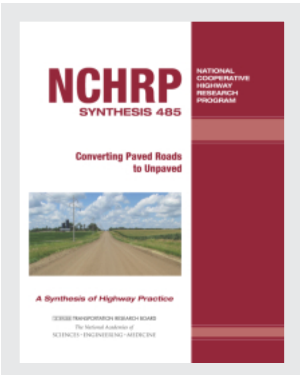

Converting Paved Roads to Unpaved

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP SYNTHESIS 485

Converting Paved Roads to Unpaved

A Synthesis of Highway Practice

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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Cover figure: A local road that has been converted to gravel (Courtesy: K. Skorseth).

FOREWORD

Highway administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to highway administrators and engineers. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire highway community, the American Association of State Highway and Transportation Officials—through the mechanism of the National Cooperative Highway Research Program—authorized the Transportation Research Board to undertake a continuing study. This study, NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an NCHRP report series, *Synthesis of Highway Practice*.

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

By Jon M. Williams
Program Director
Transportation Research Board

This study found that the practice of converting paved roads to unpaved is relatively widespread; recent road conversion projects were identified in 27 states. These are primarily rural, low-volume roads that were paved when asphalt and construction prices were low. Those asphalt roads have now aged well beyond their design service life, are rapidly deteriorating, and are both difficult and expensive to maintain. Instead, many local road agencies are converting these deteriorated paved roads to unpaved as a more sustainable solution.

Key findings from this study include: Local road agencies have experienced positive outcomes by converting roads. Many local road agencies reported cost savings after converting, compared with the costs of continuing maintenance of the deteriorating paved road, or repaving. One key to successful conversion is early involvement of the public in the planning process. Other techniques that can be used to improve the overall results of a project include treating or stabilizing granular surfaces to control dust, limiting the rate of aggregate loss, and reducing motor grader/blade maintenance frequency. Stabilization procedures can also improve safety, increase public acceptance, and reduce life-cycle costs and environmental impacts after a conversion has taken place.

Laura Fay and Ashley Kroon, Western Transportation Institute, Montana State University; Ken Skorseth and Richard Reid, South Dakota State University; and David Jones, University of California, Davis, collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on the preceding page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

Note: Photographs, figures, and tables in this report may have been converted from color to grayscale for printing. The electronic version of the report (posted on the web at www.trb.org) retains the color versions.

CONVERTING PAVED ROADS TO UNPAVED

SUMMARY

The purpose of this study was to identify agencies that have converted roads from paved to unpaved. The study also identified

- tools, metrics, and procedures that have been used in the decision-making process for when and how to convert a road;
- impacts of road conversions;
- public outreach efforts; and
- knowledge gaps and research needs.

The survey conducted for this project identified 48 local, state, and federal agencies that have conducted road conversions and nine more that are considering this action. Almost 70 conversion projects were identified and a total of 550 miles of road converted to unpaved.

Low-volume, rural roads serve as main routes for numerous industries, farmers, and ranchers to get raw material from source to distribution or processing centers, provide ingress to remote public lands, and act as transportation arteries for millions of rural residents. Most of these rural roads have low or very low traffic volumes and have unpaved, aggregate surfaces. Historically, unpaved roads have been considered the lowest level of service provided. In a demonstration of progress and an effort to improve road conditions for rural residents, many agencies paved low-volume roads with little or no base preparation when asphalt and construction prices were low. Those asphalt roads have now aged well beyond their design service life, are rapidly deteriorating, and are difficult and expensive to maintain.

The increasing sizes of agricultural and commercial equipment, including that used by the energy sector, are compounding road deterioration in many areas. Traditionally, these roads were maintained or repaved at regular intervals, but with the increasing traffic loads, increasing cost of materials, and stagnant or declining road maintenance budgets, many agencies do not have the funding to support these activities. Instead, many local road agencies are looking to convert deteriorated paved roads to unpaved ones as a more sustainable solution. The practice of converting roads from paved to unpaved is relatively widespread. Documented cases of road conversion projects were found in 27 states.

The state of the practice for converting roads from paved to unpaved involves reclaiming or recycling the deteriorated pavement surface, supplementing existing materials as needed, compacting, and for some applying or incorporating a surface treatment, such as a soil stabilizer or dust-abatement product. In a few cases, no recycling of the old pavement was done, and new surface aggregate was simply placed over the deteriorated road surface. However, most agencies that have done conversions recycle the old surface in-place and reshape and compact it as a base for a new aggregate surfacing. Thereafter, the new surfacing ranges from locally available gravel to high-quality surface aggregate that can be maintained with motor graders to sustain adequate crown and a smooth surface. Many of the roads that have been converted from paved to unpaved had annual average daily traffic (AADT) of between 21 and 100 vehicles, suggesting that many of the roads that are being

converted should not have been paved initially or that road usage patterns have changed significantly since paving.

Local road agencies are converting roads primarily as a result of a lack of funding for maintenance and construction, safety issues, and/or complaints from the public. Road budgets have remained stagnant or declined in recent decades, but the costs of labor, materials, and equipment have continued to increase. Consequently, local road agencies have been left underfunded and are struggling to maintain their existing road network. Limited maintenance of deteriorating roads (e.g., pothole patching) often is all that can be done with existing resources, with repaving often being cost-prohibitive. In seeking a cost-effective alternative to continued maintenance and repair of deteriorating pavement, agencies have begun to recognize that many roads with very low traffic volumes can be maintained more economically and at a higher level of service with an unpaved or granular surface.

Local road agencies have experienced positive outcomes by converting roads. Many local road agencies reported cost savings after converting, compared with the costs of continuing maintenance of the deteriorating paved road or repaving. The reported cost of converting ranged from $1,000 to $100,000 per road segment or mile within the United States and Canada. The variation in costs is attributed to how costs are tracked by agencies, how the conversion was done, equipment requirements, supplemental materials, surface stabilization and dust abatement, and addressing drainage and road base issues.

A significant lack of available resources, such as a handbook or design guide, for practitioners who are considering or performing road conversions was noted. Numerous survey respondents indicated that they did not use any documented resources when planning and performing the conversion and often used a trial-and-error approach. In addition, road agencies rarely document procedures and outcomes of road conversions, such as construction problems, crash rates, public concerns and reaction, and comparative maintenance costs of the new surface. Completing successful conversions is possible with appropriate investigation and design, selection of quality granular surfacing materials, and good construction, and by involving and educating the public as part of the process. However, limited information has been published to guide practitioners in these processes.

Conversion is a viable option that can be accomplished in a positive way for all stakeholders provided that the public is involved in the discussion and appropriate designs and procedures are followed. To accomplish this, local road agencies would benefit from direction in planning projects that will lead to the optimal use of available materials and equipment and a smooth, safe, and maintainable driving surface upon completion. This can be accomplished with development of guidance materials and improved technology transfer to practitioners.

Road agencies that conducted public outreach and stakeholder education about various aspects of the conversion process observed more favorable public reaction than did those who did not involve the public. Other techniques that can be used to improve the overall results of a project include treating or stabilizing granular surfaces to control dust, limiting the rate of aggregate loss, and reducing the frequency of motor grader or blade maintenance. Stabilization procedures also can improve safety, increase public acceptance, and reduce life-cycle costs and environmental impacts after a conversion has taken place.

Knowledge gaps identified point to the need for future research leading to:

- Design guidance on converting roads from paved to unpaved for use by practitioners and road agencies;
- Improved documentation of the results of conversions, procedures, and mechanisms for collecting crash rates and data on low-volume roads, specifically before and after conversions;

- A life-cycle cost analysis tool for determining whether conversion is a cost-effective solution;
- A road management framework for local road agencies that are affected by industries that use heavy-weight vehicles or that significantly increase the numbers of vehicles using the road, and that seek to recoup costs associated with accelerated road deterioration caused by such vehicles; and
- Assessment of environmental impacts associated with road conversions.

CHAPTER ONE

INTRODUCTION

BACKGROUND

Current transportation asset management practices assume that roads will be preserved to maintain the current level of service or structural condition, or improved to enhance the structural and surface condition and ride quality. In addition, the historic trend has been to reduce the number of unpaved system lane-miles. These policies were developed in the last century when the costs of asphalt, fuel, and all construction expenditures were low compared with current costs and the axle loads carried on rural low-volume roads were significantly lighter than current loads. The rising cost of asphalt and fuel and a significant increase in traffic and traffic loads on low-volume rural roads associated with commercial, agricultural, and energy sector development, combined with stagnant or decreasing budgets, are causing a situation in which the cost of rehabilitating and maintaining very low-volume paved roads on the existing road network often is no longer feasible (Figure 1).

Historically, unpaved roads have been considered the lowest level of service provided. In a demonstration of progress and an effort to improve road conditions for rural residents, many agencies paved low-volume roads with little or no base preparation when asphalt and construction prices were low. Those asphalt roads have now aged well beyond their design service life, are deteriorating rapidly, and are difficult and expensive to maintain. The increasing size of agricultural and commercial equipment, including that used by the energy sector, compounds this deterioration in many areas. Traditionally, these roads were maintained or repaved at regular intervals, but with the increasing traffic loads, the increasing cost of materials, and stagnant or declining road maintenance budgets, many agencies do not have the funding to support these activities. Instead, many local road agencies are looking to convert deteriorated paved roads to unpaved surfaces as a more sustainable solution (Figure 2). The process of converting a low-volume road from paved to unpaved is another tool in the toolbox that is a viable alternative to maintaining the road as a paved surface or rehabilitating it to an appropriate level of paved surface.

DEFINING LOW-VOLUME ROADS FOR THE PURPOSE OF THIS STUDY

The *Guidelines for Geometric Design of Very Low-Volume Local Roads* defines a low-volume road as having annual average daily traffic (AADT) of 400 vehicles or less (AASHTO 2001). For the purpose of this project, low-volume or very low-volume roads are defined as roads with AADT of less than 250 vehicles, based on research that determined that converting paved roads to unpaved was cost-effective at this threshold (Mustonen et al. 2003; Sacramento Area Council of Governments 2008; Iowa Local Technical Assistance Program 2012). Other studies found that gravel road surfaces can be effective when AADT is less than 170 vehicles (Skorseth and Selim 2000). On roads with AADT greater than 170 vehicles, significant aggregate loss, higher dust levels, and more frequent blading requirements were experienced. The current study found that many roads that have been converted from paved to unpaved in recent years had an AADT of 21 to 100 vehicles, suggesting that most of the roads currently being converted should not have been paved initially because of inadequate structural support (underdesign) or that road usage patterns have changed significantly since paving.

STUDY OBJECTIVES

Many counties and some states have already begun the process of identifying low-volume roads that can be converted from paved to unpaved. However, there is a lack of information available to public agencies on managing these conversions. The objectives of this synthesis are to identify the state of the practice of road conversions from paved to unpaved by:

- Defining the terms "very low-volume road" and "unpaved" in the context of road conversion projects,
- Identifying agencies that have converted roads from paved to unpaved,
- Identifying metrics used by road agencies in the conversion process,
- Identifying tools, such as databases or software, and procedures that have been used in deciding when and how to convert a road from paved to unpaved,
- Identifying and synthesizing information on decision-making parameters and impacts of road conversions,
- Documenting public outreach efforts, and
- Identifying knowledge gaps and research needs on this topic.

STUDY APPROACH

An extensive literature review of national and international sources was conducted to gather information on converting paved roads to unpaved roads. Technical documents, government reports, journal publications, conference presentations

(a)

(b)

FIGURE 1 A failing asphalt road (*a*), and a close-up showing breakup of the pavement surface (*b*). (Photos courtesy of D. Jones.)

and proceedings, and newspapers and online media publications were reviewed. Local, state, federal, and international government and organization web pages, manuals, field guides and reports, and published specifications also were studied to develop the content of this report. Information captured in the literature review was used to develop a survey questionnaire.

The survey questionnaire was used to gather additional information on converting paved roads to unpaved roads. The purpose of the survey was to identify locations where road conversions have occurred or will occur and locations being considered for conversion. It was also used to capture basic information on road conversions that have been performed. A total of 140 responses were received from the survey; they are discussed in relevant sections of the current report. The survey questionnaire appears in Appendix A, and a summary of the survey results is provided in Appendix B.

Follow-up interviews were conducted with 17 survey respondents who were selected based on their survey responses. Information gained from interviews has been incorporated into relevant sections of the report and used to create a summary of case examples. A list of interviewees and their contact information can be found in Appendix C, and the developed case examples appear in Appendix D. Additional case examples and information on road conversions can be found in Appendix E.

FIGURE 2 A local road that has been converted to a gravel surface. The township is able to maintain the road in acceptable condition with available funds. (Photo courtesy of K. Skorseth.)

This report consists of five chapters:

- Chapter one: Introduction and background on converting roads from paved to unpaved, an outline of the need for this synthesis report, and the objectives for the study.
- Chapter two: Summary of the state of the practice of converting roads, including how "very low-volume roads" are defined, a literature review, and results of the survey and subsequent interviews. These are summarized by the processes typically followed in deciding whether a road should be converted and how the conversion is done. Information is provided on road maintenance and pavement condition assessment tools, public outreach efforts, and public reaction to road conversion projects. The impacts of road conversion projects in terms of changes in traffic patterns, equipment, and staffing; environmental impacts; safety; and the costs of converting and maintaining converted roads are also included.
- Chapter three: Summary of the survey results and responses from follow-up interviews.
- Chapter four: Relevant reports, documents, and resources that can be used when considering or conducting a road conversion project.
- Chapter five: Summary of the findings on the state of the practice of converting paved roads to unpaved roads and suggestions for future work on this topic.

Additional information is provided in a glossary and appendices: the survey questionnaire (Appendix A), a summary of the survey results (Appendix B), list of interviewees with contact information (Appendix C), case examples and supplemental information (Appendix D and Appendix E), a sample letter used to notify the public of a proposed road conversion project (Appendix F), and a research needs statement developed based on knowledge gaps identified through this research project (Appendix G).

CHAPTER TWO

SUMMARY OF THE STATE OF THE PRACTICE

This chapter defines relevant terminology and identifies the state of the practice of converting roads from paved to unpaved, based on information gained from the literature review, survey of practitioners, and follow-up interviews. Information is presented on how low-volume roads are defined in the context of road conversion projects, active versus passive conversion, factors to consider for conversion projects, road condition assessment tools, public reaction and outreach efforts by local road agencies, changes in traffic patterns and vehicle type on converted roads, changes in agency equipment and staffing to maintain unpaved roads, health and environmental impacts associated with unpaved roads, roadway safety, and economic considerations. The chapter ends with a summary of the state of the practice gleaned from survey responses.

LOW-VOLUME ROADS

There are more than 4.1 million mi of roadways in the United States (FHWA 2014). There is no uniform agreement on how many of these are low-volume roads. About 53% are unpaved and are maintained by local and state transportation departments (Skorseth and Selim 2000; Anderson and Gesford 2007). A majority of these roads will remain unpaved because of continued low-volume traffic and economic considerations (Skorseth and Selim 2000; Anderson and Gesford 2007). Unpaved roads are nearly always considered low volume.

Low-volume roads are defined by AASHTO as those with limited use—daily traffic of fewer than 400 vehicles (AASHTO 2001) and design speeds of less than 50 mph (Keller and Sherar 2003). The *Manual on Uniform Traffic Control Devices* (FHWA 2009) similarly defines a low-volume road as "lying outside of built-up areas of cities, towns, and communities, and it shall have a traffic volume of less than 400 AADT." A Finnish study published in 2003 classified low-volume roads as those with AADT of no more than 250 vehicles, with threshold values used to define low volume in case studies across Finland as AADT of from 100 to 350 vehicles (Mustonen et al. 2003).

Many engineers use 150 to 200 vehicles per day, or equivalent heavy-weight traffic, as an unwritten guideline for defining a low-volume road (Louwagie 2011). Gravel road surfaces are considered to be generally effective where AADT is less than 170 vehicles (Skorseth and Selim 2000). Roads with AADT greater than 170 vehicles have experienced significant aggregate loss, higher dust levels, and more frequent blading requirements (Skorseth and Selim 2000). Many of the converted roads identified in the survey and interviews carried out in this study had ADT of 21 to 100 vehicles, suggesting that many of the roads being converted probably should not have been paved or that road usage patterns have changed significantly since paving.

The spectrum of options of surface types for low-volume roads ranges from gravel with no treatment to stabilized gravel to bituminous sealed bases to asphalt and concrete pavements (Figure 3). Each road surface type has its own merits and represents one tool in the road management toolbox. Unpaved roads can be defined as those with a surface course of unbound aggregate (gravel) where no binder, such as tar, bitumen, cement, lime, or other chemical additive, is used. An unpaved road often requires blading at least once annually to maintain the road surface in a drivable and safe condition. Paved roads are defined as those with an asphalt concrete or portland cement concrete surface (Humphries 2012), or roads that possess any combination of asphalt binder and aggregate intended to provide waterproofing, adhesion, structural strength, and frictional resistance (Shuler 2009).

CONVERTING ROADS FROM PAVED TO UNPAVED

Active versus Passive Conversion

Many transportation agencies facing budget shortfalls and deteriorating paved roads are converting their paved roads to gravel (active conversion), whereas other agencies are allowing roads to deteriorate to unpaved conditions owing to a lack of funding for maintenance (passive conversion) (Figure 4) (Etter 2010; Taylor 2010). Active conversion is the process of converting a paved road to an unpaved road using equipment and personnel to recycle the old pavement into a pulverized material that can be used as a base for a new aggregate surfacing or as part of the new surface (Figure 5). Passive conversion of a road from paved to unpaved is the natural process of the paved road breaking down and deteriorating to an unpaved surface as a result of exposure to the elements and wear and tear from vehicle traffic. Based on survey and interview responses, active conversion is a far more common practice, however some local road agencies find that passive conversion occurs simply as a result of a lack of funding for properly maintaining roads.

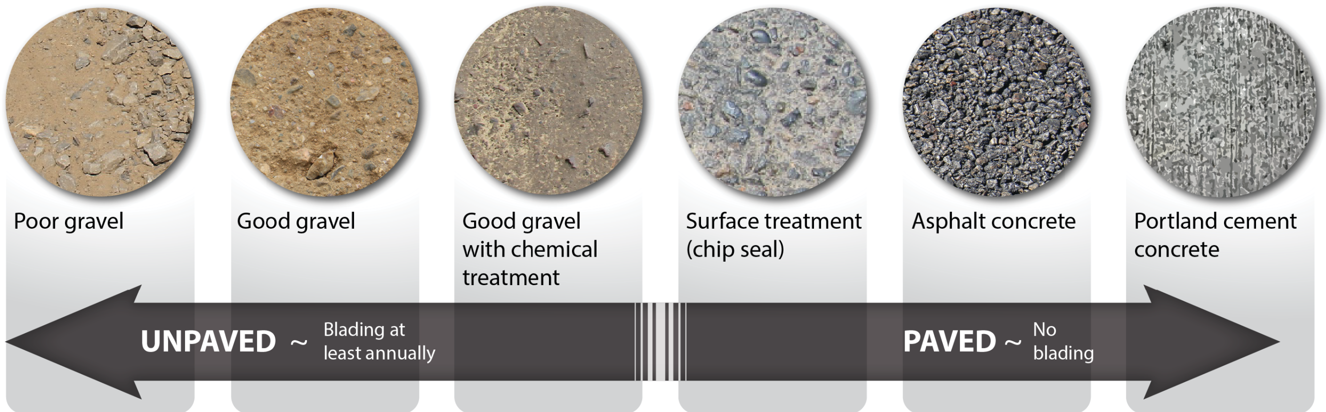

FIGURE 3 Spectrum of road surface types.

Factors to Consider for Unpaving

Factors to be taken into account when considering converting a road from paved to unpaved include the following (Mustonen et al. 2003; Sacramento Area Council of Governments 2008; Iowa Local Technical Assistance Program 2012):

- Road condition: This dictates whether a deteriorated paved surface can be economically repaired to restore it to an acceptable condition or whether there is a need for complete rehabilitation or reconstruction, which may not be affordable. In the latter instance, conversion to gravel can be considered.
- Safety: The deterioration of a paved road surface may be such that it may be safer to convert to a gravel surface either permanently or for an interim period until the road can be rehabilitated or reconstructed.
- Number of residents along the road and the social and economic aspects of the road: The impacts of variable ride quality and dust on road users, residents, animals, produce, vehicle operating costs, and vehicle productivity (possible reduced speed) when converting to an unpaved road all need to be considered. It is important that these be compared with the same impacts resulting from badly deteriorated paved roads.
- Traffic volume and vehicle fleet distribution/type
  - AADT: Traffic counts must always be considered when converting paved roads to unpaved. Depending on traffic volume, seasonal distribution of the traffic, gravel quality, and average precipitation, gravel surfaces can become difficult to maintain.
  - Presence of heavy and overweight vehicles: A high volume of heavy vehicles has a significant impact on the standard required for pavement maintenance and rehabilitation. Initial costs to repave or repair a road to an appropriate standard for these vehicles may be unaffordable for achieving an acceptable life cycle. Gravel roads can be much cheaper to repair when

FIGURE 4 Passive conversion, a local road that has been converted to gravel surfacing only when a section fails. (Photo courtesy of K. Skorseth.)

FIGURE 5 Active conversion of a failing pavement by adding new gravel and recycling. (Photo courtesy of K. Skorseth.)

damaged, but the frequency of repair may be greater. The options will need to be compared.

- Economics of road treatment options (life-cycle cost analysis): The costs of maintaining or reconstructing a paved road versus the cost of converting the road to unpaved and maintaining the gravel surface need to be accurately quantified. Cost data include materials, labor, construction, and maintenance. It is important that life-cycle costs, not only immediate costs, be considered for each alternative to determine accurately which strategy will be the most economical.
- Land use, including but not limited to residential, commercial, agricultural, and industrial, of the area accessed by the road: Most users prefer paved roads. It is important to determine if a paved road is a necessity or simply desired. Some agricultural produce and manufactured goods are susceptible to damage on rough roads, whereas users such as motorcyclists and those with vehicles towing travel trailers and boats may avoid unpaved roads, causing additional economic impacts. Future developments that may result in an increase in AADT or the type of vehicle also could be considered in the decision to pave or unpave.
- Maintenance capability: Specific equipment and skills are required for paved and unpaved road construction and maintenance. The availability and affordability of either contracted or in-house equipment or skill need to be assessed to compare the ability to maintain each surface type effectively. Dust and erosion control may be a significant factor and could be considered for unpaved surfaces.
- Environmental issues: Air and water quality impacts from dust and erosion can affect human, plant, animal, and aquatic health and create a safety hazard to drivers. Products used to stabilize the road surface and reduce dust can also affect the adjacent environment if incorrectly selected or applied.
- Dust and erosion control: These issues may or may not be a significant factor, but it is essential that they be considered for all surfaces.
- Availability and quality of suitable unpaved road–wearing coarse aggregate sources: The quality and properties of the aggregate have a significant impact on the surface condition and frequency of maintenance required on unpaved road surfaces. Appropriate unpaved road surfacing aggregates are not offered by many commercial aggregate suppliers and can be expensive or difficult to obtain. This issue is more important than many managers recognize.
- Public issues: Citizens want to know why a paved road will be converted to unpaved. They deserve information that supports the decisions of elected officials and managers. Economics should be explained clearly and accurately, with as little technical language as possible.
- Network significance of the road: Primary routes that are frequently used by public transport (including school buses) or emergency vehicles or are priority snowplow routes generally are not recommended for conversion from paved to unpaved surfaces. Local roads serving limited access to residences or businesses are better candidates. Some agencies have written or unwritten policies to provide access to paved roads whereby citizens have to travel no more than a few miles to reach a paved road. It is important that these policies be factored into the decision process.

ROAD CONDITION ASSESSMENT TOOLS

Paved roads with surfaces in poor condition with obvious distresses or safety issues often are prioritized for conversion. Ride quality [International Roughness Index (IRI) or Pavement Condition Index (PCI)] values are also often used as a trigger for considering conversions, whereas some counties use a road management program (RMP) index. Mustonen et al. (2003) suggest that roads with 30% of the surface area falling below an acceptable condition may be appropriate candidates for conversion.

Many local road agencies have developed their own methods for setting priorities for these decision metrics. For many assessment tools, the metrics can be weighted based on the importance to a road segment or to the overall road network. When combined, these factors can be used to develop agency-specific RMP policies or pavement condition indices, which in turn can be used to prioritize which roads will be maintained with their current surfacing or converted to an unpaved surface (Montpelier City Council 2009, 2010; Minnesota Department of Transportation 2010). However, RMP policies may have limitations. For one county surveyed, an issue with the RMP involved funding being allocated to higher priority roads on the road network, essentially eliminating funding for general maintenance and reconstruction on local roads and minor improvements on neighborhood routes because the road priority level was below the determined threshold.

Examples of the use of road condition assessment tools include the following.

- Stutsman County, North Dakota, is an example of a small agency using a formal documented road prioritization system to rank roads for maintenance and repair. Factors considered in the prioritization system can be weighted based on the importance of the road segment to the overall network of roads. The system aids in the decision-making process of weighing funding constraints against safety and liability on deteriorated paved roads that still cost substantial amounts of money to maintain, even in poor condition (Minnesota Department of Transportation 2010).
- The city of Montpelier, Vermont, uses a PCI to rate the roads within the municipality, with a rating of 0 indicating a completely failed road and 100 an excellent road. PCI ratings from 1 to 13 are low enough to be considered

for conversion from paved to unpaved (Montpelier City Council 2009, 2010).

- The Indiana Local Technical Assistance Program (LTAP) published a handbook in 2013 that provides guidelines for evaluating the state of paved and unpaved road surfaces and provides typical costs for various types of maintenance. Also included in the handbook are cost assessment comparisons for varying levels of maintenance on a gravel surface and varying conditions on an asphalt road surface with AADT of 100 vehicles over a 14-year period, to highlight the potential savings (or lack thereof) of converting to gravel. These cost assessments are followed by a detailed method of scaling the costs, with weighting of variables to determine which alternative is the most economical over a 14-year analysis period based on factors such as traffic volume, development, and public preference. The publication also points out the safety issues when converting to gravel, such as the possible changes of emergency response vehicle routes and subsequently increased response times (Indiana Local Technical Assistance Program 2013).
- The Pavement Surface Evaluation and Rating (PASER) system (Walker et al. 2013) is a tool that can be used to assess road pavement condition quickly on a scale from 1 to 10. A rating of 1 or 2 indicates a poor to failed road surface in need of urgent maintenance. The ratings are associated with road condition categories and prescribed treatment options. The PASER system can be used for asphalt, concrete, brick and block, sealcoat, gravel, and unimproved roads and allows for comparison of road segment quality and the identification of roads requiring treatment.
- Franklin County, Alabama, uses an asset management system with geographical information system (GIS) tools incorporated into a pavement management system, to make informed decisions about road maintenance and road conversions (D. Palmer, personal communication, May 14, 2015; see Franklin County, Alabama Case Example in Appendix D for more information). These tools are used to model the road system and prioritize roads for maintenance and upgrading. The system considers road surface condition, base condition, traffic volumes, number of residents served, segment classification, repair costs, and other variables. Each road in the county is inspected every 2 years and given a rating from 1 to 100. These values are entered into the GIS system, which has a selection of relevant metrics (e.g., the rating, road classification, AADT) that are used to prioritize and rank road maintenance needs and allocate funds based on the level of service warranted by the road. The system is linked to a database of unit prices for a variety of materials and processes. The system can be used to create color-coded maps based on the input data and recommendations. These are used to quickly and visually communicate road conditions and maintenance costs and options to decision makers and the public, rather than requiring people to read through large budget documents.

PUBLIC REACTION AND OUTREACH EFFORTS

Much of the documented initial public reaction to road conversions has been negative; however, responses from the survey and follow-up interviews indicate that agencies that work with and communicate well with the public aid in acceptance. Based on survey and interview responses, it appears that if properly maintained, roads that have been converted generally are accepted by the public because of the improved driving surface and increased level of safety. However, the range of public reaction to road conversions varies greatly, with both the literature review and surveys indicating that some affected residents are more understanding and accepting than others and highlighting the importance of using appropriate terminology when communicating with the public.

Examples highlighting the importance of public outreach include the following:

- The word “unpaved” was perceived negatively by attendees of a public county board meeting in Freeborn County, Minnesota, because the term was associated with loss of service (Minnesota Local Technical Assistance Program 2012).
- In Sequoyah County, Oklahoma, residents had difficulty accepting the change from asphalt pavement to a perceived lower level of service on the unpaved gravel road despite the poor condition of the asphalt road (Cameron 2010). One resident noted that although driving on the gravel road was not pleasant, conversions were understandable given that the county had limited funds available to keep the roads passable. A resident who lived next to a recently converted road said that the dust was bothersome but that the road condition was much better than the distressed paved road because the potholes had been removed in the process (Cameron 2010).
- To address public relations in Indiana, the LTAP conducted seminars, titled “Back to the Stone Age,” about the conversion process and discussed measures taken to ameliorate residents’ concerns, such as developing a plan to manage dust on the unpaved road (Taylor 2010).
- Some constituents believe they deserve a paved road regardless of the funding situation. In Mahnomen County, Minnesota, in a meeting with concerned citizens who lived on or near the road slated to be converted, citizens stated that regardless of cost, they believed it was their right to have the road reconstructed and paved. The residents filed complaints with legislators and the Minnesota Department of Transportation (DOT) (MnDOT) objecting to the road conversion project [Minnesota County Engineers Association (MCEA) Members Forum 2011]. For many other road conversion projects, public reaction has been negative, with residents reaching out to state

and local government officials to express concerns or prevent the conversions from taking place (Rajala 2010; Taylor 2010; Gillie 2013; Christensen 2013).

- In Texas, the public reaction to planned road conversions by the Texas Department of Transportation (TxDOT) was negative, and the lack of communication between TxDOT and county officials was of primary concern. The point was made that TxDOT should have communicated more effectively instead of simply announcing the conversion would occur (Batheja 2013). Concerns and questions raised included concern that converting the road to gravel would cause insurance rates to increase and property values to decrease, in addition to causing extra wear and tear on cars (Floyd 2013). Public opinion was sufficiently negative that in August 2013, TxDOT agreed to cease all conversions for a period of 60 days. By this time, two roads had been converted to gravel. TxDOT issued a letter announcing the end of its program of converting roads and requesting an additional $402 million for the remainder of the 2014 fiscal year to fund "critical safety projects" and tackle roads compromised by the oil boom (Batheja 2014).
- In Brown County, Indiana, residents noted that they do not miss the bad paved road because the converted road is well maintained and has a smooth driving surface (The Indy Channel 2012).
- A resident who lives along Lake Montcalm Road in Montcalm County, Michigan, noted that the converted road was smoother than it was when paved but expressed concern about how it would be maintained in the winter (Martin 2009).
- In Baldwin County, Alabama, a letter was sent to residents living along a road slated to be converted stating that if the road were left as it was, the county would not be able to plow snow from the road (MCEA Members Forum 2011). The lack of comments from residents regarding the road conversion was considered to be public acceptance of the situation.
- In Sonoma County, California, residents understood the lack of funds to repave the road but were upset that the county did not notify them that Sonoma Mountain Road was being converted (Brown 2010). In hindsight, the county acknowledged that residents should have been notified of the change (Brown 2010).

An example of a successful outreach effort by the city of Montpelier, Vermont, is a letter sent to road users to inform them of an intended road conversion (see Appendix F). In addition to the letter, a public hearing was held before and after completion of the road conversion, to address concerns such as dust control (T. McArdle, personal communication, April 24, 2015). At the hearing held after the road conversion, people (including motorcyclists) were supportive of the new unpaved road. The public outreach efforts worked well in this situation and were considered successful. The city of Montpelier acknowledged that this was a good lesson for the road agency to consider in future conversion projects and that involving the public early in the process about the reality of the current paved road condition versus the expected unpaved road condition was important.

Changes in Traffic Patterns and Vehicle Type

Modern agricultural equipment (i.e., tractors, combines, farm trucks) have greatly increased in size and carrying capacity, along with greater crop yields, creating increased maintenance issues on paved and unpaved rural roads (Anderson 2011), with accelerated degradation of low-volume roads (Figure 6). Multiaxle semis, concrete haulers, large-load log trucks, and rising traffic volume can be equally destructive (Etter 2010; Taylor 2010) (Figure 7). In some areas of the country where oil drilling and extraction have increased, such as North Dakota, Texas, and Pennsylvania, significant damage to roads from oil field traffic has occurred (Floyd 2013). Many of these rural paved roads have passed the end of their design life (Anderson 2011). For example, in South Dakota many 30-year-old pavements are still in place although they had projected life-cycles of 20 or 25 years (Landers 2011).

Examples of how changes in traffic patterns and vehicle type influence decisions to convert roads include the following:

- In Pennsylvania, two counties have used conversions from paved to unpaved as traffic-calming measures. Tinicum Township in Bucks County and Marlborough Township in Chester County have both converted paved roads to gravel in an attempt to deter and slow traffic. However, no data could be found supporting that this method of traffic calming was effective or resulted in a change in traffic patterns.
- In Michigan, a resident of Montcalm County noted a reduction in traffic speeds along Lake Montcalm Road, which was converted to gravel in 2009 (Martin 2009).
- Concerns have been expressed by business owners and residents in Stutsman County, North Dakota, about a potential reduction in customer and tourist traffic on a local road owing to portions of the road being converted from paved to unpaved (Etter 2010). Views expressed in a letter to the editor of the *Jamestown Sun* newspaper suggested that vehicle traffic would actually increase on the converted road as a result of the construction of a new industrial park, which is accessed by the road (Mosolf 2010). However, no documentation was found showing that the road conversion resulted in a change in traffic patterns or a change in the amount or type of traffic.
- Tooele County, Utah, converted 13 mi of a connector road accessing a water skiing lake and resort. The director of the Tooele County Road Department noted that although there is a different, paved route to the recreation site that is only slightly longer, traffic remains more or less the same on the road that was converted. The owner

(a)

(b)

(c)

FIGURE 6 A 1950s era farm truck (*a*). Many local roads that were designed to carry this type of vehicle carry today's larger agricultural equipment and trucks (*b*) and (*c*). (Photos courtesy of K. Skorseth.)

FIGURE 7 A township road failing because it carries heavy loads for which it was not designed. (Photo courtesy of K. Skorseth.)

of the resort noted that the only time users choose to take the longer, paved route is when they are towing a trailer (Gillie 2014). Recreationists have asked that the road be repaved, in part because of the possibility of loose rocks damaging their boats.

Changes in Agency Equipment and Staffing

Converting roads may require agencies to purchase or hire additional equipment to do the conversion or maintain the unpaved road. Numerous interviewees indicated that standard reclaiming or recycling equipment was used for conversions in their respective jurisdictions. However, few responding agencies who indicated that this type of equipment was used to convert roads from paved to unpaved actually purchased or owned it; many rented the machines. Examples from the survey include the following:

- In Vermillion County, Indiana, some agency changes were required when a 16-mi section of paved road was converted to gravel in 2013. The county has 193 mi of paved road and more than 189 mi of gravel road. To handle the increasing number of unpaved road miles, highway maintenance crews are being retrained on how to maintain gravel roads effectively (Greninger 2012).
- In 2010, Stutsman County, North Dakota, purchased a reclaiming machine ($400,000) for use in part to convert numerous roads in the county (Etter 2010).
- The public works department in Montpelier, Vermont, added a new road grader to its equipment fleet after converting two roads to gravel in part to keep up with required maintenance (Montpelier City Council 2010).

Health and Environmental Impacts

A significant environmental impact from gravel roads is dust, which has been associated with health issues, air pollution, and crop damage. Dust can be mitigated by refining gravel specifications or by using an appropriate dust suppressant. However, potential environmental impacts related to the use of chemical dust suppressant and stabilizers during and after the conversion process must be considered. Examples of concerns identified in the literature and raised during the survey include the following:

- A resident of Midland County, Michigan, suggested that dust control palliatives and dust from the pulverized road affected the fertility of his land (Warrick 2013).
- In Washington County, Oregon, a nursery owner tracked the losses associated with his fields located near gravel roads. The impact of road dust on crop production was roughly $3,000 per year for every 100 ft of gravel frontage and rendered some portions of his crop nearest to the road unsellable (Clemmons and Saager 2011).
- In Napa County, California, the Department of Public Works received an inquiry from the Department of Fish and Wildlife on behalf of a constituent concerned that pollution in a nearby creek was associated with a recent road conversion project (S. Stangland, personal communication, May 6, 2015). The creek and converted road were investigated, but no impacts were found.
- In Montpelier, Vermont, residents expressed concern that the use of calcium chloride as a dust suppressant could affect drinking water wells. Previous studies completed by the Vermont DOT found that calcium chloride can permeate the gravel but that it stays in the soil. Based on this research, the city determined there would be no impact to the well water (Montpelier City Council 2010).
- In Sonoma County, California, a resident discovered the road in front of his house had been converted while he was out of town on vacation. The resident was concerned about the impacts the dust would have on his asthma and implied that recreational use of the road may need to be reduced (Brown 2010).
- In Midland County, Michigan, residents of Shaffer Road experienced health problems following pulverization of the road in 2010. Eye, nose, and throat irritation was caused by what was defined as "toxic dust" from the pulverized road surface. Midland County did not have the funding required to test the dust for toxicity. However, similar concerns were raised when nearby Muskegon County pulverized a road. One township within the county paid for an independent analysis of the dust by a private laboratory, which found "six probable carcinogens and eight substances classified by the U.S. EPA as priority pollutants when found in drinking water" (*Midland Daily News* 2011). Recommendations from the manufacturer of the pulverizer indicated that sealing a road after it is pulverized is important to reduce dust. Shaffer Road was not sealed or resurfaced because of limited funds. To manage the dust issue, residents now pay for extra calcium chloride applications to reduce dust, have purchased home air purification systems, and avoid walking and biking on the road to minimize their exposure to the dust (Warrick 2013).
- One instance was found for which material used to seal a road was classified as a hazardous substance but rated as safe for use on roads. The product was used because it was donated to the county by Utah Power and Light (Christensen 2013). No additional information on this product or impacts was provided.

ROAD SAFETY

A primary reason for converting a road from paved to unpaved, as indicated in the literature and from the survey and interviews, is safety concerns (Figure 8). Many agencies and practitioners contend that a gravel road can be maintained to a higher safety standard than a deteriorated paved road and often at less cost. However, gravel roads can still pose a variety of safety concerns, with poorly maintained gravel roads often being dusty and having washboarding, loose gravel, and potholes, which lead to unsafe and uncomfortable driving conditions. Anecdotal evidence suggests there may be an increased rate of crashes on roads that have been converted. However, survey responses from local road agencies indicated that no

FIGURE 8 Examples of road safety effects caused by failing asphalt roads. The failures force traffic to travel outside of the lane and disrupt traffic movement. (Photos courtesy of K. Skorseth.)

documented increase in vehicle crashes has been found on any of the converted roads or road segments; interviewees indicated that the improved unpaved driving surface reduced the occurrence of crashes. According to the Sacramento Area Council of Governments (2008), converting poor-condition paved roads to unpaved roads can help prevent accidents because of decreased driving speeds.

Limited published data are available on crashes on local roads, specifically on low-volume roads that have been converted from paved to unpaved. The county engineer in Freeborn County, Minnesota, stated, "There is a need for better and more readily available crash data, specifically on local roads, as it relates to improving rural road safety." Historically, local roads have a higher rate of fatalities per million miles traveled than primary roads, but minimal information has been collected about crash rates and fatalities on roads that have undergone a conversion (Kuennen 2010). To address these issues, ongoing NCHRP Synthesis project 46-07: *State Practices for Local Road Safety* is being done to identify state programs used to address local agency road safety, particularly on low-volume roads. This report is scheduled to be available in early 2016.

The literature review and survey identified mixed responses on how road conversions affected safety, including the following:

- In Sitka, Alaska, a road was converted because of safety concerns. Motorists were swerving to avoid potholes and had difficulty navigating a hairpin turn. Anecdotal evidence suggested that safety improved after the conversion (Woolsey 2014).
- In Montcalm County, Michigan, a 15-mi section of road was converted in part because of accidents related to the surface condition of the paved road. The unpaved road has been maintained appropriately, and the county has observed no documented increase in vehicle crashes.
- In Tooele County, Utah, many residents raised concerns regarding decreased visibility resulting from dust after a 13-mi section of paved road was converted to unpaved. However, the road department treated the road with magnesium chloride as a dust abatement procedure and continues to assert that the road can be maintained to a higher safety standard as a gravel road rather than a pothole-filled paved road (Christensen 2013). The mayor and local residents suggested vehicle accidents rates decreased when the road was paved and that isolated rollover accidents occurred on the unpaved road because people "did not know how to drive on the gravel surface" (Christensen 2013).
- An accident occurred in 2010 in Rogers County, Oklahoma, in which a driver lost control of his vehicle, resulting in a rollover. The road had been converted temporarily to gravel, and although state troopers cited high speed as the cause of the accident, they noted that gravel could exacerbate the risks of speeding (Cameron 2010).
- Anecdotal evidence from residents living on Sonoma Mountain Road in California suggests that vehicle accidents can be attributed to drivers losing control on the new unpaved surface (Brown 2011).

ECONOMIC CONSIDERATIONS—COST OF CONVERTING VERSUS REPAVING

The 2010 *Wall Street Journal* article "Roads to Ruin: Towns Rip Up the Pavement" highlighted the economic strain many counties face when trying to maintain paved roads in rural areas (Etter 2010). A recent study found that the state of Iowa would need to increase road funding by $220 million annually just to maintain the current road network (Anderson 2011). Similar funding shortfalls for local road maintenance budgets are occurring across the country (Canfield 2009; Taylor 2010; Landers 2011). Cold-weather states in particular have high maintenance costs resulting from the repair of damage caused by freeze-thaw cycles but little available funding because of essential winter maintenance operations (Canfield 2009).

Coupled with declining budgets, agencies have seen raw material prices increase. Costs for gasoline, diesel, and asphalt binder, all petroleum-based products, are tied to fluctuating oil prices (Taylor 2010). However, fuel taxes, which are a primary source of funding for road maintenance, have remained constant in this time period. Improved fuel consumption technologies have further reduced this source of income.

The recent economic downturn has made governments reluctant to increase other taxes and has resulted in people driving less. In 2015, Iowa enacted a 10-cent-per-gallon increase in the state's fuel tax for the first time since 1988 in an effort to cover a $200 million road construction and maintenance deficit (Anderson 2011; Murphy 2015). Minnesota attempted to increase county maintenance budgets by raising the state's gas tax by 8.5 cents in 2008, but county officials warned it would not be enough to keep up with rising maintenance and paving costs (Louwagie 2011).

Examples of economic considerations cited in the literature and surveys follow.

Michigan

- According to a county road commissioner, Michigan is ranked 50th in per capita spending on road maintenance in the country (Canfield 2009; Rajala 2010). In Montcalm County, patching of a primary road cost more than $39,000 in 2008 and 2009. However, it cost only $7,300 for the road to be converted to gravel.
- Road conversion projects in Benzie County, Michigan, have resulted in significant savings in maintenance costs by eliminating the need for two-person patch crews working 1 to 2 days per month and replacing that process

with annual brine application (Minnesota Department of Transportation 2010).
- The Branch County Road Commission in Michigan was spending nearly $2,000 per week making repairs to a road. A 1-mi stretch of the road was converted to gravel at a cost of $6,370 (Reid 2014).
- In Emmet County, Michigan, repairing just more than 3 mi of a severely potholed road cost $20,000 to $30,000 per year. After the road was converted to gravel, maintenance costs were reduced by about $10,000 annually, with an initial (up-front) cost of $12,000 for pulverizing the paved road (Keller 2010).

Midwest

- In 2013, the Indiana LTAP published *Assessment Procedures for Paved and Gravel Roads*, a handbook that addresses some of the issues facing underfunded counties in Indiana. Cost estimates from the report place the cost of recycling a paved asphalt road, stabilization of the base, and addition of a new gravel surface at $42,000 per mile. Alternatively, the cost to maintain the asphalt with similar treatments to the subsurface and a new asphalt overlay was estimated at $112,000.
- In Hancock County, Minnesota, estimates for initial construction and 5 years of maintenance suggested a total cost savings of $3,000 per mile (Minnesota Department of Transportation 2010).
- In North Dakota, Stutsman County expenses outweigh income, and the county has revenue to maintain only 48 of the 233 mi of paved road. Cost estimates for repaving a deteriorated road segment were around $75,000 per mile, whereas projected costs for maintaining the road as gravel were $2,600 per mile (Arndt 2010; Etter 2010). The county estimated it would cost $32,000 per mile in maintenance costs over the 20-year life-cycle for a low-volume paved road, whereas that same 20-year maintenance cost would drop to $4,300 per mile for a reclaimed road and lower still to $1,700 per mile for a gravel road (Landers 2011).
- In Allamakee County, Iowa, the cost estimate for surfacing roads was about $100,000 per mile, compared with only $5,000 per mile to remove the pavement and add new gravel (Louwagie 2011).

West Coast

- In Union County, Oregon, about 5% of the 150 mi of paved roadway has been converted to unpaved gravel roads because it was cheaper than trying to maintain the roads as paved (Cooper 2008).
- In Lake County, California, paved roads were recycled with a pulverizer followed by an enzyme application (Brown 2010). The county won an award in 2009 from the California Chip Seal Association for Innovative Project of the Year for the resurfacing of two of the converted roads. Overall, the county saved about $190,000 with the technique used instead of a traditional pavement overlay (Larson 2010).

East Coast

- High asphalt and transportation costs were motivation for Cranberry Isles, Maine, to consider converting three of its major roads to gravel (Rajala 2010). Repaving was estimated to cost the town (population 118) nearly $500,000, whereas converting to gravel cost $58,000, with most labor performed by public works personnel (Montpelier City Council 2010).

CHAPTER THREE

SUMMARY OF SURVEY RESULTS

KEY OBSERVATIONS FROM INITIAL SURVEY

Road conversions from paved to unpaved surfaces identified from the literature, survey, and interview responses have occurred in at least 27 U.S. states (Figure 9) and in other countries (Canada and Finland) (Canfield 2009; Cameron 2010; Etter 2010; Louwagie 2011). Of the 139 survey responses from local, state and province, and federal roads agencies, 48 indicated that they have converted a road or road segment from paved to unpaved and nine that they are considering a road conversion project, whereas 82 indicated they have not converted any paved roads to unpaved. Based on survey responses alone, more than 550 mi of paved roadways in the United States and Canada have been converted to unpaved, with most local road agencies converting an average of 10 mi (range of 0.5 to 30 mi).

Many of the 48 survey respondents who have done conversions transformed an original pavement that was in poor condition to an unpaved surface that was considered to be "good" or "fair." Responses included asphalt concrete in poor condition (28), asphalt surface treatment (i.e., chip seal) in poor condition (24), or a combination of pavement types in poor condition (six).

The AADT on converted roads typically was low, with more than half of the converted roads having an AADT of less than 100 vehicles, and only one conversion having an ADT of more than 500 vehicles (Figure 10).

Once converted, road surfaces were left unpaved by most (41) of the survey respondents, with road surface stabilization incorporated into part of the surface layer used by 19, topical application of dust suppressant used by five, and topical application of asphalt emulsion used by four.

In most instances, pavement surfaces were recycled in place using a reclaimer or a ripper on a grader (ideally sizing the material to 1-in. top size). When necessary, additional gravel was added and mixed to supplement existing material, after which the roads were shaped and compacted. Road conversions typically were completed by agency staff with agency-owned or rented equipment. The remaining conversions were completed by a contractor.

Fifty-four of the 57 survey respondents who had converted or planned to convert a road indicated that the cost of maintaining the road was the most significant reason for converting it (Figure 11). Safety concerns were also indicated as a reason in nearly half the conversions, whereas public complaints were cited in about one-third of instances. A combination of the three reasons was cited as the impetus for conversion by 16 of these 57 respondents. For many local road agencies that participated in the survey, the final decision to convert a road from paved to unpaved was made by the county commissioner or county or supervisory board, or based on recommendations from the county engineer or highway superintendent or manager.

For many responding agencies, most road conversions were conducted in the past 5 years (2010 to 2015). Of the 52 responses received regarding road performance after the conversion, 44 indicated that the road was performing well, 43 noted that the conversion has saved the local road agency money, and 35 responded that there has been no documented increase in vehicle crashes on the converted roads or road segments. Despite these results, sentiment from those affected by the road conversions has been split, with 19 respondents noting a positive reaction from road users and 26 reporting a negative reaction. Pressure to repave the converted roads was identified by 29 of the 53 respondents answering this question. Despite this public negativity, 20 of the responding local road agencies plan to convert more roads from paved to unpaved in the future.

Responses from the survey indicate that the use of outreach efforts by local road agencies to communicate the occurrence and process of road conversions to the public was evenly split, with half indicating that some form of outreach was performed and half noting their absence. Outreach efforts commonly included public meetings; meeting with stakeholders and residents who lived along the road being converted; and to a lesser extent, letters sent to affected homeowners or use of local media (television news reports, radio, newspaper articles, and press releases). Most local road agencies that used outreach efforts reported the efforts were successful on some level. Comments from respondents on how to communicate successfully with the public include providing the public with information and an explanation of why the road is being considered for conversion (safety and cost), transparency about funding, and current and future road conditions. Of the 48 agencies that responded, 22 indicated they would use similar methods for future road conversion projects.

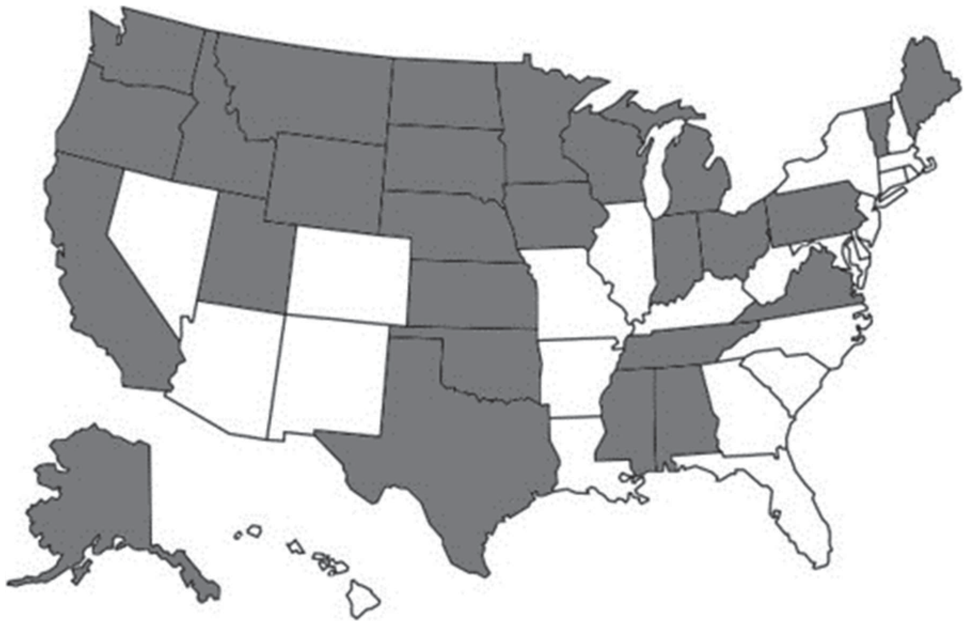

FIGURE 9 Shaded areas are U.S. states in which roads or road segments have been converted from paved to unpaved. (Identified from the literature and from survey and interview responses.)

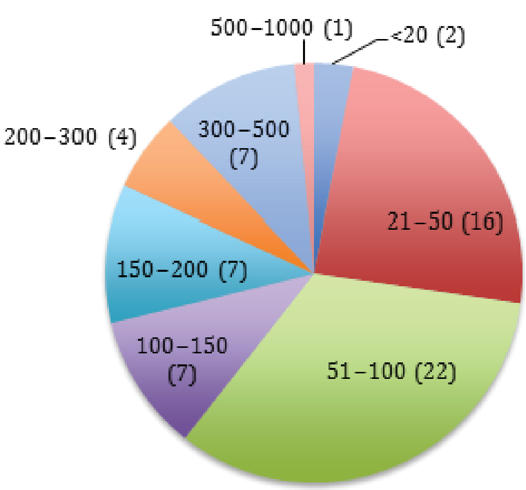

FIGURE 10 Summary of ADT on roads converted from paved to unpaved.

KEY OBSERVATIONS FROM FOLLOW-UP INTERVIEWS

This section provides an overview of the responses to follow-up interviews with 19 of the survey respondents (from 18 U.S. states and one Canadian province) who have converted paved roads to unpaved. The interviews were conducted to gather information about the conversion process that was not covered in the survey. Appendix B includes details of the responses, which highlight effective and innovative practices in design, construction, planning, public outreach, and funding.

The length of roads converted ranged from 0.2 to 42 mi. Many of the road conversions were conducted by smaller agencies with total centerline roadway miles maintained ranging from 19 mi in a rural Montana county to 3,000 mi for a respondent who supervised many counties in the state

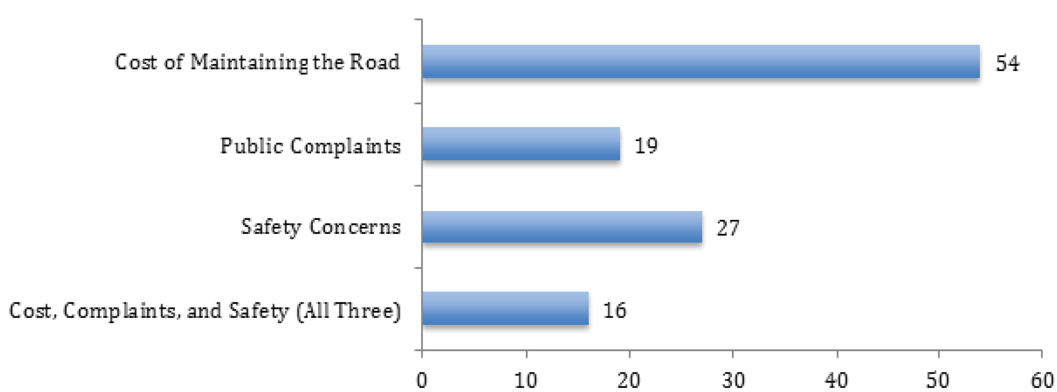

FIGURE 11 Survey responses on why roads were converted from paved to unpaved.

of Minnesota. Operating budgets for these agencies ranged from $56,600 as reported in Musselshell County, Montana, to $40 million as reported by the TxDOT (one of a few state DOTs that maintain the local road system). A total of 57 road conversions were reported in the case examples, and all occurred on low-volume roads. Annual average daily traffic for 37 of the 57 conversions was below 100 vehicles, and AADT on all conversions but one was below 400 vehicles (i.e., the AASHTO definition of a low-volume road). Most of the roads converted were asphalt concrete in poor condition, and roads were converted for a variety of reasons, including the cost of maintaining the road, safety concerns, and public complaints.

Interviewees were asked if there was anything that would have been helpful during the conversion process, such as a handbook or presentation, documentation, or other supporting materials. The objective of this question was to get practitioners to elaborate on what type of information was lacking on the subject of road conversions. Thirteen of the 19 respondents indicated that a handbook describing various aspects of the conversion process would have been helpful (Figure 12). Practitioners indicated that the lack of available information led many to perform the work with no guidance, sometimes resulting in conversions that did not meet expectations or were difficult to perform. Feedback from these respondents indicated that a handbook covering topics such as construction specifications, tactics for public relations, case studies with examples from other agencies, and lessons learned would have been helpful during the conversion process. Only two practitioners indicated that they would not have found a handbook helpful but acknowledged that they had performed many conversions and had significant experience with the process.

Five respondents indicated that a presentation to decision makers and affected individuals would have been helpful before the conversion process. Respondents noted that communicating to the public and government officials about conversions was difficult and that a presentation discussing budget constraints, detailing the process, and showing examples of successful conversions from other agencies would have made the conversion process easier overall. Two respondents indicated that they would have found a life-cycle cost analysis tool helpful to determine when a road may be considered for conversion. One respondent indicated a research project to reference on the practice would have been helpful. In Linn County, Iowa, road practitioners have implemented a dust control policy that determines the selection of road surfacing based on AADT. They have found this policy to be helpful by placing the determination of conversions on traffic counts, rather than budgets or the decisions of personnel at the agency or a county office.

Interviewees were asked if there were any special tools, products, or equipment they found particularly useful in the conversion process. A reclaimer or pulverizer was cited as the equipment of choice by 14 of the 19 interviewees (Figure 13). Many noted that the use of this equipment resulted in a better driving surface and was faster and more efficient than other options. One practitioner noted that the reclaimer must be of appropriate size and weight for the job because an underpowered and undersized reclaimer may not produce satisfactory road surfacing material. Other respondents stated they used a motor grader and scarifier to break up already deteriorated asphalt followed by application of gravel with either a dump truck or a paving machine.

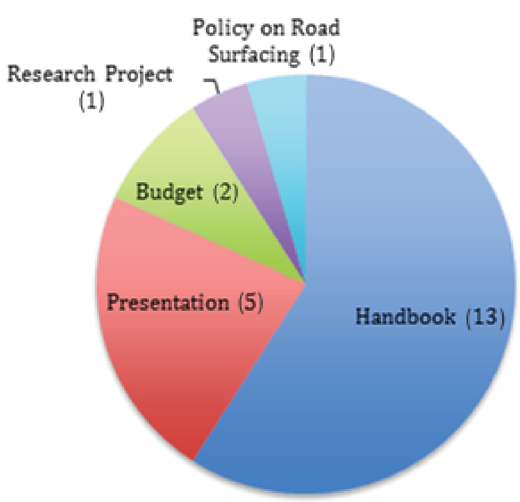

FIGURE 12 Interviewee responses concerning the need for supporting material and documents that could aid in conversions.

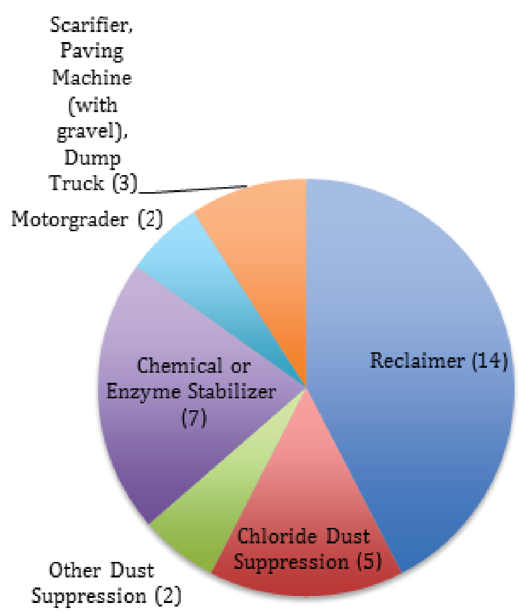

FIGURE 13 Interviewee responses concerning tools and equipment used in roads conversion.

Chlorides or enzymes were used for stabilization in 13 of the 19 road conversions. Stabilizers were used to mitigate base deficiencies and stabilize the granular portion of the reclaimed road surface, resulting in better and safer driving surfaces. Some respondents indicated they had not used a stabilizer initially during the conversion but, as a result of issues with the roadway, were now experimenting with stabilizers to find the most effective option. One respondent said that the use of an enzyme stabilizer improved the road surface, significantly reduced required maintenance, and is now commonly used for road conversions in that area. Two practitioners recommended caution when using stabilizers because overuse can result in pothole formation similar to deteriorated asphalt, which complicates maintenance.

Seven respondents indicated dust suppression products were useful. Five respondents reported use of a chloride-based product for dust suppression, whereas two respondents used asphalt emulsion or waste brine from gas and oil wells. The respondents noted that the use of dust suppressants helped to stabilize the road surface, provided a better driving surface, reduced dust levels, and contributed to gaining public acceptance of converted roads. To this end, many agencies agreed to more frequent applications on newly converted roads as requested by the road users.

One question asked respondents if they could share any successful practices with others considering a road conversion. Respondents were encouraged to include suggestions about public relations and construction aspects of conversions. Of the 19 interviewees, 14 stressed the importance of public outreach (Figure 14). Two practitioners said the public relations component of the conversion process was more difficult than the actual conversion. In conjunction with public outreach, ten of the respondents indicated that transparency when interacting with the public was crucial to the success of projects. Many respondents indicated that the public was more understanding and willing to accept the idea of a road being converted if they understood the reasoning behind the decision, how the work was going to be performed, and what the road would be like after the conversion. Additional suggestions from respondents included making the decision to convert roads based on traffic counts (three), emphasizing safety as a reason for the conversion (two), and allowing residents to perform voluntary dust suppression (two).

Suggestions of other successful practices during the construction phase of the conversion were provided by 14 of the 19 respondents. Most reiterated that using a reclaimer provided the best road surface and was the only large equipment suitable for performing a conversion (Figure 15). Several respondents (seven) indicated that ensuring the correct ratio of crushed asphalt to granular surfacing material and the appropriate top size of the crushed material (1 in. or less) is important so that the road can still be maintained with a grader or have cobbles (large pieces of crushed asphalt) on the surface that influence ride quality (Figure 16). Supplementing the existing road materials with additional aggregate, including fines, or changing the depth of reclamation were both techniques that respondents indicated could be used to achieve the proper ratio of granular material to reclaimed asphalt. Two respondents also indicated that proper maintenance after the conversion was important to gain public acceptance and ensure increased longevity of the road. Two respondents indicated that use of a stabilizer was important for success, and one respondent noted that conversions are not be performed on roads that do not have appropriate drainage.

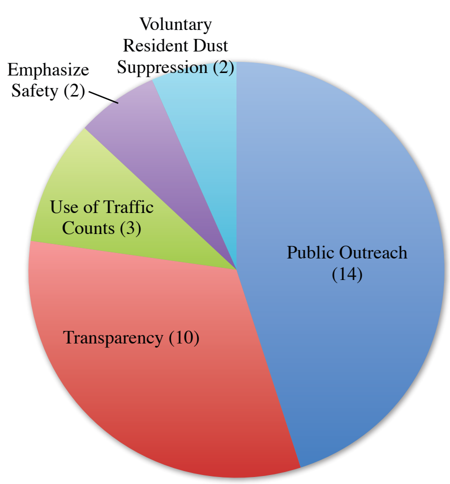

FIGURE 14 Interviewee responses regarding successful public relations practices in roads conversion.

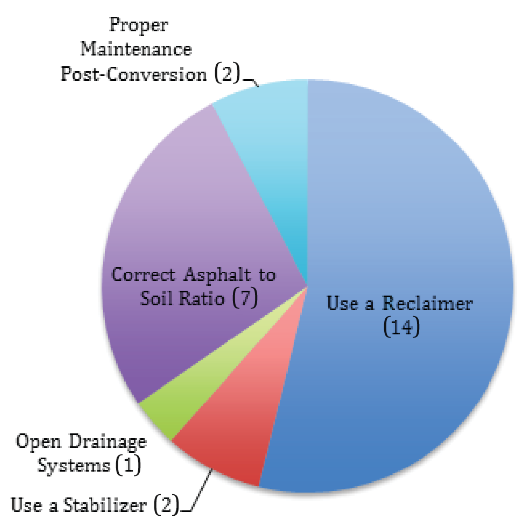

FIGURE 15 Interviewee responses regarding successful construction practices in roads conversion.

(a)

(b)

FIGURE 16 A cobbled road surface (*a*) and close-up of a piece of reclaimed asphalt greater than 1 in. in diameter, which is creating the cobbled surface (*b*). (Photos courtesy of K. Skorseth.)

The final question asked if interviewees had noticed or experienced any specific engineering issues with the road during the conversion process or with how the road performed after. Many respondents indicated that converted roads have performed well and require minimal maintenance. However, many interviewees indicated that getting roads to a point of minimal maintenance required considerable effort, much of which was trial and error. Those who did not use a reclaimer indicated issues with “chunks” of asphalt that were difficult to break up and resulted in an uneven driving surface (cobbling). Seven respondents indicated that achieving the correct ratio of granular surface material to asphalt had been difficult and often required further measures to address these issues, including additional passes with the reclaimer or a padfoot roller. Some respondents found that the existing granular surfacing material required additional modification to provide a suitable driving surface. Five respondents indicated that during the conversion process, they had issues with shaping the road and achieving the proper crown but eventually achieved a road that was easier to maintain than the original deteriorated asphalt surface. Three respondents indicated that addressing base issues was something they either did or should have done, with one respondent indicating that the use of geogrids or geotextiles may be helpful. One respondent indicated that the agency should have completed an initial geotechnical investigation of the roadway. Once the conversion was started, the agency found base material of uneven thickness and identified numerous problems in the road base. Two of the respondents noted that identifying the type of traffic that would use the converted road was important because they had “underbuilt” the converted road and had to perform additional maintenance to correct issues related to heavy truck traffic.

CHAPTER FOUR

RESOURCES AND AVAILABLE DOCUMENTS

This chapter provides a summary of relevant reports, documents, and resources that can be used when considering or conducting a road conversion. A comprehensive approach to this conversion requires, but is not limited to, assessment of the level of deterioration of the road, identification of appropriate options that are available to rehabilitate or treat the road, a life-cycle cost analysis of these options, a centerline survey to determine the existing road structure and available materials, material testing to determine the appropriate blend of materials (i.e., recycling depth) and whether additional materials are to be imported, selection of an appropriate stabilizer or dust suppressant if these are being considered, and the use of appropriate road construction and maintenance methods. At this time, there is no comprehensive document that addresses all of these variables; therefore, the information presented in this chapter provides a list of the most relevant publications on each of the variables assumed to have the greatest influence on converting roads. An annotated bibliography of the reports, documents, and resources is presented in this chapter.

RESOURCES ADDRESSING CONVERSION FROM PAVED TO UNPAVED

1. *Decision Tree for Unpaving Roads* is a preliminary assessment of the state of the practices for "issues surrounding the maintenance, preservation, and possible conversion of a low volume paved road to gravel." This document provides a summary of relevant literature and a survey of state and county transportation agencies on this topic [CTC & Associates LLC, *Decision Tree for Unpaving Roads*, Office of Policy Analysis, Research, and Innovation, Research Services Section, Minnesota Department of Transportation, St. Paul, 2010 (http://www.dot.state.mn.us/research/TRS/2010/TRS1007.pdf)].
2. "Turning Deteriorated Paved Roads Back into Gravel Roads: Sheer Lunacy or Sustainable Maintenance Policy?" is a journal article that describes circumstances in Finland that led to three local road programs developing guidelines to determine if a road qualified to be converted from paved to unpaved [Mustonen et al., "Turning Deteriorated Paved Roads Back into Gravel Roads: Sheer Lunacy or Sustainable Maintenance Policy?," *Transportation Research Record: Journal of the Transportation Research Board, No. 1819*, Transportation Research Board of the National Academies, Washington, D.C., 2003 (http://trrjournalonline.trb.org/doi/abs/10.3141/1819a-15)].
3. "Improvements to Linn Run Road: Case Study on Turn-Back of Asphalt-Paved Road Surface to Maintainable Gravel Road Surface" is a journal article detailing the conversion of a deteriorated paved road to gravel by the Pennsylvania Bureau of Forestry in conjunction with The Center for Dirt and Gravel Road Studies at Pennsylvania State University [Shearer, D.R. and B.E. Scheetz, "Improvements to Linn Run Road: Case Study on Turn-Back of Asphalt-Paved Road Surface to Maintainable Gravel Road Surface," *Transportation Research Board*, Washington, D.C., 2011, pp. 215–220 (http://trrjournalonline.trb.org/doi/abs/10.3141/2204-27)].

GRAVEL ROAD DESIGN, CONSTRUCTION, AND MAINTENANCE

1. The *Gravel Roads: Maintenance and Design Manual* was developed in 2000 but is still relevant as a guidance document. This document discusses road shaping, drainage, definition of "good" surface gravel and the volume required, and maintenance guidance for gravel roads [Skorseth, K. and A.A. Selim, *Gravel Roads: Maintenance and Design Manual*, South Dakota Local Transportation Assistance Program and Federal Highway Administration, Washington, D.C., 2000 (http://ntl.bts.gov/lib/12000/12100/12188/20020819_gravelroads.pdf)].

   A revised version of *Gravel Roads: Maintenance and Design Manual* was completed in 2015 and published with the title: *Gravel Roads: Construction and Maintenance Guide.* Updated information and photos are included to guide gravel road managers, equipment operators, and field supervisors. Roadway shape, drainage, recommended surface gravel specifications, and basic construction guidance are the key points covered (Skorseth, K., R. Reid, and K. Hieberger, *Gravel Roads: Construction and Maintenance Guide*, FHWA Publication No. FHWA-OTS-15-0002, 2015).
2. *Best Practices for the Design and Construction of Low Volume Roads Revised* presents how MnPAVE, a mechanistic-empirical software program, can be used to design pavement types based on traffic loading, design life, and vehicle type, and provides guidance on subgrade and embankment soils and recommendations for density and compaction. Although this document speaks more to pavements, information on subgrade preparation and best practices to follow specifications may be gleaned from the document [Skok, E.L., D.H. Timm,

M.L. Brown, T.R. Clyne, and E. Johnson, *Best Practices for the Design and Construction of Low Volume Roads Revised*, Minnesota Department of Transportation, St. Paul, 2003 (http://www.lrrb.org/media/reports/200217REV.pdf)].

3. *Guidelines for Geometric Design of Very Low-Volume Local Roads* developed by AASHTO (2001) addresses the unique needs of very low-volume roads (LVR) with limited traffic and reduced crash rates to avoid overdesign for safety and engineering of these roads. The document provides recommended ranges of values for critical dimensions that can be used to supplement existing road design manuals [American Association of State Highway and Transportation Officials, *Guidelines for Geometric Design of Very Low-Volume Local Roads*, 2001 (https://bookstore.transportation.org/item_details.aspx?id=157)].
4. *Low-Volume Roads Engineering: Best Management Practices Field Guide* is a handbook outlining best management practices for low-volume road design and construction. Recommended practices for topics, including planning, location, survey, design, construction, maintenance, and road closure, are covered in the book [Keller, G. and J. Sherar, *Low-Volume Roads Engineering: Best Management Practices Field Guide*, U.S. Agency for International Development, Washington, D.C., 2003 (http://www.fs.fed.us/global/topic/sfm/low_resolution_roads_bmp_guide.pdf)].
5. *Environmentally Sensitive Maintenance for Dirt and Gravel Roads* is a guidance document based on information and training products developed by the Pennsylvania State Conservation Commission and the Penn State Center for Study of Dirt & Gravel Roads that addresses environmental issues associated with gravel roads such as erosion, sediment, and dust and mitigation methods [Anderson, J.A. and A.L. Gesford, *Environmentally Sensitive Maintenance for Dirt and Gravel Roads*, Pennsylvania Department of Transportation, Harrisburg, 2007 (http://water.epa.gov/polwaste/nps/sensitive.cfm)].
6. *Unsealed Roads Manual: Guidelines to Good Practices* is a manual that provides direction and information to road authorities on management and the economics of unsealed roads. The manual was developed by the Australian Roads Research Board and is focused on gravel road maintenance in arid regions [Guimarra, G., *Unsealed Roads Manual: Guidelines to Good Practices*, 3rd ed., Australian Road Research Board, Vermont South, Victoria, Australia, 2009 (http://trid.trb.org/view.aspx?id=1162958)].
7. *Unsealed Roads: Design, Construction and Maintenance* is a guide detailing various aspects of unpaved roads from initial design, to maintenance and rehabilitation. The guide was developed in South Africa and focuses on soil, gravel, climatic conditions present in the country (Paige-Green, P., *Unsealed Roads: Design, Construction and Maintenance*, #20. Department of Transport, Technical Recommendations for Highways, Pretoria, South Africa, 2009).

ROAD CONDITION AND SURFACING OPTION ASSESSMENT TOOLS

1. *Assessment Procedures for Paved and Gravel Roads* was developed by the Indiana Local Technical Assistance Program in 2013 and provides an assessment procedure that can be used by local agencies to aid in determining the most appropriate surface type for a given road. Two assessment methodologies were developed specifically for Indiana using cost data from local roads programs. The first methodology provides a basic framework for the comparison of costs for alternative road surface treatment options. The second methodology uses a multiobjective assessment procedure to determine the relative ranking of each alternative road surface treatment option based on cost, traffic volume, development, public preference, and other variables. The tool was developed for use in Indiana, but because the costs, practices, and weighting factors can be modified, this tool can be successfully used by any state local roads program [Figueroa, C., B. Fotsch, S. Hubbard, and J. Haddock, *Assessment Procedures for Paved and Gravel Roads*, Indiana Local Technical Assistance Program, West Lafayette, 2013 (http://rebar.ecn.purdue.edu/ltap1/multipleupload/Pavement/Assessment%20Procedures%20for%20Paved%20and%20Gravel%20Roads.pdf)].
2. *Pavement Surface Evaluation and Rating* (*PASER*) *Manual for Asphalt Roads* is a tool that can be used to quickly assess road pavement condition on a scale from 1 to 10 (Walker et al. 2013). The ratings are associated with road condition categories and prescribed treatment options. The PASER assessment tool allows for comparison of road segment quality and the identification of roads requiring treatment. The PASER system is not a robust analysis of road conditions such that the ranking cannot be used in "mechanical-empirical transportation asset management programs." PASER manuals have been developed for gravel, concrete, brick and block, sealcoat, and unimproved roads [Walker, D., L. Entine, and S. Kummer, *Pavement Surface Evaluation and Rating (PASER) Manual for Asphalt Roads*, Transportation Information Center, University of Wisconsin–Madison, 2013 (http://epdfiles.engr.wisc.edu/pdf_web_files/tic/manuals/asphalt-paser_02_rev13.pdf)].
3. *Gravel Road Management Tools* is a summary of the state of the practice of gravel road management tools used and identifies the needs of local agencies. The information presented in the document was captured through two surveys by the Minnesota Local Roads Program and from county engineers across the country through the National Association of County Engineers (NACE) [Local Road Research Board (LRRB),

Gravel Road Management Tools, Minnesota Department of Transportation, St. Paul, 2014 (http://www.dot.state.mn.us/research/TRS/2014/TRS1407.pdf)].

4. *To Pave or Not to Pave* is a summary article that highlights the work completed by Jahren et al. (2005) and Skorseth and Selim (2000), both of which are summarized in this chapter, as well as additional tools that can be used when deciding whether or not to pave a road (Kansas LTAP 2006). A video associated with this document can be found at: http://www.mnltap.umn.edu/Videos/ToPaveOrNot/ToPaveOrNot.swf [Kansas LTAP, *To Pave or Not to Pave*, Lawrence, 2006 (http://www.kutc.ku.edu/pdffiles/2006_Paving_Guide.pdf)].
5. *Economics of Upgrading an Aggregate Road* was developed in Minnesota for local road programs and provides guidance on when a road should be improved and recommended procedures for doing so (i.e., grading, regraveling, dust control/soil stabilization, reconstruction/regrading, paving). This study conducted a cost analysis and looked into the effects of traffic volume and type, road surface type, and cost. A method was developed to estimate the cost of maintaining a gravel road, which includes labor, equipment, and materials. This document addresses methods for local road agencies to communicate to the public the why and how of maintenance techniques and policy decisions [Jahren, C.T., D. Smith, J. Thorius, M. Rukashaza-Mukome, D. White, and G. Johnson, *Economics of Upgrading an Aggregate Road*, Minnesota Department of Transportation, St. Paul, 2005 (http://www.lrrb.org/media/reports/200509.pdf)].
6. *When to Pave a Gravel Road* provides information on how to assess if a gravel road should be paved. This document takes a question-and-answer approach to 10 discussion points to be considered by local government officials when considering paving a gravel road [Kentucky Transportation Center, Appendix D: When to Pave a Gravel Road, Kentucky Transportation Center, University of Kentucky, Lexington, n.d. (http://water.epa.gov/polwaste/nps/upload/2003_07_24_NPS_gravelroads_appd.pdf)].
7. *Local Road Surfacing Criteria* is a document that provides a methodology for evaluating road sections. It includes a software tool and a user's guide, which is designed to aid in making local road surfacing decisions. The methodology allows users to compare costs for different road types from paved to gravel [Zimmerman, K.A. and A.S. Wolters, *Local Road Surfacing Criteria*, South Dakota Department of Transportation, Pierre, 2004 (http://sddot.com/business/research/projects/docs/sd200210_Final_Report.pdf)].
8. A *Local Road Surface Selection Tool* was developed based on the *Local Road Surfacing Criteria* (Zimmerman and Wolters 2004). The online tool serves as an analytical tool that applies low-volume road management methodologies to allow users to compare costs associated with different road surface types and the maintenance of various surface types and aids in the selection of the appropriate surface for a given set of circumstances. At this time, the tool can be used for counties in Minnesota, North Dakota, and South Dakota (http://dotsc.ugpti.ndsu.nodak.edu/SurfaceSelection/).
9. *Context Sensitive Roadway Surfacing Selection Guide* is a road surface selection tool that is designed to incorporate context-sensitive design parameters from the beginning planning stages well into design and construction. The guide provides a surface selection tool, which can be integrated easily into current processes, allows for multidisciplinary input, and provides a broad list of possible road surfacing options [Maher, M., C. Marshall, F. Harrison, and K. Baumgaertner, *Context Sensitive Roadway Surfacing Selection Guide*, 2005 (http://flh.fhwa.dot.gov/innovation/td/pavement/context-roadway-surfacing/documents/context-sensitive-roadways.pdf)].
10. "Development of Guidelines for Unsealed Road Assessment" is a journal article summarizing the manual developed for the unified standard assessment of unsealed roads in South Africa in collaboration with the South African Committee of Land Transport Officials. The manual outlines various criteria for visually assessing an unsealed road surface in an effort to provide continuity and consistency across the many road authorities in South Africa [Jones, D., P. Paige-Green, and E. Sadzick, "Development of Guidelines for Unsealed Road Assessment," *Transportation Research Record: Journal of the Transportation Research Board, No. 1819*, Transportation Research Board of the National Academies, Washington, D.C., 2003, pp. 287–296 (http://trrjournalonline.trb.org/doi/abs/10.3141/1819a-42)].

USEFUL WEBSITES

Center for Dirt and Gravel Road Studies (http://www.dirtandgravel.psu.edu/)

Minnesota Local Road Research Board (LRRB) (http://www.lrrb.org/)

Minnesota Local Technical Assistance Program (LTAP) (http://www.mnltap.umn.edu/topics/lowvolume/)

North Dakota State University, Upper Great Plains Transportation Institute (NDSU/UGPTI) (http://www.ugpti.org/)

South Dakota Local Transportation Assistance Program (LTAP) (http://www.sdstate.edu/engr/ltap/)

Transportation Engineering and Road Research Alliance (TERRA) (http://www.terraroadalliance.org/)

TRB Low-Volume Roads (LVR) Committee and Conferences (http://www.trb.org/AFB30/AFB30.aspx)

Unpaved Roads Institute (URi) (http://unpavedroadsinstitute.org)

CHAPTER FIVE

CONCLUSIONS

IDENTIFIED EFFECTIVE PRACTICES

This synthesis identified numerous practices that can facilitate a successful road conversion project. Many survey respondents identified stakeholder outreach as a crucial first step before performing a conversion, specifically reaching out to residents living along the road, road users, and the general public in an act of transparency. When communicating with stakeholders, respondents also mentioned taking time to explain budgeting issues, describe the conversion process, and emphasize that the purpose of the road conversion is to improve the driving surface and safety. Letters, press releases, public meetings, and features by local news agencies were all cited as effective means of interacting with the public and disseminating information. Road agency personnel, who expressed willingness to work with concerned residents on issues such as dust abatement strategies, indicated that this was a successful practice.

Many local road agencies use traffic counts as a common metric for setting priorities for road maintenance activities. Numerous agencies said developing and establishing an agencywide policy on which to base road surfacing, maintenance, and conversions would be an effective practice. This approach places the burden of maintenance decisions on data, not a single person or entity, and can reduce some aspects of the negative public perception associated with proposed conversions. A pavement condition index, the PASER Manual, geographical information systems (GIS) databases and techniques outlined in handbooks such as *Assessment Procedures for Paved and Gravel Roads* from the Indiana Local Technical Assistance Program (LTAP) and *Gravel Roads Management Tools*, from the Minnesota Department of Transportation, are among the various assessment methods used to rate and track pavement condition. These tools and the associated collected data, such as traffic counts and annual maintenance costs, aid in identifying roads requiring maintenance and can be used to assess if a road needs to be rehabilitated or repaved, or converted from paved to unpaved. In addition, these tools aid in communicating with the public about why a road conversion may be a viable option.

To ensure successful performance of a converted road, a number of agencies identified effective and cost-saving practices, including investigative work before construction, such as collecting material samples and addressing issues with drainage, base, and subgrade materials and improvements. Collecting material samples before road work reduced uncertainties and facilitated planning tasks, such as procurement of the correct equipment, the addition of materials as needed, and the determination of milling and mixing depths. Addressing drainage and base stabilization issues on roads being converted aided in creating a better driving surface, safer driving conditions, and in some cases, prepared the road base for future repaving.

Through a survey and interviews, respondents identified the use of a reclaimer or recycler of appropriate weight and power as integral to the successful completion of the road conversion project. Respondents found these machines to be faster and more efficient than using a motor grader with a ripper or scarifier because they require less labor and provide uniform recycled material and ultimately a better driving surface. Reclaimed road material might be milled or crushed to 1 in. or smaller and supplemented with fines or aggregate as needed to create a smooth driving surface with reduced cobbling. Another good practice was following the reclaimer with a padfoot roller to further break up the reclaimed material and aid in initial compaction, followed by smooth drum or rubber tire roller compaction to achieve an optimal driving surface.

Numerous respondents identified the use of a chemical treatment for soil stabilization or dust control as a successful method for achieving a high-quality finished driving surface. Stabilizer use appeared to be localized to distinct climatic zones and those with similar soil types but was used in a variety of situations and conditions. Dust was a common issue reported with converted roads. Stabilizers were noted to help with dust abatement, as was the application of dust suppressants. These procedures not only helped alleviate dust but also appeared to help road users accept the new road surface.

BARRIERS TO IMPLEMENTATION

Perhaps the greatest barrier to the implementation of road conversion projects is the lack of available management tools and guidance documents. Road conversions were found to be more common than originally thought. This synthesis revealed road conversions have been performed by multiple agencies in at least 26 states in the United States, as well as in Canada and Finland—far more common than initially anticipated. The limited knowledge of this practice may be the result of a lack of formal discussion on the topic, limited dissemination of available information, and a lack of communication among various local, state, and federal road agencies when a road conversion is conducted or being considered. This has prevented the sharing of information about the process of converting roads and guidance from those involved with successful and unsuccessful road conversions.

A second factor that may discourage agencies from converting roads is public and political perception. The general public often views paved roads as a sign of progress and perceives that converting them to an unpaved surface will decrease the quality of the road and reduce the level of service. At least initially, nearly all public reaction noted by survey respondents and interviewees was negative. Residents expressed feelings of "losing ground" or "deserving better than rock" when a road was converted to an unpaved surface, and they voiced concerns about decreased safety, reduced property values, and increasing vehicle wear and tear. Dust was a primary concern identified by residents living along roads being considered for conversion. Many agencies addressed the issues of road dust by applying dust suppressants or allowing area residents to contribute funds for or perform their own dust suppression. In many cases, if a converted road was well constructed and maintained and if the local road agencies addressed concerns from the public, many residents who live along or use converted roads came to appreciate the safer and improved driving surface the agency was able to maintain at a higher service level than the deteriorated paved surface. Rectifying the negative perception of converting paved roads to unpaved roads could be done effectively by providing case examples from agencies that have performed successful conversions.

IDENTIFIED RESEARCH GAPS AND NEEDS

Because of the lack of readily available and documented information on road conversions, numerous gaps in knowledge and research needs have been identified.

Improved Documentation of Safety and Crash Rates on Low-Volume Roads

Statistics on crash rates and crash causes for low-volume roads are not well documented. For many roads, a comparison cannot be made for crash rates before and after a road has been converted from paved to unpaved. There is a need for research on collection and analysis of available crash data on low-volume unpaved roads.

Improved Documentation of Road Conversions

Although the media frequently report on proposed road conversion projects, they rarely provide follow-up stories. There is a need for research leading to documentation of successful road conversion projects, how they were completed, and what lessons were learned.

Research Leading to Guidance on a Road Conversion

This study found that agencies relied on limited knowledge and experience to perform road conversion projects, with many agencies stating the project was completed "on the fly" or by "trial and error." Many of those interviewed suggested that design guidance would have helped in their conversion. Specifically, they identified the following information as potentially helpful in the road conversion process:

- Objective measures to identify candidate roads and determine when a conversion is to be considered;
- Life-cycle cost assessment tools;
- Guidance for dealing with the public and local governing bodies, including example communication and presentation materials;
- Guidance on existing road inspection and testing, assessment of existing materials, thickness design, supplemental material selection, construction techniques, equipment needs, projection of future maintenance needs, future potential for repaving, and options for stabilization, dust control, and surface treatments;
- The development of material specifications for gravel, recycled materials, and supplemental material;
- Specification language for construction and maintenance;
- Case examples;
- Materials and resources that can be used when communicating with the public and local governing bodies such as cost data, pictures, and a sample presentation of successfully completed road conversions; and
- Guidance on postconversion follow-up.

A research needs statement has been drafted for the development of a road conversion design guide or handbook and can be found in Appendix G.

Research Leading to Development of a Cost–Benefit Analysis Tool

Although some agencies already use cost–benefit and life-cycle cost analysis tools to prioritize road maintenance activities (including road conversion projects), most survey respondents and interviewees did not. Many suggested a life-cycle cost analysis tool that could assist with:

- Determining when a conversion will be considered a cost-effective alternative compared with continued maintenance or repaving;
- Prioritizing road maintenance activities on limited budgets;
- Managing data and cost for materials, maintenance, personnel, and equipment; and
- Using additional analysis tools, including integration with GIS, providing further asset management, budgetary, and public relations advantages.

Road Conversions in Areas Affected by Heavyweight Vehicles

This topic is covered in a related report, *NCHRP Synthesis 469: Impacts of Energy Developments on U.S. Roads and Bridges*. This report mentions the need for future research, including the collection of safety and crash statistics on impacted rural roads, improved methods for both pavement and geometric design of impacted rural roads, and engineering-based methods for detour routing during periods of high-activity energy development.

Research on Environmental Impacts Associated with Road Conversions

The largest potential environmental impact related to road conversions discussed by survey respondents was the issue of dust and its effect on health and safety. No documented studies have been conducted that compare dust levels before and after conversion. Survey respondents also reported that potential impacts associated with erosion of the reclaimed road surface and the use of surface stabilizers and dust abatement products need to be quantified.

GLOSSARY

AADT—average annual daily traffic
ADT—average daily traffic
AST—asphalt surface treatment
BLM—Bureau of Land Management
BOMAG—brand name road recycler/reclaimer
BST—bitumen surface treatment
$CaCl_2$—calcium chloride
Caltrans—California Department of Transportation
CSAH—County State Aid Highway
DOD—Department of Defense
DOT—Department of Transportation
FDR—full-depth reclamation
GIS—Geographic Information System
HCADT—heavy commercial average daily traffic
IRI—International Roughness Index
LRRB—Local Roads Research Board
LTAP—Local Technical Assistance Program
LVR—low-volume road
MCEA—Minnesota County Engineers Association
$MgCl_2$—magnesium chloride
MnDOT—Minnesota Department of Transportation
NACE—National Association of County Engineers
NEPA—National Environmental Policy Act
NPS—National Park Service
PASER—Pavement Surface Evaluation and Rating
PC—portland cement
PCC—portland cement concrete
PCI—pavement condition index
RAP—recycled asphalt pavement
RCI—Roadway Condition Index
RMP—Road Management Program or Road Maintenance Priority
RROMAC—Rural Roads Operations and Maintenance Advisory Committee
SRS—secure rural schools
TERRA—Transportation Engineering and Road Research Alliance
TxDOT—Texas Department of Transportation
URi—Unpaved Road Institute
USFS—U.S. Forest Service
USF&W—U.S. Fish and Wildlife Service
VPD—vehicles per day
VTrans—Vermont Agency of Transportation

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APPENDIX A

Survey Questionnaire

NCHRP 46-12 Converting Paved Roads to Unpaved Survey

Introduction

Please enter the date (MM/DD/YYYY).

Calendar

Please enter your contact information.

First Name *

Last Name *

Title

Agency/Organization *

City

State *

Country

Email Address *

Phone Number *

1. Agency Type?

- Municipal (village, town, township, city)
- County or Road District
- State or Province
- Tribal (BIA)
- Federal Lands (USFS, USF&W, NPS, BLM, DOD)
- University
- LTAP Centers

Other (specify)

2. Agency jurisdiction size?

Area of jurisdiction (sq. miles)

Total centerline miles of roadway you maintain

Total unpaved centerline miles you maintain

Population

Annual estimated roadway budget for your reported mileage

Total centerline miles already converted to gravel

NCHRP 46-12 Converting Paved Roads to Unpaved

3. Have you or your agency/organization converted paved roads to unpaved roads? *

- Yes
- Considering doing a conversion
- No

NCHRP 46-12 Converting Paved Roads to Unpaved

4. Centerline miles of road converted

5. Average Daily Traffic (ADT)

- <20
- 21 - 50
- 51 - 100
- 100 - 150
- 150 - 200
- 200 - 300
- 300 - 500
- 500 - 1000
- >1000

6. Original pavement type, condition (good, poor, etc.)

Asphalt concrete

Surface treatment (e.g., chip seal)

Combination

Portland Cement Concrete

Other (please explain)

7. Finished surface type of the unpaved road

- ○ Unpaved
- ○ Dust suppressant (surface application only)
- ○ Asphalt emulsion
- ○ Road surface stabilization (incorporated into part of the surface layer)

Other (please explain)

8. Reasons for converting from paved to unpaved

- ☐ Cost of maintaining the road
- ☐ Public complaints
- ☐ Safety concerns

Other (please explain)

9. Additional Comments on the road conversion from paved to unpaved described in the previous questions?

NCHRP 46-12 Converting Paved Roads to Unpaved

10. Would you like to provide information on another road conversion from paved to unpaved, or another road being considered for conversion?

- ○ Yes
- ○ No

NCHRP 46-12 Converting Paved Roads to Unpaved

11. Centerline miles of road converted

[ ]

12. Average Daily Traffic (ADT)

- ○ <20
- ○ 21 - 50
- ○ 51 - 100
- ○ 100 - 150
- ○ 150 - 200
- ○ 200 - 300
- ○ 300 - 500
- ○ 500 - 1000
- ○ >1000

13. Original pavement type, condition (good, poor, etc.)

Asphalt concrete [ ]

Surface treatment (e.g., chip seal) [ ]

Combination [ ]

Portland Cement Concrete [ ]

Other (please explain)

[ ]

14. Finished surface type of the unpaved road

- Unpaved
- Dust suppressant (surface application only)
- Asphalt emulsion
- Road surface stabilization (incorporated into part of the surface layer)

Other (please explain)

15. Reasons for converting from paved to unpaved

- Cost of maintaining the road
- Public complaints
- Safety concerns

Other (please explain)

16. Additional Comments on the road conversion from paved to unpaved described in the previous questions?

NCHRP 46-12 Converting Paved Roads to Unpaved

17. Would you like to provide information on another road conversion from paved to unpaved, or another road being considered for conversion?

- Yes
- No

NCHRP 46-12 Converting Paved Roads to Unpaved

18. Centerline miles of road converted

19. Average Daily Traffic (ADT)

- <20
- 21 - 50
- 51 - 100
- 100 - 150
- 150 - 200
- 200 - 300
- 300 - 500
- 500 - 1000
- >1000

20. Original pavement type, condition (good, poor, etc.)

Asphalt concrete

Surface treatment (e.g., chip seal)

Combination

Portland Cement Concrete

Other (please explain)

21. Finished surface type of the unpaved road

- Unpaved
- Dust suppressant (surface application only)
- Asphalt emulsion
- Road surface stabilization (incorporated into part of the surface layer)

Other (please explain)

22. Reasons for converting from paved to unpaved

- ☐ Cost of maintaining the road
- ☐ Public complaints
- ☐ Safety concerns

Other (please explain)

23. Additional Comments on the road conversion from paved to unpaved described in the previous questions?

NCHRP 46-12 Converting Paved Roads to Unpaved

24. Were documents, guidelines, and/or decision tools available to make the decision and carry out the procedure of converting from a paved road to an unpaved road?

- ○ Yes
- ○ No

25. If yes, please list the documents and resources used and upload if possible.

Browse... Choose File No file selected Upload

Describe documents here.

If No, how was your decision made?

NCHRP 46-12 Converting Paved Roads to Unpaved

26. Who performed the conversion from paved to unpaved surface?

- ○ With agency personnel and equipment
- ○ By contract
- ○ Combination of agency and contractor personnel and equipment
- ○ Other

27. Who or what ultimately makes the decision whether to convert to unpaved roadways in your jurisdiction?

28. What materials were used (check all that apply)?

- ☐ Removed the old surface and disposed of it offsite
- ☐ Recycled the old surfacing into the unpaved road
- ☐ Trucked in new gravel to supplement existing materials
- ☐ Used a chemical stabilizer or dust suppressant

Other (please explain)

29. How long since the conversion from paved to unpaved surface was done?

- ○ One year or less
- ○ Two to four years
- ○ Five or more years

30. Results of conversion to unpaved surface (check all that apply):

- ☐ The road is performing well
- ☐ The road is not performing well
- ☐ Saved money for the agency
- ☐ Spent more money
- ☐ No increase in documented vehicle crashes
- ☐ Increase in documented vehicle crashes
- ☐ Positive reaction from road users
- ☐ Negative reaction from road users
- ☐ Less maintenance than anticipated
- ☐ More maintenance than anticipated
- ☐ We plan to convert more roads to unpaved

Additional comments

NCHRP 46-12 Converting Paved Roads to Unpaved

31. Were any agency outreach efforts used to justify and explain the decision to convert paved roads to unpaved roads to the public, external stakeholders, legislators, etc.?

- ○ Yes
- ○ No

NCHRP 46-12 Converting Paved Roads to Unpaved

32. If yes, please explain the outreach efforts made, the intended audience (public, external stakeholders, legislators, etc.), if it was successful, what worked and what did not, would you do it again?

Outreach efforts made

Intended audience (public, external stakeholders, legislators, etc.)

Was it successful?

What worked?

What did not work?

Would you do it this way again? (Yes/No)

NCHRP 46-12 Converting Paved Roads to Unpaved

If no, why and would you do it this way again?

NCHRP 46-12 Converting Paved Roads to Unpaved

33. Has there been any pressure to repave the road?

- Yes
- No

Additional Comments, or if yes, please explain

34. Have you developed methods to improve performance of gravel surfacing that makes it more cost effective or the conversion politically acceptable?

- Yes
- No

Additional comments, or if yes, please explain

35. May we contact you for a follow-up interview regarding your experience converting paved roads to unpaved roads?

- Yes
- No

NCHRP 46-12 Converting Paved Roads to Unpaved

36. Is there anything else you would like to share regarding converting paved roads to unpaved roads?

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Please explain here

APPENDIX B

Summary of Survey Results

SURVEY SUMMARY

A survey was disseminated through the online survey tool SurveyGizmo during the months of February and March 2015. The purpose of the survey was to gather information regarding the practice of converting paved roads to unpaved from road maintenance practitioners at state, provincial, and local transportation agencies. A total of 139 responses were received. The number of survey responses varies for each question and is reported for each question. Information detailing the responses to the survey is provided in the following sections.

Q1: Agency Type

Respondents were asked to provide contact information including agency affiliation. A total of 133 responses were received for this question. Survey respondents indicated they were most commonly associated with county or road district agencies, followed by municipal (village, town, township, or city) agencies, with state and provincial, federal land agencies (U.S. Forest Service, U.S. Fish and Wildlife, National Park Service, Bureau of Land Management, and Department of Defense), university, and Local Technical Assistance Program (LTAP) centers sparsely represented (Figure B1). Other survey responses were from an engineering consultant, forest sector research and development firm, a dust control/road stabilization distributor, and from the Office of Federal Lands Highway (FHWA).

A total of 139 responses were gathered from 21 states in the United States and the Canadian provinces of Alberta, Ontario, and Quebec. Of the 21 states, South Dakota had the most responses with 27, followed by Iowa (25), North Dakota and Minnesota (15), New York and Nebraska (10), Kansas (five), Montana (six), California (five), Texas and Oklahoma (three), Alabama and Oregon (two), and Colorado, Georgia, Idaho, Louisiana, Michigan, Ohio, Utah, and Vermont with a response of one each. The three Canadian provinces each had one response.

Q2: Agency Jurisdiction Size

Agency jurisdiction size varied greatly across the respondents. Those responding from LTAP centers, universities, and the research/consulting sector indicated a jurisdiction size of 0 mi^2 and 0 mi of roadway. The area of agency jurisdiction for those responding from maintenance agencies varied from a municipal agency with 0.5 mi^2 to an agency servicing the entirety of a state consisting of 87,000 mi^2. Similarly, centerline miles of roadway maintained varied from 2.5 to 16,600 mi (Table B1). Variation was comparable for total unpaved centerline miles maintained and annual estimated budget for road maintenance.

Q3: Have You or Your Agency/Organization Converted Paved Roads to Unpaved Roads?

Of 139 total respondents, 48 indicated that they and/or their agency had converted a paved road to an unpaved road (with an additional 12 road conversions reported by these respondents in Q10), for a total of 60 road conversions reported by survey respondents. An additional nine respondents indicated that they were considering a conversion, whereas 82 responded that they had not converted a paved road to an unpaved surface.

Figure B2 shows the 16 states in the United States in which road conversions from paved to unpaved have occurred, as indicated by survey responses.

Q4 & Q11: Centerline Miles of Road Converted

Of the 48 respondents who indicated they or their agency had converted a paved road to an unpaved road, 46 provided data on the number of centerline miles converted. This value ranged from 0.2 to 42 mi, indicating wide variation in the implementation of the practice. Question 11 asked if respondents would like to provide information on a second road conversion. Of the 12 respondents who indicated they would, 11 provided data about the number of centerline miles of road converted. Values provided ranged from 0.5 to 30 mi, with a majority (seven of 11) of the responses indicating 10 mi or less. Responses garnered in the survey indicated that just over **550 (556.4) total miles of paved roadway had been converted to an unpaved surface.**

The number of centerline miles for the nine respondents who indicated they were considering converting a roadway varied from 0.2 to 10 mi, although more than half of these respondents (five) did not indicate a value.

Q5 & Q12: Average Daily Traffic

Questions 5 and 12 asked respondents to provide the average daily traffic (ADT) on the road converted from paved to gravel. Of the 66 respondents who provided data for this question, including those who had converted a road ($n = 48$ individual responses, $n = 58$ identified converted roads) and were considering a conversion ($n = 8$), the majority indicated an ADT of between 21 and 100 vehicles per day. The highest proportion **(22 of 66 respondents) indicated an ADT of 51 to**

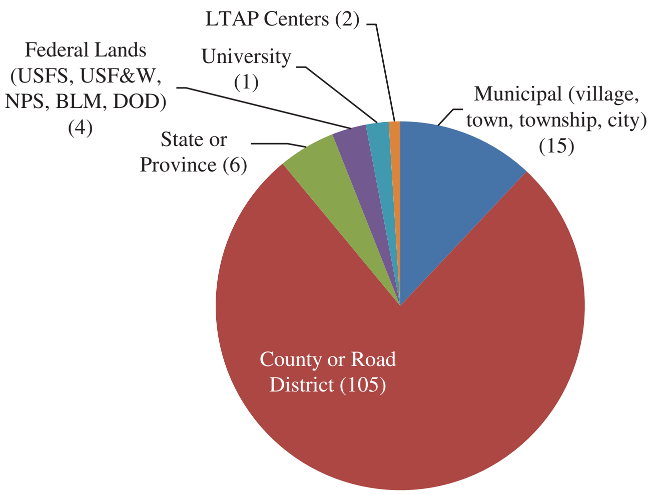

FIGURE B1 Agency type represented in the survey responses ($n = 133$).

100 vehicles, followed closely by an ADT of 21 to 50 vehicles (16 of 66 respondents). Other respondents indicated ADT values ranging from 100 to 1,000 vehicles, as shown in Figure B3. At the extreme ends of the spectrum, two respondents indicated an ADT of less than 20 vehicles and only one respondent indicated an ADT of 500 to 1,000 vehicles.

Q6 & Q13: Original Pavement Type, Condition (Good, Poor, etc.)

A total of 56 respondents provided information for these questions, including those who had converted a road, were considering a conversion, or provided data on a second road conversion. A total of 35 respondents indicated that asphalt concrete was the original pavement type on 40 different roads. **The majority (28 of 40) of respondents rated the condition of the original asphalt concrete pavement as "poor."** A condition of "fair"

TABLE B1
RESPONDING STATES/PROVINCES, AGENCIES, TOTAL NUMBER OF UNPAVED CENTERLINE MILES MAINTAINED, AND ANNUAL ESTIMATED ROADWAY BUDGET ($N = 139$)

State or Province	Agency/Organization	Total Unpaved Centerline Miles/Kilometers Maintained	Annual Estimated Roadway Budget
Agencies that have NOT converted paved roads to unpaved			
Alberta	Rocky View County	1,500 km	$11,000,000
California	Napa County Public Works	12	$7,000,000
Colorado	FHWA, Office of Federal Lands Highway	—	—
Georgia	City of Oakwood	0	$250,000
Idaho	Bonner County Road & Bridge	400	$8,000,000
Iowa	Clayton County	900	$5,000,000
Iowa	Bremer County Highway Department	590	$5,000,000
Iowa	Cedar County	810	$6,000,000
Iowa	Pottawattamie County Secondary Roads	1,269	$12,000,000
Iowa	Cherokee County	787	$3,000,000
Iowa	Hamilton County	717	$5,670,000
Iowa	Union County	600	$4,326,628
Iowa	Adams County	621	$2,800,000
Iowa	Black Hawk County	522	$7,000,000
Iowa	Buchanan County	763	$6,000,000
Iowa	Cerro Gordo County	700	$7,000,000
Iowa	Ida County	601	$3,400,000
Iowa	Pocahontas County Engineer's Office	814	$4,645,660
Iowa	Keokuk County	922	$4,389,395
Iowa	Wayne County	721	$2,700,000
Iowa	O'Brien County	802	$5,000,000
Iowa	Mahaska County Secondary Roads	842.585	$5,660,000

TABLE B1
(*continued*)

State or Province	Agency/Organization	Total Unpaved Centerline Miles/Kilometers Maintained	Annual Estimated Roadway Budget
Kansas	Franklin County	794	$5,107,023
Kansas	Scotwood Industries Inc.	N/A	N/A
Louisiana	Louisiana Department of Transportation and Development	71	—
Minnesota	Minnesota Department of Transportation	0	—
Minnesota	Big Stone County	250	$3,500,000
Minnesota	Wright County Highway Department	0	$9,000,000
Minnesota	Nobles County	150	$5,300,000
Minnesota	Hubbard County	205.82	$7,900,000
Minnesota	Lac qui Parle County Highway Department	300	$2,800,000
Minnesota	Beltrami County	345	$5,000,000
Minnesota	Rock County Highway Department	109	$3,000,000
Montana	LVR Consultants LLC	—	—
Montana	Yellowstone County	1,100	$9,000,000
Montana	Blaine County	1,190	—
Montana	Sheridan County	1,150	$2,700,000
Nebraska	York County	979	$4,000,000
Nebraska	Lincoln Public Works—Engineering Services	—	—
Nebraska	City of Lincoln	—	—
Nebraska	Nebraska Department of Roads	—	—
Nebraska	Howard County Roads	863	$2,200,000
Nebraska	City of Ogallala	11.02	$3,066,000
New York	Allegany County Department of Public Works	0	$16,500,000
New York	Tioga County	0	$1,200,000
New York	Yates County	0	$4,075,500
New York	Rockland County Highway Department	0	$11,000,000
New York	Wyoming County Highway	0	$9,257,000
New York	Herkimer County	0	$17,000,000
New York	Genesee County	0	$6,200,000
New York	Wayne County Public Works	2	$8,000,000
New York	Westchester County	0	—
New York	Oneida County Department of Public Works	0	$8,000,000
North Dakota	North Dakota Department of Transportation	—	—
North Dakota	Dunn County Highway Department	880	$80,000,000
North Dakota	McKenzie County	800	$90,000,000
North Dakota	Pembina County	7	1672400
North Dakota	Pierce County	1,071	$838,562
North Dakota	Grand Forks County	262	$10,500,000

(*continued on next page*)

TABLE B1
(*continued*)

State or Province	Agency/Organization	Total Unpaved Centerline Miles/Kilometers Maintained	Annual Estimated Roadway Budget
North Dakota	Oliver County	280	$250,000
North Dakota	Nelson County Highway Department	351	$1,700,000
North Dakota	Williams County Highway Department	850	$100,000,000
Oklahoma	Texas County	940	$5,500,000
Oklahoma	Tulsa County	10	$7,100,000
Quebec	FPInnovations	—	—
South Dakota	City of Miller	4.6	$290,678
South Dakota	Union County Public Works Department	58	$4,000,000
South Dakota	City of Hosmer	0	$16,934
South Dakota	Walworth County	728	$1,600,000
South Dakota	Beadle County	352	$3,400,000
South Dakota	City of Aberdeen	1 plus alleys	$1,000,000
South Dakota	Moody County Highway Department	122	$1,700,000
South Dakota	Gregory County	530	$2,300,000
South Dakota	Codington County Highway Department	180	$4,100,000
South Dakota	City of Mitchell	3	$2,000,000
South Dakota	Sanborn County	239	$1,627,930
South Dakota	Minnehaha County	2	$13,000,000
South Dakota	City of Onida	2	$221,176
South Dakota	Custer County	396	$2,820,637
South Dakota	South Dakota Department of Transportation	82	$220,000,000
South Dakota	City of Watertown	29.1	$1,150,000
Texas	Lone Star LTAP Center/Texas A&M Engineering Extension Service	—	—
Agencies that are CONSIDERING converting a paved road to unpaved			
California	United States Department of Agriculture Forest Service	3,500	—
California	Tehama County	263	$4,500,000
Iowa	Winneshiek County	804	$7,500,000
Iowa	Woodbury County	1,008	$14,000,000
Kansas	Reno County	0	$2,500,000
Minnesota	Norman County Highway Department	395.1	$6,000,000
Minnesota	Dodge County Highway Department	36	$6,000,000
South Dakota	Potter County Highway	570	$1,542,000
South Dakota	City of Alcester	1.44 miles	—
Agencies that HAVE CONVERTED a paved road to unpaved			
Alabama	Butler County Commission	250	$4,000,000
Alabama	Franklin County	200	$2,300,000
California	Yolo County Planning, Public Works, and Environmental Services	200	$3,500,000

TABLE B1
(*continued*)

State or Province	Agency/Organization	Total Unpaved Centerline Miles/Kilometers Maintained	Annual Estimated Roadway Budget
California	Lake County Public Works	175	$5,000,000
Iowa	Washington County	740.4	$5,500,000
Iowa	Linn County	850	$15,000,000
Iowa	Jefferson County Road Department	617	$3,700,000
Iowa	Buena Vista County Secondary Roads	750	$6,800,000
Iowa	Louisa County Roads	447	$3,900,000
Iowa	Decatur County	616	$3,000,000
Kansas	Stafford County	42	$2,200,000
Kansas	Montgomery County Public Works	800	$5,114,480
Michigan	Montcalm County Road Commission	845	$6,500,000
Minnesota	Clearwater County Highway Department	142	$1,049
Minnesota	Freeborn County	228	$10,000,000
Minnesota	Jackson County	150	$8,000,000
Minnesota	St. Louis County	1,500	$35,000,000
Minnesota	Mahnomen County	144	$2,756,000
Montana	Lake County Roads Department	—	$2,000,000
Montana	Musselshell County Road Department	624	$56,600
Nebraska	Sheridan County	1,140	$2,200,000
Nebraska	Gosper County	629.25	$1,410,429
Nebraska	Phelps County	805	$2,300,000
Nebraska	Arthur County	200	$400,000
North Dakota	Stutsman County Highway Department	1,868	$1,500,000
North Dakota	North Dakota State University—Upper Great Plains Transportation Institute	250	$6,000,000
North Dakota	Ramsey County	146.5	$3,500,000
North Dakota	Wells County	1,300	—
North Dakota	Bowman County	141	$7,000,000
North Dakota	McIntosh County	920	$500,000
Ohio	Coshocton County Engineer	180	$4,000,000
Oklahoma	Sequoyah County	250	$580,000
Ontario	Town of Bracebridge	77	$2,900,000
Oregon	United States Department of Agriculture Forest Service	2,300	$571,000
Oregon	United States Department of Agriculture Forest Service	—	—
South Dakota	South Dakota Local Transportation Assistance Program	300	$2,000,000
South Dakota	Yankton County Highway Department	253	$3,800,000
South Dakota	McCook County	125	$2,603,149
South Dakota	Miner County Highway Department	225	$1,968,000

(*continued on next page*)

TABLE B1
(*continued*)

State or Province	Agency/Organization	Total Unpaved Centerline Miles/Kilometers Maintained	Annual Estimated Roadway Budget
South Dakota	Day County Highway Department	355	$2,500,000
South Dakota	Edmunds County	258	$2,570,457
South Dakota	Deuel County	100	$2,200,000
South Dakota	Brown County Highway Department	180	$9,000,000
South Dakota	Kingsbury County	152	$2,400,000
Texas	Texas Department of Transportation	0	$40,000,000
Texas	Texas Department of Transportation	0	$29,500,000 (contracted maintenance)
Utah	Tooele County Road Department	750	$3,200,000
Vermont	City of Montpelier	3.4	$2,100,000

was indicated by four of the 40 responses. A total of eight responses were spread across "good" (three), "N/A" (three), and "asphalt" (two) conditions.

An original pavement type of surface treatment (e.g., chip seal) was indicated by 34 respondents on 36 roads. Again, **a majority (24 of 36) responded that the condition of the surface was "poor,"** and two responses indicated that the condition was very bad/poor. Nine respondents indicated that the surface treatment was "chip seal," with two of those responses providing "sand sealed cold-mix asphalt roads" or "double shot chip seal." Three responses indicated the condition of the surface treatment was "good," whereas only one response each was received for "fair" and no condition provided.

Twelve respondents indicated the original pavement type was a combination of pavement types and materials on 14 roads. Only one respondent defined the pavement combination as "asphalt over concrete." Six respondents indicated "poor" condition, two indicated "fair" condition, one indicated

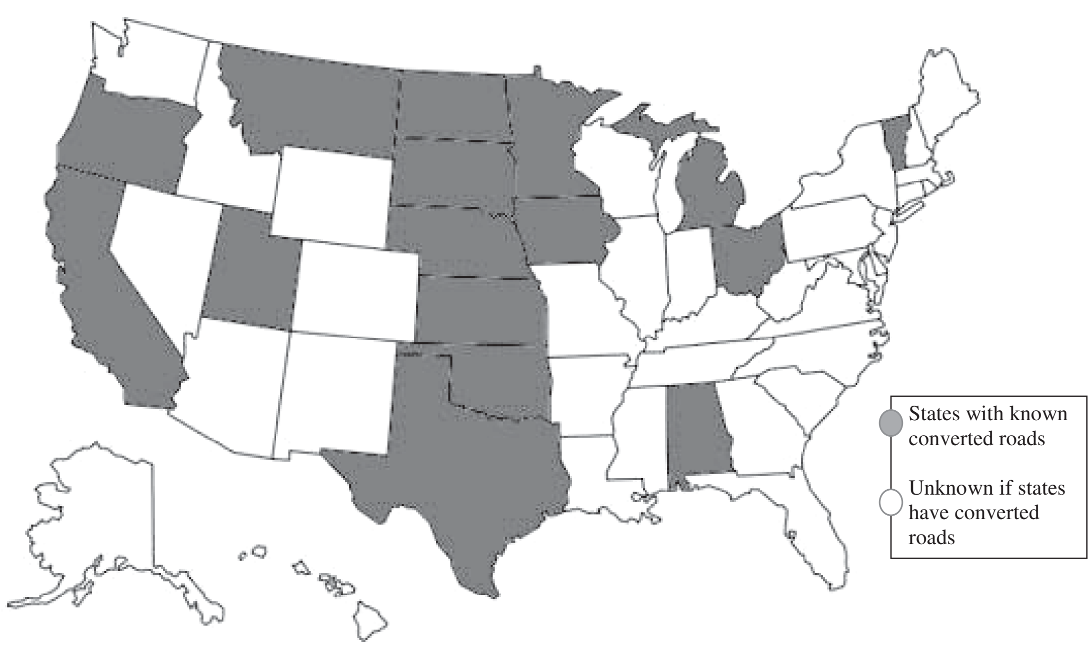

FIGURE B2 States where road conversions from paved to unpaved have occurred (gray), based on survey responses ($n = 16$ states).

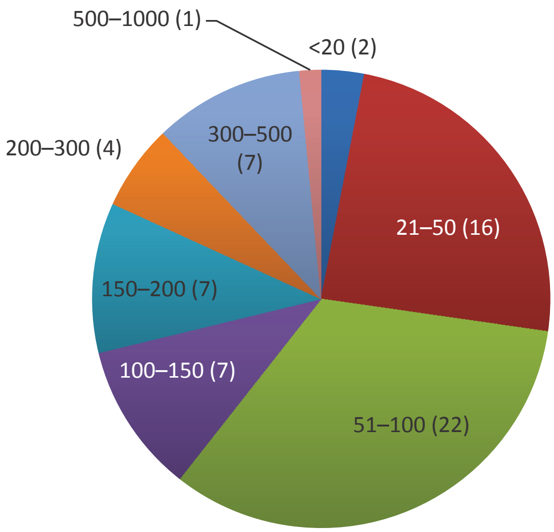

FIGURE B3 Average daily traffic (ADT) values for roads converted from paved to unpaved surface ($n = 66$).

"good" condition, and one respondent provided a varying condition of "good to poor." Three respondents provided "N/A" or "none" as a response.

A total of six respondents provided "none" or "n/a" as a response to an original pavement type of portland cement concrete. One additional respondent indicated a condition of "fair." A pavement type of "other" was specified by eight of the respondents. Responses ranged from the type of road (sand/chip seal for four of the descriptions) to reasons why the road was or might be converted, such as budget constraints and road base issues. These descriptions are provided in Table B2.

Q7 & Q14: Finished Surface Type of the Unpaved Road

A total of 48 respondents provided information on 57 of the 60 different roads regarding the finished surface of the converted road. A majority of the roads were **untreated (36 of 57),** followed closely by 14 reported instances of road surface stabilization (incorporated into part of the surface layer), and dust suppressant applications (surface only) on four roads, as shown in Figure B4. Only three respondents selected an asphalt emulsion.

Additional comments for this question reflected different techniques used in the conversion process, stabilization procedures, and efforts conducted to suppress dust. These comments are presented in Table B3.

Q8 & Q15: Reasons for Converting from Paved to Unpaved

The overwhelming response received from 57 respondents was that **the cost of maintaining the road was the most significant reason (54 of 57) for converting a paved road to an unpaved road** (Figure B5). Safety concerns followed closely behind (27 of 57 respondents), and one-third of respondents (19 of 57) indicated that public complaints were also a factor. A total of 16 respondents indicated that all three factors were reasons for converting a paved road to an unpaved surface.

TABLE B2
COMMENTS RECEIVED ABOUT ORIGINAL PAVEMENT TYPE AND CONDITION

State or Province	Agency/Organization	Additional Comments
Iowa	Woodbury County	Seal coat placed for residential subdivisions lining a road. Seal coat is in poor condition and failing.
Kansas	Reno County	Sand sealed roads are getting rough, we keep them sealed, and pothole patched and some crack sealing. They are at the end of their life cycle. Looking to reduce the total miles by 100–150. County Roads converted to un-paved would be reclassified and the maintenance transferred to the respective townships as local roads.
Minnesota	Clearwater County Highway Department	1 mile of a narrow gravel road was paved with bituminous surfacing for dust control due to a detour for an adjacent project. The pavement was under-designed but still lasted 10 years. It became unserviceable.
Minnesota	Freeborn County	Subgrade is a peat bog with a flowing artesian spring.
Minnesota	Dodge County Highway Department	This is a 3 mile road we are currently not patching. We are reclaiming it to gravel slowly as it deteriorates.
Montana	Musselshell County Road Department	Millings were laid out over gravel and not chip sealed.
Nebraska	Arthur County	Complete rehab would have been needed.
Utah	Tooele County Road Department	Cold mix asphalt with a chip seal.

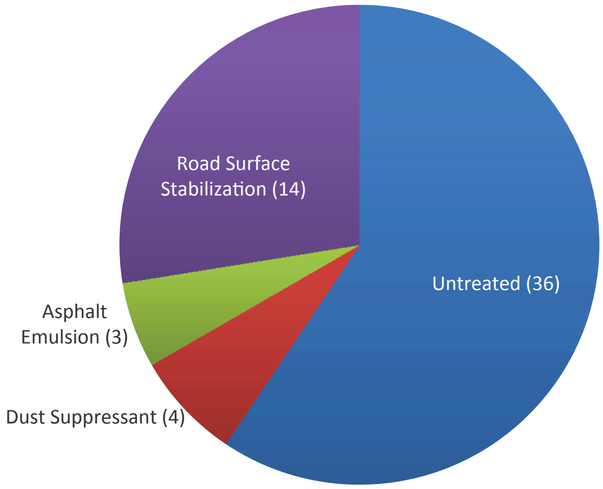

FIGURE B4 Finished surface type for unpaved road ($n = 57$).

Additional information regarding the reason(s) for converting roads was received from 14 respondents. Comments provided from these respondents are presented in Table B4 and vary from deteriorated condition of the road surface to prohibitive costs to changes in traffic (both increases and decreases). One comment received from Montpelier, Vermont, indicated that the road was converted at the request of area residents. Two comments indicated that environmental conditions—freeze/thaw and high water table—contributed to the conversion.

Q9 & Q16: Additional Comments on the Road Conversion from Paved to Unpaved Described in the Previous Questions?

An additional 15 comments were received from the 57 respondents who indicated they had converted or considered converting a road. These comments are presented in Table B5 and provide further insight into the conversion. Respondents commented on public reaction, the reason for the conversion, changes in traffic patterns, and the actual conversion process.

Q10: Would You Like to Provide Information on Another Road Conversion from Paved to Unpaved, or Another Road Being Considered for Conversion?

Of the 139 responses received, 12 additional road conversions were reported, for a total of 60 total road conversions reported in the survey. The 12 respondents provided the information that was summarized in the previous questions. However, one of the 12 affirmative respondents did not provide any further information beyond Q10.

No responses were received for questions 17 through 23 requesting data on a third road conversion.

TABLE B3
COMMENTS RECEIVED ABOUT "OTHER" FOR UNPAVED ROAD

State or Province	Agency/Organization	Additional Comments
Alabama	Franklin County	Our unpaved roads primarily consist of a red clay/gravel mixture. When we unpaved a road we generally haul a thin layer of crushed limestone "crusher run."
California	Yolo County Planning, Public Works, and Environmental Services	Enzyme
California	Lake County Public Works	Full depth reclamation (FDR) using Perma-zyme.
Iowa	Washington County	Have not converted the road yet. It is an asphalt road that is in poor shape and one we are considering because of the cost to maintain/fix and the lower traffic volume. In addition, this road parallels a state road by approximately 0.5 mile for the entire length.
Iowa	Jefferson County Road Department	Also apply surface dust suppressant.
Minnesota	Freeborn County	Class 2 limestone over Class 5 aggregate base with magnesium chloride stabilization.
Nebraska	Arthur County	Added aggregate to pulverized asphalt.
South Dakota	South Dakota Local Transportation Assistance Program	Road was simply recycled, reshaped, re-compacted and a chip seal was placed on the surface.
Texas	Texas Department of Transportation	Crews applied an HFRS-2 emulsion on unsurfaced roadway for dust control.
Vermont	City of Montpelier	Recycled asphalt/concrete/crushed gravel mix.

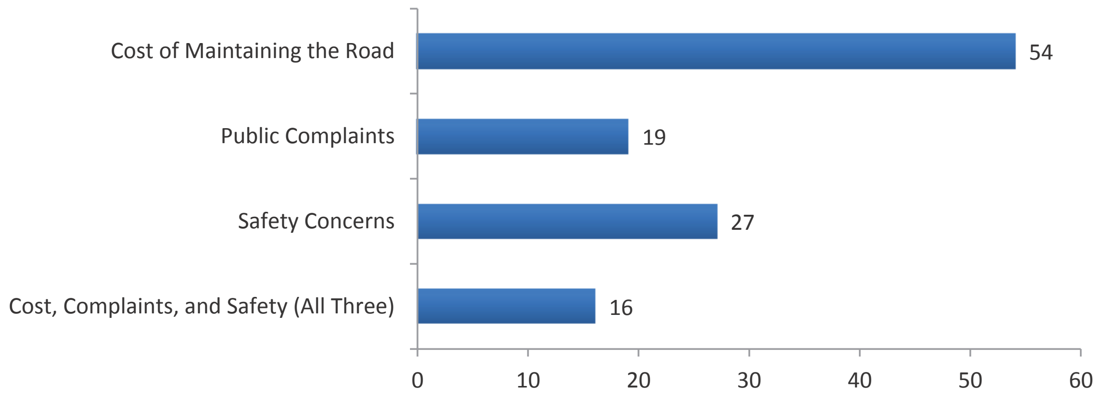

FIGURE B5 Reasons cited for converting roads from paved to unpaved (57 responses were received, for which multiple options could be selected).

TABLE B4
ADDITIONAL REASONS PROVIDED FOR CONVERTING A PAVED ROAD TO UNPAVED

State or Province	Agency/Organization	Additional Comments
Alabama	Franklin County	All of the above are reasons for converting paved roads to unpaved roads.
Iowa	Linn County	Change in traffic count and use.
Iowa	Buena Vista County Secondary Roads	Change in usage.
Iowa	Winneshiek County	Road is shared with a city and city did not want to pay to repave the roadway.
Kansas	Reno County	These roads are rural roads that carry predominately local traffic. As the county wants to maintain a high quality county road rural secondary system, we expect local roads to be maintained at a local quality. Expecting the traffic counts to reduce after they are unpaved and increase on the remaining paved roads.
Minnesota	Clearwater County Highway Department	Would have overlaid the road, but it would have become too narrow. It was already too narrow. I considered converting another road one time, but did the math and a thin overlay was cheaper if the road held up for 10 years. It has been 15 years and road is still ok. Money ahead on that one.
Montana	Musselshell County Road Department	Condition beyond repair.
Montana	Musselshell County Road Department	Chip sealing is very expensive; we just do not have the funds to allow chip sealing to be done when necessary for smaller/shorter roads. Timing is always a problem when laying out millings.
Nebraska	Gosper County	Road was damaged due to heavy rains and it cost too much to put back to asphalt.
Nebraska	Arthur County	No Federal funds for rehab.
North Dakota	Stutsman County Highway Department	All of the above are reasons for converting paved roads to unpaved roads.
South Dakota	South Dakota Local Transportation Assistance Program	Traffic volume did not justify re-constructing the pavement in a life-cycle cost analysis.
South Dakota	South Dakota Local Transportation Assistance Program	Cost of total reconstruction back to a pavement was prohibitive, but an asphalt surface needed to be placed once again. A seal was adequate.
South Dakota	Yankton County Highway Department	Roadway surface faced heaving when coming out of the freeze/thaw cycle.
South Dakota	Edmunds County	Due to the heavy truck traffic, the road fell apart. Costs were way too high to keep to a chip seal.
South Dakota	City of Alcester	Road is soft/spongy.
Vermont	City of Montpelier	One road by resident group request.

TABLE B5
ADDITIONAL COMMENTS ON THE ROAD CONVERSION FROM PAVED TO UNPAVED

State or Province	Agency/Organization	Additional Comments
Alabama	Franklin County	The lack of revenue is the primary cause for the conversion and any other issues are the effects of the lack of funding. We would obviously prefer to keep these roads patched, but simply do not have the revenue to continue.
Iowa	Linn County	Old primary road transferred to county with very little traffic with new primary relocation taking all traffic with it.
Iowa	Linn County	Traffic count dropped to below our trigger of 200 vehicles per day to maintain seal coat surface
Iowa	Decatur County	We have only converted chip seal roads back to gravel.
Kansas	Reno County	1,265 sq miles; 1 mile grid road system; of that we have 6-mile county paved road system. Can't afford to provide this level of service for only 60,000 population.
Kansas	Montgomery County Public Works	The roads converted back to gravel were done in the 1980s.
Minnesota	Jackson County	Importance of road was diminished with reconstruction of other roads serving the community.
Minnesota	Dodge County Highway Department	This road is low traffic and parallels a paved road 1 mile away. It is too narrow to reasonably maintain as a paved surface.
Montana	Lake County Roads Department	Reconstructed road received double-shot chip seal. Sand/gravel and concrete business contributed to premature failure of chip seal. Surface was ground and replaced for maintenance. Cost prohibitive to pave at this time.
Nebraska	Arthur County	Road surface was ground and left in place as aggregate surface.
North Dakota	McIntosh County	The road was full of potholes; we had it milled up and simply bladed it. Later we added some gravel. Mostly all public comment was positive.
Oklahoma	Sequoyah County	We put 1½ crusher run over top of the chip/seal.
South Dakota	South Dakota Local Transportation Assistance Program	Public initially objected, but was happy after getting a good gravel surfaced road to drive on.
South Dakota	South Dakota Local Transportation Assistance Program	Public was happy and didn't know it wasn't repaved.
South Dakota	Yankton County Highway Department	Roadway had drainage tile to alleviate groundwater from infiltrating roadbed.
South Dakota	McCook County	Budget will not sustain the current number of asphalt miles into the future.
South Dakota	McCook County	These 17 miles are planned to be reverted back to gravel when they reach the end of the useful life as an asphalt surface.
South Dakota	City of Alcester	Conversion has not taken place at the time of this survey.

Q24: Were Documents, Guidelines, and/or Decision Tools Available to Make the Decision and Carry Out the Procedure of Converting from a Paved Road to an Unpaved Road?

A total of 57 responses were received for this question with 12 respondents indicating that supplemental material was used in their decision making and/or conversion process. Conversely, 45 respondents did not use any supplemental materials.

Q25a: If Yes, Please List the Documents and Resources Used and Upload if Possible.

A total of 13 respondents provided information for this question, with one response originating from a respondent who indicated "No" to Q24. Responses are provided in Table B6. Notably, only one of the documents referenced, the Minnesota Department of Transportation (MnDOT) *Decision Tree for Unpaving Roads,* deals directly with the issue of converting paved to unpaved roads. Other tools used to make the decision to convert roads from paved to unpaved include traffic counts, geographic information system (GIS) or more basic tools that are used to prioritize route maintenance, the AASHTO *Guidelines for Geometric Design of Very Low-Volume Local Roads* (the Green Book), and local citizen input.

Q25b: If No, How Was Your Decision Made?

Of the 43 additional comments received, 24 indicated that cost, economics, or budget constraints were a driving factor

TABLE B6
DOCUMENTS USED IN THE CONVERSION PROCESS

State or Province	Agency/Organization	Description of Documents
Alabama	Franklin County	We have a very robust GIS system that we incorporate into our asset management system, "CarteGraph," and pavement management system, "GeoTrans." We rely on these tools to model our road system so that we can prioritize and make informed decisions. Algorithms within the software take into account factors such as surface condition, base condition, traffic volumes, number of residents, segment classification, repair costs, etc.
California	Yolo County Planning, Public Works, and Environmental Services	Citizen complaints and constant maintenance.
Iowa	Linn County	We use traffic count from traffic survey conducted by Iowa DOT every 4 years to set our seal coat surface policy. If road drops below 200 vehicles per day on our farm-to-market grid, we stop seal coating.
Iowa	Decatur County	AASHTO Green Book, Very Low Volume Roads—used to establish finished section. Did not handle process of reclaiming.
Kansas	Reno County	No. 11, yes but not many 2004 S. Dakota Study. I did not unpave any roads. I am interested in doing some.
Minnesota	Norman County Highway Department	MnDOT *Decision Tree for Unpaving Roads*
Minnesota	Mahnomen County	State Aid Operation 8820.
North Dakota	Ramsey County	We held public meetings explaining that it would be cost prohibitive to keep maintaining the amount of asphalt roads we had in our system. At the same time we were asking the voters to add 10 mills to road maintenance to maintain the remaining asphalt roads and the voters voted to assess the extra 10 mills.
North Dakota	Wells County	I did not work for the county then.
South Dakota	McCook County	Traffic counts, road core information, and a basic grid designing a plan to have all residents within four miles of an asphalt road.
South Dakota	Brown County Highway Department	General Internet research and industry reps.
South Dakota	Kingsbury County	ADT study was done...Also a cost analysis on maintenance
Vermont	City of Montpelier	Resident notice of city council meeting agenda–public hearing and Mill Rd follow-up survey.

in the decision to unpave the road. Decisions to move forward with unpaving were often made by engineers, county commissioners, and/or road superintendents. Agencies relied on research materials and anecdotal data from other road maintenance practitioners for information, with one respondent citing "trial and error" as a method for conversion. Further comments are included below in Table B7.

Q26: Who Performed the Conversion from Paved to Unpaved Surface?

A total of 56 responses were received for this question, with **24 responses indicating that the conversion was performed with agency personnel and equipment.** Seventeen respondents indicated that the work was performed by a combination of agency and contractor personnel and equipment, whereas 10 respondents indicated that a contractor performed the work (Figure B6). A further five respondents selected the "other" option and provided further details. Three of the five "other" respondents indicated that they had yet to perform a conversion but were considering it. Another one hired a contractor by the hour, one utilized agency personnel with a rented reclaiming machine, and lastly, one agency responded with "deterioration."

Q27: Who or What Ultimately Makes the Decision Whether to Convert to Unpaved Roadways in Your Jurisdiction?

A total of 54 responses were collected for this question, from respondents whose agencies had performed or were considering a conversion. Of those 54 responses, 26 indicated that the County Commission was ultimately responsible for making the final decision regarding converting a paved road to unpaved. **A county or supervisory board was indicated as being involved by 12 respondents. Often county boards and commissions worked on the advice and recommendation of an engineer (county, district, forest, staff, etc.)**

TABLE B7
COMMENTS RECEIVED REGARDING HOW THE DECISION TO UNPAVE THE ROAD WAS MADE

State or Province	Agency/Organization	Additional Comments
Alabama	Butler County Commission	This was the only cost-effective option.
California	Tehama County	Condition, average daily traffic (ADT), area served, cost to maintain.
California	Lake County Public Works	Due to budget constraints the road budget could no longer afford to patch this road, but did not have the budget to reconstruct.
California	United States Department of Agriculture Forest Service	Past experience and discussions with other road managers.
Iowa	Buena Vista County Secondary Roads	Approved by Board.
Iowa	Louisa County Roads	Chip seal on road was in poor condition.
Iowa	Decatur County	Discussion with other engineers, trial and error on what methods provided the best-finished surface.
Iowa	Jefferson County Road Department	Experiences of others with same predicament.
Iowa	Washington County	It was a decision based on the economics to maintain the current condition of the road.
Iowa	Winneshiek County	Road was left to deteriorate on its own.
Iowa	Woodbury County	The residents are not willing to pay for a new seal coat application and are split on contributing to pay for paving, even with county assistance on cost.
Kansas	Montgomery County Public Works	Commissioners.
Kansas	Stafford County	Verbal recommendation from the Supervisor.
Michigan	Montcalm County Road Commission	Looked at cost history, accident reports, and future funding levels.
Minnesota	St. Louis County	Average daily traffic (ADT) was too low to warrant bituminous surface. Decided on Full Depth Reclamation (FDR) with stabilized base to increase strength below.
Minnesota	Jackson County	By involving/educating County Board and City Council of why reverting road was necessary.
Minnesota	Mahnomen County	Cost analysis
Minnesota	Freeborn County	Necessity
Minnesota	Dodge County Highway Department	Not enough traffic to justify the needed money.
Montana	Lake County Roads Department	The cost to place 3 in. of asphalt pavement is $150,000, while the cost to grind and maintain the road as gravel is $1,500.
Nebraska	Arthur County	Common sense and lack of funds.
Nebraska	Sheridan County	Cost factor of oil versus gravel.
Nebraska	Phelps County	Maintenance costs to upgrade pavement versus cost to change road back to gravel/dirt surface.
North Dakota	North Dakota State University–Upper Great Plains Transportation Institute	Cost analysis
North Dakota	Stutsman County Highway Department	Decision made by former highway superintendent. We assume that the decision was made on the basis of repair costs.
North Dakota	Bowman County	There were too many failures in the road to do anything else.
North Dakota	McIntosh County	We didn't have much choice; the road was in terrible shape.
Ohio	Coshocton County Engineer	Engineering judgment and economics.
Oklahoma	Sequoyah County	It had gotten to the point that it was costing too much to patch it, so we just covered up the chip/seal, thus leaving the base and not disturbing it.
Ontario	Town of Bracebridge	Budget limitations. Investigation to determine if low traffic volume roads, with surface treatment in very bad condition, could be converted back to gravel at an affordable cost.

TABLE B7
(*continued*)

State or Province	Agency/Organization	Additional Comments
Oregon	United States Department of Agriculture Forest Service	It was made on the fact we could no longer afford to repair the Bituminous Surface Treatment Chip Seal and could not leave it in an unsafe condition.
Oregon	United States Department of Agriculture Forest Service	Safety concerns and couldn't afford to maintain as a paved road.
South Dakota	City of Alcester	Asphalt is broken up and only partially covering the road.
South Dakota	Miner County Highway Department	Cost and complaints.
South Dakota	Potter County Highway	Cost of rehabilitating and repaving.
South Dakota	Deuel County	Explained to board the cost and showed the damage from spring breakups. Was an easy decision when traffic counts were so low.
South Dakota	South Dakota Local Transportation Assistance Program	In-house knowledge of existing base depth and quality, recycling, base reconstruction, priming and seal coating.
South Dakota	Day County Highway Department	Past and future costs to maintain as asphalt.
South Dakota	Yankton County Highway Department	Roadway was crumbling and we decided to mill the road up to provide a safe means of travel to the public, we then covered the milled up asphalt with approximately 6 inches of gravel and treated the surface with an aggregate base stabilizer.
South Dakota	Edmunds County	The condition of the road.
Texas	Texas Department of Transportation	District and Department Decision.
Texas	Texas Department of Transportation	Using expertise from research centers along with experience of staff engineers.
Utah	Tooele County Road Department	We have had a pavement inventory since 1988 we have a limited number of dollars to do road work with. We subscribe to the theory that you do your best roads first. When we were faced with a budget shortfall in 2012 and 2013, Tooele County prioritized our road funding. Faust Road, which had a low average daily traffic (ADT) and low remaining service life, became a candidate for turning it back to a gravel surface. There were two reasons: the main reason was for safety. The cars were traveling at 55 mph or faster and encountering potholes in the road. Estimated cost to reclaim the road was cheaper than rebuilding it.

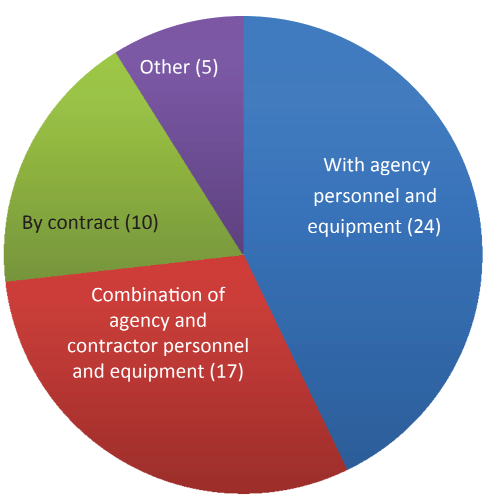

FIGURE B6 Entities responsible for performing the conversion work ($n = 56$).

(15 of 54 respondents) or Highway Superintendent/Manager (13 of 54 respondents). Other respondents noted financial motivation (6 of 54) and safety (2 of 54). All of the responses received are presented in Table B8 and summarized in Figure B7.

Q28: What Materials Were Used?

A total of 54 respondents provided information for this question. A majority of respondents **(46 of 54) indicated that the old road surfacing was recycled into the unpaved road** (Figure B8). Additionally, 34 respondents indicated that new gravel was trucked in to supplement the existing materials. Nearly one-quarter (13 of 54) responded that a chemical stabilizer or dust suppressant was used, and only two respondents indicated that the old road surface was removed and disposed of offsite. Over half the respondents (28 of 54) reported using

TABLE B8
COMMENTS RECEIVED REGARDING WHO OR WHAT ULTIMATELY DECIDES TO UNPAVE A ROADWAY

State or Province	Agency/Organization	Additional Comments
Alabama	Butler County Commission	County Engineer.
Alabama	Franklin County	I make the decision (county engineer). However, I always inform the County Commission and move forward with their support. The decision is made based on the roadway condition index "RCI" for a segment and the cost for repair relative to the traffic count and number of residents. We also consider the functional classification of the segment (Dead-End, Through Road, Minor Collector, Major Collector, etc.); a cost/benefit analysis of sorts.
California	United States Department of Agriculture Forest Service	Road manager makes the decision based on road condition, cost, and safety concerns.
California	Yolo County Planning, Public Works, and Environmental Services	Engineering staff.
California	Lake County Public Works	The road commissioner makes a recommendation to the Board of Supervisors.
California	Tehama County	It would be a Board of Supervisors action at the recommendation of the Department of Public Works.
Iowa	Washington County	The Board of Supervisors
Iowa	Linn County	County Engineer with Board of Supervisor approval.
Iowa	Buena Vista County Secondary Roads	Board of Supervisors
Iowa	Winneshiek County	Pavement maintenance was stopped by the County.
Iowa	Decatur County	Board of Supervisors, with recommendations by County Engineer.
Iowa	Woodbury County	County engineer in consultation with the county board of supervisors.
Kansas	Reno County	Board of County Commissioners
Kansas	Stafford County	The County Commissioners, but we have not done converted any roads in the last 7 years.
Kansas	Montgomery County Public Works	County Commissioners
Michigan	Montcalm County Road Commission	Safety and yearly costs drive the decision.
Minnesota	Clearwater County Highway Department	Recommendation by the County Engineer with discussion and approval by the County Board.
Minnesota	Freeborn County	Money
Minnesota	Jackson County	County Board and Engineer work together to make fiscally restrained decision.
Minnesota	St. Louis County	Budget combined with average daily traffic (ADT).
Minnesota	Dodge County Highway Department	County Board
Minnesota	Mahnomen County	The County Engineer makes the recommendation and the County Board of Commissioners make the decision.
Montana	Lake County Roads Department	County Commissioners and the Road Superintendent
Montana	Musselshell County Road Department	County Commissioners and road supervisor
Nebraska	Sheridan County	County Commissioners and the Road Superintendent
Nebraska	Gosper County	Board of Commissioners
Nebraska	Phelps County	Myself (Highway Superintendent) and the Board of Commissioners
Nebraska	Arthur County	County Board

TABLE B8
(*continued*)

State or Province	Agency/Organization	Additional Comments
North Dakota	Stutsman County Highway Department	County Commission
North Dakota	North Dakota State University —Upper Great Plains Transportation Institute	County Board
North Dakota	Pembina County	County Commissioners
North Dakota	Ramsey County	The County Commission made the decision when they were told how much money it would take to bring the 35 miles back to a safe drivable condition.
North Dakota	Wells County	Commissioners
North Dakota	Bowman County	Superintendent
North Dakota	McIntosh County	Board of County Commissioners
Ohio	Coshocton County Engineer	I do, the County Engineer
Oklahoma	Sequoyah County	The commissioner and the road foreman
Ontario	Town of Bracebridge	Director's decision
Oregon	United States Department of Agriculture Forest Service	Our District Land Manager and Forest Engineer
Oregon	United States Department of Agriculture Forest Service	Forest Engineer and District Ranger
South Dakota	South Dakota Local Transportation Assistance Program	Recommendation by the highway department head, the final decisions made by the County Commission.
South Dakota	Yankton County Highway Department	Yankton County Commission
South Dakota	McCook County	County Commission
South Dakota	Potter County Highway	County Commission
South Dakota	Miner County Highway Department	Highway Superintendent and Commissioners
South Dakota	Day County Highway Department	The Day County Commissioners with the input and recommendation of the Highway Superintendent.
South Dakota	Edmunds County	County Commission
South Dakota	Deuel County	County Commission
South Dakota	Brown County Highway Department	Money
South Dakota	Kingsbury County	The County Commission and the Highway Superintendent make the decision with the help of LTAP, state officials, and consulting engineers.
South Dakota	City of Alcester	City Council
Texas	Texas Department of Transportation	District Engineer
Texas	Texas Department of Transportation	District Engineer and Agency Administration
Utah	Tooele County Road Department	County Commissioners
Vermont	City of Montpelier	City Council

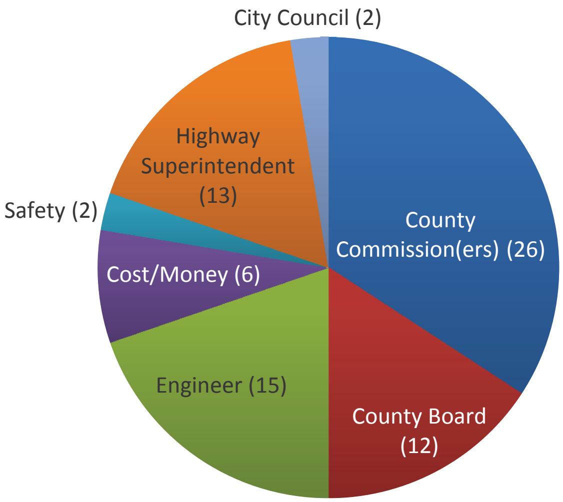

FIGURE B7 Entities and factors that ultimately result in the decision to unpave a roadway ($n = 54$).

two or more of the materials in the conversion process. A combination of materials comprised of recycling the road surface, trucking in new material, and chemical stabilization was reported by 11 of the respondents. Only two respondents reported using a combination of all four materials.

An additional six comments were received from respondents and are shown in Table B9. Two comments were received from agencies considering road conversions and reflect such. Other comments discussed the specific equipment used, dust suppression and stabilization measures, and what types of new materials were added prior to conversion.

Q29: How Long Since the Conversion from Paved to Unpaved Surface Was Done?

Over one-third (19) of the 52 respondents indicated **that the conversion had occurred 5 or more years ago,** whereas

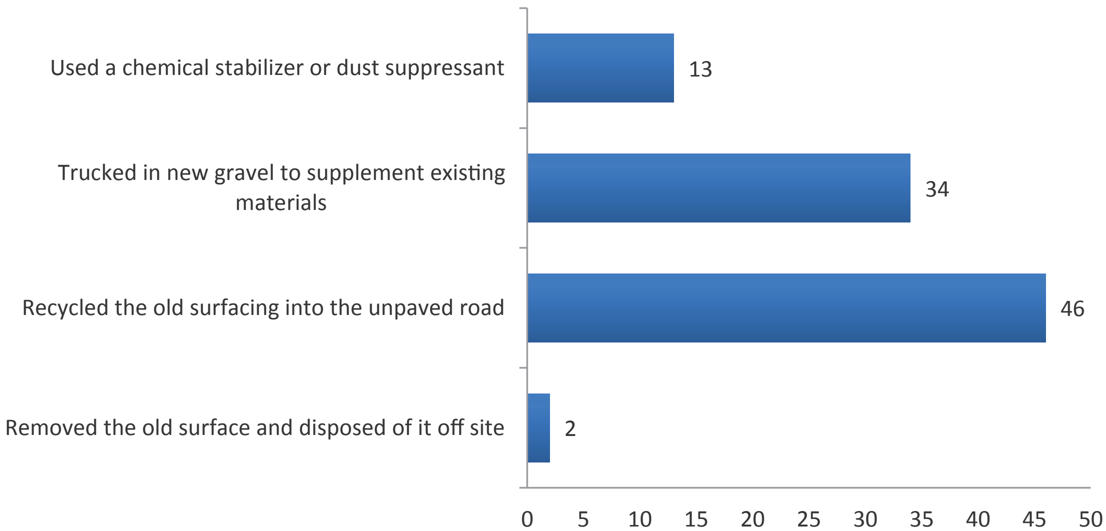

FIGURE B8 Materials used in the conversion process (54 responses were received, for which multiple materials could be selected).

TABLE B9
ADDITIONAL COMMENTS ABOUT MATERIALS USED IN THE CONVERSION PROCESS

State or Province	Agency/Organization	Additional Comments
Alabama	Franklin County	We use a full-depth road reclaimer to recycle the old surfacing and we haul crushed aggregate limestone. The limestone is sort of a transitional surface that softens the blow of losing pavement.
Kansas	Reno County	We did not do any—just interested in doing some.
Minnesota	Dodge County Highway Department	We are doing the conversion over time as the pavement deteriorates.
Oregon	United States Department of Agriculture Forest Service	Once the asphalt was mixed into roadbed, 4 in. of gravel was placed.
South Dakota	South Dakota Local Transportation Assistance Program	0.5 gal of AE200S emulsion was injected and mixed into the upper three inches of the recycled layer to strengthen the recycled base.
Utah	Tooele County Road Department	We rented an asphalt reclaimer. When we reclaimed it then we sprayed magnesium chloride on the road as a dust palliative.

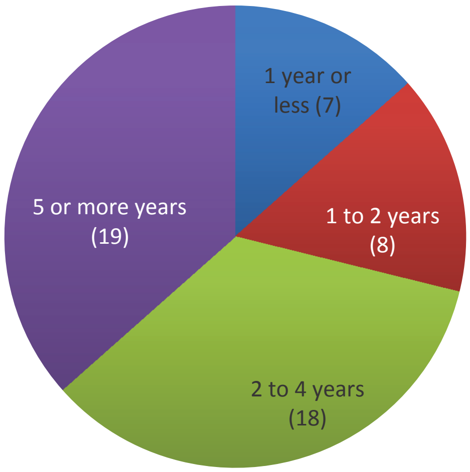

FIGURE B9 Length of time since conversion process was completed ($n = 52$).

18 responded that the conversion had been performed within the last 2 to 4 years (Figure B9). Fifteen respondents indicated the conversion occurred in the last 2 years.

Q30: Results of Conversion to Unpaved Surface

Following the conversion to an unpaved surface, an **overwhelming proportion of the 52 responses to this question indicated that the road was performing well (44 responses), that the conversion had saved money for the agency (43 responses), and that there were no documented increase in vehicle crashes (35 responses)** (Figure B10). Respondents provided input on the reaction from road users: **26 of those responses were negative, and 19 were positive.** Less maintenance than was anticipated was reported by 20 respondents compared with the five who indicated the road required more maintenance. One respondent reported that the agency spent more money as a result of the conversion, and three respondents reported that the road was not performing well. No respondents indicated that there had been a documented increase in vehicle crashes. Overall, **20 of the 52 total respondents indicated that their agency planned to convert more roads to unpaved in the future.**

A number of additional comments were received for this question and are provided in Table B10. Respondents indicated that residents have mixed opinions of the road after the conversion, with some appreciating the improved driving surface and others disliking the dust. Comments suggest that with time, residents become more accepting of the new surface and the higher level of maintenance that agencies are able to provide after unpaving. Some respondents indicated that if low funding levels persist, it will cause the practice of conversion to continue and be more widespread.

Q31: Were Any Agency Outreach Efforts Used to Justify and Explain the Decision to Convert Paved Roads to Unpaved Roads to the Public, External Stakeholders, Legislators, etc.?

Responses regarding outreach efforts were nearly even, with 27 of the 53 total respondents indicating that some form of

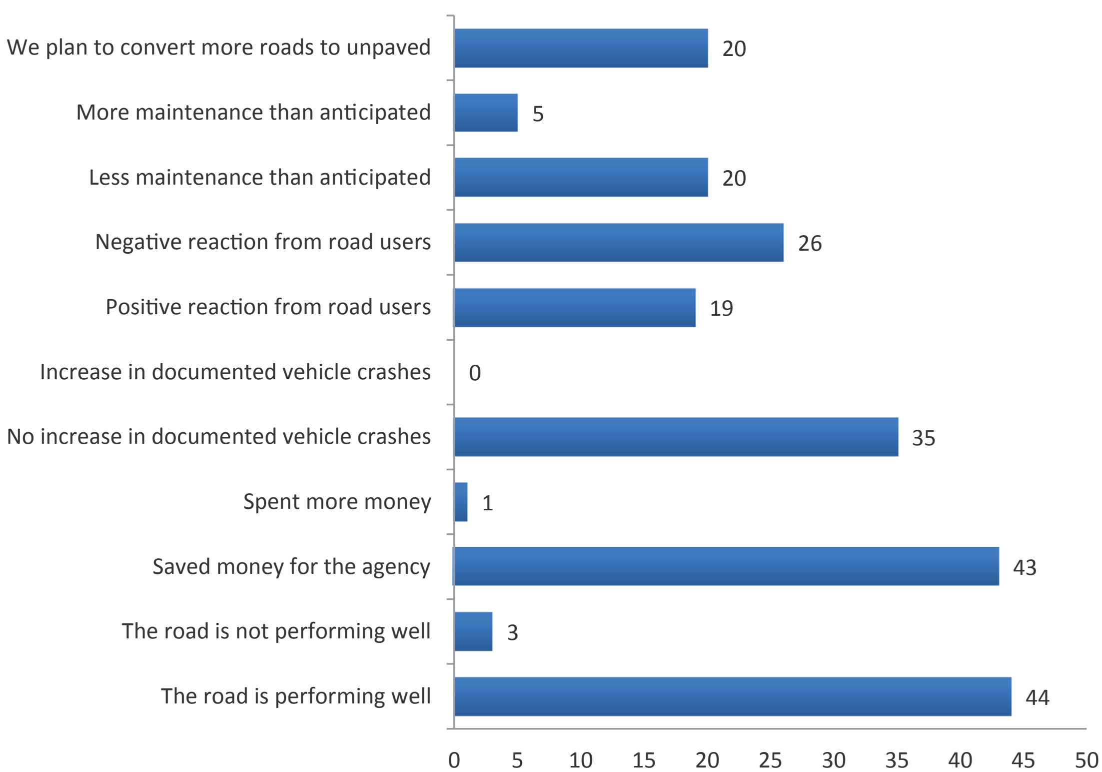

FIGURE B10 Results of the conversion process (from 52 responses).

TABLE B10
COMMENTS RECEIVED REGARDING RESULTS OF THE CONVERSION FROM PAVED TO UNPAVED

State or Province	Agency/Organization	Additional Comments
Alabama	Franklin County	We've had both negative and positive reaction from the public. Accident analysis has not been an issue because the roads we mill up are very low volume dead end roads for the most part. I don't know of any accidents that have occurred on any roads we have converted before or after the conversion.
Iowa	Linn County	The county citizens select travel paths and our program prescribes our dust control and paving policy.
Iowa	Decatur County	Some in the public are happy to have a uniform surface; most are unhappy that it is not paved and dust free anymore.
Kansas	Reno County	Interested in the results. However, again in our case we would lower the classification of the road and required the townships to maintain it.
Michigan	Montcalm County Road Commission	If funding levels don't increase we will have no other choice than revert more roads to granular surfaces
Minnesota	Freeborn County	Did not check box that we are planning to unpave more. Currently are considering several alternatives such as added revenue and lightly surfaced roads in lieu of hard surfaced roads where heavy commercial average daily traffic (HCADT) is low enough
Minnesota	Dodge County Highway Department	Conversion is ongoing.
Montana	Lake County Roads Department	We will ultimately have to pave this road due to traffic and dust concerns. The high cost of asphalt is outpacing our budget.
Montana	Musselshell County Road Department	Residents now complain about dust. Right after road was recycled they did not complain about anything.
North Dakota	Ramsey County	Road users had a negative reaction for the first couple of years but once they got used to the gravel conditions they were positive. The roads are much safer now.
North Dakota	McIntosh County	We may have to convert more roads to unpaved due to lack of funding.
Oregon	United States Department of Agriculture Forest Service	We may have to convert more roads to gravel as road maintenance funds decrease
South Dakota	South Dakota Local Transportation Assistance Program	As we gain experience, we are more confident in doing this work.
South Dakota	McCook County	Some areas were too rich with asphalt and required extra effort to keep from reverting back to an asphalt state.
South Dakota	Brown County Highway Department	Users like it. People that live along them hate it.
Utah	Tooele County Road Department	The road is performing as expected. The cost of spraying with magnesium chloride is prohibitive so there will be more dust this year.

outreach efforts were performed, and the remaining 26 respondents reporting that no outreach efforts were made.

Q32a: If Yes, Please Explain the Outreach Efforts Made, the Intended Audience (Public, External Stakeholders, Legislators, etc.), if it Was Successful, What Worked and What Did Not, Would You Do it Again?

Of 27 responses to previous question, 26 responses were received describing the types of outreach efforts performed. Among those, 11 responded that some sort of **public meeting (including county commission)** was held during which the conversion was discussed. **Meetings with stakeholders and/or residents** of the road were performed by seven of the respondents. Local media, such as news reports, radio shows, newspaper articles, and press releases were utilized by four of the respondents to publicize the conversion process. Two respondents indicated that their outreach efforts consisted of letters to residents, and another two responded that cost and budgets were utilized. One respondent indicated that the county had a policy posted on its website, whereas yet another respondent indicated that "long term education of the County Board and City Council" were the only outreach efforts performed. Many respondents indicated a combination of efforts, such as a public hearing and a press release or letters to residents coupled with a newspaper article.

Twenty-four respondents provided information describing the target of outreach efforts: 17 respondents indicated that **the public was their main audience.** Four respondents indicated information was targeted at residents along the road who were affected, one additional response each mentioned other road users, including school officials, emergency responders, the trucking industry, and area residents. Legislators, ranging from local to state levels, were the target audience of five respondents, and one respondent indicated that voters were the main target of outreach efforts.

Twenty-five responses were received describing whether outreach efforts regarding the conversion process were successful. Seventeen "yes" responses were received. The remaining eight responses indicated mixed reviews, including comments such as "somewhat," "so-so," and "partially" in describing the success of outreach efforts. **No negative responses were received, indicating that all outreach efforts performed by agencies were, at a minimum, successful on some level, if not entirely.**

The following comments were received from respondents describing what outreach efforts they found most effective. **Providing the public with information—being transparent—was the most often mentioned tactic.** The full range of comments is provided in Table B11.

A total of nine responses were received explaining what outreach efforts were unsuccessful during the conversion process. Comments reflect the difficulty agencies faced in relaying technical and funding information to the public as a means of justification in addition to general public dislike of the conversion. The full range of comments is provided in Table B12.

Q32b: Would You Do it this Way Again?

A total of 24 responses were received, with 22 of the respondents indicating they would choose to perform the conversion outreach the same way again. Two respondents indicated they would not perform the conversion outreach efforts in the same manner. Of the 22 positive responses received, one comment highlighted the need to keep the public informed of the process and the need to convert roads to unpaved surfaces.

Q33: Has There Been Any Pressure to Repave the Road?

A majority of the 54 respondents (30 of 54) indicated that there had been pressure to repave the road, whereas only 24 respondents indicated an absence of pressure to repave.

Additional comments received for this question are shown in Table B13. Comments range from concerns regarding dust and rock chips to satisfied residents who appreciate the higher level of maintenance and improved driving surface. Many comments mention a lack of funding with regard to repaving.

Q34: Have You Developed Methods to Improve Performance of Gravel Surfacing that Makes it More Cost-Effective or the Conversion Politically Acceptable?

Of the 53 total responses received, over half (28 respondents) indicated that they had not developed methods. Of the 25 respondents who did indicate they had developed methods for improving performance, many mentioned dust control measures, the addition of supplemental materials to the road surface, and road base stabilization as successful techniques. Other comments discussed the actual conversion process and techniques that those agencies found particularly successful. A full account of all additional comments received for this question is provided in Table B14.

Q35: May We Contact You for a Follow-up Interview Regarding Your Experience Converting Paved Roads to Unpaved Roads?

A total of 57 responses were received for this question, with nearly 47 respondents indicating that they would be willing to participate in a follow-up interview and 10 respondents declining.

Q36: Is There Anything Else You Would Like to Share Regarding Converting Paved Roads to Unpaved Roads?

Supplemental materials/documents were provided by two respondents and consisted of an *Aggregate Prioritization Plan Excel Workbook* and a course presentation entitled "Alternatives to Paving." Additional comments were provided from respondents, including those who had considered a conversion, converted roads, and had not converted roads. Comments received varied greatly but included helpful techniques for completing a conversion, discussion of funding issues and public reaction, expression of interest in the process or disbelief that it has been done, and discussion of the future prospect for many agencies of converting additional paved roads to gravel. A few comments expressed opposition to the conversion process, whereas others stated that it was inevitable because of the current funding environment. Table B15 includes the additional comments received.

TABLE B11
COMMENTS RECEIVED ABOUT SUCCESSFUL OUTREACH EFFORTS

State or Province	Agency/Organization	Additional Comments
Alabama	Butler County Commission	Local news article.
Alabama	Franklin County	Mostly through the local media outlets. Also one-on-one meetings with residents and legislators. Flooding the media is good, but face-to-face interaction is better.
California	Lake County Public Works	Public hearing and making the public understand the road would reopen.
Iowa	Washington County	Talked with stakeholders about why and the need for the change of road surface. Explaining the costs to maintain the current surface compared to the new surface.
Iowa	Linn County	Policy and general information is posted on website.
Iowa	Woodbury County	Letters to residents.
Minnesota	Jackson County	Long-term planning and education of County Board and City Council as to why action needed to be taken. The actual reversion took place 10+ years after the first discussion.
Minnesota	Dodge County Highway Department	Capital Improvement Plan Hearing
Minnesota	Mahnomen County	Public Hearing at County Board meeting and being able to get factual information to the public.
Nebraska	Gosper County	Cost of asphalt and budget.
Nebraska	Arthur County	Public hearings and explaining cost issues.
North Dakota	North Dakota State University—Upper Great Plains Transportation Institute	Public meetings and correcting misconceptions.
North Dakota	Ramsey County	Held public meetings and radio interviews. Explaining what our intentions were and handing out sheets of projected costs to repair the roads.
Oklahoma	Sequoyah County	Conversations with stakeholders and transparency.
Ontario	Town of Bracebridge	Communication, meeting with ratepayers.
Oregon	United States Department of Agriculture Forest Service	Project scoping.
South Dakota	South Dakota Local Transportation Assistance Program	Public meetings & informal contact with residents, along with good cost and budget data to justify decisions.
South Dakota	McCook County	Public input meetings and keeping the public informed.
South Dakota	Day County Highway Department	Commission meeting followed by actual use.
South Dakota	Brown County Highway Department	Let the road get so bad there is no other option and then town meetings to facilitate public discussion.
South Dakota	Kingsbury County	Public meeting with LTAP, state officials, and consulting engineering on hand to help answer questions.
Texas	Texas Department of Transportation	Press Releases, getting information out.
Utah	Tooele County Road Department	Informational meeting was held and people knew what was happening.
Vermont	City of Montpelier	Letter and public hearing.

TABLE B12
COMMENTS RECEIVED ABOUT UNSUCCESSFUL OUTREACH EFFORTS

State or Province	Agency/Organization	Additional Comments
California	Lake County Public Works	Public understanding of budget constraints.
Iowa	Linn County	Individual discussion with adjacent owners.
Minnesota	Mahnomen County	Local residents upset, thought they were getting unfair treatment.
North Dakota	North Dakota State University—Upper Great Plains Transportation Institute	No examples to show public.
North Dakota	Ramsey County	Should have worked with residents living on the routes more.
South Dakota	South Dakota Local Transportation Assistance Program	Trying to convey some technical data not understandable to public.
South Dakota	McCook County	Public didn't care for the ultimate decision.
Texas	Texas Department of Transportation	Justifying why it was done.
Utah	Tooele County Road Department	The people did not like what was happening.

TABLE B13
COMMENTS REGARDING PRESSURE TO REPAVE THE ROAD

State or Province	Agency/Organization	Additional Comments
Alabama	Franklin County	In some cases we have had pressure to repave the road. In some cases the residents are happy and understand that we can provide better maintenance if the road remains unpaved.
California	Lake County Public Works	The road was closed due to severe deterioration, once converted to dirt the road was re-opened.
Iowa	Linn County	Owners would like to have paving without cost. We provide equity with the traffic count approach.
Iowa	Winneshiek County	Locals that live on the road only.
Kansas	Stafford County	We put 2 miles for road back to asphalt because of the high truck volume
Kansas	Montgomery County Public Works	Home owners were told that the road would be re-asphalted in a couple of years.
Minnesota	Dodge County Highway Department	No one wants to see their road go back to gravel but they have not come up with any funds.
North Dakota	Stutsman County Highway Department	High Average Daily Vehicle Counts mandated repaving.
Ohio	Coshocton County Engineer	Complaints about dust and gravel road.
Oklahoma	Sequoyah County	Some of the residents have asked when we could do it and I explained that we must let it set up and then we must find the funding to do that.
Ontario	Town of Bracebridge	Concern about stone chips on cars.
Oregon	United States Department of Agriculture Forest Service	Use is less than 20 average daily traffic (ADT).
South Dakota	South Dakota Local Transportation Assistance Program	No distress and road is performing well. No one is asking for paving.
South Dakota	Yankton County Highway Department	Some people want pavement and others don't seem to mind.
South Dakota	Miner County Highway Department	Requests from locals to repave the road at first, but not anymore.
Utah	Tooele County Road Department	There is a water ski lake with several part-time residents that use the road to access their property and they don't like hauling expensive boats on a gravel road.

TABLE B14
ADDITIONAL COMMENTS RECEIVED REGARDING METHODS TO IMPROVE PERFORMANCE

State or Province	Agency/Organization	Additional Comments
Alabama	Franklin County	Adding a thin layer of Crushed Aggregate limestone really helps. Most of these roads were chip seals before the conversion so adding the crusher run leaves a white versus red look and is more acceptable.
California	Yolo County Planning, Public Works, and Environmental Services	Working with outside parties to aid in the proper method used to convert paved to unpaved.
Iowa	Linn County	Using a countywide policy and sticking with the program has worked.
Iowa	Jefferson County Road Department	Dust suppressant applied.
Iowa	Decatur County	Use of a rotary reclaimer, addition of new aggregate, “re-cutting” road section, and cleaning of ditches helps to ease the transition to a gravel surface.
Kansas	Reno County	If we unpaved roads, it would be my recommendation that the gravel surfacing would be standardized at a level exceeding existing township roads before we transferred the maintenance to them.
Kansas	Stafford County	Capped the road with a clay type mix, which made it smoother and more driver-friendly.
Michigan	Montcalm County Road Commission	Timely application of Chloride (26%). Grading only on days with excess moisture. Our grading success is on days that it is raining. Mud one day, hard surface the next.
Minnesota	Freeborn County	Created a method, let’s call it the SKORSETH METHOD, to assess all our miles of gravel surfaced roads, cored 3 pts/mile in zig-zag pattern to determine average aggregate thickness. Set targets based on average daily traffic (ADT)/presumed heavy commercial average daily traffic (HCADT) and prioritized for additional aggregate base then aggregate surfacing (class 2 & $MgCl_2$) if average daily traffic (ADT) was less than 100. Also began working with aggregate producers on quality of aggregates and altering our spec to find a better surface versus base aggregate.
Minnesota	Jackson County	In Jackson County we have extensive experience with Wind Farm projects stabilizing gravel roads with cement and fly ash. I see that reverting roads with some type of full depth reclamation (FDR) as a solution that can work.
Nebraska	Sheridan County	Bringing a better gravel to place on top. We try using more dust free material.
Nebraska	Arthur County	Addition of crushed concrete.
North Dakota	Ramsey County	We do apply dust suppressant in front of [residences] along the routes at a minimal cost share to the resident.
North Dakota	Bowman County	Dust control.
Oklahoma	Sequoyah County	Occasionally we oil the surface to hold down the dust.
Ontario	Town of Bracebridge	Addition of magnesium chloride.
South Dakota	South Dakota Local Transportation Assistance Program	Used a modified surface gravel specification to get a better-bound surface to reduce blade maintenance and reduced loose aggregate on surface, which brings complaints.
South Dakota	Yankton County Highway Department	We treat the surface with a base stabilizer and apply a topical dust control agent.
South Dakota	McCook County	Added clay to tighten up the surface resulting in more dust. Public preferred the dust rather than a loose surface with the asphalt/gravel blend.
South Dakota	Potter County Highway	Proper maintenance and gravel of proper specification.
South Dakota	Day County Highway Department	Good quality surface gravel.
South Dakota	Deuel County	The old blotter mixed with the gravel appears to help with dust and also makes a strong surface.
South Dakota	Brown County Highway Department	Occasional dust proofing, reclamation.
South Dakota	Kingsbury County	By use gravel stabilization and adding more gravel to the base. Also by proper watering and rolling of the material while being placed.
Utah	Tooele County Road Department	We would like to see what other jurisdictions are doing.

TABLE B15
ADDITIONAL COMMENTS RECEIVED

State or Province	Agency/Organization	Additional Comments
Agencies that have NOT converted paved roads to unpaved		
Alberta	Rocky View County	We have converted old, oiled surfaces back to gravel over the past 3 years with positive results. This allows Rockyview to maintain these roads to a higher standard than with the oil treated surface
Kansas	Scotwood Industries Inc.	We deal with end users and help educate them on best practices for maintaining gravel roads and sell chlorides to complete road projects.
Colorado	FHWA, Office of Federal Lands Highway	While technically not an un-paving event, we did construct on Guanella Pass, Colorado, an initial unpaved section on a Forest Service access road up to an outfitter's ranch to convey a "rustic and wilderness" feel. Then from his place on up the road into the forest we installed hot mix asphalt (HMA). This was due to a commitment in the National Environmental Policy Act (NEPA) process.
Iowa	Pottawattamie County Secondary Roads	We've recycled a paved road into a rolled stone base with a thin overlay. So while we didn't exactly un-pave it, we did find a more politically tolerable solution in the middle of paving or un-paving.
Iowa	Hamilton County	All of our paved roads are full depth hot mix asphalt (HMA) or Portland Cement (PC) Paving and it would be unrealistic to consider converting these routes to unpaved roads considering the traffic and demand for these roads. It is more conceivable to believe there will be additional miles of paving as agricultural and industrial businesses develop in the rural area.
Iowa	Union County	We are approaching the end of the useful life of a few paved routes and the choices may be converting to gravel or bonding for reconstruction.
Iowa	Pocahontas County Engineer's Office	Conversion would only happen when a road needed rehab and there was no money. The roads that might be candidates are the ones that are not being beaten apart. Therefore, it will be a long time before they need rehab.
Iowa	Keokuk County	I brought this idea up regarding a rural paved road, with less than 200 average daily traffic (ADT), and my Board of Supervisors were not in favor of it due to anticipated public opposition.
Iowa	Mahaska County Secondary Roads	Our road use funds and local taxes only pay for the partial maintenance of the existing roads in the county. Required pavement maintenance and repair has been not affordable in the past several years due to lack of adequate financing to perform the tasks.
Minnesota	Lac qui Parle County Highway Department	Current funding is not sustainable.
Minnesota	Beltrami County	We have done a Full Depth Reclamation (FDR) on a deteriorated paved road and surfaced it with only a double chip seal. The road users believe this is no longer a paved road.
Montana	LVR Consultants LLC	I have some experience with counties that have converted paved to unpaved roads.
Nebraska	City of Lincoln	Can't imagine why you'd want to unless the condition of the paved road is worse than a gravel road.
Nebraska	Howard County Roads	Howard County does not have any paved county roads. All the roads maintained by the county are gravel.
New York	Tioga County	The towns in the County may be looking at converting.
New York	Yates County	Not going to happen here as long as I am the highway superintendent.
New York	Rockland County Highway Department	Our population would not tolerate that.
New York	Wyoming County Highway	While it is significantly less cost to have gravel roads vs. paved, the level of service in a climate that has freeze/thaw cycles is very poor.

(*continued on next page*)

TABLE B15
(*continued*)

State or Province	Agency/Organization	Additional Comments
Oklahoma	Tulsa County	Once a road is paved, it is hard to get the public to accept changing it back to unpaved.
Quebec	FPInnovations	I have not heard of any paved roads or even chip seal (thin surface treatments) that have been converted to unpaved surfaces in Canada.
South Dakota	Union County Public Works Department	Negative reaction from constituents; don't like to return to dust conditions and rock chips in windshields.
South Dakota	Minnehaha County	We have yet to do any conversions. However, we will inevitably face this challenge in the coming years. Looking forward to the results of this survey.
Agencies that are CONSIDERING converting a paved road to unpaved		
California	Tehama County	The action is being considered; however no proposal has been brought forward as of this date.
Kansas	Reno County	I am very interested in this process.
Minnesota	Dodge County Highway Department	Some of these roads should never have been paved.
Agencies that HAVE CONVERTED a paved road to unpaved		
Iowa	Decatur County	We reclaim chip seals as they are not possible to maintain due to short life cycle and cost. Short of adding miles of hard pavements (portland cement or asphalt concrete), we are only left with one option. We do not have the funding to pave new miles of hard surfaced roads, even with the new fuel tax increase.
Michigan	Montcalm County Road Commission	We have found no cure-all application. The most cost-effective process for Montcalm County is 4,000 gal per mile of 26% Chloride every 21 days. The cost for that product is $550.00 per mile.
Minnesota	Norman County Highway Department	We have yet to convert any paved roads to unpaved roads, but are starting the process.
Minnesota	Freeborn County	Mr. Skorseth has been a tremendous supporter!
North Dakota	North Dakota State University—Upper Great Plains Transportation Institute	We are in the process in developing a web-based surface selection tool which uses all life-cycle costs to determine which surface treatments are most cost-effective for various average daily traffic (ADT) values.
North Dakota	McIntosh County	I think it would have been wise to add the right gravel before milling and mix in a soil stabilizer, water it and roll it, but those things were not available to us.
Ontario	Town of Bracebridge	Proposing to add an additional 0.7 mi of converted road to the system in 2015.
South Dakota	South Dakota Local Transportation Assistance Program	Provided a document that may be useful to others.
South Dakota	Day County Highway Department	Once completed, do not reduce the normal maintenance. Extra care to gravel depth and integrity.
South Dakota	Deuel County	Thin blotters are easy to convert by using just a scarifier, a sheepsfoot, and water. Compaction is tight.
South Dakota	Kingsbury County	As you may already realize, local roads that were built in the 50s, 60s, 70s, 80s, and even early 90s were not built for the traffic that is on the local road system that we are experiencing today. The base of these roads is not adequate to sustain the heavier farm equipment or the semi traffic that they use to haul grain (farm to market). Hence the blotter or emulsion treated roads are failing drastically.
Utah	Tooele County Road Department	Since 2013 Tooele County has instituted a Municipal Service Fee for the unincorporated county. The State of Utah just raised the gas tax and has given Counties the option to institute a local gas tax.
Vermont	City of Montpelier	Importance of low traffic volume, open drainage systems, flat to moderately steep grade.

APPENDIX C

List of Interviewees

Alabama: Franklin County
David Palmer
County Engineer
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256-332-8434

California: County of Napa Department of Public Works
Steve Stangland
Public Works Superintendent
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Iowa: Washington County
Jacob Thorius
County Engineer
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Iowa: Linn County
Steve Gannon
County Engineer
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319-892-6400

Kansas: Stafford County Road Department
Phil Nusser
Road Supervisor
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620-549-3597

Michigan: Montcalm County Road Commission
Mark Christensen
Superintendent/Manager
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989-831-5285

Montana: Lake County Roads Department
Jay Garrick
Road Department Superintendent
jgarrick@lakemt.gov

Nebraska: Arthur County
Kent Anderson
County Highway Superintendent
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North Dakota: Ramsey County Road Department
Kevin Fieldsend
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Ohio: Coshocton County
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Oregon: USDA Forest Service, Suislaw National Forest
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South Dakota: Brown County Highway Department
Dirk Rogers
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South Dakota: Day County Highway Department
Highway Superintendent

Texas: TxDOT
Chris Caron
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Texas: TxDOT
Tomas Trevino
Maintenance Engineer
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Utah: Tooele County Road Department
Director

Vermont: City of Montpelier
Tom McArdle
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Ontario, Canada: Town of Bracebridge Public Works
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APPENDIX D

Case Examples

This section provides case examples from 15 states in the United States and one Canadian province for which transportation agencies have converted paved roads to unpaved. The case examples were developed using information gained from the survey, follow-up interviews, and the literature.

ALABAMA

In Franklin County, Alabama, 20 mi of very poor condition road were converted to unpaved. The road was converted using a full-depth reclaimer and consists of a red clay and gravel mixture and the recycled old surfacing. A thin layer of crusher run (crushed limestone) was hauled in to supplement the existing materials creating a white overlay that differentiates this road from the other red dirt roads in the county, thus "softening the blow" of the transition from paved to unpaved. The road has an average daily traffic (ADT) of 21 to 50 vehicles and was converted within the last year (2014). The road was changed to an unpaved surface because of the costs of maintaining the road, complaints from the public, and safety concerns, but the lack of revenue was the primary cause for the road conversion. They would have preferred to keep patching the road but did not have the funds to support this. The converted road is performing well, the county has saved money by doing the conversion, and there has been no documented increase in vehicle crashes. Public reaction has been both positive and negative. Outreach efforts included contacting the local media outlets and one-on-one meetings with road residents and legislators, which were deemed somewhat successful. There has been some pressure to repave.

Franklin County is unique because it uses a robust geographic information system (GIS) tool that is incorporated into the asset and pavement management systems. They use these tools to model their road system, prioritize their needs, and make informed management decisions. They can easily enter data into the system, which they can adjust and supplement with additional information to fit their needs. The software allows for consideration of surface condition, base condition, traffic volumes, number of residents, segment classification, repair costs, and other factors when rating a road. They inspect each road in the county every 2 years and enter the new data into the GIS system. A rating from 1 to 100 is given to each road for the surface and base condition. The system then uses a combination of the rating, road classification, ADT, and a few other factors to prioritize roads for maintenance and repaving. The system then suggests the level of service warranted for the road—for example, paved, gravel, or chip sealed surface—and provides a relative ranking for each road that helps the county determine where to spend money and the level of maintenance required. All of this information helps with budgeting. They also have a database of unit prices for a variety of materials and processes, by which they can check boxes on a computer screen for various maintenance and construction procedures and the system will provide a budget based on these selections. One aspect of the system the county really likes is that it is easy to make and change maps, which are great tools for communicating with the public. The maps can show roads as red if they are in bad condition and green if they are in good condition. They have found these color codes better convey the reality of the road network condition than do pages of budgets and condition data. Ultimately this system is an integral part of what they do Franklin County, and is a great tool for making strategic decisions.

CALIFORNIA

A total of 6 mi of road converted from paved to unpaved in Napa County (4 mi) and Yolo County (2 mi), California, and are discussed here. In Napa County, the 4 mi of road converted was a connector road with ADT of 150 to 200 vehicles. The original pavement was asphalt concrete in poor condition. The old surface material was recycled into the new road surface using a contracted pulverizer, and gravel was trucked in to supplement the existing materials. The road surface was stabilized using an enzymatic soil stabilizer that was mixed into the water in a truck that was attached to the pulverizer; the stabilizer was then incorporated into the surface layer. They feel this method utilizing the enzyme made for a better driving surface. The road is graded about once a year; in addition, clay has been added to a coarse rocky section to get a better soil mix, and water has been added to reactivate the enzyme stabilizer. The road was converted more than 5 years ago because the cost of maintaining the road was unsustainable. Public reaction to this road conversion project was negative. A public hearing was held, with mixed results in terms of success. There was pressure to repave, and this may be due in part to homeowners being told the road would be repaved in a couple of years. At one point in time, complaints on the newly converted road were coming from a federal agency on behalf of a constituent.

In Yolo County, California, 2 mi of road with ADT of 21 to 50 vehicles were converted from a poor condition pavement to an unpaved road surface more than 5 years ago (prior to 2010). The old pavement surface was recycled and incorporated in the new surface, gravel was hauled in to supplement the existing materials, and the surface was stabilized with an enzyme product incorporated into the surface layer. The road was converted because of high maintenance costs, complaints from the public, and safety concerns. At this time the converted road is performing well, the county has saved money, the road has required less maintenance than anticipated, and there has been no documented increase in vehicle crashes. The county does have plans to convert more roads from paved to unpaved. The county worked with outside parties to determine the proper methods to be used to convert the road. No public outreach efforts have been made, and there has been no pressure to repave.

IOWA

In this section, 50 mi of road converted from paved to unpaved in three Iowa counties are reviewed.

In Decatur County, Iowa, 41 mi consisting of asphalt concrete in fair condition, pavement with a surface treatment in poor condition, a combination of pavements in fair condition, and portland cement concrete pavement in fair condition were converted to unpaved. The old surfaces were recycled, and new gravel was hauled in to supplement the existing materials. At this time they have converted only roads with chip seal surface treatment back to gravel. Documents used to provide guidance in the road conversion project included the AASHTO *Guidelines for Geometric Design of Very Low-Volume Local Roads* (the Green Book), the *Very Low Volume Roads Guide*, which was used to establish the finished section, and communications with other engineers discussing the trials and errors of what methods provided the best finished surface. ADT on the road segments ranges from 100 to 150 vehicles, and the reason for the conversion was the cost of maintaining the roads. The road were converted 1 to 2 years ago (2013–2014), and at this time the road is performing well and there has been no documented increase in vehicle crashes. Public reaction to the road conversion has been both positive and negative, with some of the public happy that they now have a uniform driving surface, whereas others are unhappy the road is no longer a paved and dust-free surface. There has been pressure from the public to repave the road. In this county they do not have the funding to pave new miles of hard-surfaced roads, even with a new fuel tax increase.

In Jefferson County, Iowa, 6 mi of pavement with a surface treatment in poor condition were converted to an unpaved road. The original pavement was recycled and mixed with gravel that was hauled in to supplement the existing material, followed by the application of a chemical stabilizer or dust suppressant that was incorporated into the surface layer. Jefferson County relied on the experience of others who have conducted road conversion projects to aid in their conversions. The road, with an ADT of 300 to 500 vehicles, was converted 2 to 3 years ago (2011–2013) because of the cost to maintain the road. At this time the road is performing well, has required less maintenance than anticipated, and the county has saved money. Public sentiment to the road conversion was negative, and there has been pressure to repave. The county has plans to convert more roads from paved to unpaved in the future.

In Washington County, Iowa, 3 mi of paved road with a seal coat surface treatment in poor condition and an ADT of 21 to 50 vehicles were converted to unpaved more than 5 years ago (prior to 2010). The old road was recycled using a motor grader, and gravel was hauled in to supplement the existing materials to create the new unpaved road surface. The road was converted because of the cost of maintaining the road. The county determined it was more economical to maintain the road as unpaved. At this time the road is performing well, has saved the agency money, and has required less maintenance than anticipated. Outreach efforts included talking with stakeholders, explaining why the county was converting the road and the high cost to maintain the current surface compared to a new unpaved surface. There has been no pressure to repave the road, but high average daily vehicle counts may require repaving of the road. The converted road has had issues with gravel loss because of varying transportation modes (e.g., Amish horse-drawn buggies); for this reason they will be testing a road stabilizer (summer 2015). They also had some issues with breaking up the chunks of seal coat, which caused issues with the driving surface and lack of uniformity.

KANSAS

In Montgomery and Stafford Counties in Kansas, about 45 mi of road have been converted from paved to unpaved. In Stafford County, 42 mi of road were converted with an ADT of 21 to 50 vehicles. The original asphalt surface treatment was in poor condition. Recycling machines were used to grind up, recycle, and incorporate the old surface into the new unpaved surface. A clay mix was used to cap the gravel road and aided in providing a smoother driving surface. The road has an extremely sandy soil type that is unstable, so the clay functioned as a stabilizer. The reasons for converting the road were the cost to maintain the road and safety concerns. Input from supervisors was used to complete the conversion, and the road conversion took place 5 or more years ago (prior to 2010). The converted road is not performing well. They have spent more money than anticipated, the road has required more maintenance than anticipated, and the overall reaction to the conversion has been negative. In addition to this, there has been pressure to repave the road. Consequently, a 2-mi section of the converted road was repaved with asphalt because of high truck volume.

In Montgomery County, Kansas, 4 mi of road were converted from paved to unpaved in the 1980s. The original pavement consisted of a mix of asphalt concrete in good condition, an asphalt surface treatment in good condition, and a combination of pavements types in good condition. The original pavement surface was recycled and incorporated into the new unpaved surface. The rationale for the conversion was the high cost to maintain the road and low ADT, from 51 to 100 vehicles. Input on how to convert the road was provided by the commissioners at the time. At this juncture, the road is not performing well, public reaction to the road conversion has been negative, and there has been pressure to repave. This may be in part because homeowners were told the road would be reasphalted a couple years after it was converted to unpaved, and this has not occurred.

MICHIGAN

In Montcalm County, Michigan, 15 mi of road surfaced with asphalt concrete in poor condition or pavement with a surface treatment in poor condition were converted to unpaved. New gravel was hauled in to supplement the existing materials, and then the old surfacing was recycled and mixed with the new gravel to better incorporate both into the road surface. A surface application of a dust suppressant was applied at 4,000 gal per mi of 26% calcium chloride every 21 to 28 days (from mid-May to mid-September) at a chloride cost of $550.00 per mile. Application rates and frequency of application varied based on moisture and ADT. The road was converted because of the cost to maintain the road, complaints from the public, and safety concerns. Ultimately the decision to convert the road was based on the cost history of the road, accident reports, and estimated future funding levels. ADT for this road is 500 to 1,000 vehicles. The road conversion occurred over a 6-year period, with 2 to 3 mi converted each year.

By converting the road, the county has saved money and there has been no documented increase in vehicle crashes, but the public reaction to the road conversion was negative, and the converted road has required more maintenance than anticipated. Additionally, there has been pressure to repave the road. The county did conduct outreach efforts, but no details were provided. The county does plan to convert more roads from paved to unpaved.

MINNESOTA

In this section, three counties in the state of Minnesota that have converted about 22 mi of road from paved to unpaved are discussed.

In Freeborn County, Minnesota, 0.2 mi of asphalt concrete road in poor condition, with an ADT of 300 to 500 vehicles, were converted to an unpaved road 2 to 3 years ago (2010–2013). The road segment has the unique issue of a subgrade consisting of peat bog with a flowing artesian spring. The conversion process consisted of recycling the old pavement surface and hauling in and placing Class 2 limestone over Class 5 aggregate base. Magnesium chloride surface stabilization was incorporated into part of the surface layer. The road was converted because of the cost of maintaining the road, complaints from the public, and safety concerns. The decision to convert this road segment came from an aggregate prioritization plan. At this time, the converted road segment is performing well, has saved the agency money, has required less maintenance than anticipated, and there has been no documented increase in vehicles crashes. Public reaction to the road conversion has been negative, and there has been pressure to repave the converted road segment. Failure of the road has occurred in the springtime as the road thawed, and the county does not plan on doing a conversion this same way again. The county is currently working with elected officials to help educate the road users.

Freeborn County has developed a method to assess all of the miles of gravel surfaced roads, which entails coring three points per miles in a zig-zag pattern to determine average aggregate thickness, setting targets based on ADT and presumed heavy commercial ADT, and prioritizing for additional aggregate base and then aggregate surfacing (Class 2 and magnesium chloride) if ADT is less than 100 vehicles. Freeborn County also began working with aggregate producers on the quality of the aggregates and to alter the state specifications to find a better surface versus base aggregate.

In Jackson County, Minnesota, 1 mi of asphalt concrete in poor condition with an ADT of 51 to 100 vehicles was converted to an unpaved road within the last year (2014). The original pavement was recycled and incorporated into the new unpaved road surface. The road was converted because of the cost to maintain the road, as well as the diminished importance of the road owing to the reconstruction of another thoroughfare serving the community. At this time, the road is performing well and has saved the county money. Outreach efforts prior to the conversion included educating the County Board and City Council on the process, educating them on why converting the road was necessary, and involving them in the conversion. The county found that long-term planning and discussion with the County Board and City Council worked well. The road conversion took place more than 10 years after initial discussions began. The county has plans to convert more roads from paved to unpaved in the future.

In St. Louis County, Minnesota, 20 mi of asphalt concrete in poor condition were converted to an unpaved road 1 to 2 years ago (2012–2014). The original surface was recycled, new gravel was hauled in to supplement the existing material, and a chemical stabilizer was incorporated into part of the surface layer. For this road, the ADT (51 to 100 vehicles) was too low to warrant bituminous surface treatment—instead they decided on full-depth reclamation with a stabilized base to increase strength. The road was converted because of the cost of maintaining the road and safety concerns coupled with complaints from the public. At this time the road is performing well, has required less maintenance than anticipated, has saved the county money, and there has been no documented increase in vehicle crashes on the converted road. However, there has been pressure to repave the converted road. For this conversion project, timing did not allow for outreach, but they would conduct public outreach going forward with future road conversion projects. The county has plans to convert more roads in the future.

MONTANA

In Musselshell County, Montana, two road conversions of more than 5 mi occurred. The first conversion was on road with less than 20 ADT; the road had a surface constructed of a combination of materials and was in poor condition. The new unpaved surface had a road surface stabilizer incorporated into part of the surface layer. The road was converted because of costs associated with maintaining the road and because some sections were deteriorated beyond repair. The second road conversion project in Musselshell County, Montana, involved the conversion of 3 mi of paved road constructed from a combination of materials that was in good to poor condition. ADT on this road is 51 to 100 vehicles. The new, unpaved road consists of millings (reclaimed asphalt from other roads) laid out over gravel with a road surface stabilizer incorporated into part of the surface layer. The conversion occurred because of the cost to maintain the road and the high cost of chip sealing.

For both conversions in Musselshell County, the original pavement surface was recycled and incorporated into the unpaved surface. Both road conversion projects occurred 2 to 3 years ago (2010–2013), and the roads are performing well. Converting the roads from paved to unpaved has saved the county money, and subsequently they have plans to convert more roads. The reaction from the public regarding the road conversion was both positive and negative, with some residents complaining about the dust. For these conversions, the county determined it was better to have a recycled surface that can be kept smooth using a motor grader than a road full of potholes and other hazards. At this point in time there has been no pressure to repave.

NEBRASKA

In this section, two counties in the state of Nebraska that have converted about 25 mi of road from paved to unpaved are discussed.

In Arthur County, 5 mi of local farm-to-market road with an ADT of 51 to 100 vehicles were converted from paved to unpaved. The original pavement surface was asphalt cement in poor condition, and to fix the existing road would have required a full rehabilitation. The road was recycled in place with a rented pulverizer, and aggregate was added to supplement the existing materials. The recycled asphalt served as a stabilizer, and no additional surface treatment was required. The road was converted because of costs to maintain the road and a lack of available federal funds for rehabilitation. The road conversion occurred 5 or more years ago (prior to 2010), and at this time the road is performing well, has saved the county money, and there has been no documented increase in vehicle crashes. Public outreach efforts consisted of a public hearing and were deemed to be successful. There has been no pressure to repave the road, and currently this is the best gravel road they have in the county.

In Sheridan County, Nebraska, 15 mi of paved road with an original pavement type of asphalt concrete were converted to unpaved. To construct the new road surface, gravel was hauled in to supplement existing materials, and a stabilizer was incorporated into the surface layer of the unpaved road. The road was converted because of safety concerns and the cost of asphalt versus the cost of gravel. The road was converted 2 to 3 years ago (2010–2013), and at this time the road is performing well, has saved the county money, and there has been no documented increase in vehicle crashes, but the road has required more maintenance than anticipated. Public reaction to the road conversion has been negative, and there has been some pressure to repave. Outreach efforts to the public included meeting with road district patrons and explaining the associated costs to them. The county says they would perform the conversion again.

NORTH DAKOTA

In this section, two counties in the state of North Dakota that have converted about 40 mi of road from paved to unpaved are discussed.

In Cass County, North Dakota, 5 mi of road were converted from asphalt concrete in poor condition to an unpaved road. The old surface was recycled and mixed with gravel that was hauled in to supplement the existing materials, followed by application of a road surface stabilizer that was incorporated into part of the surface layer. The road was converted because of the cost to maintain the road, as well as safety concerns. The decision to convert the road was made using a cost analysis tool called the *Surface Selection Tool* that was developed by the Upper Great Plains Transportation Institute. They are currently developing a web-based surface selection tool, which will use life-cycle costs to determine which surface treatments are most cost-effective for various ADTs (additional information on this document can be found in chapter four, Resources and Available Documents). The road was converted 1 to 2 years ago (2013–2014) and is performing well. The conversion has saved the county money, and no documented increase in vehicle crashes has occurred. Public outreach consisted of a public meeting in which they were able to correct some misconceptions about converting roads from paved to unpaved, and there has been no pressure to repave the road.

In Ramsey County, North Dakota, 35 mi of farm-to-market road with an ADT of 21 to 50 vehicles were converted from asphalt concrete in poor condition to an unpaved road more than 5 years ago (prior to 2010). The original pavement surface was recycled with an asphalt recycling machine, and new gravel was hauled in to supplement the existing materials. Dust suppressant has been applied in front of residences along the route at a minimal cost share to the residents. The road was converted because of cost to maintain the road, complaints from the public, and safety concerns. Outreach included public meetings to explain that the costs of maintaining the road as asphalt were prohibitive and radio interviews. Both efforts were deemed successful. The county explained what their intentions were for the road conversion project and handed out sheets with projected costs to repair the road and maintain as asphalt. The county acknowledges that they should have worked with residents living on the route more. As a side note, the county asked the voters to add $10 million to road maintenance funds at around the time the conversion was occurring; the vote was passed. At this time the road is performing well, has saved the county money, has required less maintenance than anticipated, and there has been no documented increase in vehicle crashes. Road users had a negative reaction to the road conversion the first couple of years after it was converted, but once they got used to gravel road conditions they were positive about the conversion because the road is now safer. There has been no pressure to repave.

OHIO

In Coshocton County, Ohio, 30 mi of road were converted from paved to unpaved. The original asphalt concrete was in poor condition, and the roads were converted because of the cost of maintenance and safety concerns. Although no documents were available for use in the conversion process, engineering principles and economics analysis were used. The ADT on the converted roads is 200 to 300 vehicles.

A second road conversion project in the county involved the conversion of 3 mi of asphalt concrete roadway in poor condition into an unpaved road surface. This conversion took place because of safety concerns.

For both road conversions, they used a road grader and dump truck to place gravel on top of the deteriorating roads, to supplement the existing material, making the conversion somewhere between active and passive conversion. They do not typically use a dust suppressant or stabilizers, with the exception of occasionally using brine from oil and gas operations that is sprayed on the road as a means of disposal. Additionally, both road conversions took place 5 or more years ago (prior to 2010). The reaction to the conversions was negative, but the county still has plans to the convert more roads from paved to unpaved in the future. No outreach efforts were made for either conversion, and there has been pressure to repave, with specific complaints about dust. In this county the public felt like converting roads from paved to unpaved was losing ground and had trouble understanding why there was not enough money for repaving. If funds permit, they will try full-depth reclamation to improve the unpaved roads.

OREGON

In the Malheur and Siuslaw National Forests in Oregon, 25 lane-miles of road have been converted from paved to unpaved. The ADT for the road conversion that occurred in Malheur National Forest was less than 20 vehicles along the 5-mi stretch of road. The original pavement type was asphalt concrete in poor condition. The paved surface was recycled in place using an asphalt pulverizer, which was adjusted to reclaim down to 1.5 ft, essentially digging out the road and laying it back down, followed by compaction three times with a roller. Four inches of crushed rock/gravel were then added as a cap, and the surface was treated with a road surface stabilization product that was incorporated into the surface layer. Prior to the road conversion, they consulted with geotechnical engineers. Plans were made to address any base issues that arose, and consequently they ended up replacing a couple of failed culverts. The road was converted 2 to 3 years ago (2010–2013) because of the cost to maintain the road and safety concerns.

The converted road is performing well, has saved the agency money, requires less maintenance than anticipated, and there has been no documented increase in vehicle crashes. The agency has plans to convert more roads from paved to unpaved. Outreach efforts included project scoping, which was deemed successful, and there has been no pressure to repave. This was an old timber harvest road that was used again for timber harvesting immediately after the conversion, so increased traffic and compaction occurred, and the road has held up well.

The second road conversion project occurred in Siuslaw National Forest more than 5 years ago (prior to 2010) and involved 20 mi of road with an ADT of 51 to 100 vehicles. The original surface had a bituminous surface treatment chip seal surfacing that was unsafe. The old surface was recycled into the surface layer of the unpaved road. The road conversion occurred because of the cost of maintaining the road and safety concerns. The converted road surface is performing well, has saved the agency money, and there has been no documented increase in vehicle crashes. Overall reaction has been positive, and the forest has plans to convert more roads. No public outreach efforts were used, and there has been pressure to repave.

PENNSYLVANIA

The Pennsylvania Bureau of Forestry, in conjunction with Pennsylvania's Center Dirt and Gravel Road Maintenance Program, performed a demonstration project on a portion of Linn Run Road located in Linn Run State Park in Westmoreland County. Initially, the work plan proposed using full-depth reclamation to break up the asphalt and mix it with the existing base material to a depth between 6 and 8 in. Water and chemical stabilizers would then be added to achieve optimum moisture content, followed by crowning and road shaping performed by a road grader and compacted using a roller. Drainage issues were addressed in the work plan, with numerous underdrains wrapped with permeable geotextile and ditching to prevent water movement across the top of the road surface (Shearer and Scheetz 2011).

Upon installation of the first drainage element, large boulders beneath the 1 to 2 in. of asphalt overlay were discovered and prevented the use of the full-depth reclamation process because of machinery limitations. The large boulders were used in the original construction of the road as a base to cover an impermeable clay layer found during excavation for the drainage system. The work plan was updated, and the asphalt was crushed with a crawler tractor fitted with a ripper and mixed with the minimum amount of aggregate to prevent the asphalt from rebinding. A geotextile was placed on top of the reclaimed base and then covered with 6 in. of driving surface aggregate applied using a paver. The geotextile was chosen because it allows for the flow of water through the layer but prevents the downward migration of fine soil particles that could clog the underdrain system in addition to providing stabilization and even load distribution. The aggregate was delivered to the site at optimum moisture content and compacted with rollers (Shearer and Scheetz 2011).

The final product of the reclaimed road was a hard-wearing surface that required less maintenance and lost less sediment to runoff than does a traditional gravel road. Despite the complications from the large boulders in the original road base, the project budget did not exceed the initial value of $100,000. Proper site investigation was cited as one reason for the success of the project, primarily the installation of a drainage system to route water off of and away from the road surface. If initial core samples and other evaluations were not performed, proper preparation of the road base could not have been completed prior to the recycling of the asphalt road surface. This could have led to issues with the road stability and increased maintenance costs because of poor construction (Shearer and Scheetz 2011).

SOUTH DAKOTA

In this section, four counties in the state of South Dakota that have converted more than 100 mi of road from paved to unpaved are discussed.

In Brookings, South Dakota, two road conversion projects were conducted. The first road conversion to be discussed involved 20 mi of asphalt concrete that was converted to an unpaved road surface. The road was converted because the low ADT on the road (100 to 150 vehicles) did not justify reconstructing the pavement in a life-cycle cost analysis. Information available included a Transportation Learning Network video conference titled *Alternatives to Paving.* In addition to this, in-house knowledge of existing base depth materials and the material quality, recycling, base construction, priming, and seal coating were used. The public initially objected to the converted road but was then happy after getting a good gravel surface to drive on. The second road conversion involved 2 mi of asphalt concrete converted to an unpaved road with an asphalt emulsion surface. Additionally, they used a modified surface gravel specification to get a better bound surface to reduce blade maintenance and loose aggregate on the surface (which brings complaints). The road was recycled, reshaped, recompacted, and a chip seal was placed on the surface. A half-gallon per square yard of AE200 emulsion asphalt was injected and mixed into the upper 3 in. of the recycled layer to strengthen the recycled base. ADT on this road was 300 to 500 vehicles, but the cost of maintaining and the cost of total reconstruction to pavement were prohibitive. For these reasons, a seal coat was determined to be adequate. Following the conversion, the public was happy and did not even know the road was not repaved.

Both road conversions were completed 2 to 3 years ago (2010–2013), and the roads are performing well. By performing the road conversions, the road agency has saved money, there has been no documented increase in vehicle crashes on the converted roads, and the converted roads have required less maintenance than anticipated. At this time there are plans to convert more roads from paved to unpaved, in part because of the experience gained in the process and increased confidence in the process. Outreach efforts included public meetings and informal contact with residents. The agencies found presenting good cost and budget data to justify the decision to convert the roads helped in public understanding but noted that trying to convey technical data can be confusing to the public. Public reaction to the road conversions has been positive, and there has been no pressure to repave the roads.

In Brown County, South Dakota, 40 mi of asphalt concrete pavement (in good condition) with a chip seal surface treatment (in fair condition), and a combination of pavements including portland cement (in fair condition) were converted to unpaved. A second road conversion project in Brown County involved 30 mi of asphalt concrete pavement (in poor condition), with a chip seal surface treatment (in poor condition), and a combination of pavement types (in poor condition) being converted to unpaved road segments. For both road conversion projects in Brown County, the unpaved road surface was made using recycled materials from the original paved surface, and new gravel was hauled in to supplement the existing materials, followed by application of dust suppressant. Brown County has used different recycling equipment (mills) and has purchased a loader-mounted reclaimer they use for projects of less than 0.5 mi. (The larger reclaimers are faster and more efficient for longer road sections.) Brown County runs a padfoot roller (sheepsfoot) behind the mill to help break down the chunks and aid in compaction.

In 2015, Brown County experimented with a soybean-derived base and surface stabilizer and has used cement as a base stabilizer in the past on roads that will be repaved but avoids this on reclaimed roads that remain unpaved because of the potential for pothole formation. For both road conversion projects, the road segments were converted because of the cost of maintaining them. Both roads have an ADT of 21 to 50 vehicles, and the road conversions took place 5 or more years ago (prior to 2010). Information used to convert the road was found in documents on the Internet and gleaned from talking with industry representatives. At this time the roads are performing well, have saved the county money, and there has been no documented increase in vehicle crashes on the converted road segments. Outreach efforts by the county consisted of town meetings and public discussions that were deemed somewhat successful. Public reaction to the road conversion has been overall positive; the road users like it, but the residents living adjacent to the roads do not like it. The county has plans to convert more roads from paved to unpaved in the future. The next time they convert a road, they will likely collect cores to make sure they have the correct quantity of gravel for a proper mix of gravel to asphalt after reclaiming.

In Kingsbury County, South Dakota, 16 mi of asphalt concrete in fair condition and pavement with a surface treatment in poor condition were converted to an unpaved road 2 to 3 years ago (2010–2013). The original pavement surface was recycled with new gravel hauled in to supplement the existing materials. The recycled material and gravel mix was watered and rolled while being placed, creating the new unpaved road surface that was then treated with a dust suppressant. The road was converted because of cost of maintaining the road and safety concerns. ADT on the road is 21 to 50 vehicles. At this time the road is performing well, has saved the county money, and has required less maintenance than anticipated. Public reaction to the road conversion has been both positive and negative, and there has been pressure to repave the road. Outreach efforts included public meetings that were deemed somewhat successful. Kingsbury County found working with the local technical assistance program and state officials and having a consulting engineer on hand for questions and answers during the public meeting to be helpful. Kingsbury County has plans to convert more roads from paved to unpaved in the future.

Within the last year (2014–2015), in McCook County, South Dakota, 3 mi of road with asphalt concrete in poor condition and an ADT of 51 to 100 vehicles were converted to an unpaved road with surface stabilization incorporated into part of the surface layer. They added clay to tighten up the surface, which resulted in more dust, but the public preferred dust over a loose surface with an asphalt/gravel blend. The road was converted because of cost of maintaining it. Information used to support the decision to convert the road included traffic counts, road core information, and a basic grid design plan that involved having residents within 4 mi of an asphalt road. The converted road is performing well and has saved the county money but is requiring more maintenance than anticipated. There has been no increase in documented vehicle crashes on the converted road. Public reaction to the road conversion has been negative. Outreach efforts were made, including public input meetings. There has been no pressure to repave the converted road. In the future 17 mi of asphalt concrete road in poor condition in McCook County will be converted to gravel once it has reached the end of its service life.

UTAH

In Tooele County, Utah, approximately 13 mi of local access connector roads have been converted from paved to unpaved within 1 to 2 years (2012–2013). The original pavement surfaces consisted of asphalt concrete in poor condition and cold mixed asphalt with a chip seal. They rented an asphalt reclaimer and recycled the old surfacing into the unpaved road, then used a surface application of 28% magnesium chloride as a dust palliative (applied at about 0.5 gal/yd^2). The road has an ADT of 100 to 150 vehicles and was converted from paved to unpaved because of the high cost to maintain it and safety concerns. To support this road conversion project, Tooele County has conducted a pavement inventory analysis since 1988 and because of limited funds prescribe to a "treat your best roads first policy." They determined it was less expensive to convert the road to gravel than it would have been to repave.

The converted road is performing as expected, but they have found the cost of spraying magnesium chloride is now cost prohibitive, so there will be more dust this year (2015). Tooele County did hold an informal meeting as outreach to the public and deemed this effort a success because the people knew what was happening. Despite these efforts, reaction to the road conversion was negative because the public did not like that the road was being converted. Part of the dislike for the road conversion was because local residents access a water ski lake using the road and do not like towing boats on the gravel road. Consequently, there has been pressure to repave the road.

One of the challenges they faced in converting this road was that it varied in thickness because there were many older roads underneath that had already been milled at least once. There was no geotechnical information on the thickness variation, which made it challenging. Based on this experience, they will consider collecting core samples before any future roads conversion projects.

As a side note, Tooele County instituted a municipal service fee for the unincorporated county, and the state of Utah just raised the gas tax and has given counties the option to institute a local gas tax, which could be used to fund local roads projects.

VERMONT

Within the city limits of Montpelier, Vermont, 1.25 mi of asphalt concrete that were in poor condition (PCI = 1, on a scale of 0–100) were converted to an unpaved surface of recycled asphalt, concrete, and crushed gravel mix. The old surface was recycled, new gravel was hauled in to supplement the existing material, and a chemical stabilizer/dust suppressant was used. The decision to convert the road to unpaved was because of the cost to maintain the road as an asphalt surface treatment in addition to the request to do so by a group of residents living on the road. Average daily traffic on the road was 300 to 500 vehicles. The conversion was performed 5 or more years ago (prior to 2010) using repaving equipment the agency has on hand. Converting the road required using a recycling machine, spot repairs, grading, and placement or repair of culverts and ditches. The recycled asphalt was stockpiled and supplemented with crushed reclaimed asphalt pavement, with a goal of 50/50 mix of underlying gravel with the recycled asphalt.

When converting the road, compaction was difficult initially, and the city ended up using a compaction aid and dust suppressant–flake/pellet calcium chloride ($CaCl_2$). The converted road required typical gravel road winter maintenance, not reapplication of chemicals, but instead placement of traction materials. The converted road is performing well. Ultimately, the road agency saved money by converting the road, requiring less maintenance than anticipated. There has been no increase in documented vehicle crashes, and overall the public reaction to the conversion has been positive.

To involve the public, a letter was sent to road users (see Appendix F), and a public hearing was held. Once the road conversion was completed, they held another public hearing to address initial concerns, such as dust control. At the follow-up hearing, people were supportive, even motorcyclists. All of these public outreach efforts worked well and were considered successful. There has been no pressure to repave the road. This was a good lesson for the road agency to consider in future conversion projects, including involving the public early in the process and having a conversation with road users about the reality that the road would not be repaved and so they needed to consider potholes or gravel.

ONTARIO, CANADA

In Ontario, Canada, 2 center-line mi from three paved roads were converted to unpaved by recycling the old surface and incorporating it into the new road surface. New gravel was hauled in to supplement existing materials, and a dust suppressant surface treatment was applied and incorporated into the surface layer of the new road. The pulverized road surface was overlaid with 3 in. of gravel, but they prefer crusher run granite, so they added magnesium chloride and pulverized it again to mix it thoroughly. After this, a smooth drum roller was run over the surface before opening the road to the public. The road was converted because of the costs to maintain the road and complaints from the public. A budget limitation investigation was conducted to determine if low-volume traffic roads with paved surfaces in bad condition could be converted to gravel at an affordable cost. The roads were identified for conversion based on high maintenance costs, mostly associated with patching; the worst roads were identified, and treatment options were explored. The road has an ADT of 50 to 100 vehicles and was converted less than 1 year ago (2013–2014).

They are currently conducting a 2-year study to determine how the converted road performs, and if this is a viable option for the future. At this time the converted road is performing well, and there has been no documented increase in vehicle crashes. Initially there was some concern from a few members of the public about the use of magnesium chloride and the road conversion, but in the end the public reaction to the road conversion has been positive, in part because of outreach efforts, which included a successful meeting with ratepayers in one cottage association. Some complaints have been received about frost heaving on the converted road in the spring. There has been some pressure to repave because of concerns about stone chips on cars. At this point in time they have plans to convert an additional 0.7 mi of road in 2015.

REFERENCES FOR APPENDIX D

American Association of State Highway and Transportation Officials (AASHTO), *Guidelines for Geometric Design of Very Low-Volume Local Roads*, AASHTO, Washington, D.C., 2001.

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APPENDIX E

Additional Examples of Road Conversion Projects from Paved to Unpaved

This section provides information on additional road conversion projects where roads have been converted from paved to unpaved. Information presented in this section was identified in the literature review, survey, and interviews, and is not presented in the body of the report.

ALABAMA

Baldwin County converted 1.5 mi of paved road, which was reclaimed, graded, and compacted in October 2011. No complaints were received from the public, and the county attributes this to a letter sent out "stating that if we left the road as it was we weren't going to be able to plow snow" (Minnesota County Engineers Association Members Forum 2011).

A total of 26 mi of road converted from paved to unpaved by Franklin (20 mi) and Butler (6 mi) Counties in Alabama are reviewed here. In Butler County, the original surface was in poor condition and was converted to an unpaved road by recycling the old surfacing and hauling in new gravel to supplement the existing materials. The reasons for the conversion included the high costs of maintaining the road and complaints from the public. The road was converted 2 to 4 years ago (2010–2013) because they felt this was the only cost-effective option. Since the conversion occurred, the road has performed well, the agency has saved money, road has required less maintenance than anticipated, and there has been no documented increase in vehicle crashes. The county has plans to convert more roads from paved to unpaved. Overall public reactions were both positive and negative, and there has been some pressure to repave the road. Outreach efforts were made through the local newspaper and were somewhat successful.

ALASKA

A quarter mile stretch of road in poor condition was considered in Sitka in 2014 because of safety concerns with cars swerving to avoid potholes while navigating a hairpin turn. The road was converted from poor condition asphalt to gravel, which has increased safety (Woolsey 2014).

CALIFORNIA

Counties in California have been struggling with converting paved roads to gravel since the 1980s because of funding deficiencies. Many of the counties are considering converting some paved roads to gravel (Associated Press 1980) or have been doing so since the 1980s because of lack of maintenance funds and "increasing pressure to meet demands."

Caltrans, the state road maintenance agency, converted a 4.5-mi stretch of Highway 175 on Hopland Grade west of Lakeport, California. The asphalt pavement surface was failing, exposing gravel, and there were no plans to repave because of limited funds (Brown 2013).

In 2010, the asphalt on 4,000 ft of Sonoma Mountain Road was pulverized along with the top 10 in. of dirt and injected with a hardening enzyme in an experiment by the Sonoma County Transportation and Public Works Department (Taylor 2010). After the winter of 2010, road crews checked on the condition of the three sections of Sonoma Mountain Road. Two of three sections, those with a higher amount of ground asphalt, showed significant potholes, likely a result of the enzyme not binding with the asphalt or not drying properly because of rain (Brown 2010). Recommended maintenance included reworking the trouble spots and sending out a road grader, as well as encouraging motorists to drive at slower speeds to help maintain the road surface (Brown 2011).

IDAHO

Idaho has a few counties that have converted paved roads to gravel. Like many states in the West with acres of national forest, Idaho is facing the loss of federal timber payments from the Secure Rural Schools (SRS) and Community Self-Determination Act. The year 2015 will be the first in a long time that Idaho counties do not receive SRS funds. In 2014, Idaho received $28 million in SRS funding, whereas in 2015, the state will receive 25% of the proceeds from federal timber sales, approximately $2 million (Saunders 2015). The impact of the loss of funds will be felt across the state, but particularly by road maintenance agencies. The Ferdinand Highway District will suffer an almost 50% decrease in the road maintenance budget without SRS funding, resulting in half as much money to maintain the same amount of roadway miles. Based on this reality, the option of converting paved roads to unpaved was discussed at a February 2015 meeting of northern Idaho highway departments (Rauzi 2015).

In Nez Perce County, Idaho, a portion of road leading to the airport in Lewiston was constructed atop a closed city landfill. Seepage caused large ripples to form in the road. The original paving cost of the road was $32,000. Maintaining the road as gravel, even with three applications of magnesium chloride per year, was found to be less expensive than repaving (Lee 2011). The original asphalt surface was pulverized, supplemented with millings (recycled asphalt from other locations), and compacted to create the new road surface (Lewiston-Nez Perce County Airport Authority 2012).

INDIANA

Numerous counties in Indiana with budget shortfalls have converted paved roads to gravel surfaces. Brown County, Indiana, converted an asphalt-paved road to gravel in an attempt to reduce maintenance costs. The budget for road maintenance and repairs was $200,000, which has left the county with a lack of funding. Some roads suffer from issues with drainage, base construction, and stability, which can be patched only temporarily (The Indy Channel 2012). For the county, it was determined that it makes more sense to convert these roads to gravel and maximize what limited funding the county does have on road surfaces that are more economical to maintain (Lane 2012).

In Clay County, Indiana, 2 years of particularly harsh winters damaged many chip sealed roads. For this reason, 8 mi of chip seal road were converted to gravel after the county could no longer maintain them because of limited budgets. It cost about $10,000 a mile to maintain a chip seal road, which they could not afford. In addition to this, the county maintenance budget has been reduced by about $1 million over the past 4 years. This has led to the loss of five crew personnel and limited equipment funds (Greninger 2012).

In Hancock County, Indiana, 11 mi of paved road were converted to gravel in 2009. The converted roads are performing well, leading the county to consider converting an additional 3 mi of road in 2010 (Rajala 2010). The county's decision to convert a road to gravel is based on annual evaluations of road condition. Once a road has been selected for conversion, additional factors are used in the evaluation, including average daily traffic (ADT) and the number of homes near the road. Historically, roads that are in the worst condition and end up being selected for conversion often were old double seal roads. Roads that have been converted have an ADT of less than 200 vehicles. The county is expecting the practice of converting deteriorating paved roads back to gravel will result in overall cost savings. Estimated construction and 5-year maintenance costs suggest a cost savings of $3,000 per mile for the gravel road.

Nearly 19 years ago, Parke County, Indiana, predicted the decline of revenues for road maintenance and formulated a plan to be applied to the County's budget. Based on the plan, 200 mi of paved roads were converted to gravel. Because of this foresight, the county does not anticipate needing to convert any additional paved roads to gravel (Greninger 2012).

In Vermillion County, Indiana, about 16 mi of paved road were milled up and converted to gravel, and the county is considering converting more roads that are failing, especially those that are secondary, dead end, or connecting. In Southern Vermillion County, about 1 mi of paved road has been converted to gravel, but that number likely will increase if funding and road maintenance budgets continue to decline. The roads being converted are mostly chip seal (Greninger 2012).

IOWA

In Buena Vista County, Iowa, two road conversion projects have occurred. Both road conversion projects involved 0.5 mi of asphalt concrete in poor condition being converted to unpaved surfaces. The original pavement surface was recycled to create the new unpaved road. The roads were converted because of maintenance costs and changes in usage patterns. ADT on both roads is 51 to 100 vehicles. The conversions occurred 2 to 4 years ago (2010–2013). At this time the roads are performing well, have saved the county money, have required less maintenance than anticipated, and there has been no documented increase in vehicle crashes. Public reaction to the road conversions from paved to unpaved has been negative. Buena Vista County verbally communicated with the public and deemed these outreach efforts successful. There has been no pressure to repave the roads.

In Linn County, Iowa, 2 mi of a farm-to-market road that was a combination of pavement types, including asphalt over concrete, were converted to unpaved. The road was converted because of the cost to maintain the road, complaints from the public, and changes in traffic count and use of the road. The road was an old primary road that was transferred to the county; ADT on the road is 51 to 100 vehicles. When ADT drops below 200 on the farm-to-market road grid, the county will no longer perform seal coating on the road. A second road conversion project in Linn County, Iowa, involved 3 mi of chip sealed road converted to unpaved. ADT on the road is 51 to 100 vehicles, so the county was no longer able to seal coat the road (per stated policy). The county has a dust control program that states roads with ADT greater than 150 vehicles get dust control treatment with chlorides. The road was converted because of the cost of maintaining it.

For both road conversions in Linn County, the old pavement surface was recycled using a scarifier with stinger blades and ripper teeth—because renting a recycling machine was too expensive—to create the new unpaved surface. Gravel was hauled in to supplement the existing materials. Linn County has had issues when scarifying the road if they got into the macadam road base. Both road conversions occurred 2 to 4 years ago (2010–2013). The converted roads are performing well, have saved the county money, and there has been no documented increase in vehicle crashes since the conversions. Public reaction to the road conversions has been negative. However, there has been no pressure to repave the road. The county has plans to convert more roads from paved to unpaved in the future.

In Louisa County, Iowa, 1 mi of paved road with a chip seal surface treatment in poor condition and an ADT of 21 to 50 vehicles was converted to unpaved. The original pavement surface was recycled and used as the new surfacing material on the unpaved road. The road was converted because of the cost to maintain it, and the conversion was performed 5 or more years ago (prior to 2010). At this time the road is performing well, has saved the county money, and there has been no pressure to repave the road. No outreach efforts were made for this road conversion because it affected only a few users who were notified of the decision to convert the road.

MICHIGAN

Alpena County, Michigan, has converted paved roads into gravel. Although cost was noted as the biggest factor in choosing which roads to convert, safety issues because of repeated patching of an asphalt surface also were noted. Improved safety was more easily achieved with regular grading of the gravel roads. No formal process exists in Alpena County for choosing which roads to convert to gravel.

Calhoun County, Michigan, converted 2.5 mi of paved surface road to gravel in 2008 and 2009 and expected to convert between 15 and 40 mi in 2010. Calhoun County uses the PASER ratings as a measure of road conditions, where a rating of 1 or 2 indicates a failed road surface in need of urgent maintenance and a candidate for conversion.

In Cass County, Michigan, Pioneer Street in Marcellus Township was converted from asphalt to gravel. Originally paved in 1987, Pioneer Street had deteriorated significantly and was filled with potholes and failing sections of road. The township did not have the funding to repave the road. Instead regular grading and maintenance of the new gravel surface were used to provide residents with a smooth driving surface (Lerner 2009).

In Midland County, Michigan, Shaffer Road was converted to gravel in 2010 because of a lack of funding to continue patching the road. The road was reclaimed as a "last resort." In the last 10 years, the county has converted about 8 mi of asphalt to unpaved.

Montcalm County, Michigan, has converted a primary stretch of road to gravel. Cost analysis was the driving factor in deciding which roads to convert because the road can be reclaimed and bladed for less money than repaving. In Montcalm County, they hope to limit the number of roads converted to gravel in the future, but the decision to convert a road is made as maintenance issues arise. Montcalm County utilizes maintenance cost and road condition as the primary metrics when deciding which roads are candidates for conversion to gravel.

MINNESOTA

Becker County, Minnesota, considered reverting County Road 118 to gravel in 2011. The asphalt was more than 30 years old and badly deteriorated, with numerous potholes presenting what the county considered a safety concern. With an ADT of less than 200 vehicles, County Road 118 was not a priority, and the County did not have the $300,000 required for full-depth reclamation and resurfacing (Bowe 2011). In the summer of 2014, the asphalt surface of County Road 118 was reclaimed, and a surfaced calcium chloride surface treatment was used for dust control (Becker County Highway Department 2014).

In Clearwater County, Minnesota, 1 mi of asphalt concrete in poor condition was converted to an unpaved road. The road was a narrow gravel road that was paved with bituminous surfacing for dust control because of a detour for an adjacent project. The pavement was underdesigned, but still lasted 10 years. Eventually the road became unserviceable. The county had planned to put another overlay on the road, but it would have made the already narrow road even narrower and therefore a safety concern. For this reason, the road was converted to unpaved. The original pavement was recycled, and new gravel was hauled in to supplement the existing materials to create the unpaved road surface. The road was converted 5 or more years ago (prior to 2010) and has ADT of 51 to 100 vehicles. At this time the road is performing well, but public reaction to the road conversion has been negative, and there has been pressure to repave the road.

Mahnomen County, Minnesota, converted two stretches of road to gravel in 2011: County State Aid Highway (CSAH) 15 and CSAH 1. CSAH 15 originally was paved in 1978 from revenue share dollars and had an ADT of 122 vehicles; it also had "a commissioner living along it at the time it was paved. It was an island of pavement surrounded by gravel roads." By 2011, the ADT was 115 vehicles, and the pavement surface had deteriorated significantly. About 2 mi of the road underwent full-depth reclamation, followed by an overlay of calcium chloride stabilized aggregate (Mahnomen County 2011; MCEA Members Forum 2011).

In Mahnomen County, Minnesota, 2.4 mi of asphalt concrete in poor condition with ADT of 100 to 150 vehicles were converted to an unpaved road 2 to 4 years ago (2010–2013). The original surface was recycled, gravel was hauled in to supplement the existing material, and a surface stabilizer was incorporated into part of the surface layer. The road was converted because of high maintenance costs, and ultimately the decision to convert the road came down to a cost analysis. Documents used in the conversion process by Mahnomen County include the state aid rules for operation changes (state Aid Operation 8820). At this time the road is performing well and has saved the county money. Outreach efforts included a public hearing at a County Board meeting, which was deemed successful. Additionally, when the road conversion was approved, the county notified affected users. The county felt they were able to present factual information to the public; however, some local residents were unhappy and felt they were getting unfair treatment. There has been no pressure to repave.

In St. Louis County, Minnesota, a number of roadways have been converted to gravel in recent years. Most of these roads were paved for political reasons when the county had excess funding but often with no base improvements, causing maintenance issues as the road surfaces aged. The county did not have money for other options and informed the area commissioner and residents of their plans to convert the roads. Results of the road conversions have been successful, with one road located south of Buhl now safer and able to handle higher vehicle speeds since being converted (MCEA Members Forum 2011).

MISSISSIPPI

Mississippi is experiencing road damage because of the oil boom in the Tuscaloosa Marine Shale deposit located in the southwest portion of the state. Counties are hoping to prepare for the increase in vehicle traffic and the associated impacts before they begin by working on agreements with energy companies for infrastructure improvements and road upgrades. The goal is for this to serve as a model for the rest of the state.

In Amite County, massive truck traffic associated with the Tuscaloosa Marine Shale deposit has caused damage to the roads. It is anticipated there will be 2,500 18-wheeler loads per well. In the last year and a half, the county has experienced 100% failure of county roads, with asphalt roads deteriorating to gravel. Some oil companies have worked with the county to repair the damaged roadways by providing materials, but the county does not realistically expect reimbursements until drilling companies start seeing profits (Carter 2013).

MONTANA

The conversion in Lake County involved 4,500 ft of a road with high truck traffic leading to a gravel pit. The ADT for this road segment is 200 to 300 vehicles, and the road was converted within the last year (2014). The original surface treatment had a double shot of chip seal and was in good condition. The deteriorating surface was ground using an asphalt zipper and replaced at a cost of $1,500. The road was converted because of the cost of maintaining the road, complaints from the public, and safety concerns. The sand, gravel, and concrete businesses that use the road contributed to premature failure of the double shot of chip seal.

The converted road is performing well, has saved the county money, and there has been no documented increase in vehicle crashes. Reaction to the road conversion has been both positive and negative. The public was notified ahead of time that the conversion would take place. There has been some pressure to repave, with concerns expressed about dust on the road segment that was converted. There are plans in place to repave the road segment with 3 in. of hot mix asphalt when funding is available, at a cost of $150,000.

NEBRASKA

In Custer County, Nebraska, many of the roads paved in the 1960s and 1970s have deteriorated. The high cost of repaving led the county to convert many of those roads back to gravel. To seal coat a road would cost the county $15,000, whereas converting the same section of road to high-quality gravel would cost $8,000. For roads with ADT of less than 150 vehicles, the county can no longer maintain the road as asphalt. Four sections of road, more than 10 mi, were converted to gravel in 2011, with more conversion projects planned including in the county's 6-year highway plan (McCaslin 2012).

In Hall County, Nebraska, many of the roads in poor condition that are being converted are from the 20 mi^2 that was once occupied by the Cornhusker Army Ammunition Plant. The plant is now defunct, and the land is being used for agriculture. The county is now responsible for the roads. For the converted roads, the old pavement surface is being pulverized to create the gravel road. The public has been accepting of the change with the improved driving surface (Keen 2008; World-Herald News Service 2011).

In Gosper County, Nebraska, about 1.5 mi of road were converted from paved to unpaved. The original pavement was asphalt concrete in fair condition. The road conversion took place 5 or more years ago (prior to 2010), and the old surface was recycled and used for the new surface of the unpaved road. The reason this road segment was converted was the high cost of maintaining the road because of damage from heavy rains. Repaving was cost prohibitive. The ADT on this road segment is 300 to 500 vehicles. At this time the road is performing well, has saved the county money, has required less maintenance than anticipated, and there has been no documented increase in vehicle crashes. Despite outreach efforts made to convey the cost of asphalt versus the county budget, which were deemed successful, public reaction to the road conversion was negative. There has been pressure to repave, but the county says they would perform the conversion again.

In Phelps County, Nebraska, an unknown number of miles were converted from paved to unpaved. The original pavement type was asphalt concrete in poor condition. They ended up removing the old surface and disposing of it offsite and hauling in new gravel to supplement the existing materials on site. The reason the road was converted was because of high maintenance costs, public complaints, and safety concerns. The decision to the convert the road was based on cost estimates for upgrading road pavement versus the cost to change the road to gravel. ADT on the road is 51 to 100 vehicles, and the road was converted 1 to 2 years ago (2012–2014). At this time the road is performing well, has saved the county money, required less maintenance than anticipated, and there has been no documented increase in vehicle crashes. If they do another road conversion, they will utilize the same methods because they worked well. Additionally, there has been no pressure to repave.

NORTH DAKOTA

Because of the Bakken and Three Forks oil formations in North Dakota, traffic is increasing and heavier. In the 1990s, a typical drill rig weighed as much as 90,000 pounds, whereas drill rigs today weigh 110,000 pounds, which is

4,500 pounds greater than the North Dakota legal load limit of 105,500 pounds with the correct number of axles. A typical vertical well requires about 400 truckloads to drill, and a horizontal well requires 1,150 loads. These are legal loads for well-built paved roads, but to access the pad requires use of county roads that were designed for much lower volumes of single-axle farm trucks. At this time, damage to county roads includes ruts that are 4 in. deep in paved roads and no legislation requiring tax revenue from oil and drilling to be earmarked for road maintenance (Minnesota Local Technical Assistance Program 2012).

Between 2009 and 2011 in McKenzie County, North Dakota, along North Dakota Highway 1806 north of Watford City, truck traffic jumped from 85 to 545 daily, a 541% increase (Weigel and Bruins 2011). Oil traffic has been particularly hard on the road, even causing a closure to all but local residents in 2011; it also has created safety issues. The road had deteriorated beyond repair with numerous pavement breakups (Shipman 2011). Full-depth reclamation with cement-treated base and an overlay of aggregate and chip seal was used to convert the road to unpaved (Sundeen 2011). The North Dakota Department of Transportation (DOT) plans to keep the road as gravel for 1 or 2 years until funding is available to repave (Shipman 2011).

In Bowman County, North Dakota, 12 mi of chip sealed road were recycled and incorporated into the unpaved road surface and treated with a dust suppressant. The road was converted because of the cost to maintain the road, complaints from the public, and safety concerns. The ADT for the road is 51 to 100 vehicles, and the conversion was performed within the last year. At this time the road is performing well, has saved the county money, has required less maintenance than anticipated, and public reaction to the road conversion has been positive. The county has plans to convert more roads from paved to unpaved in the future.

In MacIntosh County, North Dakota, 2 mi of road with an ADT of 51 to 100 vehicles were converted from a paved road with a surface treatment in poor condition to an unpaved road. The old road surface was full of potholes, so it was milled and reshaped to create the unpaved surface. At a later date additional gravel was added. The road was converted because of high maintenance costs, complaints from the public, and safety concerns. The road conversion was performed 2 to 4 years ago (2010–2013), and overall the public reaction was positive. At this time the road is performing well, has saved the agency money, has required less maintenance than anticipated, and there has been no increase in documented vehicles crashes. There has also been no pressure to repave the road. The county does not have plans to convert more roads right now but acknowledges that they may need to in the future because of lack of funds to maintain the existing road network. In hindsight, they would have added the gravel prior to milling the old road so that it is mixed well, then add a soil stabilizer, applied water and compaction, but these options were not available at the time of the conversion.

In Stutsman County, North Dakota, two road conversion projects were done. The first involved 4 mi of road with an ADT of 21 to 50 vehicles that was converted from asphalt concrete in poor condition to an unpaved road. The second road conversion project involved 9 mi of asphalt concrete in poor condition with an ADT of 300 to 500 vehicles that was converted to unpaved. Both roads were converted because of the cost of maintaining the road, complaints from the public, and safety concerns. On both roads, the old road material was recycled to create the new unpaved road surface, and both road conversion projects occurred 2 to 4 years ago (2010–2013). One of the roads, not specified, is not performing well, has required more maintenance than anticipated, and public reaction to the road conversion has been negative. There has been some pressure to repave, and this may be attributable in part to high average daily vehicle counts, which mandate repaving. At this time the county has no plans for future road conversions.

In Wells County, North Dakota, 6 mi of road were converted from asphalt concrete to an unpaved surface. The following information provided on this road conversion is limited because of the lack of information passed to newer employees who were not involved in the conversion. The road was converted because of the cost to maintain the road. The original surface was recycled and used to create the new unpaved surface, with additional gravel hauled in to supplement the existing materials. This road was converted 5 or more years ago (prior to 2010). At this time the road is performing well, has saved the county money, required less maintenance than anticipated, and public reaction to the road conversion has been positive. There has been no pressure to repave the road. Outreach efforts were made, but no additional information was provided.

OHIO

In Ohio, some counties are letting roads passively convert to gravel because of declining budgets attributable to weakening revenue from fuel taxes and vehicle registration fees (Etter 2010). In Coshocton County, Ohio, a 5% decline in road maintenance resources in 2010 was the first reduction in funding in almost 20 years (Etter 2010). The county noted in the 2013 Annual Report that more roads would be converted and aging bridges would need to be closed unless additional funding was procured for maintenance. Some roads in Coshocton County have been passively converted to gravel, such as County Road 58, for which the county has received complaints from local residents because of safety concerns. The county prioritizes roads and bridges for maintenance based on traffic counts, inspections (both by office staff and an independent consulting firm), road usage, and the type of user serviced by the roadway (Hayhurst 2013).

In Ross County, Ohio, Shoemaker Lane was converted to gravel in 2014 because the cost of paving was prohibitively expensive; local residents along the road were grateful the county was able to take care of the potholes (Twin Township Trustees 2014).

OKLAHOMA

Numerous counties in Oklahoma are suffering because of the economic downturn and facing shrinking budgets for road maintenance. For one county, the road budget in 2010 was down $600,000 from the previous year, a decline of nearly 10%. The trend of declining funds is affecting many counties in the state. In Sequoyah County, Oklahoma, conversion to gravel is considered a temporary solution. The county hopes to resurface roads with asphalt when funding becomes available. Heavy truck traffic and severe freeze-thaw cycles in early 2010 deteriorated the road. Additionally, a lack of funding led to the conversion. Prior to the conversion, the roads were a safety issue (Cameron 2010).

In Sallisaw County, Oklahoma, 10 mi of chip sealed road in poor condition with an ADT of 150 to 200 vehicles were converted to unpaved 2 to 4 years ago (2010–2013). The road was converted because of the high costs associated with patching it. The chip sealed surface was covered with ¾-in. crusher run aggregate. The chip seal was left in place to use as base if paving should occur in the future and serves as a water barrier. In another road conversion project in the county, an additional 10 mi of road with similar ADT were converted from chip seal to unpaved. The old surface was recycled and incorporated into the unpaved surface, and new material was hauled in to supplement the existing material. Occasionally oil (MC30 or SS1) is applied to the surface as a dust suppressant and provides dust abatement for 3 to 6 months, depending on the traffic. The converted road is performing well. The agency has been able to save money, and there has been no documented increase in vehicle crashes. Reaction to the road conversion has been both positive and negative. Outreach efforts included conversations with the public and were deemed successful. Sallisaw County found transparency with the plan and process works well when communicating with the public. There has been some pressure to repave the converted roads, but overall the road users enjoy the smooth road, and the road agency no longer has to repair potholes. Sallisaw County viewed this project as a pavement preservation project, focusing on a long-lasting, well-maintained road surface.

OREGON

Some counties in Oregon are in a particularly desperate position trying to fund road maintenance. Federal "safety net" funding, provided for 12 years as replacement for revenue from federal timber harvests through the Secure Rural Schools and Community Self-Determination Act, ended temporarily in 2006, before being included for an additional 4 years in the Emergency Economic Stabilization act of 2008. Two funding extensions later, the payments officially ceased in 2014. Some counties planned for the end of the payments and budgeted accordingly, but others did not and are now operating many county services on an essentials-only basis (Burns 2014). Road maintenance budgets have been affected by this, with many counties leaving staff positions unfilled, performing the bare minimum for pavement preservation and maintenance, and simply stopping maintenance on some roads entirely (O'Toole 2007).

Because of budget cuts of an estimated $800,000, in Tillamook County, Oregon, roads in poor condition were converted to gravel, including two roads: Makinster and Chance (*Tillamook Headlight Herald* 2010). It would have required more than $1 million to fully address all of the issues that led to Makinster Road's poor condition. Because of flooding and silt buildup, the road base had sunk, leading to poor drainage and constant maintenance issues. Converting the road to gravel allowed for easier grading of the roadway to promote proper drainage and easier rehabilitation from future flooding events (*Tillamook Headlight Herald* 2007). Chance Road had numerous potholes and was converted to a gravel surface in May 2007 (O'Toole 2007).

Washington County, Oregon, has a road fund of about $17 million per year because of county's large population, which exceeds 530,000 residents. About 90% of the population lives in urban areas, and the remaining 10% reside in rural areas. The road maintenance budget covers 1,279 mi of roadway, including 250 mi of gravel roads. Historically, the road fund has been split equally between urban roads (620 mi) and rural roads (659 mi), including 413 mi of low-volume roads (Clemmons and Saager 2011). The Road Maintenance Division utilizes a road maintenance priority policy to determine which roads require maintenance and repaving and when this is needed. Because of funding constraints associated with the road maintenance priority levels, many of the local and low-volume roads did not qualify for maintenance or repaving funds. Voters passed an Urban Road Maintenance District in 1987 and a property tax in 1994 to fund maintenance on urban low-volume roads, but the rural counterpart failed to attain voter approval and funding. The result was that low-volume roads in rural areas deteriorated, which was the reasoning in forming the Rural Roads Operations and Maintenance Advisory Committee (RROMAC) to provide guidance on these issues (Clemmons and Saager 2011).

Flooding and severe weather in 1997 turned many rural roads into a safety issue. As a result many rural roads needed to be rebuilt, but there was a lack of funding to do this. Instead, more than 10 mi of deteriorating asphalt on 12 low-volume roads were converted to gravel. Proposed alternatives to unpaving required adjacent property owners to assume the cost for repaving per a countywide policy, both of which were not popular solutions. RROMAC stepped in to mediate the negative public reaction to proposed conversions to gravel and adopted a resolution that 10% of any new road money be earmarked for improvements to rural roads, particularly gravel road upgrades (Clemmons and Saager 2011). Despite the 10% new money policy, funding for rural roads was still limited in Washington County in 2014 (RROMAC 2014).

PENNSYLVANIA

Some counties and townships in Pennsylvania are testing alternatives to traditional asphalt pavements, including using road conversions of pavement to gravel to calm traffic. In Bucks County, Pennsylvania, Tinicum Township has converted a paved road to gravel to calm traffic, where little to no speeding now occurs. Residents in Tinicum Township can apply for a "scenic" designation on area roads. The "scenic" designation means the Township will cease road maintenance, allowing the road to passively convert to a gravel surface. This process has already occurred on two of the four roads with "scenic" designation, and the township has not paved a road since the ordinance passed in 1989 (Mason 2005; Moore 2005).

In Chester County, Pennsylvania, Marlborough Township approved converting a ¾-mi. section of Wilson Road from paved to gravel, with the intended purpose that the gravel surface would make commuters slow down or avoid the road altogether. Some of the residents along the road said the original paving took away the character from that section of the road, where horseback riders favor gravel over pavement for riding (Moore 2005).

SOUTH DAKOTA

South Dakota had converted more than 120 mi of asphalt road surfaces to gravel as of 2012 (Etter 2010; Louwagie 2011). In Brown County, South Dakota, a 2012 study found the county had budgeted roughly one-tenth the funding necessary to preserve its road system. The county maintains more than 675 mi of road—479 mi topped with asphalt, 195 mi with gravel surface, and a few miles of concrete. The study found that the county should be spending about $10.6 million annually to maintain the road network but was only budgeted $900,000. The study suggested that, at a minimum, 105 mi of paved roads should be converted to gravel to reduce maintenance expenses and provide a better driving surface (*Aberdeen American News* 2010; Waltman 2012).

Because of the significant funding shortfall, Brown County has converted a number of asphalt roads to gravel during the last 15 years. By 2010, county officials estimated that about 25 mi of roadway had been reverted to gravel and projected the milling of another 125 mi. Many of the asphalt roads consisted of a thin layer of asphalt, making them vulnerable to rutting and failure during wet months or under heavy agricultural loads. Most roads converted to gravel were in poor condition because of large areas of breakup coupled with high water tables, which had caused large pavement sections to passively convert to gravel despite patching efforts (Kadrmas, Lee, and Jackson 2012).

In Day County, South Dakota, 7 mi of asphalt concrete in poor condition, pavement with a surface treatment in poor condition, and a combination of pavement types in poor condition were converted to an unpaved road. The original pavement surfaces were milled, and the recycled material was used as the new unpaved road surface. They found that after milling the asphalt it is important to blade to ensure it is sealed. If it rains, the unconsolidated recycled asphalt can wash away or become saturated on the surface and be difficult to work. Day County found that they need to watch the aggregate size coming out of the reclaimer. Ideally the aggregate is 1 in. or smaller; this will ensure a proper mix and good driving surface. The road was converted because of the cost to maintain it. ADT on the road is 21 to 50 vehicles, and the road was converted 2 to 4 years ago. At this time the road is performing well, and the road conversion has saved the county money, has required less maintenance than anticipated, and there has been no documented increase in vehicle crashes. Public outreach included a commission meeting, which was deemed a partial success. The county found that informing the public of actual traffic count data works well when discussing why a road is slated to be converted from paved to unpaved. Public reaction to the road conversion has been positive. There has been no pressure to repave the road.

An example of a successful conversion in Day County, South Dakota, is County Road 12-A, which was recycled in 2012 and has been successfully maintained as a gravel road. The road was carefully compacted during the recycle process and did not require any grader maintenance after a harvest that saw 200 trucks per day (Fromelt 2012).

In Deuel County, South Dakota, 6 mi of road with an ADT of 51 to 100 vehicles and surface treatment consisting of chip seal were converted to an unpaved road. This road was a recently constructed road that failed because of inadequate base material. The original pavement was recycled with new gravel hauled in to supplement the existing materials and create the unpaved road surface. The road was converted because of the cost of maintaining the road. The road was converted 5 or more years ago (prior to 2010) with the decision to convert the road based on low traffic counts, cost data, and damage to the road caused by spring breakup. At this time the road is performing well, has saved the county money, required less maintenance than anticipated, and there has been no documented increase in vehicle crashes on the converted road.

In Edmunds County, South Dakota, 8 mi of road with a chip sealed surface treatment in poor condition were converted to an unpaved road. The original pavement surface was recycled, and new gravel was hauled in to supplement existing materials to create the new unpaved road surface. The road was converted because of the cost of maintaining the road and heavy truck traffic leading to the road failing. The decision to convert the road was made by the Commissioner, with the purpose of saving taxpayer money. ADT on this road is 51 to 100 vehicles, and the conversion was performed 2 to 4 years ago (2010–2013). The road is performing well, has saved the county money, has required less maintenance than anticipated, and there has been no increase in documented vehicle crashes on the converted road. The county has plans to convert more roads from paved to unpaved in the future. Public reaction to the conversion was negative, and there has been pressure to repave the road.

In Miner County, South Dakota, 6 mi of road with a surface treatment in poor condition was converted to an unpaved road. The original pavement was recycled and used as the new unpaved road surface. The road was converted because of the cost to maintain the road, complaints from the public, and safety concerns. ADT for this road is 21 to 50 vehicles, and the road was converted 5 or more years ago (prior to 2010). At this time the road is performing well, has saved the county money, and there has been no documented increase in vehicle crashes on the converted road. The public was informed of the decision to convert the road but did not seem to care, and overall public reaction to the road conversion has been positive. There was some pressure to repave the road soon after the conversion but not since then.

In Yankton County, South Dakota, 2 mi of asphalt concrete in poor condition and a combination of other pavement types in poor condition were converted to unpaved. The original pavement was milled and recycled, and 6 in. of gravel was added to create the new unpaved road, with surface stabilization incorporated into part of the surface layer (base stabilizer) and topical application of dust control agents. The road surface experienced heaving during freeze-thaw cycles; to address this, drainage tile was used to alleviate groundwater infiltration into the roadbed. The road was converted because of the cost of maintaining the road, complaints from the public, and safety concerns. ADT on the road is 150 to 200 vehicles. The road was converted 1 to 2 years ago (2010–2013). At this time the road is performing well, has required less maintenance than anticipated, and has saved the county money. For this road conversion project, no public outreach was conducted because of the immediate safety issues with the road, but in the future they would like to be able to give the public notice ahead of time. There has been pressure to repave the converted road.

TENNESSEE

In Franklin County, Tennessee Ridge Road was converted back to gravel in 2013 because of maintenance costs and increasing safety concerns. The annual county budget for road maintenance of about $2.7 million was not enough to adequately keep up with the condition of the roads. The county has more than 600 mi of asphalt roads and 80 mi of gravel roads to maintain on this budget. The county acknowledges that the longer it waits to perform preventative maintenance on roads, the more expensive it will be to bring that road back to serviceable condition as the roads continue to deteriorate (Shang 2013).

TEXAS

The Texas Department of Transportation (TxDOT) converted 12 mi of road from paved to unpaved in two separate projects. One road conversion project, in which 8 mi were converted, involved a road with a surface treatment in good condition being converted to an unpaved road. Reclaiming equipment was used to remove the old surface, and the milled material was either disposed of offsite or recycled into surfacing for the unpaved road. New gravel was hauled in to supplement existing materials, and the top layer was stabilized with cement and covered with an asphalt emulsion for dust control. The road has ADT of 300 to 500 vehicles and was converted because of the high cost to maintain the road, complaints from the public about the quality of the road, and safety concerns. The road was converted 1 to 2 years ago (2013–2014). To convert the road, they utilized expertise from research centers and staff engineers. Outreach efforts to the public included a press release to get the information out, but they were less successful in trying to justify why the road conversion was being completed. There has been pressure to repave, and in this case, there was discussion of repaving the road once oil and gas traffic reduces. The road is performing well and has required less maintenance than was anticipated.

The second road conversion project conducted by TxDOT involved converting 4 mi of road in poor condition to unpaved. The original surface was recycled using existing equipment, new gravel was hauled in to supplement the existing material, and recycled material was well mixed with the new gravel and tightly bladed then treated with an asphalt emulsion (HFRS-2 emulsion or SS1) for dust control. The district and department ultimately made the decision to convert the road based on high maintenance costs, complaints from the public about the condition of the driving surface, and safety concerns. This conversion occurred 1 to 2 years ago (2013–2014), the road is performing well, and TxDOT has realized cost savings from the conversion. Additionally there has been no observed increase in vehicle crashes where the road conversion occurred. Overall the public's reaction has been positive, but there has been pressure to repave. Although outreach efforts occurred, no details were provided. This road segment has since been rebuilt using the existing reclaimed surface for the subgrade, 6 in. of unbound limestone was added, and a chip seal was placed on top. (Note that the TxDOT is one of the few DOTs responsible for all roads in the state.)

A recent NCHRP synthesis identified agencies in Texas that have converted both asphalt and concrete pavement surfaces to gravel. The purpose was to save money on maintenance costs for municipalities with funding shortages (McCarthy et al. 2015).

Eagle Ford, Texas, is a section of Dallas. The Eagle Ford Shale Play area is a region bounded by San Antonio to the north, Laredo to the west, Corpus Christi to the east, and the Rio Grande Valley (U.S.–Mexican border) to the south. The Eagle

Ford Shale Play area has a large amount of oil extraction. In July 2013, the TxDOT announced plans to convert more than 80 mi of road to gravel in six counties—Live Oak, Dimmit, LaSalle, Zavala, Reeves, and Culberson (Floyd 2013). Funding shortfalls coupled with the extensive traffic and road surface damage from traffic related to oil extraction led to the decision the convert the roads (Batheja 2013b). Roads that were built for 90 vehicles per day (vpd) but experienced 90 vpd plus 1,900 trucks experienced damage that required frequent patching. The road issues were presented to legislators and county officials at a meeting to discuss options of converting some roads from paved to unpaved (Batheja 2013a). Previous estimates from TxDOT put the cost of reconstructing damaged infrastructure at around $4 billion, with about half earmarked for repair of county roads and city streets (Batheja 2013c). Because of the extensive damage to roads and limited funds, TxDOT said that converting the roads to gravel was the only other option to provide a safe driving surface. The Texas Legislature found an additional $225 million to address road damage from the energy sector. The funds were not enough to cover all needed repairs and could not be used for many of the roads selected for conversion because they were ineligible for federal funding (Floyd 2013).

Safety was a primary concern on the deteriorating roads. A report from the Texas Department of Public Safety found an increase in vehicle accidents, specifically those involving commercial vehicles. In the Eagle Ford area, accidents involving commercial vehicles increased 470% over the 2-year period between 2009 and 2011 (Batheja 2013c). Converting the roads to gravel effectively reduced speed limits from 70 to 30 mph, which is hoped will lead to improvements in safety and reduced crash rates (Batheja 2013b).

UTAH

In Tooele County, Utah, the summer of 2013 saw more than 13 mi on two roads converted to gravel. The two roads, Faust and Lookout Pass, were originally treated with an asphalt-type product provided at no cost to the county by Utah Power and Light (Gillie 2013). The applied product was classified as hazardous but was rated for application on road surfaces. The road being converted was paved but had no base or subbase. The paved surfaced was mixed with asphalt to bind it and then put it down. The new surface was expected to last a few years, and it did but is now failing (Christensen 2013). The lack of base preparation had caused continuous maintenance problems on the road, including potholes, and the road was not safe. It was determined that milling the road was the most cost-effective way to improve safety (Gillie 2013). Filling in the potholes would cost about $92,000 each year, and paving the road with sufficient base preparation was estimated to cost $1 million per mile. The county could not afford either option (Christensen 2013).

Initially, residents were not happy about the road conversion and informed the mayor's office in the nearby town of Vernon, Utah (Gillie 2013). There were concerns from the public and mayor about tearing up a paved road, wear and tear on vehicles, and possible reduced safety on gravel roads. Safety concerns mentioned included rolling vehicles because of lack of knowledge of how to drive on a gravel road, reduced visibility from dust, and decreased traction on the gravel surface (Christensen 2013). To address these concerns, the county looked into applying magnesium chloride or some other product to the gravel to keep the dust down (Gillie 2013). The county says the roads could be maintained to a higher level of safety as a gravel surface as opposed to an asphalt surface filled with potholes (Christensen 2013).

After the conversion, some residents were surprised at the good condition of the gravel road, stating that it was a better driving surface. The county noted that proper maintenance will be key to keeping residents in the area accepting of the new surface (Gillie 2014).

WASHINGTON

The Washington State Transportation Commission conservatively estimated that a minimum of $175 to $200 billion in funding was necessary to address the state's transportation needs in the next 20 years. The Washington Transportation Plan 2030 identified the primary underlying issue facing the state's roadways as an aging infrastructure system requiring maintenance and preservation far exceeding available funding. In addition, the primary source of funding for road improvements in Washington comes from fuel taxes, which have declined as vehicles improve fuel efficiency and people drive less. The transportation plan noted that this environment of delayed preventative maintenance and lack of funds had led to many roads passively converting to gravel (Washington State Transportation Commission 2010).

In King County, Washington, a reduction in tax revenue to rural areas has led to the passive conversion of many roads with low ADT and limited winter maintenance operations (Kelleher 2011; Lindblom 2013). County officials projected in 2013 that more than 72 mi of road would fail because of lack of funds and that delayed preservation efforts would end up costing the county more in the long run because more roads would need to be fully reconstructed (KING Staff 2013).

ONTARIO, CANADA

The town of Bracebridge, Ontario, converted three roads from paved to unpaved in 2014 as part of a 2-year pilot program to see if the practice could help reduce maintenance costs and improve safety. Patching had become cost prohibitive on the roads, with potholes being the primary issue. The mayor approved the road conversions and aided in public outreach (Bowman 2013). Initially, some residents were concerned about the project, but once reasoning for the conversion and the outcomes of the conversion were explained, most of the public understood. The conversion project cost about $340,000, whereas repaving would have cost about $100,000 more (Driscoll 2014). The town is collecting feedback from residents and will continue with the project if public sentiment is positive. If the feedback is negative or the town has problems maintaining the gravel surface, the roads will be in a condition to easily repave, and the town will not have lost any money from the test (Bowman 2013; Driscoll 2014).

SASKATCHEWAN, CANADA

In the Canadian province of Saskatchewan, a number of roads have been converted from paved to unpaved. Nearly 13 mi of Highway 355 were converted to gravel after the road deteriorated because of heavy truck traffic and a high water table in the area. The road was a thin membrane road with no foundation that was milled and supplemented with gravel to create a base and treated with dust suppressant. The goal of the conversion was to create a safer driving surface for the travelling public. Segments of other highways were also converted to gravel because of similar safety issues. Comments from the public suggest accidents have increased on one of the highways since the conversion, but this has not been validated with a study. Saskatchewan has no official policy to convert paved roads to unpaved, but numerous conversions have occurred because of safety concerns arising from deteriorated road conditions (Legislative Assembly of Saskatchewan—Twenty-fifth Legislature 2007).

FINLAND

Many low-volume roads across Finland were paved with thin overlays in the 1980s when asphalt prices were low. As these roads began to deteriorate and asphalt prices rose, some road authorities began converting them back to gravel. In 1999, the three southernmost road districts in Finland—Häme, Turku, and Uusimaa—began a pilot project of converting road segments at 15 different locations because of lack of funding for road maintenance. In 2001, the three districts formulated a protocol for conversions from paved to unpaved and have successfully utilized the policy extensively (Mustonen et al. 2003).

The developed road conversion policy focuses on six major factors to be considered (Mustonen et al. 2013):

- The road should "be in such poor condition that motorists are experiencing obvious disturbance or even danger while driving."
- Traffic volume should not exceed 250 average annual daily traffic (AADT), particularly in summer when traffic counts can be higher.
- An economic analysis should be performed examining three options—light maintenance including pothole filling and patching; reconstruction and repaving including drainage improvement, supplementing with outside material, and resurfacing; reconstruction as a gravel road with crushed stone added to supplement the base course, drainage improvements, and a new aggregate driving surface.
- Land use in the area the road services, both present and future, should also be considered especially as dust can present concerns for homes adjacent to the roadway and for agricultural operations.
- Per the policy, only rural access roads are candidates to be converted to gravel because more industrialized areas could require a paved surface for the transport of sensitive materials.

Initially, local politicians were concerned about a reduction in the level of service on the road. Since the conversion, many road users agree that the level of maintenance on the gravel roads provides a superior driving surface to the deteriorated paved roads. Across the three districts, few complaints from the public have been received regarding the conversions (Mustonen et al. 2013).

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APPENDIX F

Letter to Residents and Property Owners


CITY HALL

CITY *of* MONTPELIER *Vermont*

THE CAPITAL CITY OF THE STATE OF VERMONT

Department of Public Works, City Hall, 39 Main Street, Montpelier, VT 05602
Phone 802.223.9508 FAX 802.223.9524 email tmcardle@montpelier-vt.org

April 4, 2011

To Residents of Mill Road

RE: Road Surface – Revert to Gravel
Opinion Survey

Dear residents and property owners:

We are writing to solicit your thoughts, comments, concerns, and suggestions regarding the October, 2010 road work performed on your street which resulted in a gravel surface.

As we mentioned last fall, Mill Road is only the third city street to be converted to a gravel surface, which is currently considered to be a viable a cost-saving road treatment initiative. As a relatively new initiative, the Public Works Department, City Management and your City Council representatives are interested to learn if you believe this to be a reasonable road maintenance approach that should be retained and repeated elsewhere in town.

As was described during the City Council deliberations, the rehabilitation and recycling work that resulted in a gravel surface on your street was a normal step in the preparation process prior to the application of the various surface materials available. Deferring the application of an asphalt surface has the potential of saving a considerable amount of money.

City staff and councilors would like to hear from you about how the street is holding up and whether there have been any problems or issues associated with the gravel surface that you would like to bring to our attention. The City Council wishes to invite you to share your opinions by mail, email, or in person at their regularly scheduled meeting on **Wednesday evening, April 27th.**

Thank you for your time and consideration. We look forward to hearing from you.

Sincerely,

Tom McArdle

Thomas McArdle
Assistant Director

C: Hon. Mary Hooper, Mayor
William Fraser City Manager
T. Andrew Hooper, City Council Representative, District #1
Thomas Golonka, City Council Representative, District #1
Todd Law, Director of Public Works
Dean Utton, Interim Street Supervisor

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APPENDIX G

Research Needs Statement

A GUIDE TO SUCCESSFULLY CONVERTING SEVERELY DISTRESSED PAVED ROADS TO UNPAVED ROADS

Previous work (NCHRP 46-12) that synthesized the state of the practice of converting paved roads to unpaved roads identified a need for a guideline that highlights effective practices in the realm of:

- Objective methods for the identification of roads that are suitable candidates for conversion;
- Information on how to successfully convert a road; and
- Guidance for outreach, communication to the public, and visualization tools.

To date limited information is available on roads that have been converted from paved to unpaved, and what information is available often comes in the form of newspaper articles and anecdotal accounts of road conversions. The purpose of the guide is to document proven, effective practices that can be used in road conversion projects. The document will serve as a formal and peer-reviewed information source that local road agencies can use when road conversions are being considered. The use of the guide and acceptance of the practice of converting from paved to unpaved surfaces (unpaving) will provide a case for the acceptance of road conversions as another pavement management technique.

Although low-volume roads are typically identified as having an annual average daily traffic (AADT) of less than 400, roads that are appropriate candidates for conversion will typically have an AADT of less than 150. These road are often used to access homes, are used by agricultural and extraction industries, or serve to access recreational areas. The wide variety of road users, traffic patterns, and vehicle types are factors that need to be considered in the decision to unpave a road. Other factors include road condition, safety, required maintenance, as well as a life-cycle cost comparisons of different options, such as continued maintenance of the deteriorating road, rehabilitating the paved road, or converting the road to an unpaved surface. By identifying candidate roads for conversion, local road agencies can more effectively manage dwindling budgets.

Road conversions are currently being undertaken without supporting documents or knowledge and typically involve pulverizing the deteriorating surface and mixing it with the underlying base materials. Supplemental material may be added where required, and in some instances the mixed material is stabilized with an appropriate chemical treatment. The processed materials are then compacted and shaped. Some converted roads are treated with dust abatement products. Once the road has been converted, follow-up maintenance is required in the form of blading, reapplication of dust abatement products, and periodic regravelling.

The extent of knowledge on this topic is limited, but the practice of converting roads to unpaved is becoming more and more common. This is occurring in a climate in which budgets for local road agencies are decreasing, and for some, pavement deterioration is accelerating because of heavy vehicles, which often exceed legal load limits.

RESEARCH OBJECTIVE

To develop a guide that can serve as a comprehensive information source on effective practices for converting severely distressed paved roads to acceptable unpaved surfaces.

POTENTIAL BENEFITS

The main benefit of this project will be the ready availability of a comprehensive guidance document on converting severely distressed paved roads to acceptable unpaved surfaces. No such document currently exists. The guide will aid in more effective selection of candidate roads for conversion, more effective conversions, and more effective communication with the public on how and why a conversion is taking place. The guide will allow for appropriate management of road maintenance funds and will serve as the basis for road conversions being accepted as another pavement management tool.

TASKS

Task 1 – Develop an outline of the guideline
Task 2 – Conduct a review of available information
Task 3 – Conduct a survey and or interviews to capture information on effective practices
Task 4 – Prepare the guideline
Task 5 – Construct pilot test roads to illustrate implementation of the recommended procedures

ESTIMATE OF FUNDING AND RESEARCH PERIOD

Estimated Budget for Tasks 1 through 4: $300,000
Estimated Project Duration: 2 years

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FAST	Fixing America’s Surface Transportation Act (2015)
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TDC	Transit Development Corporation
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

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