Sewall
The evolution of expertise

Gravel Roads Review

TOWN OF APPLETON

June 5, 2023

A TFIC Company
77 Exchange Street · Suite 401 · Bangor, Maine 04401 · +1 207.827.4456 · sewall.com · info@sewall.com

1. INTRODUCTION

James W. Sewall Company (Sewall) is pleased to submit this gravel roadway evaluation to the Town of Appleton. On Monday, April 17th, 2023 Sewall engineer's visually assessed the following roadways condition, culvert crossing sizes/locations, and noted areas of concern:

1. Appleton Ridge Road
2. Guini Ridge Road
3. Collinstown Road
4. Peabody Road
5. Magog Road
6. Jones Hill Road

The findings of Sewall's visual assessment is documented within this report. Figure 1 below illustrates the sections of roadway visually assessed on an aerial map. Additionally, the .kmz file with field notes and geospatial positioning data is provided with this report.

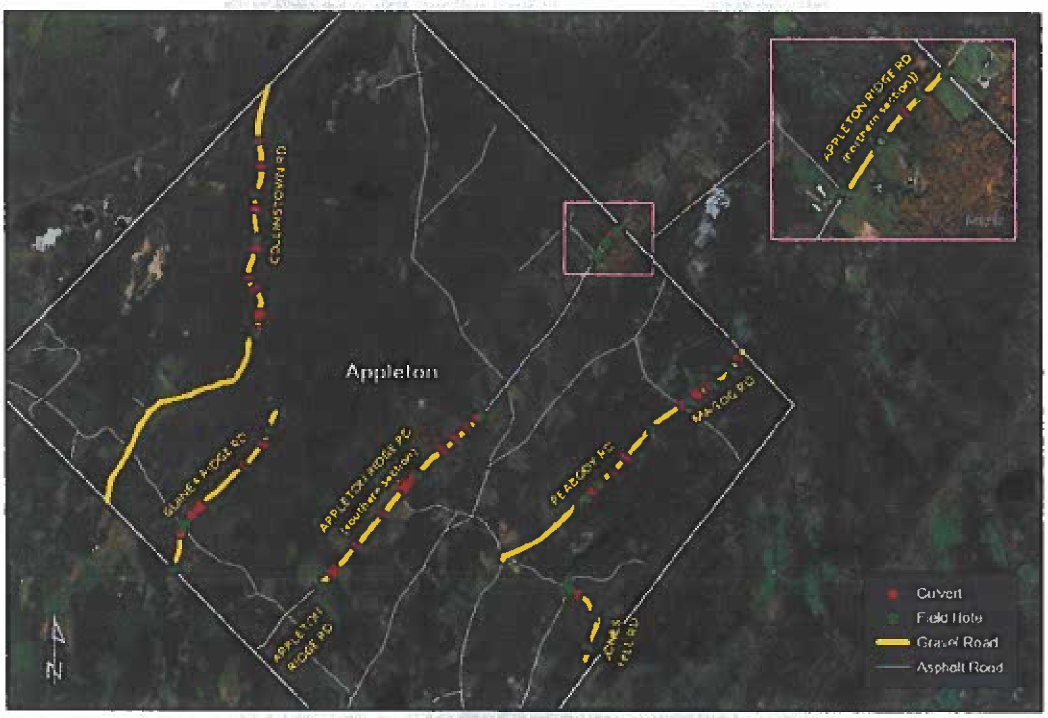


Figure 1 – Study area

2. APPLETON RIDGE ROAD - NORTH

The following section documents the condition of the northerly gravel portion of Appleton Ridge Road, as was present on Monday, April 17, 2023. Please note that no subsurface exploration was performed, only a visual assessment.

2.1. GENERAL CONDITION

There are two sections of gravel surface on Appleton Ridge Road, separated by a paved segment. The northernmost gravel segment that terminates at the town line is approximately 1,900' in length and 22' wide. The overall condition of the road was good with the following recommended improvements noted:

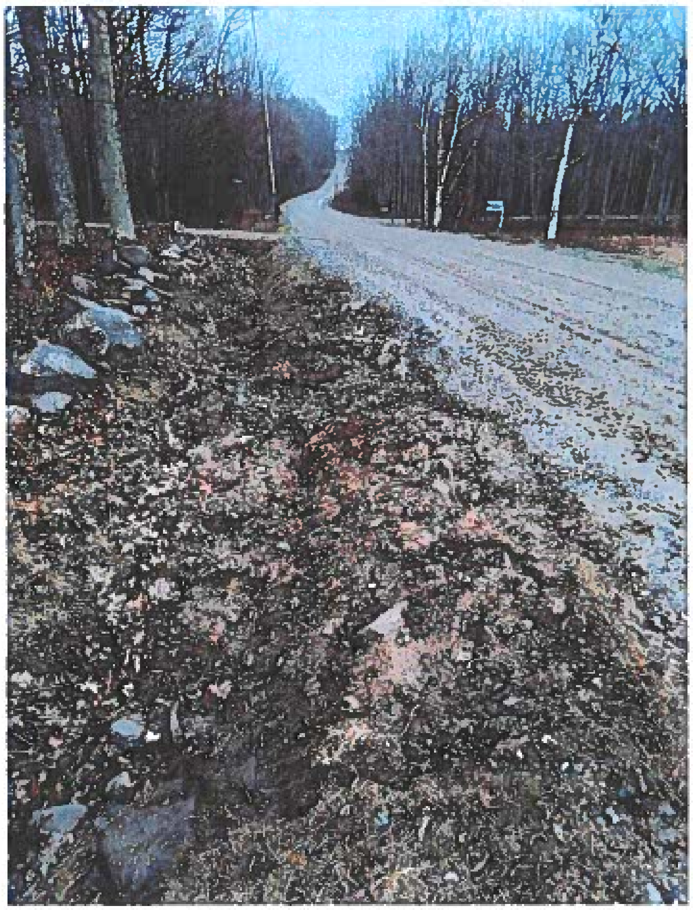
- There is a "false ditch" on the southeast side of the roadway preventing the water from draining off the roadway surface. This berm should be removed to allow for proper drainage and to reduce the likelihood of erosion. The location of the berm is approximately 400' south of the town line. The issue is present for 170' between utility pole #47 for the length of the hill to the field located at the town line.

Picture 1 – False Ditch on southern side of roadway

- Approximately 65' north of Blackberry Lane, ditching is required on the western side of the road for a length of 125' to promote proper drainage.

Picture 2 – Ditching Required

- Erosion is occurring within the ditch line located on the western side of the road approximately 100' south of Blackberry Lane. The section noted was measured to be 22' wide x 40' long. The ditch cross section should be restored and stabilized with erosion control mesh or potentially riprap to prevent future erosion.



Picture 3– Stabilization Required

2.2. DRAINAGE STRUCTURES

No culvert crossing locations were identified for this stretch of roadway.

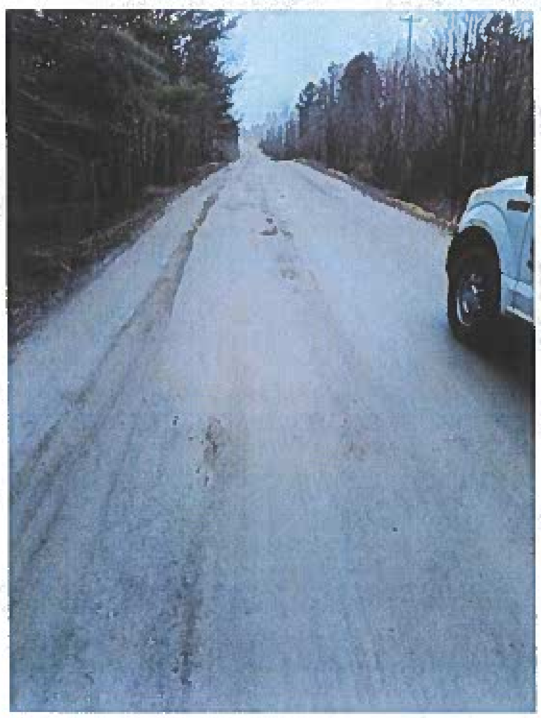
3. APPLETON RIDGE ROAD - SOUTH

The following section documents the condition of the southerly gravel portion of Appleton Ridge Road, as was present on Monday, April 17, 2023. Please note that no subsurface exploration was performed, only a visual assessment.

3.1. GENERAL CONDITION

The southernmost gravel segment of Appleton Ridge Road begins approximately 2,000' south of W Appleton Road and is approximately 12,000' in length and 22' -25' wide. The overall condition of the road was good with the following recommended improvements noted:

- Approximately 1,500' north of Town Hill Road an area of poor draining roadway was located. The area is 250' x 22' in size. The recommended repair is to remove the existing aggregate to a depth of 18" and rebuild with 12" of Maine Department of Transportation (MaineDOT) Type D subbase gravel and top with 6" of MaineDOT Type A base gravel. A reinforcement/separation geotextile should be considered as an underlayment to the gravel depending on subgrade conditions.



Picture 4 – Insufficient roadway surface and/or poor roadway aggregate

3.2. DRAINAGE STRUCTURES

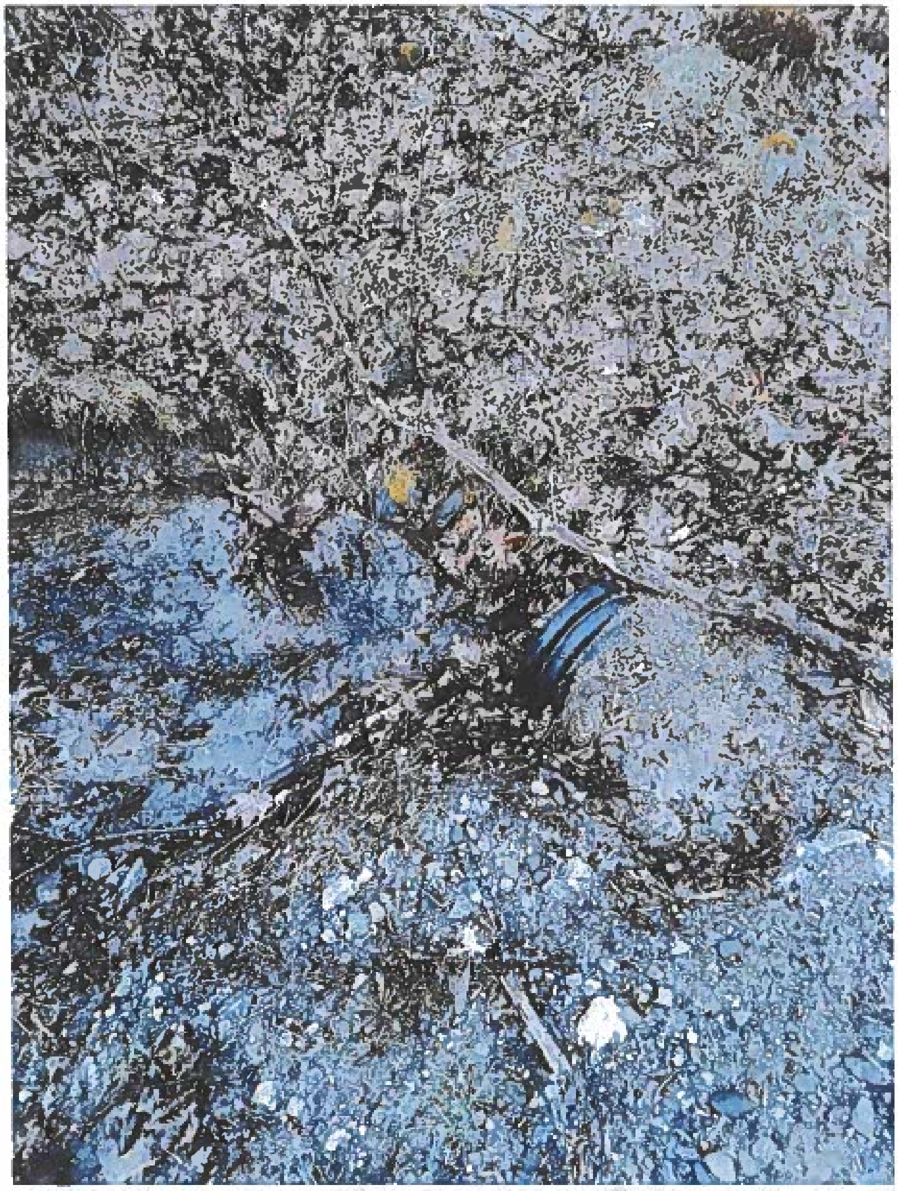
Sixteen culvert crossings were identified on this roadway. Of these (9) were measured to be 15", (3) were measured to be 18", (3) were measured to be 24" and (1) could not be measured. Materials were either corrugated metal (CMP) or high-density polyethylene (HDP). Nine of the structures require some repair or maintenance. Please note that it is advisable to provide riprap aprons on culvert inlets/outlets for all town way cross-culverts.

- Approximately 35' south of the beginning of gravel is an 18" CMP culvert with insufficient cover. A new culvert should be installed to a minimum of 2' of cover (preferred) and the surrounding area should be ditched and a rip rap aprons installed at the inlet/outlet.

Picture 5 – 18" CMP Culvert

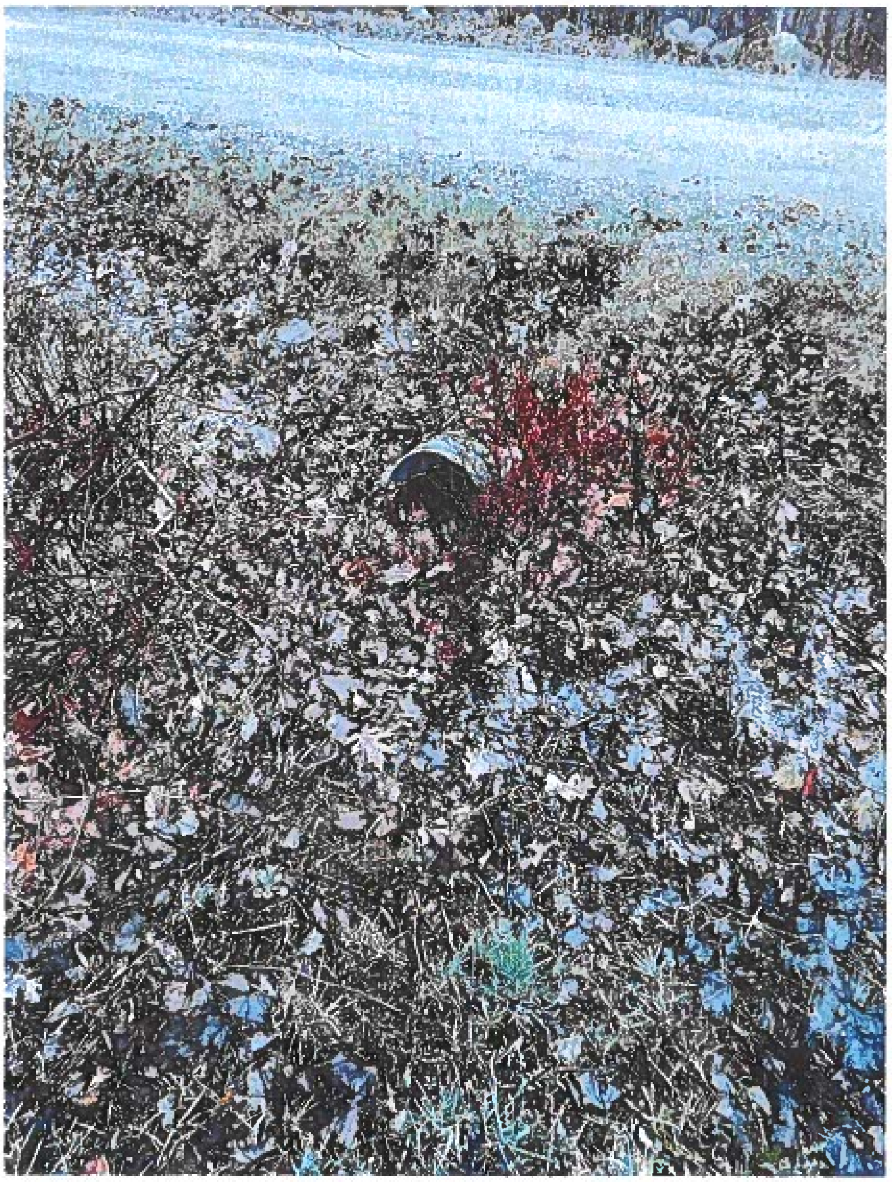
Sewall
The evolution of expertise

- Approximately 380' south of the beginning of gravel is a 15" HDP culvert in good condition. Both ends should be armored with rip rap to prevent additional erosion.



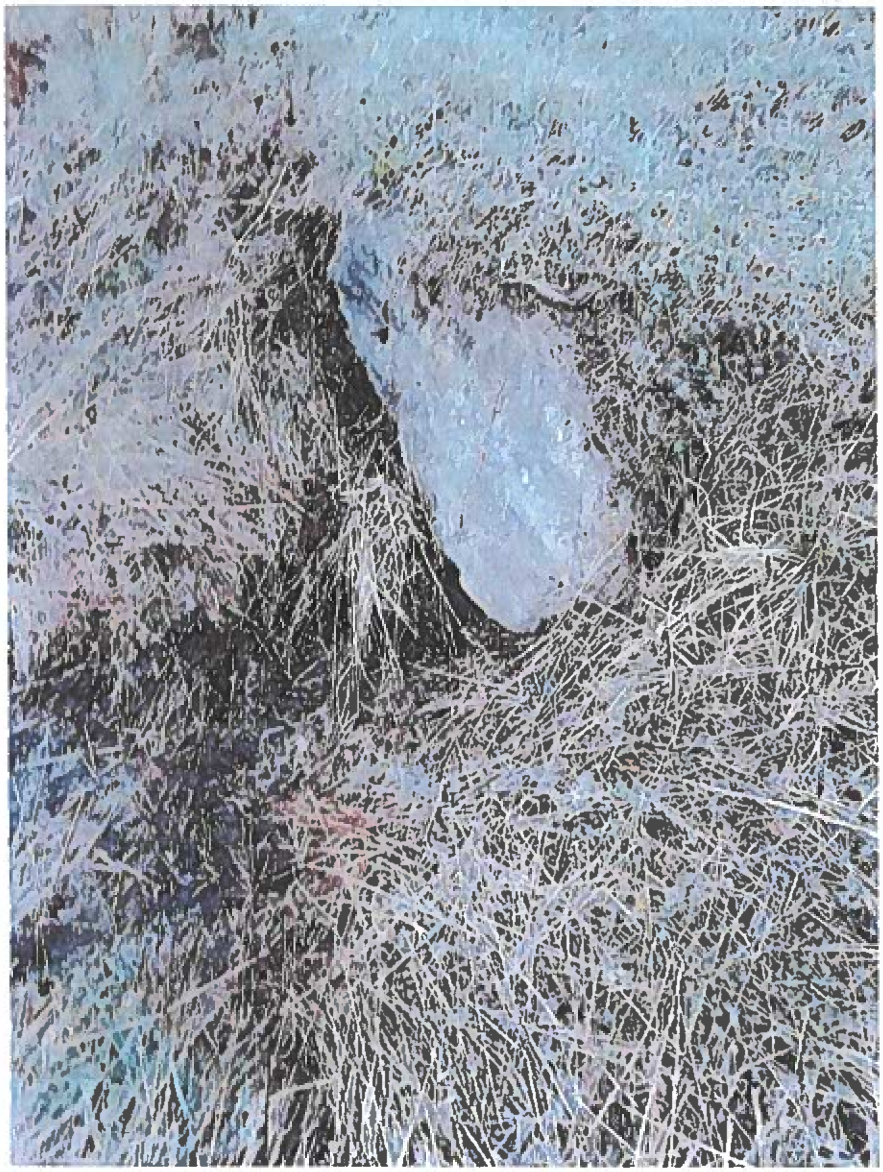
Picture 6 – 15" HDP Culvert

- Approximately 1,050' south of the beginning of gravel is a 15" CMP culvert in poor condition. The existing structure should be removed and replaced with a longer HDPE culvert. Armor inlet/outlet with riprap apron.



Picture 7 – 15" CMP Culvert

- Approximately 2,725' south of the beginning of gravel is an 18" CMP culvert in poor condition. The existing structure should be removed and replaced with an HDPE culvert and armored inlet and outlet.

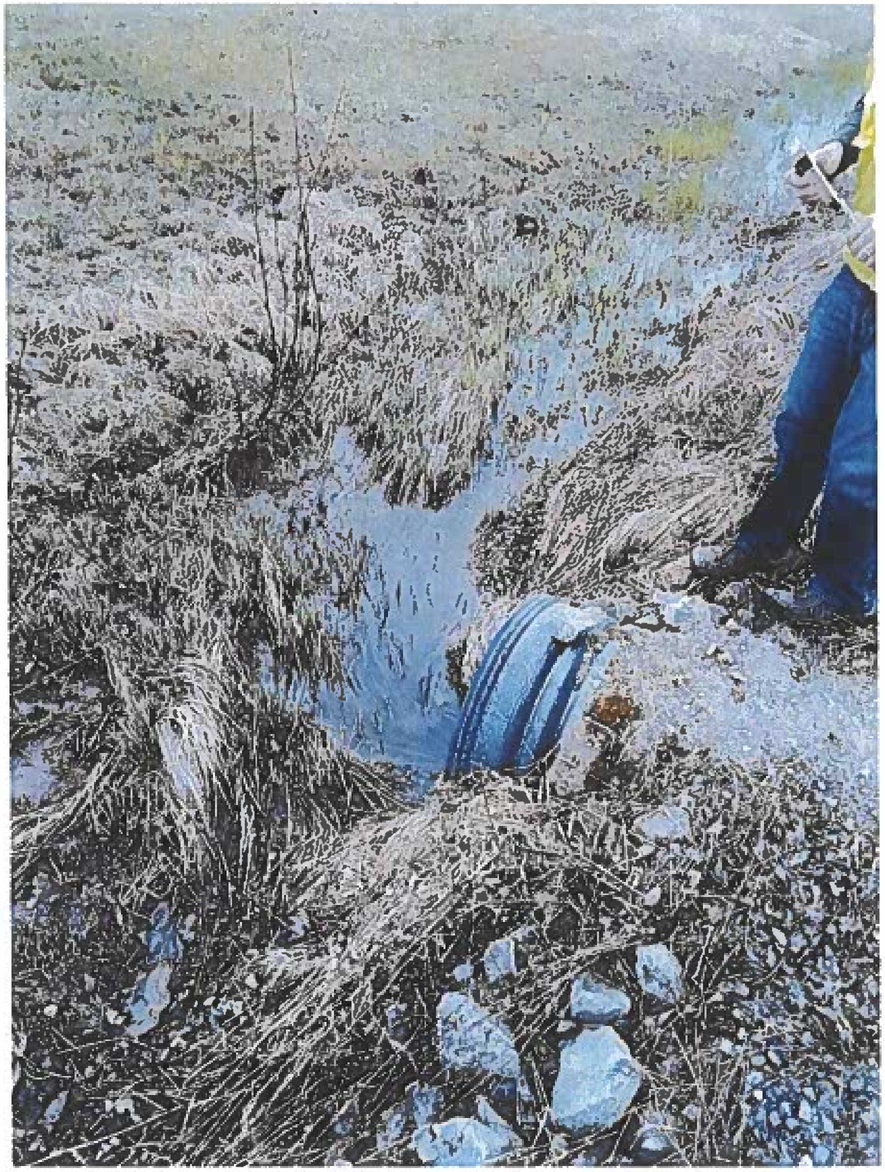


Picture 8 – 15" CMP Culvert

- Approximately 1,475' north of Town Hill Road is a CMP culvert in poor condition. The existing structure should be removed and replaced with a longer HDP culvert and armored inlet/outlet.

Picture 9 – CMP Culvert

- Approximately 1,215' south of Town Hill Road is a 24" HDP culvert in good condition. The amount of cover is limited; MaineDOT Type A aggregate should be added onto the roadway surface to provide additional cover.



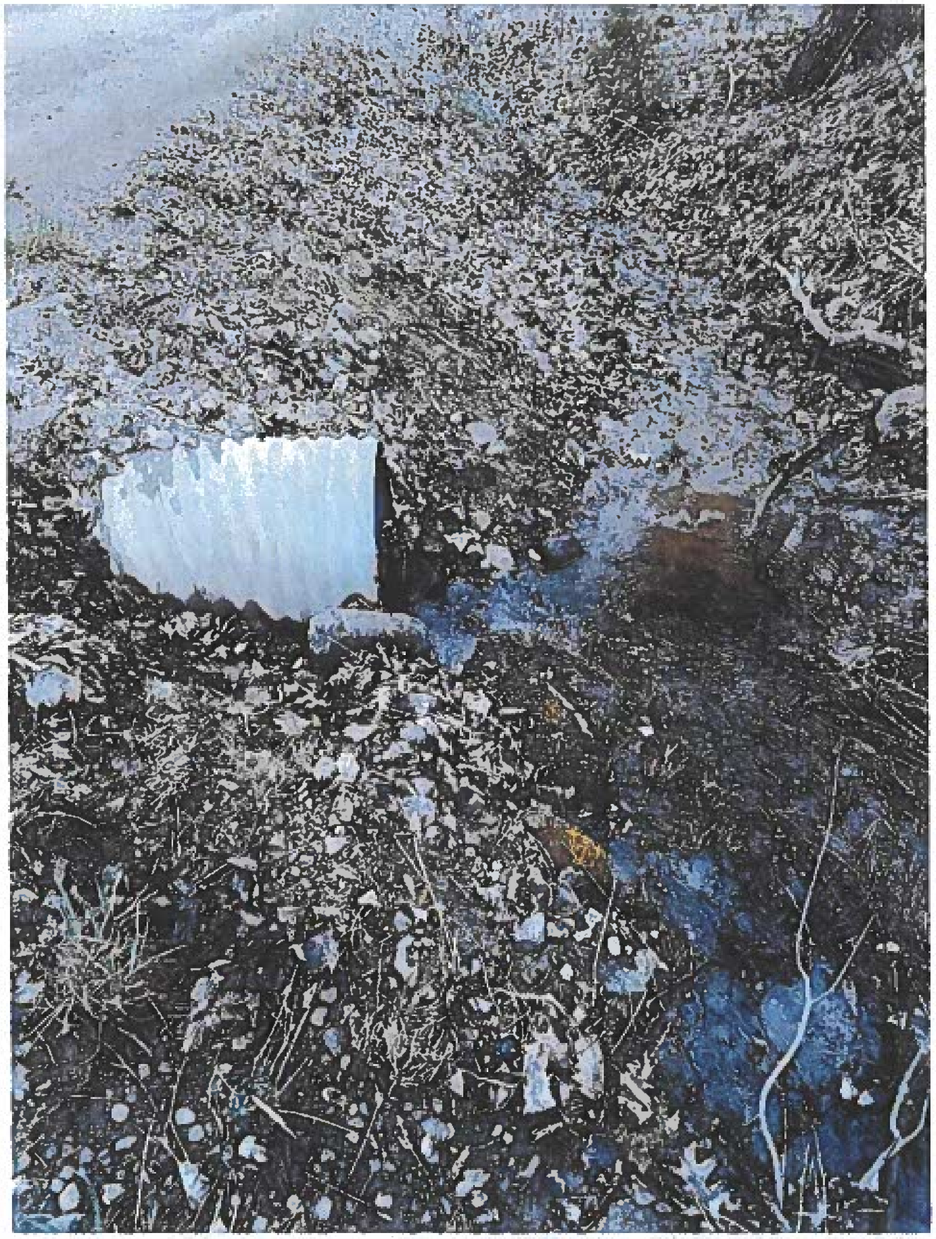
Picture 10 – 24" HDP Culvert

- Approximately 3,380' south of Town Hill Road is a 24" HDPE culvert in good condition. The culvert is plugged and needs to be cleaned out.

Picture 11 – 24" HDP Culvert

Sewall
The evolution of expertise

- Approximately 1,125' north of the change to gravel is a 24" CMP culvert in poor condition. The culvert should be removed and replaced with inlet/outlet riprap aprons.



Picture 12 – 24" HDP Culvert

- Approximately 825' north of the change to gravel is a 15" CMP culvert in good condition. The amount of cover is limited; MaineDOT Type A aggregate should be added onto the roadway surface to provide additional cover.

Picture 13 – 24" HDP Culvert

4. GUINEA RIDGE ROAD

The following section documents the condition of Guinea Ridge Road, as was present on Monday, April 17, 2023. Please note that no subsurface exploration was performed, only a visual assessment.

4.1. GENERAL CONDITION

There are two sections of Guinea Ridge Road, separated by the intersection with Route 105. The southern segment is approximately 2,200' in length and 21' -22' wide. The northern segment is approximately 7,550' in length and 16' wide. The overall condition of the road is poor. Generally, the road requires widening, ditching, additional and/or replaced aggregate material and tree trimming.

4.2. DRAINAGE STRUCTURES

Seven culvert crossings were identified on this roadway. Of these (3) were measured to be 15", (3) were measured to be 18" and (1) was measured to be 24". Materials were either corrugated metal (CMP) or high-density polyethylene (HDPE). Two of the structures require some repair or maintenance:

- Approximately 375' south of the intersection with Route 105 is a 15" CMP culvert in poor condition. The culvert should be removed and replaced with an HDPE culvert with inlet/outlet riprap aprons.

- Approximately 4,380' north of the intersection with Route 105 is a 18" CMP culvert in poor condition. The culvert should be removed and replaced with an HDPE culvert with inlet/outlet riprap aprons.

5. COLLINSTOWN ROAD

The following section documents the condition of Collinstown Road, as was present on Monday, April 17, 2023. Please note that no subsurface exploration was performed, only a visual assessment.

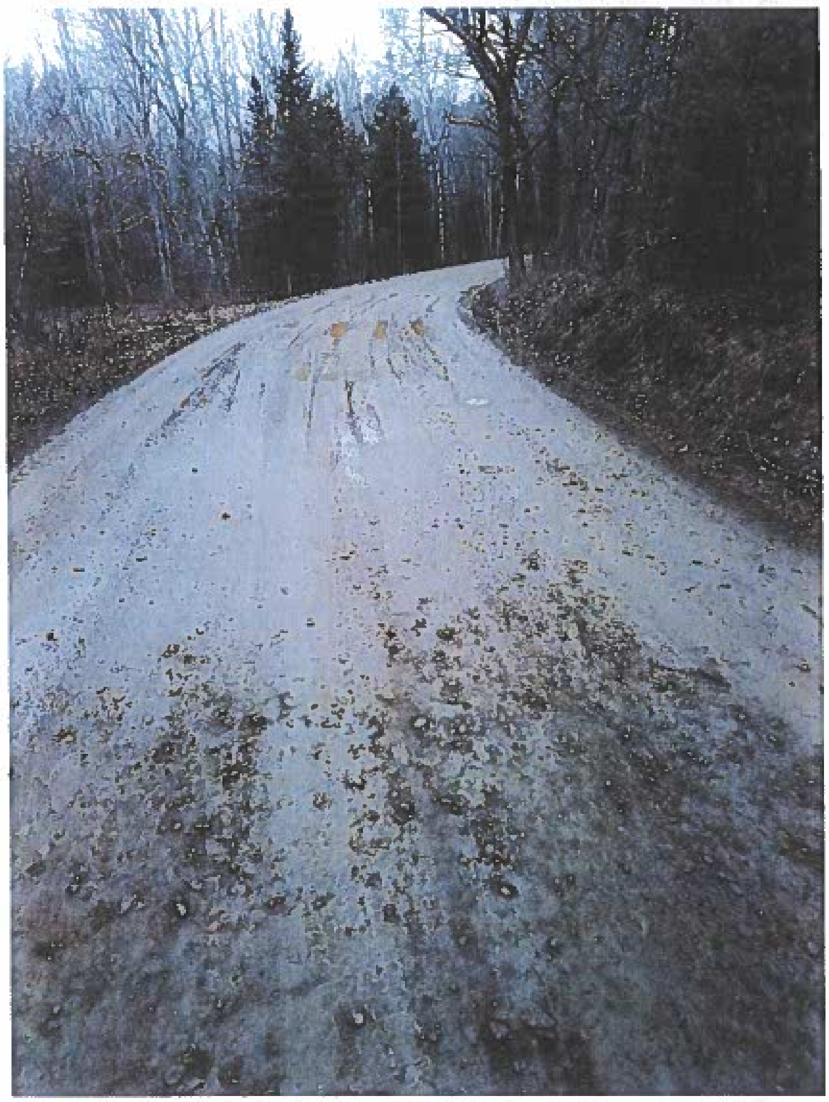
5.1. GENERAL CONDITION

There gravel segment of Collinstown Road begins approximately 9,650' north of Route 105 and extends approximately 13,000' to the town line. The width is generally 22'. The overall condition of the road was good with the following recommended improvements noted:

- Approximately 150' north of Spur Lane add an 18" HDPE culvert with a minimum of 2' (preferred) of aggregate cover with inlet/outlet riprap aprons.

Picture 14 – Proposed Culvert location – north and south view from the low point

- Approximately 4,150' south of the power line right of way an area of poor draining roadway was located. The area is 175' x 18' in size. The recommended repair is to remove the existing aggregate to a depth of 18" and rebuild with 12" of MaineDOT Type D subbase gravel and top with 6" of MaineDOT Type A base gravel. A reinforcement/separation geotextile should be considered as an underlayment to the gravel depending on subgrade conditions. Additionally, a culvert should be added in the low point near this area and the ditch needs to be reshaped.



Picture 15 – Insufficient roadway surface and/or poor roadway aggregate

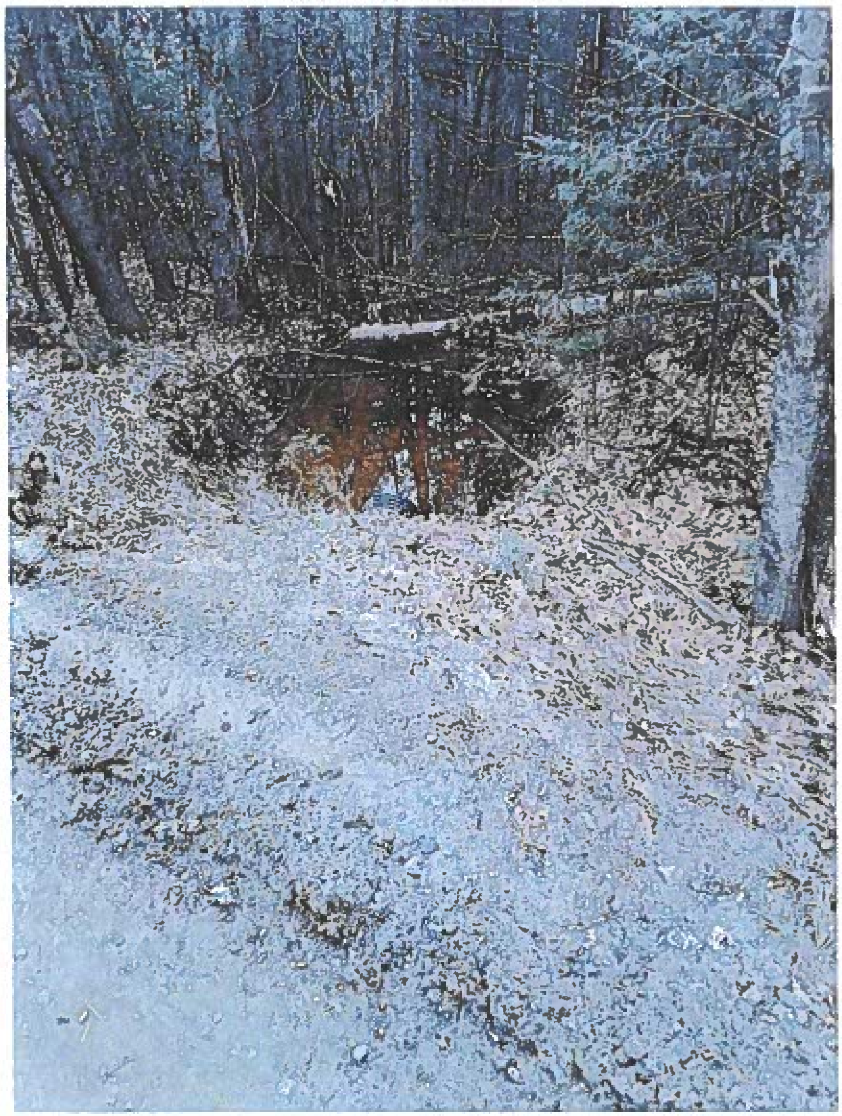
5.2. DRAINAGE STRUCTURES

Nine culvert crossings were identified on this roadway. Of these (6) were measured to be 15", (2) were measured to be 18", (1) was measured to be 64". Materials were either corrugated metal (CMP) or high-density polyethylene (HDPE). Four of the structures require some repair or maintenance:

- Approximately 225' north of the beginning of gravel is a 15" CMP culvert in poor condition. The culvert should be replaced with inlet/outlet riprap aprons.

Picture 16 – 15" CMP Culvert

- Approximately 2,370' north of the beginning of gravel is an 18" HDP culvert in good condition. The inlet of the culvert is blocked with debris and requires cleaning.

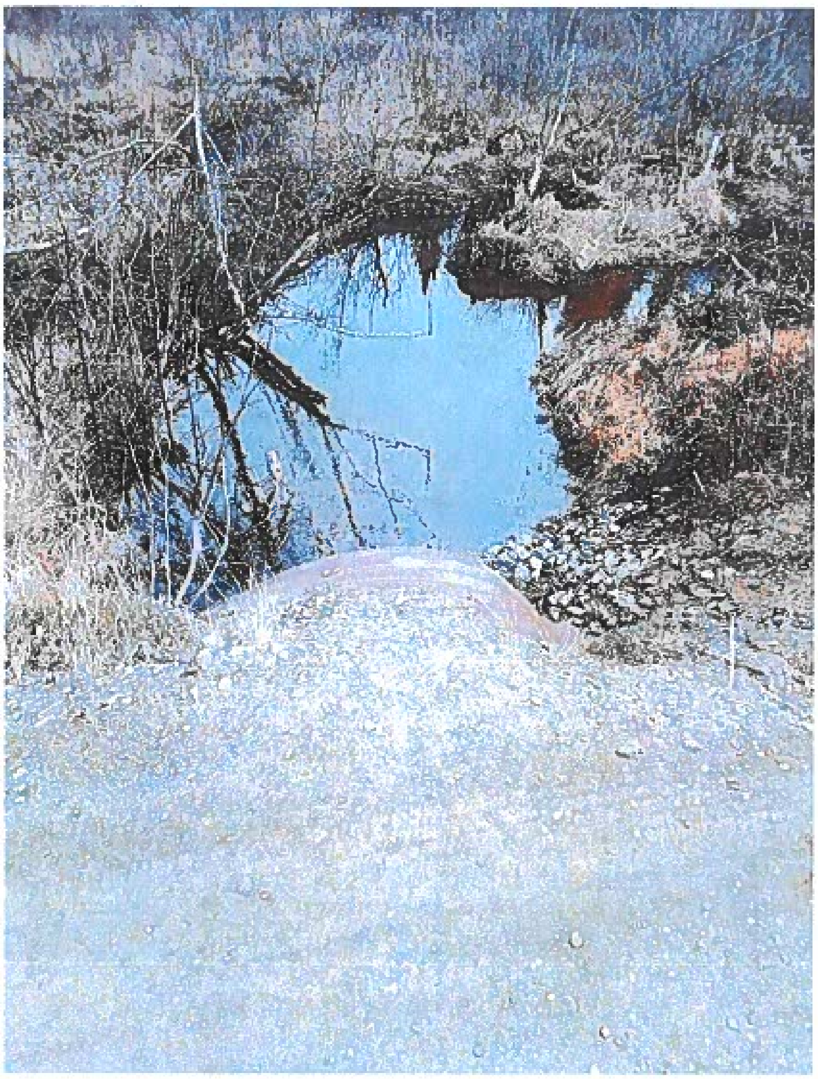


Picture 17 – 18" HDP Culvert

- Approximately 1,670' north of Spur Lane is an 15" CMP culvert in poor condition that requires replacement.

No Picture Available

- The 64" structure at Harriet Brook is in poor condition with minimal cover and should be replaced with an open bottom structure.



Picture 18 – 64" CMP Culvert

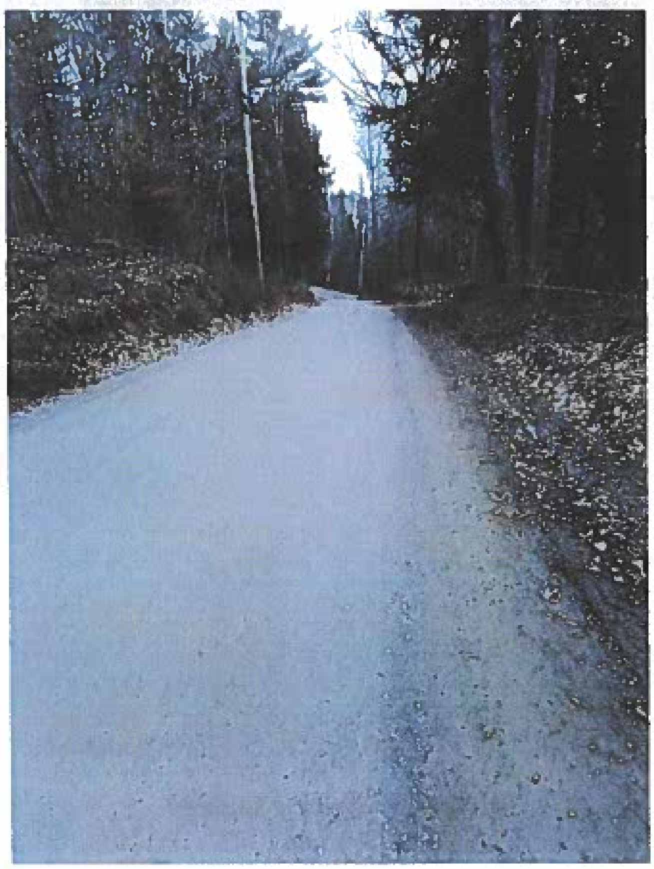
6. PEABODY ROAD

The following section documents the condition of Peabody Road, as was present on Monday, April 17, 2023. Please note that no subsurface exploration was performed, only a visual assessment.

6.1. GENERAL CONDITION

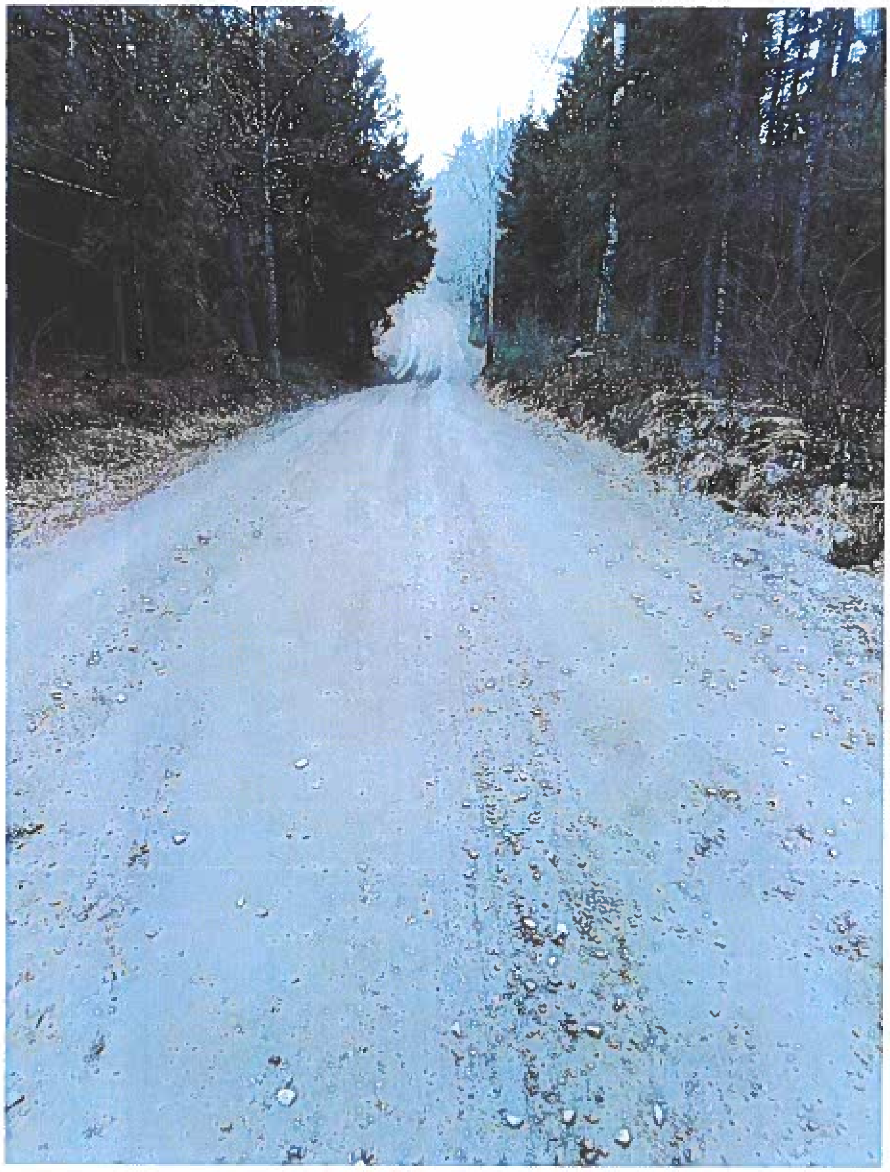
The gravel segment of Peabody Road begins approximately 4,700' north of Sleepy Hollow Road and ends approximately 1,900' south of Route 105. The width is generally 22'. The overall condition of the road was good with the following recommended improvements noted:

- Approximately 475' north of where the gravel roadway begins an area requiring ditching is present on both sides of the roadway for approximately 350'. Tree removal and trimming is required to accommodate the ditching and will further assist the road with sunlight exposure for melting and drying.



Picture 19 – Ditching Required

- Approximately 1,425' north of where the gravel roadway begins an area requiring ditching is present on both sides of the roadway for approximately 200'.

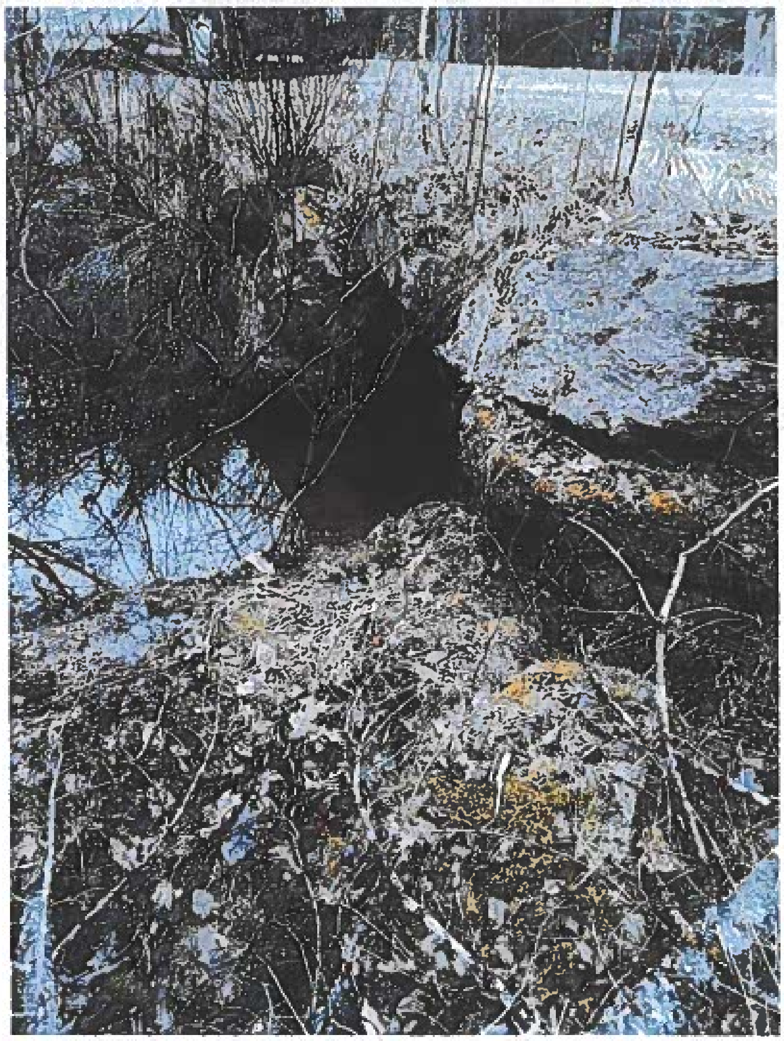


Picture 20 – Ditching Required

6.2. DRAINAGE STRUCTURES

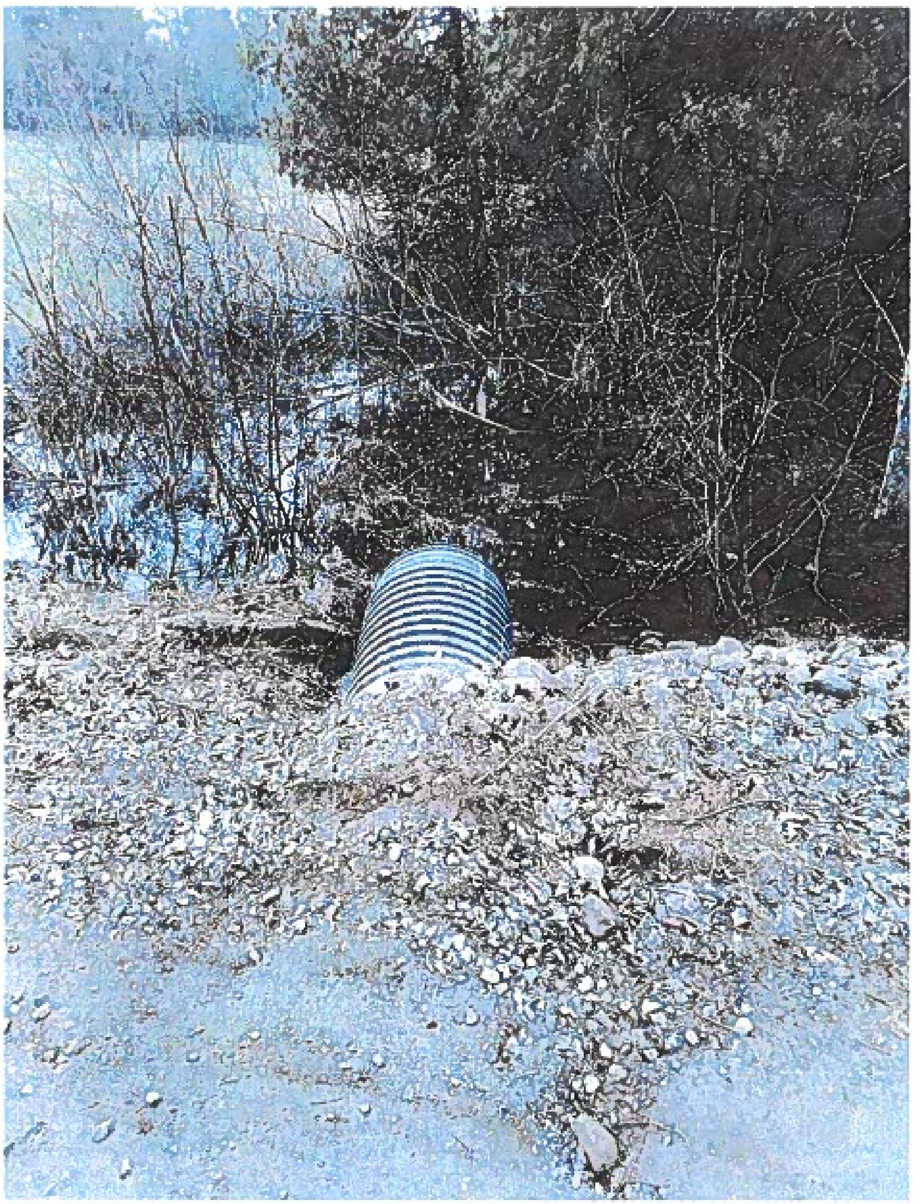
Four culvert crossings were identified on this roadway. Of these (1) was measured to be 15", (1) was measured to be 24", and (2) were measured to be 36". Material for all four was found to be high-density polyethylene (HDPE). Two of the structures require some repair or maintenance:

- Approximately 900' north of the beginning of gravel is a 36" HDP culvert in poor condition. The culvert is partially deflected, and capacity is limited due to damage by a rock. This culvert should be replaced including inlet/outlet riprap aprons.



Picture 21 – 36" HDP Culvert

- Approximately 2,050' south of the end of gravel is a 24" HDPE culvert in fair condition with inadequate cover. This culvert should be replaced and adjacent drainage should be modified as necessary to accommodate lower culvert inverts.



Picture 22 – 24" HDP Culvert

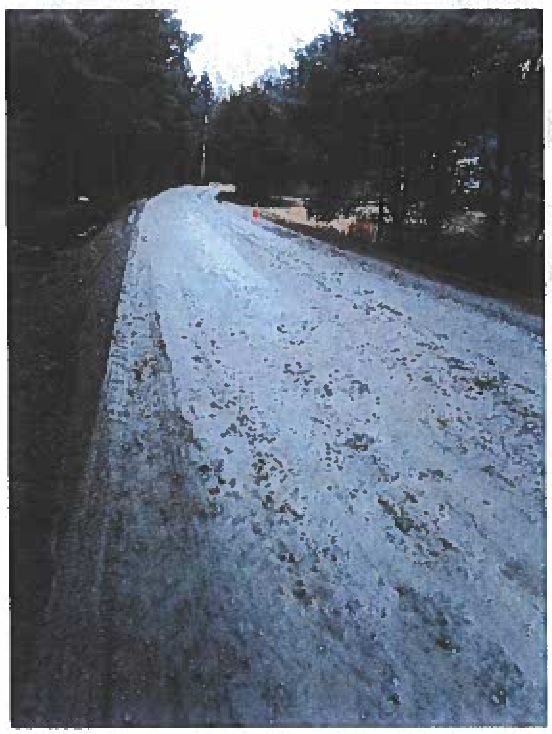
7. MAGOG ROAD

The following section documents the condition of Magog Road, as was present on Monday, April 17, 2023. Please note that no subsurface exploration was performed, only a visual assessment.

7.1. GENERAL CONDITION

Magog Road begins at Route 105 and extends north approximately 4,200' to the town line. The width is generally 20' and the overall condition of the road was found to be good with the following recommended improvements noted:

- Approximately 1,065' south of the town line an area of poor draining roadway was located. The area is 320' x 20' in size. The recommended repair is to remove the existing aggregate to a depth of 18" and rebuild with 12" of MaineDOT Type D subbase gravel and top with 6" of MaineDOT Type A base gravel. A reinforcement/separation geotextile should be considered as an underlayment to the gravel depending on subgrade conditions.. Ditching on the southern side of the road should also be reestablished.

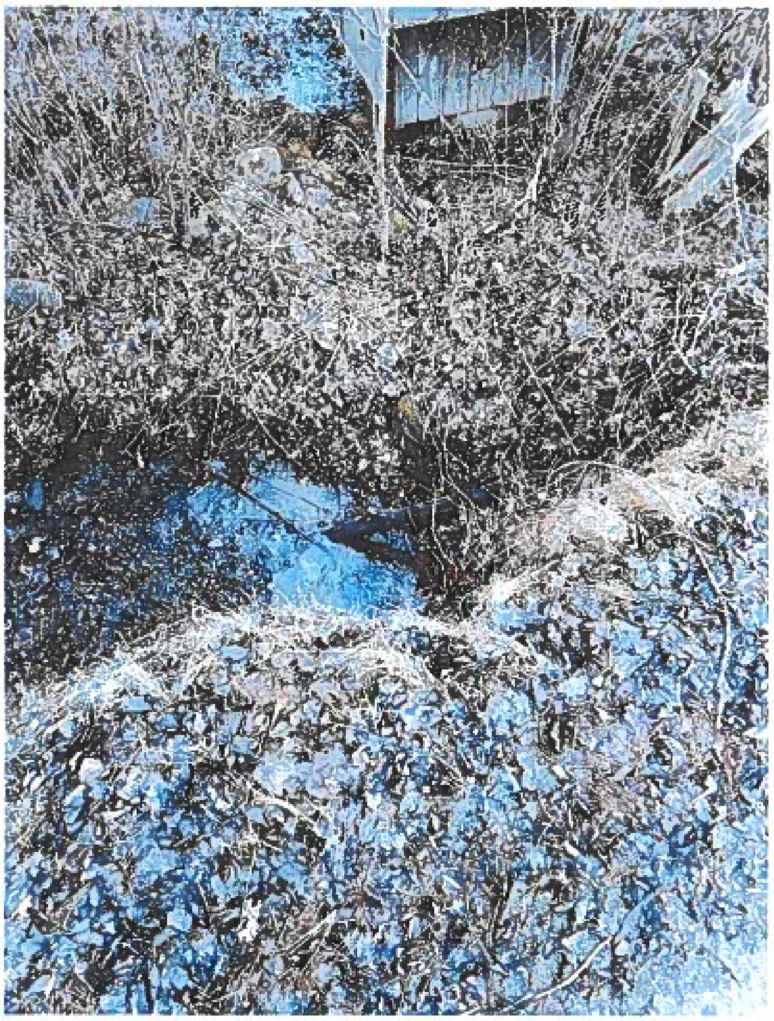


Picture 23 – Insufficient roadway surface

7.2. DRAINAGE STRUCTURES

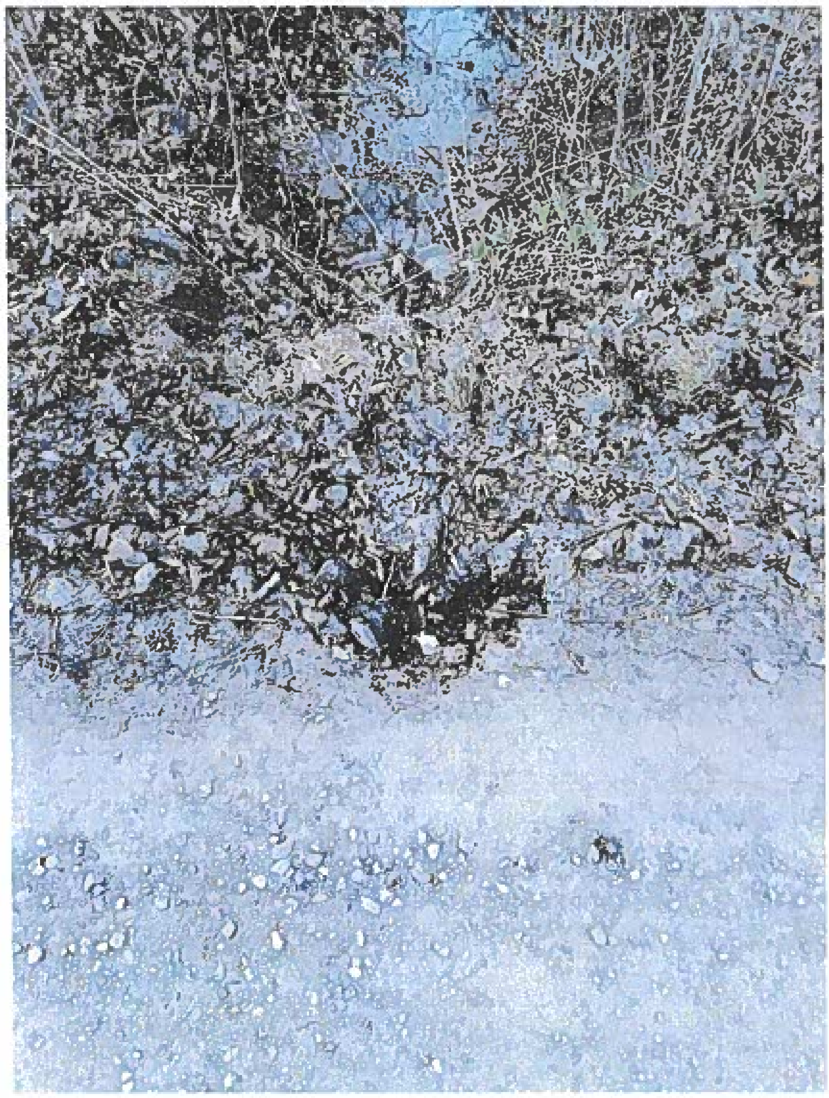
Five culvert crossings were identified on this roadway. Of these (2) were measured to be 12", (2) were measured to be 15", and (1) was measured to be 24". Materials were either corrugated metal (CMP) or high-density polyethylene (HDPE). Three of the structures require some repair or maintenance:

- Approximately 1,050' north of the beginning of the road is a 15" CMP culvert in poor condition with significant erosion. The culvert should be replaced with a 15" HDPE culvert and lengthened. Inlet/outlet riprap aprons should be installed.



Picture 24 – 15" CMP Culvert

- Approximately 1,690' north of the beginning of the road is a 12" CMP culvert in poor condition with significant erosion. The culvert should be replaced with a 15" diameter HDPE and lengthened. Inlet/outlet riprap aprons should be installed.



Picture 25 – 15" CMP Culvert

- Approximately 425' south of the town line is a 12" CMP culvert in poor condition with insufficient cover. The culvert should be replaced with a 15" diameter HDP.

No Picture Available

8. JONES HILL ROAD

The following section documents the condition of Jones Hill Road, as was present on Monday, April 17, 2023. Please note that no subsurface exploration was performed, only a visual assessment.

8.1. GENERAL CONDITION

Jones Hill Road begins at the intersection with Gurneytown Road and extends approximately 1,900' to the termination point. Measured widths ranged from 14' to 20'. The overall condition of the road was good with no recommended improvements beyond the current routine maintenance.

8.2. DRAINAGE STRUCTURES

Two culvert crossings were identified on this roadway; one measuring 18" and the other measuring 24". Both were made of high-density polyethylene (HDP) material and found to be in good condition.

9. COST ESTIMATES

Based on the recommendations stated above cost estimates were created. These are based on the most current available MaineDOT bid archive data and are likely to be conservative. Please note that potential right-of-way acquisition, environmental permitting and engineering costs have not been included.

9.1. APPLETON RIDGE ROAD - NORTH

The estimated cost to improve the northern portion of Appleton Ridge Road, based on the recommendations presented above is $8,000. This is based on the units and quantities as shown below.

Roadway	Treatment Method	Unit	Quantity	Unit Cost	Total Cost
Appleton Ridge Road - North	Ditching	LF	170	$20.00	$3,400.00
Appleton Ridge Road - North	Ditching	LF	125	$20.00	$2,500.00
Appleton Ridge Road - North	Rip Rap	CY	35	$60.00	$2,100.00

9.2. APPLETON RIDGE ROAD - SOUTH

The estimated cost to improve the southern portion of Appleton Ridge Road, based on the recommendations presented above is $74,775. This is based on the units and quantities as shown below.

Roadway	Treatment Method	Unit	Quantity	Unit Cost	Total Cost
Appleton Ridge Road - South	Replace Roadway Surface	SF	5500	$6.00	$33,000.00
Appleton Ridge Road - South	New Culvert	LF	25	$150.00	$3,750.00
Appleton Ridge Road - South	Rip Rap Armor	SF	200	$3.00	$600.00
Appleton Ridge Road - South	New Culvert	LF	40	$150.00	$6,000.00
Appleton Ridge Road - South	New Culvert	LF	40	$150.00	$6,000.00
Appleton Ridge Road - South	New Culvert	LF	40	$150.00	$6,000.00
Appleton Ridge Road - South	Additional Aggregate	CY	75	$110.00	$8,250.00
Appleton Ridge Road - South	Culvert Cleaning	HR	1	$412.50	$412.50
Appleton Ridge Road - South	New Culvert	LF	40	$150.00	$6,000.00
Appleton Ridge Road - South	Additional Aggregate	CY	75	$63.50	$4,762.50

9.3. GUINEA RIDGE ROAD

The estimated cost to improve the Guinea Ridge Road, based on the recommendations presented above is $898,100. This is based on the units and quantities as shown below.

Roadway	Treatment Method	Unit	Quantity	Unit Cost	Total Cost
Guinea Ridge Road	Widening	SF	67,950	$6.00	$407,700.00
Guinea Ridge Road	Ditching	LF	15100	$20.00	$302,000.00
Guinea Ridge Road	Tree Clearing	HR	480	$305.00	$146,400.00
Guinea Ridge Road	New Culverts	LF	280	$150.00	$42,000.00

9.4. COLLINSTOWN ROAD

The estimated cost to improve the Collinstown Road, based on the recommendations presented above is $450,800. This is based on the units and quantities as shown below.

Roadway	Treatment Method	Unit	Quantity	Unit Cost	Total Cost
Collinstown Road	New Culvert	LF	40	$150.00	$6,000.00
Collinstown Road	Replace Roadway Surface	SF	3150	$6.00	$18,900.00
Collinstown Road	New Culvert	LF	40	$150.00	$6,000.00
Collinstown Road	Culvert Cleaning	HR	1	$412.50	$412.50
Collinstown Road	New Culvert	LF	40	$150.00	$6,000.00
Collinstown Road	Open Bottom Structure	LS	1	$400,000	$400,000.00

9.5. PEABODY ROAD

The estimated cost to improve the Peabody Road, based on the recommendations presented above is $46,050. This is based on the units and quantities as shown below.

Roadway	Treatment Method	Unit	Quantity	Unit Cost	Total Cost
Peabody Road	Ditching	LF	700	$20.00	$14,000.00
Peabody Road	Tree Trimming	HR	10	$305.00	$3,050.00
Peabody Road	Ditching	LF	400	$20.00	$8,000.00
Peabody Road	New Culvert	LF	40	$300.00	$12,000.00
Peabody Road	New Culvert	LF	40	$225.00	$9,000.00

9.6. MAGOG ROAD

The estimated cost to improve the Magog Road, based on the recommendations presented above is $56,800. This is based on the units and quantities as shown below.

Roadway	Treatment Method	Unit	Quantity	Unit Cost	Total Cost
Magog Road	Replace Roadway Surface	SF	6400	$6.00	$38,400.00
Magog Road	Ditching	LF	320	$20.00	$6,400.00
Magog Road	New Culvert	LF	40	$150.00	$6,000.00
Magog Road	New Culvert	LF	40	$150.00	$6,000.00

9.7. JONES HILL ROAD

Jones Hill Road was recently improved, and no major improvements are recommended.

Sewall
The evolution of expertise

10. RECOMMENDATIONS

The possibility of converting the gravel roads to paved roads was noted during our meetings. There are many aspects to be considered before a substantial investment to pave a roadway is made. This is outlined in some detail in the following document, which is attached as an appendix: Gravel Roads: Maintenance and Design Manual-- Appendix D: When to Pave a Gravel Road (epa.gov).

Sewall does not recommend a town-wide move to upgrade the gravel roads to asphalt. If there is a desire to reduce annual maintenance costs by contributing the up-front capital for asphalt surfacing the northern section of the Appleton Ridge Road and Peabody Road are the most likely candidates for further review. A gravel road must work well through proper drainage and base materials prior to being paved, otherwise it will fail. If the town does desire to pave the roadways, we would recommend performing a geotechnical analysis of the existing roadways to determine aggregate quality/depth. This would provide more detail as to whether there may be portions of the existing roads that may be suitable to pave as is; without complete replacement of aggregate materials. However, based on anecdotal evidence of surface conditions during the spring and our visual review, we suspect the majority of the existing aggregates would not be conducive to a long term pavement lifespan.

As for the recommendations for the roadways presented, the cost estimates are intended for planning purposes only to allow the Town to budget improvements over the next 5-7 years. The roads are in generally good condition and the annual maintenance plan is serving the residents well.

Appendix D: When to Pave a Gravel* Road

by Kentucky Transportation Center, University of Kentucky at Lexington, KY

Contents

*Gravel as used here may refer to sand and gravel, or to crushed stone.

A Word About the Term "Paved"

What is meant by a "paved" road? For some, a light chip seal coat is considered paving. For others, paving is four or more inches of bituminous asphalt or "hot mix." The primary purpose of a pavement is to protect the subgrade. As the loads get heavier, the pavement thickness must be increased.

Generally speaking, bituminous concrete (hot mix asphalt) has little real load-bearing capacity of its own until it reaches a thickness of two inches. In fact, the Asphalt Institute has a firm policy of recommending a minimum pavement thickness of 4 inches full depth asphalt or 3 inches asphaltic concrete plus a suitable granular base even for low volume roads. Their research shows that 4 inches of hot mix will carry about 10 times as much traffic as 2 inches of hot mix when constructed over thin granular bases.

A pavement less than two inches thick primarily protects the base materials by shedding water and providing a smooth riding surface. Such a road is more properly called a surface-treated road. Roads with thin pavements must have excellent drainage designed into them and be diligently maintained throughout their service life.

In this paper we will consider even a light surface treatment as paving,however. The assumption is that,when a town first applies a chip seal treatment,for example, it has taken a first step toward eventually achieving a load-bearing pavement.

Introduction

Two-thirds of the highway systems in the United States and more than 90 percent of all the roads in the world are unsurfaced or lightly surfaced low volume roads. In Kentucky, more than 19,000 miles of local roads have gravel surfaces.

Most local roads were not designed with the same considerations used in the design of state and interstate highways. Most have evolved from primitive trails. Paths of least resistance first created by wild animals were later used by settlers. As needs and traffic increased, these traveled ways became roads which were gradually improved with gravel or crushed rock. Little engineering went into these improvements. Using available materials and "keeping them out of the mud" were the extent of efforts to maintain a road.

As paving occurred, the tendency was to make minor modifications to the foundations of the evolved road and to seal or pave the surface. As a result,many low volume roads in Kentucky now have continual maintenance problems because of inadequate base support in addition to alignment and drainage problems.

To add to the problem, roads throughout Kentucky are experiencing ever-increasing weights and volumes of traffic. Population growth and tourism make traffic demands. Coal trucks and other commercial vehicles are carrying heavier loads than ever before. These higher volumes and greater weights are putting a steadily increasing strain on local road maintenance and reconstruction budgets.

Gravel or Paved: A Matter of Trade-Offs

The decision to pave is a matter of trade-offs. Paving helps to seal the surface from rainfall, and thus protects the base and subgrade material.It eliminates dust problems, has high user acceptance because of increased smoothness, and can accommodate many types of vehicles such as tractor-trailers that do not operate as effectively on unsurfaced roads.

In spite of the benefits of paved roads, well-maintained gravel roads are an effective alternative. In fact, some local agencies are reverting to gravel roads. Gravel roads have the advantage of lower construction and sometimes lower maintenance costs. They may be easier to maintain, requiring less equipment and possibly lower operator skill levels. Potholes can be patched more effectively. Gravel roads generate lower speeds than paved surfaces. Another advantage of the unpaved road is its forgiveness of external forces. For example, today vehicles with gross weights of 100,000 pounds or more operate on Kentucky's local roads. Such vehicles would damage a lightly paved road so as to require resealing, or even reconstruction. The damage on a gravel road would be much easier and less expensive to correct.

There is nothing wrong with a good gravel road. Properly maintained, a gravel road can serve general traffic adequately for many years.

Should We Pave This Gravel Road? A Ten Part Answer

When a local government considers paving a road,it is usually with a view toward reducing road maintenance costs and providing a smooth riding surface. But is paving always the right answer? After all, paving is expensive. How does a county or city know it is making the most cost-effective decision?

We will consider ten answers to the question,"Should we pave this gravel road?" In fact they are ten parts of one answer. If one of the ten is not considered, the final decision may not be complete. The ten answers taken together provide a framework for careful decision making.

Answer 1: After Developing a Road Management Program

If the road being considered for paving does not fit into a countywide road improvement program,it is quite possible that funds will not be used to the fullest advantage. The goal of a road management system is to improve all roads or streets by using good management practices. A particular road is only one of many in the road system.

A road management system is a common sense, step-by-step approach to scheduling and budgeting for road maintenance work. It consists of surveying the mileage and condition of all roads in the system,establishing short-term and long-term maintenance goals and prioritizing road projects according to budget constraints.

A road management system helps the agency develop its road budget and allows the use of dollars wisely because its priorities and needs are clearly defined.

Through roadway management, local governments can determine the most cost-effective, long-term treatments for their roads, control their road maintenance costs, and spend tax dollars more wisely. Local governments that stick with the program will be rewarded with roads that are easier and less costly to maintain on a yearly basis. Pertinent information about all roads will be readily available for years to come instead of scattered among files or tucked away in an employee's head.

Steps in a Road Management Program:

1. Inventory the roads. The amount of time available and the miles of road in a county or city will determine how much detail to go into.
2. Assess the condition of the roads. Develop simple and easy techniques to use each year. Maintain a continuing record of the assessed condition of each road so that changes in condition can be noted easily and quickly.
3. Select a road management plan. Select the most appropriate treatment to repair each road, bridge, or problem area.
4. Determine overall needs. Estimate the cost of each repair job using generalized average costs and tally up the total.Establish long-range goals and objectives that in turn will help the agency justify its budget requests.
5. Establish priorities. Keep good roads in good shape (preventive maintenance) and establish a separate budget, or request a temporary increase, to reconstruct really bad roads.

Answer 2: When the Local Agency Is Committed to Effective Management

A commitment to effective management is an attitude. It is a matter of making sure that taxpayers' money is well spent—as if it were one's own money. It does not mean paving streets with gold but it does mean using the best materials available. It does not mean taking short cuts resulting in a shoddy project but it does mean using correct construction techniques and quality control.A commitment to effective management means planning for 5 or even 10 years instead of putting a band-aid on today's problem. It means taking the time to do things right the first time and constructing projects to last.

Consider a child's tree house compared to a typical three-bedroom house in a Kentucky town. Because each protects people from the wind and rain each comes under the definition of a shelter. However, the tree house was built with available materials and little craftsmanship. The other was planned, has a foundation, sound walls and roof and, with care, can last hundreds of years. One is a shack and the other is a family dwelling. Only one was built with a commitment to excellence.

Many roads are like the tree house. They qualify under the definition but they are not built to last.

The horse and buggy days are over. We are in an age of travelers' demands, increasing traffic, declining revenues and taxpayer revolts. We are expected to do more with less. Building roads to last requires an attitude of excellence. Such an attitude helps to make better decisions, saves money in the long run, and results in a better overall road system.

Answer 3: When Traffic Demands It

The life of a road is affected by the number of vehicles and the weight of the vehicles using it.Generally speaking, the more vehicles using a road,the faster it will deteriorate.

The average daily traffic volumes (ADT) used to justify paving generally range from a low of 50 vehicles per day to 400 or 500.When traffic volumes reach this range, serious consideration should be given to some kind of paving.

Traffic volumes alone are merely guides. Types of traffic should also be considered. Different types of traffic (and drivers) make different demands on roads. Will the road be used primarily by standard passenger cars or will it be a connecting road with considerable truck traffic? Overloaded trucks are most damaging to paved roads.

The functional importance of the highway should also be considered.Generally speaking, if the road is a major road, it probably should be paved before residential or side roads are paved. On the other hand, a residential street may be economically sealed or paved while a road with heavy truck usage may best be surfaced with gravel and left unpaved until sufficient funds are available to place a thick load-bearing pavement on the road.

Answer 4: After Standards Have Been Adopted

Written standards in the areas of design,construction and maintenance define the level of service we hope to achieve. They are goals to aim for. Without written standards there is no common understanding about what a local government is striving for in road design, construction and maintenance. In deciding to pave a gravel road, is the local government confident it would be achieving the desired standards?

Design and construction standards do not have to be complex. It takes only a few pages to outline such things as right-of-way width, traveled way width, depth of base, drainage considerations (such as specifying minimum 18"culvert pipe),types of surfacing and the like.

Maintenance standards address the need for planned periodic maintenance. A good maintenance plan protects local roads, which for most counties represents many millions of dollars of investment. It also is an excellent aid when it comes time to create a budget.

Considerations include: How often shall new gravel be applied to a gravel road? (Some roads require it more than others do.) How many times per year are roads to be graded? How often and in what locations should calcium chloride or other road stabilizers be applied? What is our plan for checking road signs? (Because of legal liability, a missing sign can be very costly if not replaced.) What is our plan for ditching and shouldering?

Answer 5: After Considering Safety and Design

Paving a road tempts drivers to drive faster. As speed increases, the road must be straighter, wider, and as free as possible from obstructions for it to be safe. Paving low volume roads before correcting safety and design inadequacies encourages speeds which are unsafe, especially when the inadequacies "surprise" the driver. Because of the vast mileage of low volume roads, it is difficult to reduce speeds by enforcement.

Roads must be designed to provide safe travel for the expected volume at the design speed. To do this a number of physical features must be considered:

- Sight Distance
- Alignment and Curves
- Lane Width
- Design Speed
- Surface Friction
- Superelevation

It may be necessary to remove trees or other obstructions such as boulders from the road's edge. Some engineers insist that no road should be paved that is less than 22 feet wide. If this standard is accepted, gravel roads must be widened before paving. Bridges may need widening. Considering these and other safety and design factors in the early stages of decision making can help to achieve the most economical road and one that will meet transportation needs. It makes no sense to pave a gravel road which is poorly designed and hazardous.

Answer 6: After the Base and Drainage Are Improved

"Build up the road base and improve drainage before paving." This cardinal rule cannot be stressed enough. If the foundation fails, the pavement fails. If water is not drained away from the road, the pavement fails. Paving a road with poor base or with inadequate drainage is a waste of money. It is far more important to ask, "Does this road need strengthening and drainage work?" than it is to ask, "Should we pave this gravel road?"

Soil is the foundation of the road and, as such, it is the most important part of the road structure. A basic knowledge of soil characteristics in the area is very helpful and can help avoid failures and unneeded expense. Soils vary throughout the country. For highway construction in general, the most important properties of a soil are its size grading, its plasticity, and its optimum moisture content.

There is a substantial difference in the type of crushed stone or gravel used for a gravel road-riding surface versus that used as a base under a pavement. The gravel road surface needs to have more fines plus some plasticity to bind it together, make it drain quicker and create a hard riding surface. Such material is an inferior base for pavement. If pavement is laid over such material, it traps water in the base. The high fines and the plasticity of the material make the wet base soft. The result is premature pavement failure.

Answer 7: After Determining the Costs of Road Preparation

The decision to pave a gravel road is ultimately an economic one. Policy makers want to know when it becomes economical to pave.

There are two categories of costs to consider: total road costs and maintenance costs.

Local government needs to determine what the costs are to prepare a road for paving. Road preparation costs are the costs of construction before paving actually takes place.

For example, if standards call for a traveling surface of 22 feet and shoulders of two feet for a paved road, the costs of new material must be calculated. Removing trees, brush or boulders, adding new culverts or other drainage improvements, straightening a dangerous curve, improving slopes and elevations, constructing new guardrails, upgrading signs and making other preparations – all must be estimated.

Costs will vary greatly from project to project depending on topography, types of soils, availability of good crushed stone or gravel, traffic demands and other factors. One important factor is the standards. That is one reason why we should carefully consider what is contained in the road policy (#4 above). For larger projects it may be desirable to hire an engineering consulting firm (another cost) to design the road and make cost estimations. For smaller projects construction costs can be fairly closely calculated by adding the estimated costs of materials, equipment and labor required to complete the job.

Answer 8: After Comparing Pavement Costs, Pavement Life and Maintenance Costs

A second financial consideration is to compare maintenance costs of a paved road to maintenance costs of a gravel road. To make a realistic comparison we must estimate the years of pavement life (how long the pavement will be of service before it requires treatment or overlay) and the actual cost of paving. It is at this point that we can begin to actually compare costs between the two types of roads.

Consider the following maintenance options:

A. For both paved and gravel roads, a local government must: maintain shoulders – keep ditches clean – clean culverts regularly – maintain roadsides (brush, grass, etc.) – replace signs and signposts.

B. PAVED roadways require: patching – resealing (chip, slurry, crack seal) and striping.

C. GRAVEL roadways require: regraveling – grading and stabilization of soils or dust control.

Since the maintenance options in "A" are common to both paved and gravel roads, they do not have to be considered when comparing maintenance costs. These costs for either type of road should be about the same. But the costs of the maintenance options in "B" and "C" are different and therefore should be compared.

Figure 16 shows costs for maintaining gravel roads over a six-year period in a hypothetical situation. If records of costs are not readily available, you may use a "best guess" allowing for annual inflation costs.

Three paving options are listed in Figure 17. Each includes estimated costs for paving and an estimated pavement life. You should obtain up-to-date cost estimates and expected pavement life figures for these and other paving options by talking to your state department of transportation, contractors, and neighboring towns and counties.

YEAR	1	2	3	4	5	6	TOTALS
GRADING							
Equipment	270	280	290	300	310	320	1,770
Labor	90	100	110	120	130	140	690
REGRAVEL							
Materials	–	–	4,000	–	–	–	4,000
Equipment	–	–	2,500	–	–	–	2,500
Labor	–	–	2,300	–	–	–	2,300
STABILIZATION/DUST CONTROL							
Materials	800	900	1,200	920	950	975	5,745
Equipment	30	35	70	40	50	60	285
Labor	100	110	150	125	140	150	775
Totals	1,290	1,425	10,620	1,505	1,580	1,645	$18,065

Figure 16: Gravel Road Maintenance Cost Per Mile

Let's consider the cost of a double surface treatment operation and the projected cost of maintaining it before anything major has to be done to the pavement (end of pavement life). We see in Figure 17 that the estimated cost to double surface treat one mile of road is $20,533. Estimated maintenance costs over a six-year period could be:

Patching	$1,800	Total maintenance	$4,300
Striping	$500	Construction	$20,533
Sealing	$2,000	Total cost over six years	$24,833
	$4,300		

When we compare this cost to the cost of maintaining an average mile of gravel road over the same period of six years ($18,065), we find a difference in dollar costs of $6,768. It is not cost beneficial to pave in this hypothetical example, even without considering the costs of road preparation (#7).

This is not a foolproof method, but it does give us a handle on relative maintenance costs in relation to paving costs and pavement life. The more accurate the information, the more accurate the comparisons will be. The same method can be used in helping to make the decision to turn paved roads back to gravel.

Option	Life	Cost Per Mile	Cost/Mile Per Year	Calculations	Maintenance Per Mile/Year
Chip Seal-Double Surface Treatment	6 yrs.	$20,533	$3,422	Based on price of $1.75 per sy; 20 ft. wide x 5,280 ft. = 105,600 sf 105,600 sf ÷ 9 = 11,733 sy s $1.75 = $20,533	?
Bituminous Concrete-Hot Mix	12 yrs.	$58,080	$4,840	Based on estimated price of $30 per ton; 1 sy of stone and hot mix/ cold mix 1" thick weighs about 110 lbs. Therefore 3" = 330 lbs. per sy. 11,733 sy (1 mile of pavement) s 330 lbs. = 3,871,890 lbs. 3,871,890 lbs. = 1936T x $30 = $58,080	?
Cold Mix	8 yrs.	$48,390	$6,048	At $30 per ton, using same formula as hot mix, 2 1/2" of cold mix equals 1,613T x $30 = $48,390	?

*These costs must be determined before any conclusions can be reached regarding the most cost-effective pavement method. The thinner the pavement, the greater the maintenance cost. Traffic, weather conditions, proper preparation before paving and many other factors can affect maintenance costs. No Kentucky data exists upon which to base estimates of maintenance costs on low volume roads of these paving options; and, therefore, we offer no conclusion as to the "best" way to pave.

Figure 17: Paving Options (Costs and road life are estimates and may vary)

Answer 9: After Comparing User Costs

Not all road costs are reflected in a highway budget. There is a significant difference in the cost to the user between driving on a gravel surface and on a paved surface. User costs, therefore, are appropriate to consider in the pave/not pave decision. By including vehicle-operating costs with construction and maintenance costs, a more comprehensive total cost can be derived.

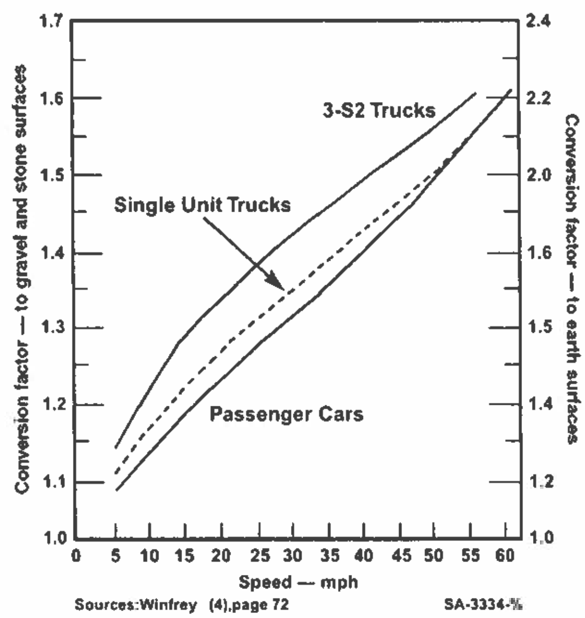
Vehicles cost more to operate on gravel surfaces than on paved surfaces, often 2 or 3 times greater than for bituminous concrete roads in the same locations. There is greater rolling resistance and less traction which increase fuel consumption. The roughness of the surface contributes to additional tire wear and influences maintenance and repair expenses. Dust causes extra engine wear, oil consumption and maintenance costs. Figure 18 from AASHTO'S "A Manual on User Benefit Analysis of Highway and Bus-Transit Improvements" shows the impacts of gravel surfaces on user costs. For example, an average running speed of 40 MPH on a gravel surface will increase the user costs of passenger cars by 40% (1.4 conversion factor). The general public is not aware that their costs would actually be less if some of these roads were surface treated.

Add to the gravel road maintenance the user costs over a six-year period. Estimate an average daily traffic (ADT) of 100 cars and 50 single unit trucks, traveling at 40 mph. Estimate that it costs $.25 per mile to operate the vehicles on pavement. Using the chart in Figure 3, we see it costs 1.4 times as much (or $.35) to drive a car 40 mph one mile on gravel road and 1.43 times as much (or $.36) to drive a single unit (straight frame) truck 40 mph one mile on gravel road.

100 cars x 365 days x $.10 added cost x 1 mile = $3,650

50 trucks x 365 days x $.11 added cost x 1 mile = $2,008

User costs for the gravel road is $5,659 per year or $33,954 for a six-year period.Assuming we still do not consider road preparation costs, it now appears justified to pave the road.Such an approach can be used to establish a "rule of thumb" ADT. For example, some agencies give serious consideration to paving roads with an ADT above 125.



To use this chart, determine the type of vehicle, the speed and the type of road surface. Follow the speed line vertically to the vehicle type. Go horizontally to multiplier factor of road surface. Multiply the cost of travelling on a paved surface by this number to determine the cost of operating the same vehicle on gravel surface or dirt surface. Example: If it costs 28¢ per mile to operate a passenger car* at 40 mph on pavement, it will cost 39¢ per mile to operate it on a gravel road at the same speed and 50¢ per mile on a dirt road.

*1984 Federal Highway Administration Statistics quotes an operating cost of 28¢ per mile for an intermediate size passenger car traveling on average suburban pavement. You must determine your own vehicle operating costs on pavement in order to use these multiplicative factors to calculate

Figure 18: Impacts of Gravel Surfaces on User Costs

Answer 10: After Weighing Public Opinion

Public opinion as to whether to pave a road can be revealing, but it should not be relied upon to the exclusion of any one of points 1-9 already discussed.If a decision to pave is not based on facts, it can be very costly. Public opinion should not be ignored, of course, but there is an obligation by government leaders to inform the public about other important factors before making the decision to pave.

Stage Construction

Local government may consider using "stage construction design" as an approach to improving roads. This is how it works. A design is prepared for the completed road, from base and drainage to completed paving. Rather than accomplishing all the work in one season, the construction is spread out over three to five years. Paving occurs only after the base and drainage have been proven over approximately one year. Crushed gravel treated with calcium chloride serves as the wearing course for the interim period. Once all weak spots have been repaired, the road can be shaped for paving.

There are some advantages to keeping a road open to traffic for one or more seasons before paving:

1. Weak spots that show up in the sub-grade or base can be corrected before the hard surface is applied, eliminating later expensive repair;
2. Risky late season paving is eliminated;
3. More mileage is improved sooner;
4. The cost of construction is spread over several years.

Note: Advantages may disappear if timely maintenance is not performed. Surface may deteriorate more rapidly because it is thinner than a designed pavement.

Summary

Some local roads are not well engineered. Today, larger volumes of heavy trucks and other vehicles are weakening them at a fast rate. Paving roads as a sole means of improving them without considering other factors is almost always a costly mistake. Counties and cities should consider these ten points first. Carefully considering them will help to assure local government officials that they are making the right decision about paving a gravel road.