.9 Ft^3
Volume per Foot of Chamber = 178.9 Ft^3 / (90"/12) = 23.85 Ft^3/Ft
Feet of Chamber per Lot (10 Year Storm) = (361 Ft^3/Lot) / (23.85 Ft^3/Ft) = **15.1 Ft/Lot**
Feet of Chamber per Lot (2 Year Storm) = (109 Ft^3/Lot) / (23.85 Ft^3/Ft) = **4.6 Ft/Lot**



Map Scale: 1:5,910 if printed on A portrait (8.5" x 11") sheet.

N

Meters
0 50 100 200 300

Feet
0 250 500 1000 1500

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Lewis and Clark County Area, Montana
Survey Area Data: Version 10, Sep 3, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Data not available.

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Lewis and Clark County Area, Montana (MT630)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
1B	Aridic Ustifluvents, channeled, 0 to 4 percent slopes	B	0.0	0.0%
209A	Thess loam, 0 to 2 percent slopes	B	133.2	77.1%
218A	Meadowcreek-Fairway complex, 0 to 2 percent slopes	C	16.1	9.3%
309A	Thess-Scravo complex, 0 to 2 percent slopes	B	13.8	8.0%
637B	Crago gravelly loam, 0 to 8 percent slopes	B	9.6	5.6%
Totals for Area of Interest			**172.7**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher