Report No. K-TRAN: KU-97-2
FINAL REPORT

PB98-149537

PERFORMANCE OF KDOT TEMPORARY EROSION CONTROL MEASURES

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DECEMBER 1997

K-TRAN

A COOPERATIVE TRANSPORTATION RESEARCH PROGRAM BETWEEN:
KANSAS DEPARTMENT OF TRANSPORTATION
THE KANSAS STATE UNIVERSITY
THE UNIVERSITY OF KANSAS

1. Report No. K-TRAN: KU-97-2	2. Government Accession No.	3. Recipient Catalog No.
4. Title and Subtitle PERFORMANCE OF KDOT TEMPORARY EROSION CONTROL MEASURES		5. Report Date December 1997
		6. Performing Org. Code
7. Author(s) Bruce M. McEnroe and Brian J. Treff		8. Performing Org. Report No.
9. Performing Organization Name and Address University of Kansas Department of Civil & Environmental Engineering Lawrence, Kansas 66045		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. C-940
12. Sponsoring Agency Name and Address Kansas Department of Transportation Docking State Office Bldg. Topeka, Kansas 66612		13. Type of Report and Period Covered Final Report May 1996 to Dec 1997
		14. Sponsoring Agency Code 106 RE-0108-01

15. Supplementary Notes

Additional funding was provided by the Mid America Transportation Center.

16. Abstract

The objective of this study was to develop practical guidance for temporary erosion control measures on highway projects in Kansas. Recommendations are based on the field monitoring of current measures, on-site testing of alternative measures, questionnaire responses from KDOT construction personnel, and a comprehensive review of the practices of other organizations. These recommendations include changes to the current KDOT specifications and changes in the implementation of the current specifications.

Whether a temporary erosion control measure succeeds or fails depends on where and how it is installed and how it is maintained. Most of the measures found in the KDOT specifications provide adequate erosion and/or sediment control when correctly followed. Improper placement, faulty installation, use of sub-standard materials, and inadequate maintenance were examples of failure to follow specifications fully. Based on findings and comments received from field personnel, most of these errors appear to be caused by a misunderstanding of how the temporary erosion control measures operate.

The on site testing of new temporary erosion control products yielded some successes and some failures. The Triangular Silt Dike and the Rock Ditch Check performed very well and were included in the final recommendations. The High-Porosity Silt Fence and the Bio-log Ditch Check proved ineffective. KDOT should institute a program of on-site testing to determine the effectiveness of new erosion control products as a way to continually improve the erosion control specifications.

The primary product of this research is the KDOT Temporary Erosion Control Manual. This manual provides the practical guidance needed for the design, installation, inspection, and maintenance of the most appropriate temporary erosion control measures for KDOT construction sites. It will be used statewide by designers, contractors, installers, and inspectors.

17. Key Words	18. Distribution Statement
Temporary erosion control, sediment, silt, installation, maintenance, manual, construction, specification, silt fences.	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161

19. Security Classification (of this Report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	56	

Form DOT F 1700.7 (8-72)

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porosity silt fence and the bio-log ditch check proved ineffective. In an effort to continually improve their erosion-control specifications, KDOT should institute a program of on-site testing to determine the effectiveness of new erosion-control products.

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Another product of this research is a map that shows the relative potential for erosion on construction projects across Kansas. The mapped quantity is the product of the soil erodibility factor and the rainfall intensity factor in the universal soil-loss equation. The map is intended to serve as an index of general trends across the state and should be used only for large-scale planning.

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PREFACE

This research project was funded by the Kansas Department of Transportation K-TRAN research program and the Mid-America Transportation Center(MATC). The Kansas Transportation Research and New-Developments (K-TRAN) Research Program is an ongoing, cooperative and comprehensive research program addressing transportation needs of the State of Kansas utilizing academic and research resources from the Kansas Department of Transportation, Kansas State University and the University of Kansas. The projects included in the research program are jointly developed by transportation professionals in KDOT and the universities.

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Chapter 1

Introduction

1.1 Background

Erosion control is becoming an increasingly large part of highway design and construction. The Kansas Department of Transportation (KDOT) must comply with current federal and state erosion-control requirements and prepare to meet even more stringent requirements in the future. The development and implementation of an erosion-control plan that meets these requirements is both time-consuming and expensive.

Current state and federal regulations require a detailed stormwater pollution prevention plan (SWPPP) for most highway improvement projects. An SWPPP is a plan of action that prevents the pollution of the environment surrounding a project site through the use of temporary erosion-control measures. Although KDOT has developed standard drawings and specifications for temporary erosion-control measures (TECMs) based on AASHTO guidelines, more effective and efficient methods for meeting TECM requirements are needed.

1.2 Objective and Scope of Study

The objective of this project was to investigate the effectiveness of KDOT's current temporary erosion-control measures. The number and nature of the variables involved in determining whether or not a TECM is effective are extensive and difficult to accurately measure. Field performance of temporary erosion-control measures depends on a multitude of variables that are difficult to control and accurately measure. For this reason, our research was based on qualitative observations rather than quantitative measurements. This approach involved monitoring and documenting erosion-control practices at active construction sites throughout the state, interviewing experienced design and construction personnel, field testing new erosion-control practices and products against existing ones, and reviewing the erosion-control policies of other transportation-related organizations. Based on our findings, we have recommended changes and additions to KDOT's current Standard Specifications and Standard Drawings. KDOT has already implemented several of these recommendations.

The primary product of our research is the *KDOT Temporary Erosion-Control Manual.* This manual provides the practical guidance needed for the design, installation, inspection, and maintenance of the most appropriate temporary erosion-control measures for KDOT construction sites. It is intended to be used statewide by designers, contractors, installers, and inspectors.

Another product of this research is a map that shows the relative potential for erosion on construction projects across Kansas. This map was created with GIS technology. The mapped quantity is the product of the soil erodibility factor and the rainfall intensity factor in the universal soil-loss equation. This product is an excellent index of the erosion potential of disturbed soils. The map illustrates general trends across the state. It is intended to be used for large-scale planning.

Chapter 2

Investigations

2.1 Review of Current Work

Environmental legislation passed during the late 1970s and through the 1980s has led to a major expansion of the erosion-control industry in the 1990's. Consequently, the industry has produced a wealth of information on erosion-control technology. Many state departments of transportation (DOTs) and academic institutions have assembled valuable information through experience and testing of erosion-control measures.

Our first goal in researching erosion control for the state of Kansas was to examine the work of these other agencies, determine its usefulness, and apply it to our own research to avoid "re-inventing the wheel". We accomplished this goal by reviewing past and current publications, practices of other DOTs, and testing done by other academic institutions. The following three subsections present the findings of these reviews.

2.1.1 Past and Current Publications

Organizations such as the American Association of State Highway and Transportation Officials (AASHTO), the International Erosion Control Association (IECA), the Federal Highway Administration (FHWA), and the Environmental Protection Agency (EPA) have all produced general guidelines for erosion control.

All of these organizations agree on the mechanics of erosion and the need for preventative plans, but they do not agree on the design and implementation of structural and non-structural measures to control erosion. As we and many others have found, this discrepancy in viewpoints is a leading cause of confusion when trying to put together an erosion-control plan—whose methods are best? Many leaders in the erosion-control field have expressed the need for industry specifications. A move to establish such standards is underway.

Several academic institutions have researched the efforts toward erosion-control implementation by state DOTs. A report by Gayle Mitchell of the Ohio University Center for Geotechnical & Environmental Research entitled *Assessment of Erosion/Sediment Control in Highway Construction Projects* (1993) provided a view of the erosion-control efforts of all fifty state DOTs. The report also outlined the various methods that each state used. Erosion-control measures varied from state to state, but most used various types of silt-fence or bale ditch checks, sediment basins, and seeding. At the time of the report, Kansas' efforts were about average compared to the other DOTs.

Manufacturers' publications were another source of knowledge on erosion-control measures. The publications provided useful information on new products and ideas for improving old ones. The level of effort put forth by many of the industry's top manufacturers is evident in their innovative products. Several of the new measures we tested on site were manufactured products. However, most manufacturers are also struggling with the lack of erosion-control standards. With so many different state standards, they have a difficult time producing products marketable to all DOTs. Manufacturers are supportive of the movement toward erosion-control specifications.

In our review of past and current publications, a few recurring themes were discovered: the need for improved and more specific guidelines, the need for more effective and inexpensive erosion-control measures, and the need for the training of personnel who deal with erosion control on a daily basis. Primarily, the publications we reviewed were published in 1990 or later. Most of the work done in the late 1970's and through the 1980's is either replicated in current works or is out of date.

2.1.2 Current Field Methods Used by Other Organizations

We contacted several state DOTs and local distributors of erosion-control products to learn about their erosion-control methods. We obtained much more practical guidance from these sources than from the publication review.

The Nebraska Department of Roads (NDR) presented us with the most useful information. NDR has adopted a very rigorous erosion-control program for the state. Nebraska tests out as many new products as they can and determines acceptability on field performance and effectiveness. Several of their measures are similar to KDOT's, but they have made modifications that solve some of the problems that KDOT is experiencing. The most useful modification prevents scouring that occurs downstream of a bale ditch check. NDR also makes extensive use of a class of products called erosion-control blankets. Erosion-control blankets are used to help limit erosion and establish vegetation on slopes and in ditches. Some blankets are temporary (biodegradable); others are permanent (non-biodegradable). They can be used in conjunction with other measures such as ditch checks or they can be used alone, placed directly on a slope or in a ditch. Many states have adopted only limited use of these blankets because of their higher initial cost. But many states, including Nebraska, have found that these blankets can pay for themselves by reducing the need for regrading and reseeding.

The local distributors we contacted provided us with practical information both on existing and new products (several of which we later tested). A few of the distributors we spoke with had both educational backgrounds and work experience in the field of erosion control and were very knowledgeable on the technical aspects of their products. Several of the distributors emphasized the distinction between erosion control and sediment control: you either control erosion or you control sedimentation. When controlling erosion, soil movement is actually prevented from occurring. Sediment control on the other hand, is the collection of soil that has already been eroded. When only sediment control is utilized, the risk of polluting the environment is high and extensive regrading may be needed to repair eroded slopes and ditches. It's a question of preventing a problem or fixing one.

Based on this philosophy, most experts highly recommended an erosion-control plan that emphasizes erosion control rather than sediment control. A plan of this nature would stress the timely use of temporary seeding, erosion-control blankets, and better grading sequencing to limit the amount of exposed soil exposed at any one time.

2.1.3 Laboratory Testing

Several institutions have tested various erosion-control measures. These institutions include Colorado State University, Utah State University, Drexel University, and the Texas Transportation Institute (TTI). The tests performed at TTI for the Texas Department of Transportation (TxDOT) are the most relevant to this project.

The Texas Department of Transportation (TxDOT) has a major ongoing program for testing erosion-control products at the Texas Transportation Institute. The TxDOT/TTI Hydraulics and Erosion-Control Laboratory conducts large-scale outdoor tests of three types of erosion-control products: erosion-control blankets, hydraulic mulches and flexible channel liners. Figure 2-1 is a photograph of the embankment used to test erosion-control blankets and hydraulic mulches. Figure 2-2 is a photograph of one of the ten channels used to test flexible channel liners. The research methodology developed at this laboratory is recognized by the erosion-control industry and several other state departments of transportation. We visited the TxDOT/TTI laboratory to learn as much as possible about their testing and evaluation procedures and research findings.

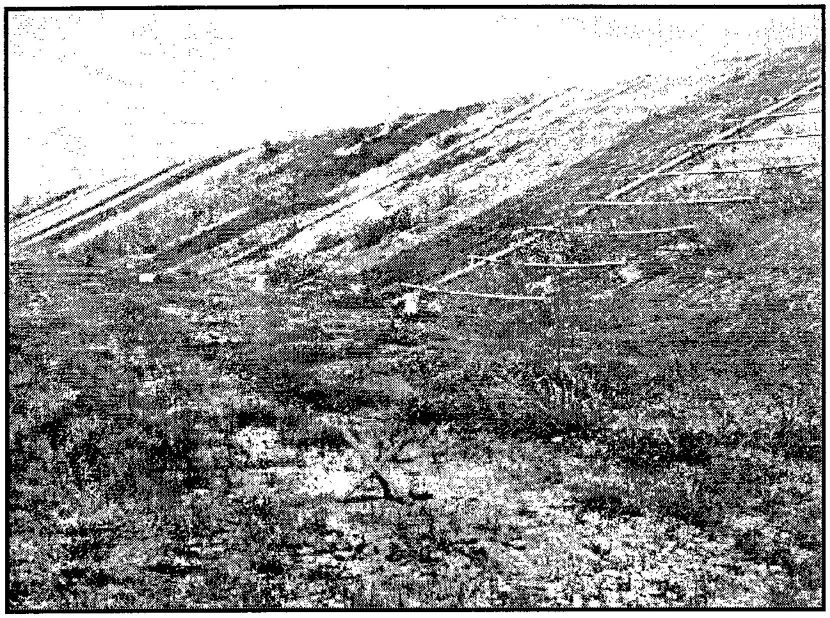

Figure 2-1: Individual plots at the test embankment.

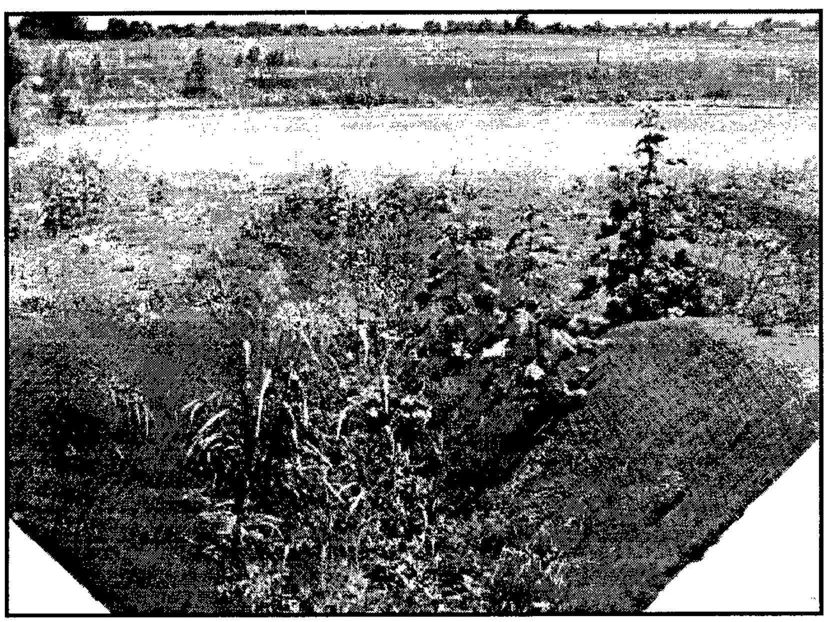

Figure 2-2: Channel liner test plot.

TTI has defined two critical performance factors for rating erosion-control blankets. First, the blankets are evaluated on how well they protect the seedbed of a slope or the geometry of a channel from sediment loss during rainfall or flow events. Second, the blankets are evaluated on how well they promote the establishment of vegetation within a single growing season. Sediment loss is measured by the direct capture of runoff water from rainfall simulations. Vegetative density is measured using video and computer masking technology. Maximum sediment loss values and minimum vegetation densities are defined for a number of slope and channel conditions. Each product is tested over one growing season. Blankets that meet or exceed established performance standards for soil loss and vegetation density are added to TxDOT's list of approved materials.

TTI's findings illustrate the added benefits of erosion-control blankets over traditional erosion-control methods. The best erosion-control blankets provide protection against the effects of rain-drop impact and sheet flow while at the same time allowing the establishment of vegetation. They can be installed quickly with minimal equipment. After installation, no more work is required; the blankets either biodegrade or become part of the vegetative root system. The TTI findings affirmed the feedback received from local distributors and other state DOTs on the recommended increased use of erosion-control blankets.

2.2 Review of KDOT's Current Specifications

KDOT's current specifications on temporary erosion control are based on

AASHTO guidelines. These specifications were adopted several years ago in response to the National Pollutant Discharge Elimination System (NPDES) permit requirements. NPDES permits require owners with construction sites larger than 2 hectares to develop an erosion-control plan to limit the migration of sediment off the site. For most DOTs, including Kansas, this necessitated an upgrading of any previous erosion-control efforts.

The current temporary erosion-control specifications include both structural and non-structural methods for controlling erosion and sedimentation. The structural methods include soil berms, slope drains, ditch checks (bales and silt fence), slope barriers (bales and silt fence), drop-inlet barriers (bales and silt-fence), and sediment basins. Soil berms are used to divert water to stabilized areas. Slope drains work in conjunction with soil berms to divert water down the face of a slope through a pipe. Ditch checks, slope barriers, and drop-inlet filters intercept and pond sediment-laden water, allowing most of the suspended sediment to settle out. Sediment basins work in much the same manner but usually on a much larger scale. The non-structural methods include seeding, mulching (hay or straw), and erosion-control blankets. Seeding is usually used in conjunction with either mulching or erosion-control blankets to protect seed in the early stages of germination. Mulching and erosion-control blankets can also be used without seeding.

The specifications also provide general descriptions of the measures, permit requirements, a general stormwater pollution prevention plan (SWPPP), and the measurement and payment arrangements. KDOT employs a general SWPPP for all of its projects. This SWPPP includes special provisions, standard drawings and specifications, inspection and maintenance report forms, the contractor's site-specific erosion-control schedule, the KDOT erosion-control policy statement, and a memorandum for design and field engineers. Payment for erosion-control measures is made on the basis of length, area, volume, or set contract price.

The standard drawings included with the specifications provide very basic design and installation procedures. They also lay out minimum and maximum tolerances for each measure. The drawings also give a general idea of where the measures should be placed on site.

Most of KDOT's temporary erosion-control measures are methods that are used nationwide. With the exception of erosion-control blankets and silt-fence, most of these items have been in use for two to three decades. Most of these measures have come into use through on-site experimentation by contractors and state DOTs.

2.3 Observations in the Field

After reviewing both the work done by other organizations and KDOT's current specifications, several active construction sites were chosen throughout the state for field observation and documentation. The following sites were chosen by our KDOT contacts:

I-435

# 435-46 K-3637-01	I-435 from Metcalf Avenue east to the KS-MO
Johnson County	state line

K-10

# 10-23 K-3359-03 *Douglas County*	K-10 from the KS turnpike south to US-40
# 10-23 K-3359-05 *Douglas County*	K-10 from US-40 south and east to US-59

US-24

# 24-52 K-4441-01 *Leavenworth County*	US-24 from Tonganoxie east to the Leavenworth/Wyandotte County line

K-254

# 254-87 K-5048-01 *Sedgwick County*	K-254 from existing 4-lane section northeast of Wichita east to the Sedgwick/Butler County line

K-96

# 96-103 K-3295-01 *Wilson County*	K-96 (new alignment) from the junction with K-47 approx. ½ mile east of Fredonia southeast to Wilson/Montgomery County line ¼ mile west of US-75

US-81

# 81-15 K-4429-01 *Cloud County*	US-81 from the Ottowa/Cloud County line north 9.1 miles

All sites were visited, but only two were eventually monitored on a regular basis—the US-24 and K-10 sites. These two sites were chosen because of their coincidence with the project timeline and their proximity to the University of Kansas' Lawrence Campus. The I-435 site would have been monitored regularly, but the project was nearing completion at the time monitoring was to begin.

Meetings were set up with the KDOT project supervisor at each site. An initial site meeting started with a tour of the entire site. Special attention was paid to areas that used some form of temporary erosion control. These areas were photographed and analyzed for compliance with specifications and overall effectiveness. After touring a site, we interviewed the site field engineers and documented their observations on the successes and failures of current KDOT temporary erosion-control measures. We also solicited their ideas for improvements. These initial visits and interviews provided us with very practical and useful information. Most construction personnel we interviewed had several years of experience working with temporary erosion-control measures.

The three most common erosion-control measures at these sites were ditch checks (bales and silt fence), slope barriers (bales and silt fence), and temporary seeding. The most widely used item was temporary seeding and mulching. Only one site (K-10) used erosion-control blankets. A few drop-inlet barriers were in use. No slope drains or sediment basins were found to be in use. Sediment basins are rare on highway projects due to the limited space within the right-of-way.

The K-10 site was monitored over one construction season and the US-24 site was monitored over two seasons. These two sites were observed on a regular basis prior to, during, and after rainstorms. We evaluated the effectiveness of each measure qualitatively with the following questions; Was substantial erosion being prevented? Was sediment effectively trapped? Was soil migrating onto adjacent property? What were the inherent weaknesses of the measure? If a failure occurred, why? What improvements would make the measure more effective or less expensive?

Through our observations and answers to the above questions, we discovered that the biggest factor in determining whether a temporary erosion-control measure succeeded or failed was its implementation. Most of the measures found in KDOT's specifications provide adequate erosion and/or sediment control. The failures that we discovered were caused by errors in implementation. These errors were in the form of improper design and placement, use of substandard materials, and a lack of attention to detail. Based on our own findings and the comments that we received from field personnel, we speculated that the cause for these errors was most likely a misunderstanding of how the temporary erosion-control measures operate.

The site observations provided most of the insights that eventually led to our recommendations for additions and modifications to KDOT's current specifications (Chapter 4). They were also the basis for the *KDOT Temporary Erosion-Control Manual.*

2.4 State-wide Questionnaire

Because our interviews with the field personnel at the monitoring sites were so successful, we decided to gather additional information from KDOT design and construction personnel across the state. We assembled a questionnaire entitled *Performance of KDOT Temporary Erosion-Control Measures.* This questionnaire contained questions on current measures employed by KDOT, general questions on the negative effects of erosion on the construction process, a section soliciting any new ideas, and a question on the respondent's familiarity with NPDES Permits. A copy of the questionnaire is provided in Appendix A.

The questionnaire was sent to the six KDOT district offices where it was directed to employees with experience in erosion control. Approximately 30 questionnaires were completed and returned. Summarized responses to separate questions are also included in Appendix A. In addition to providing direct answers to specific questions, many respondents expanded on such topics as the need for a better understanding of the design and installation of current measures, the need for better compliance by contractors, and the need for more effective and less expensive alternatives. The questionnaire responses augmented the earlier field interviews and provided us with a stronger basis for our final recommendations.

2.5 Field Testing New Measures

The early 1990s saw an increase in environmental regulations that related to soil erosion. The erosion-control industry has responded to these new regulations with new products that are more effective and easier to install. While many of these new products are intended as permanent erosion-control measures, several are suitable for temporary applications. We field-tested several of these new measures at the US-24 project site.

The first and most successful item we tested is called a Triangular Silt Dike (TSD). The TSD is a recently developed alternative to bales. Our field testing of the TSD as both a ditch check and a drop-inlet control device demonstrated that it is more than comparable in performance. The TSD installed in less than half the time of a standard bale installation (ditch check or drop-inlet barrier) and no major equipment was required. TSDs are fastened to the soil with landscape staples, making them well suited to ditches underlain by shallow rock. Figure 2-3 illustrates the ease with which

TSDs can be installed. Only a shovel and handsledge are needed.

The TSD is made of a geotextile fabric and flexible polyurethane foam making it extremely easy to lift and transport. The flexible foam construction also allows the TSD to conform to different terrain. TSDs are less prone to blowouts and undermining than bales due to their overlapping joints and upstream/downstream scour aprons. Downstream scour is one of the leading causes of bale ditch check failure. The built-in scour aprons on the TSD solve this problem.

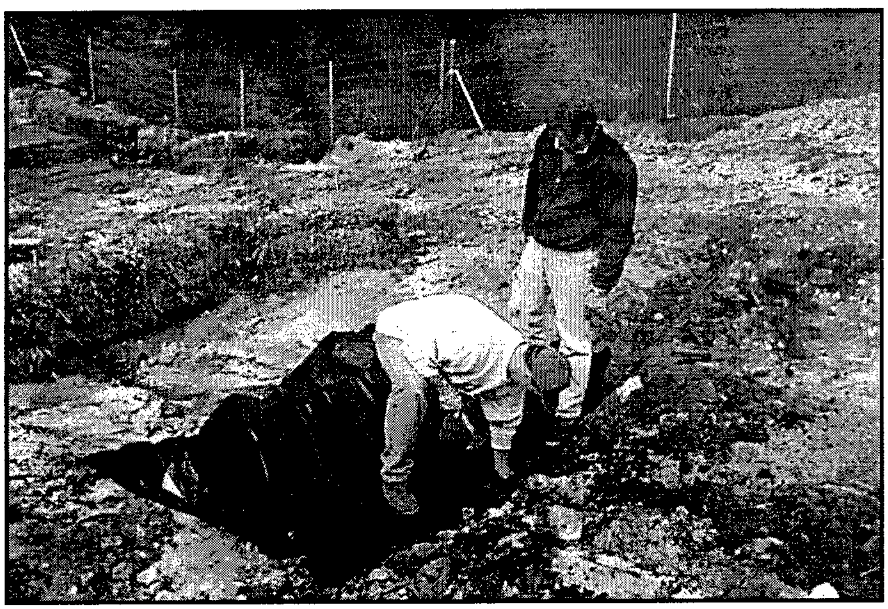

Figure 2-3: Installation of a TSD ditch check.

The initial material cost of the TSD is more than a standard bale ditch check or drop-inlet barrier. However, bales deteriorate and need to be replaced at least every three months. This does not include replacement due to storm damage. The TSD will not degrade and will last the entire life of the project—which makes the

TSD cost competitive over the life of the project. The inner polyurethane foam core of the TSD can be slipped into a new geotextile sleeve and reused on future projects. The recommendations presented in Chapter 4 further expand on the benefits of TSDs.

Rock ditch checks were the next items we tested. Many field personnel we interviewed recommended the use of this measure. In areas with steep slopes and high discharges (large drainage areas), bales and silt fence are inadequate. The force and velocity of the ditch flow in these areas is beyond the material limits of bales and silt fence. The rock ditch check provides the added strength needed in extreme conditions. Maintenance of a rock ditch check is minimal (this does not include sediment removal). Rock ditch checks are very efficient for ditches that will eventually be rip-rapped—checks are constructed of rip-rap sized aggregate which are spread out after final grading is complete.

Rock ditch checks were installed at the project site in ditches that had previously been protected by bales. These ditches were particularly steep and received high flows. The prior bale ditch check installations failed during nearly every storm. The rock ditch checks proved to be a drastic improvement over the bales for challenging conditions. Sediment capture was high and no blowouts were experienced during the testing. The recommendations presented in Chapter 4 further expand on the benefits of rock ditch checks.

While reviewing the practices of the Nebraska Department of Roads (NDR), we discovered that they were utilizing two types of silt fence: the standard low-porosity fence and a new high-porosity fence. The high porosity silt fence was essentially the wind screen that can be found surrounding most public outdoor tennis courts. Theoretically, a high-porosity silt fence can pass more water while at the same time still effectively filtering out sediment. A greater permeability is advantageous because silt fence often filters too slowly and backs up so much water that it is eventually overtopped. Water overtopping a silt fence can often cause failure.

We installed and tested the high porosity silt fence as a drop-inlet filter (Figure 2-4). The material held up well, but very little sediment was captured. A TSD drop-inlet barrier placed in a nearly identical basin on the site captured three to four times the amount of sediment that the high-porosity silt fence barrier captured. The increased porosity of our test material allowed too much sediment to pass through. Further testing should be done on determining an ideal porosity for silt fence. This testing was beyond the scope of this project and was not even technically possible due to the limited number of silt fence porosities that exist. Based on our testing, we did not recommend the use of high-porosity silt fence.

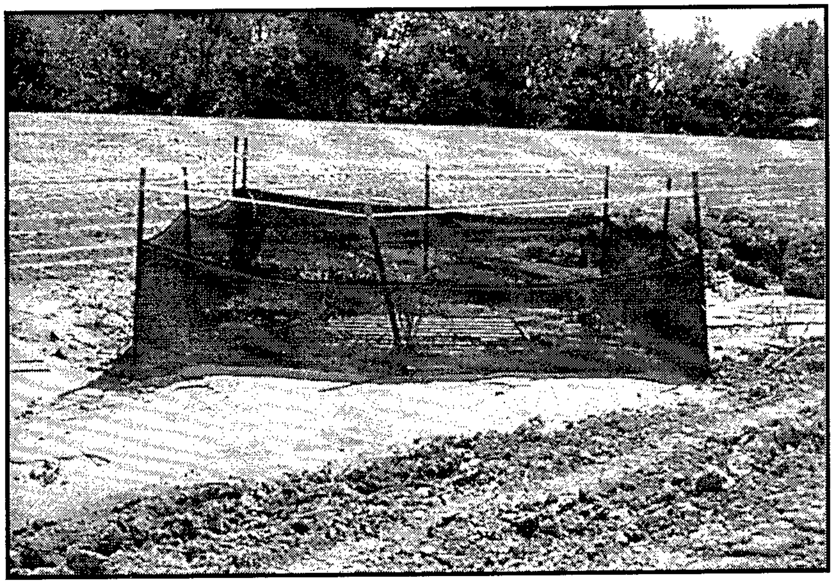

Figure 2-4: High-porosity drop-inlet barrier after a storm.

The final item we tested was a bio-log ditch check. This was another idea we received from the Nebraska Department of Roads. A bio-log ditch check is constructed of an erosion-control blanket. The blanket is rolled out along its long axis perpendicular to the ditch flowline (arrow "A", Figure 2-5), and then loosely re-rolled along its short axis to form a "log" that spans the ditch (arrow "B", Figure 2-5). Landscape staples are then used to anchor the check to the ditch bottom. Figure 2-5 shows one of the installed bio-log ditch checks.

The advantages of the bio-log ditch check are low material cost, minimal installation effort, and low maintenance. However, after testing the check, it was found to be ineffective in trapping sediment. Most ditch check bases are anchored to the ground through the use of a trench or by the check's own weight (as with a rock ditch check). This proved to be the downfall of the bio-log ditch check. Even with a tight spacing of landscape staples, the check was easily undermined during rainstorms. This allowed sediment-laden water to pass freely beneath the check.

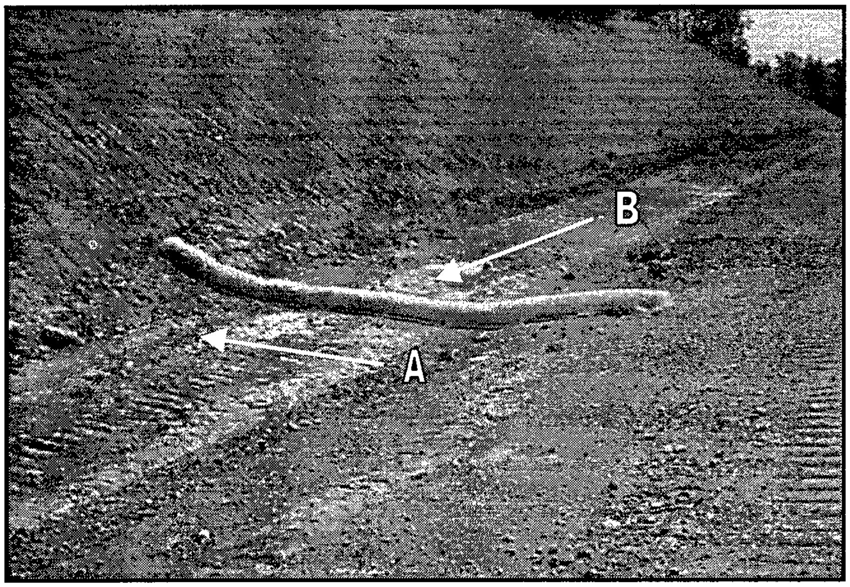

Figure 2-5: Bio-log ditch check.

The successes of the Triangular Silt Dikes and the rock ditch checks prompted us to include them in our final recommendations (Chapter 4). The high-porosity silt fence and the bio-log ditch checks proved too ineffective to be included.

As environmental regulations continue become more restrictive, the need for even tighter control on erosion will become necessary. The erosion-control industry continues to address this movement by producing new and improved erosion-control measures. In an effort to continually improve their erosion-control specifications, KDOT should institute a program of on-site testing to determine the effectiveness of new erosion-control measures that the industry has to offer.

Chapter 3

Erosion Potential Map

Using GIS technology, we have created a map that shows the relative potential for erosion across the state of Kansas. The mapped quantity is the product of the soil erodibility factor (K) and the rainfall factor (R) used in the universal soil-loss equation (USLE). This product is an excellent index of the erosion potential of disturbed soils.

The USLE was developed by W.H. Wischemeier in the early 1960s for prediction of sediment losses from agricultural lands over prolonged periods—usually about a year. The complete USLE is:

$$\mathbf{A = R \cdot K \cdot L \cdot S \cdot C \cdot P} \qquad \mathbf{(3\text{-}1)}$$

where

A = soil loss average over the slope length
R = combined erosivity of rainfall and runoff
K = soil erodibility factor
L = length factor
S = slope factor
C = cover management factor
P = practice factor

For our analysis, we use only the R-factor and K-factor. The remaining factors deal with site-specific conditions. The R-factor and K-factor both reflect regional (large-scale) conditions.

The Natural Resources Conservation Service (NRCS) has determined values of the soil erodibility factor (K) for all soil types. We obtained K-values for Kansas soils from the STATSGO database of the NRCS. The R-factor is the product of the total kinetic energy of a given storm (E) and its maximum 30-minute intensity (I). For an analysis of a particular historical period, both E and I are computed from actual rainfall data for individual storms over a specified period of time (e.g.-months or years). For our analysis of long-term average conditions, we estimated the R-factor from the 2-year, 6-hour rainfall depth with a regression equation developed by the NRCS. This equation is:

$$\mathbf{R = 27.38 \cdot P^{2.17}} \qquad \textbf{(3-2)}$$

where
P = the 2-year, 6-hour rainfall depth in inches

We obtained 2-year, 6-hour rainfall intensities from the KDOT rainfall tables for Kansas counties, which are derived from the rainfall frequency atlases of the National Weather Service. These rainfall intensities vary geographically across the state, from a minimum of .30 inches per hour along the western border and a maximum of .47 inches per hour in the southeast corner. The R-factors corresponding to the intensities were then spatially referenced to the centroid of each county. A contour map of R-values was created from these data points.

Using ARC/INFO GIS software, we multiplied the geo-referenced K-factor and R-factor and created the final product—a map of the erosion potential of bare soils across the state (Figure 2-1). The darkest areas of the map are those areas with the highest potential for erosion. The potential for erosion is influenced more by storm intensity than the soil erodibility factor. This explains why those areas with the greatest potential for erosion are predominantly in the eastern part of Kansas and not in the west. While the western portion of the state typically contains more erodible soil types, the eastern portion of Kansas is more likely to receive high-intensity storms.

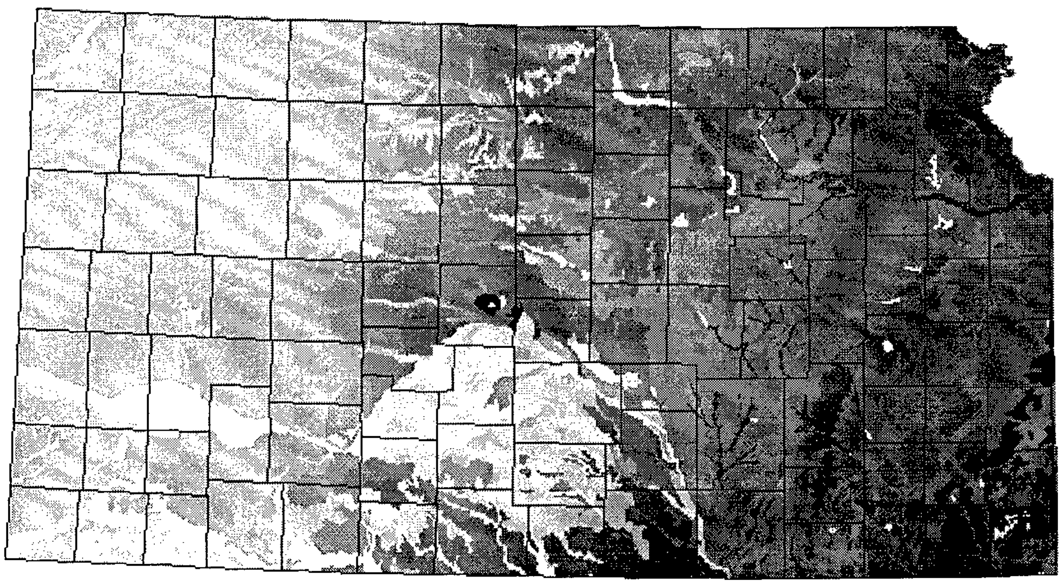

Figure 3-1: Kansas erosion potential map.

This map is not intended to be used as a design aid. The actual erosion potential at any location depends strongly on slope grade, ditch grade, and drainage area. The map is intended to serve as an index of general trends across the state and should be used only for large-scale planning.

Chapter 4

Recommendations

The following recommendations are based on the field monitoring of current temporary erosion-control measures, questionnaire responses from KDOT construction personnel, on-site testing of alternative measures, and a comprehensive review of the temporary erosion-control practices in use by other organizations. These recommendations include both changes to the current KDOT Standard Drawings and Specifications and changes in the implementation of current specifications by design and construction personnel. KDOT has already adopted several of these recommendations.

1.) Design and construction personnel need more training on the design, installation, and maintenance of temporary erosion-control measures.

Most of the problems that we found in the field were caused by improper location, installation, or maintenance of temporary erosion-control measures. These mistakes indicate an inadequate understanding of how these measures work. A training program would alleviate most of the misunderstandings that lead to failures.

The *KDOT Temporary Erosion-Control Manual*, developed as part of this project, is intended to provide essential training needed for successful erosion control. This manual should be distributed to KDOT design and construction personnel. The manual could also form the basis for a training seminar, which could include design problems and hands-on installation. The DOTs of Maryland, Delaware, Idaho, and several other states have implemented successful erosion-control training programs employing these activities.

2.) The prompt application of temporary seeding should be stressed.

Establishing vegetation is by far the most effective way to control erosion. Temporary seeding saves the contractor time and money in the long run by preventing the loss of topsoil and costly regrading. Current KDOT specifications require temporary seed to be applied within 14 days after construction activities have temporarily or permanently ceased on a portion of the project site, unless activities are expected to resume within 21 days. This specification is satisfactory, but contractors rarely comply with the specification.

The prompt application of temporary seed must be stressed to contractors. In many east-coast states, seeding is one of the only erosion-control procedures used during construction. By rigorously stressing their seeding specifications, the DOTs have helped their highway contractors realize the benefits of early establishment of vegetation. The DOTs no longer have compliance problems and the contractors operate more efficiently.

3.) Timely maintenance of temporary erosion-control measures and sediment removal should be stressed.

Temporary erosion-control measures require maintenance for a number of reasons. These include heavy rains, weather, time, and construction equipment to name a few. Heavy rains can produce ditch flows that exceed the practical limits of some erosion-control measures. The effects of weather and time induce the natural degradation of erosion-control materials. Erosion-control measures in close proximity to construction activity can be damaged by construction equipment. Temporary erosion-control measures must be inspected regularly for integrity and performance. The current KDOT specifications require that measures be inspected every seven days and within 24 hours of a rainfall of more than 10 millimeters. Any damage must be repaired promptly. This specification is satisfactory, but compliance is rare. Damage to a temporary erosion-control measure can drastically reduce its effectiveness and will eventually cause a total failure. Prompt inspection and maintenance of temporary erosion-control measures is essential.

Sediment removal is another important aspect of maintenance. Once a device is nearly filled with sediment, it can no longer serve its intended purpose. Sediment should be removed when it reaches half the exposed height of the temporary erosion-control structure. Figure 4-1 depicts a bale ditch check that is completely filled with sediment. Any additional sediment-laden flow in the ditch check will pass over the check.

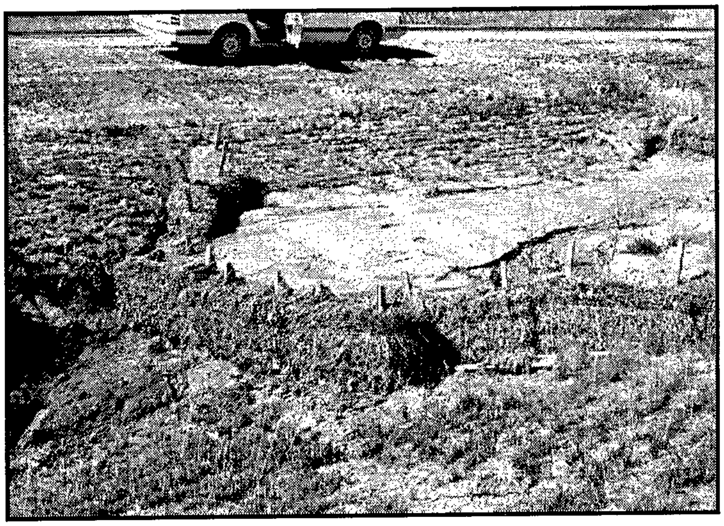

Figure 4-1: Bale ditch check full of sediment.

4.) Temporary erosion-control blankets should be used more often for challenging slopes and ditches.

Erosion-control blankets can help limit erosion and establish vegetation on slopes and in ditches where conventional seeding and/or structural methods would not work well. By reducing rainfall impact, erosion-control blankets provide slopes and ditches with a stable environment for seed to germinate.

KDOT specifications currently include temporary erosion-control blankets. However, their use is extremely limited. We recommend increased use of temporary erosion-control blankets for challenging slopes and ditches. Design and construction personnel should be made aware of the appropriate uses of these products.

5.) The maximum silt fence post spacing should be 1.2 meters.

The new AASHTO M288-96 Silt Fence specification calls for a 1.2-meter post spacing for silt fences. The current post spacing of 1.6 meters (or greater) allows for too much sag in the fence, which decreases its storage capacity and overall effectiveness. The excessive sag increases the likelihood of overtopping which usually leads to total failure. Figure 4-2 demonstrates this condition. Here, the post spacing was too far apart. The fence failed by overtopping which led to the severe erosion downstream.

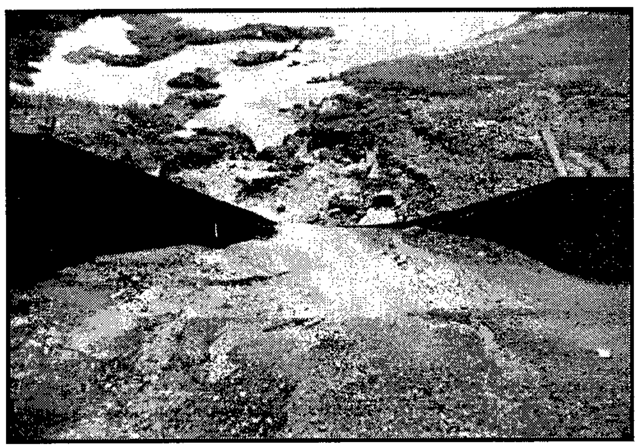

Figure 4-2: Collapsed silt-fence slope barrier.

6.) Slope barriers should be placed along contours to avoid concentrated ponding.

When a slope barrier is not placed along contours, two things can happen. First, water can flow along the base of the structure instead of through it, thereby eroding adjacent soil. This erosion can undermine the barrier, allowing water to flow freely beneath it. Second, the water that concentrates at the low point of the structure can eventually overtop it. This usually causes a collapse of the barrier material.

Figure 4-3 is a good example of such an occurrence. Here, failure of the fence caused severe erosion below the failure point. Even if the barrier does not collapse, this configuration drastically decreases the storage volume (and therefore the effectiveness) of the barrier. Figure 4-4 shows water flowing along the base of a silt-fence slope barrier. The flowing water has eroded a trench along the base of the fence.

Figure 4-3: Erosion caused by silt-fence failure.

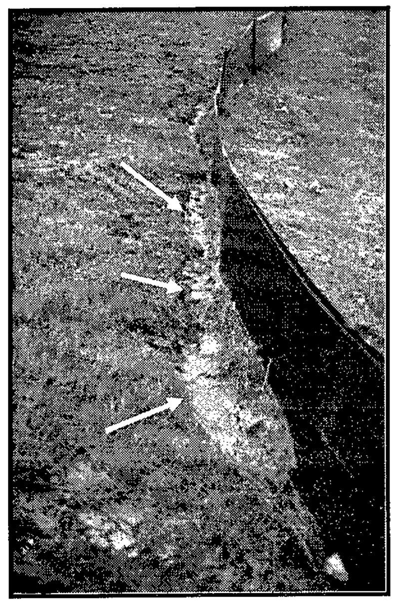

Figure 4-4: Erosion along base of silt-fence.

7.) The ends of a bale ditch check should not be angled.

The original KDOT Standard Drawings and Specifications for temporary erosion control called for the ends of bale ditch checks to be angled slightly upstream. We have found that this arrangement served no hydraulic purpose. Furthermore, these "wings" impeded sediment removal near the check, which is usually performed by a dozer or a backhoe. When the bales are placed in a straight line, a dozer or backhoe can easily make a pass right next to them, removing all trapped sediment. In Figure 4-5, the angled ends of the bale ditch check prevented the dozer operator from making a clear pass next to the bales (note the angled tracks), so a good deal of sediment remained behind the check. The current KDOT Standard Drawings and Specifications call for the bales to be placed in a straight line.

Figure 4-5: Bale ditch check with angled ends.

8.) An erosion-control blanket should be used as part of the standard bale ditch check to limit downstream scour.

Bale ditch checks work by ponding sediment-laden runoff, which allows much of the suspended sediment to settle out. Water leaves the check by weir flow over the bales and drops about a foot to the ditch bottom (Figure 4-6). We have found that this action generally causes a scour hole to form directly downstream from the check. The formation of the scour hole not only creates more soil loss, but also undermines the foundation of the check. The center bale eventually falls into the hole and much of the sediment trapped behind the check is released (Figure 4-7). This mechanism is one of the leading causes of ditch-check failure.

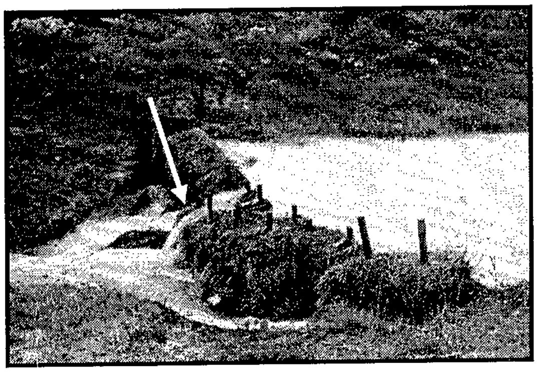

Figure 4-6: Water flowing over a ditch check.

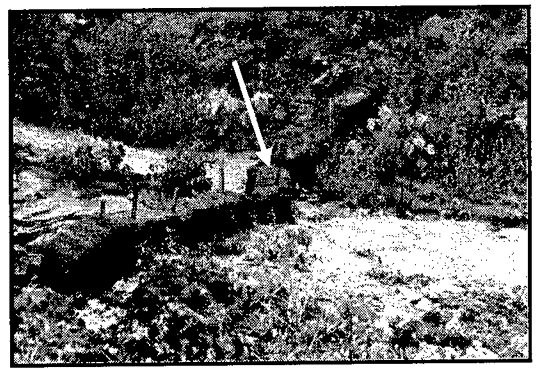

Figure 4-7: Failure of a ditch check due to scour.

To combat the formation of the scour hole, we propose the use of an erosion-control blanket on the downstream side of the check. A 1.8-meter-wide blanket is rolled out perpendicular to the flowline of the ditch and is anchored in the same manner as the bales. This "scour mat" limits downstream scour and prolongs the useful life of the ditch check. The erosion-control blanket also promotes vegetation, further fortifying the ditch check. The material cost for the erosion-control blanket is approximately $1.60/meter. The cost of the additional labor would be minimal.

9.) For steep ditches and/or ditches that are likely to experience high flows, rock ditch checks should be considered.

In ditches with steep slopes and/or large drainage areas, bales and silt fence are inadequate. The force and velocity of the ditch flow in these areas is beyond the material limits of a bale. In these cases, a rock ditch check should be used. The rock ditch check provides the added strength needed in extreme conditions. A rock ditch check requires minimal maintenance beyond sediment removal. Rock ditch checks are very efficient for ditches that will eventually be rip-rapped. Checks constructed of rip-rap sized aggregate (as in Figure 4-8) can be spread out after final grading is complete (as in Figure 4-9).

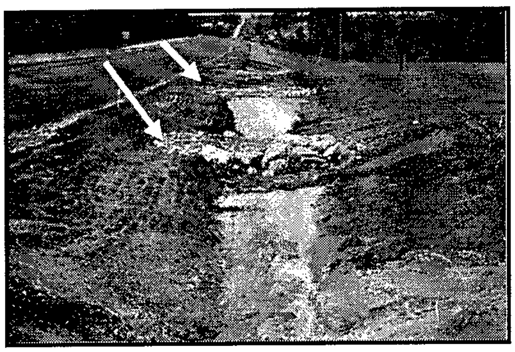

Figure 4-8: Rock ditch checks.

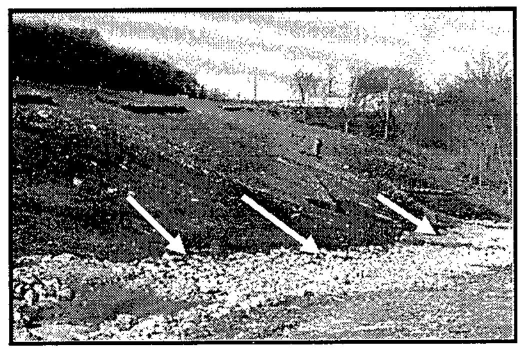

Figure 4-9: Rock ditch checks spread out.

10.) The Triangular Silt Dike should be added to the Approved Materials List for use as a drop-inlet barrier and as a ditch check.

The Triangular Silt Dike (TSD) is a recently developed alternative to bales and silt fence. A TSD is made of a geotextile fabric wrapped around a polyurethane foam core. The geotextile fabric forms aprons on the upstream and downstream sides of the TSD and connecting sleeves on either end. Field testing of the TSD as both a ditch check and a drop-inlet barrier show that it performs comparably to bales and silt fence. The TSD can be installed in less than half the time of a standard bale or silt fence structure and no major equipment is required. TSDs are fastened to the soil with 150-millimeter landscape pins, making them well suited to ditches underlain by shallow rock. Because the TSD is made of geotextile fabric and flexible polyurethane foam, it is extremely easy to lift and transport. The flexible foam construction also allows the TSD to conform to irregular terrain. Bales and silt fence often fail when water penetrates between or below sections. TSDs are less prone to blowouts between sections because of their overlapping connecting sleeves. The TSD is also more resistant to undermining because the upstream and downstream aprons prevent water from flowing below sections.

In terms of initial material cost, the TSD is more expensive than a standard bale structure. However, bales naturally deteriorate and need to be replaced after about three months. The TSD does not degrade and should last throughout the project period. Therefore, over the life of the project, the TSD may be cost-competitive. The inner polyurethane foam core of the TSD can be slipped into a new geotextile sleeve and reused on future projects.

Figures 4-10 through 4-13 are before-and-after photographs of TSDs that were tested in the field at an active KDOT construction site. Figure 4-10 shows the TSD installed around a large drop-inlet structure. This inlet drained a substantial area. Figure 4-11 shows the collected sediment after a rainstorm. This particular installation is still in service after 5 months and has withstood many rainfall events without any failure or deterioration. Figure 4-12 shows the TSD installed as a ditch check, placed behind a failed bale ditch check. This TSD application has also worked well. Figure 4-13 shows the operation of the check during a rainstorm.

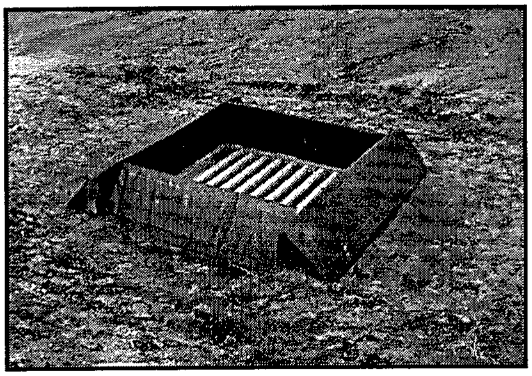

Figure 4-10: TSD drop-inlet barrier.

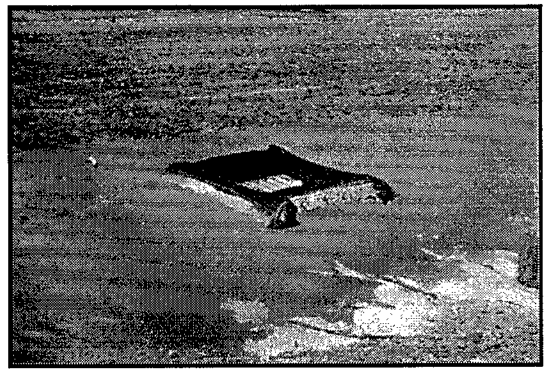

Figure 4-11: TSD drop-inlet barrier after a storm.

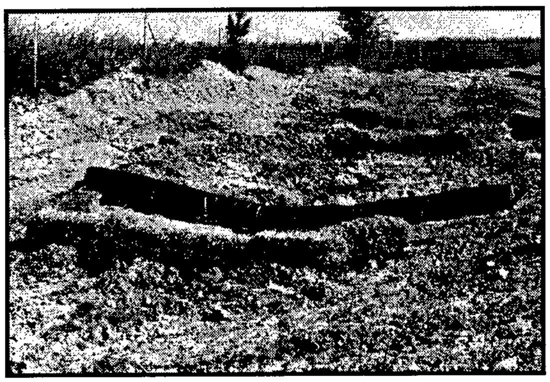

Figure 4-12: TSD ditch check.

Figure 4-13: TSD ditch check during a storm.

11.) Erosion-control blankets should be considered for temporary erosion control on highway shoulders.

An erosion-control blanket could be used on any shoulder that experiences erosive flows. A typical application would be on the downhill shoulder of a superelevated curve, which can be subjected to high-velocity sheet flow from pavement runoff. If a final shoulder grade is allowed to erode, costly regrading will be necessary. An erosion-control blanket would prevent erosion of the final grade until vegetation could be established.

Chapter 5

Summary & Conclusions

The objective of this study was to develop practical guidance for temporary erosion-control measures on highway projects in Kansas. Our recommendations are based on the field monitoring of current measures, on-site testing of alternative measures, questionnaire responses from KDOT construction personnel, and a comprehensive review of the practices of other organizations. These recommendations include both changes to the current KDOT Standard Drawings and Specifications and changes in the implementation of the current specifications. KDOT has already adopted several of these recommendations.

Whether a temporary erosion-control measure succeeds or fails depends on where and how it is installed and how it is maintained. Most of the measures found in KDOT's specifications provide adequate erosion and/or sediment control when implemented correctly. The failures that we discovered were caused by errors in implementation. These errors included improper placement, faulty installation, use of substandard materials, and inadequate maintenance. Based on our own findings and the comments we received from field personnel, most of these errors appear to be caused by a misunderstanding of how the temporary erosion-control measures operate. In the open-ended portion of our questionnaire, many respondents expanded on the need for a better understanding of the placement and installation of current measures, the benefits of timely temporary seed applications, the need for better compliance by contractors, and the need for more effective and less expensive alternatives.

The on-site testing of new temporary erosion-control measures yielded some successes and some failures. The Triangular Silt Dike and the rock ditch check performed very well and were included in our final recommendations. The high-porosity silt fence and the bio-log ditch checks proved ineffective. The erosion-control industry continues to respond to more stringent environmental regulations by producing new and improved erosion-control products. In an effort to continually improve their erosion-control specifications, KDOT should institute a program of on-site testing to determine the effectiveness of new erosion-control measures that the industry has to offer.

The primary product of our research is the *KDOT Temporary Erosion-Control Manual*. This manual provides the practical guidance needed for the design, installation, inspection, and maintenance of the most appropriate temporary erosion-control measures for KDOT construction sites. It is intended to be used statewide by designers, contractors, installers, and inspectors.

Another product of this research is a map that shows the relative potential for erosion on construction projects across Kansas. The mapped quantity is the product of the soil erodibility factor and the rainfall intensity factor in the universal soil-loss equation. This product is an excellent index of the erosion potential of disturbed soils. The map shows that the potential for erosion in the state of Kansas is influenced more by storm intensity than the soil erodibility factor. The map is intended to serve as an index of general trends across the state and should be used only for large-scale planning.

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Appendix A

KDOT Temporary Erosion-Control Questionnaire and Summarized Responses

Performance of KDOT Temporary Erosion-Control Measures

Questionnaire for KDOT Construction Personnel

This questionnaire is intended to gather observations and suggestions from KDOT construction personnel who have field experience with temporary erosion control. It is a key component of a KDOT-sponsored research project (K-TRAN Project KU-97-2). The objective of this research project is to develop practical guidance for design and implementation of temporary erosion-control measures for KDOT projects. We need your ideas!

The principal investigator on this project is Bruce McEnroe, P.E., Department of Civil and Environmental Engineering, University of Kansas. The KDOT project monitor is James Richardson, P.E., Senior Road Squad Leader, Bureau of Design. The KDOT contact in the Bureau of Construction and Maintenance is Dennis Weinrich, P.E., Field Construction Engineer. If you have any questions about this questionnaire or project, or wish to discuss any aspect of temporary erosion control, please call Bruce McEnroe at (913) 864-3807, Jim Richardson at (913) 296-4099, or Dennis Weinrich at (913) 296-3576.

KDOT's current requirements for temporary erosion control are contained in the Special Provision to the Standard Specifications, Section 904, Erosion and Pollution Control (90P-151-R4), and the Standard Drawings (LA852A - LA852E).

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1. **Are you aware that every KDOT project that disturbs 5 or more acres is required to submit a Storm Water Pollution Prevention Plan (SWPPP) to KDHE as part of the federally mandated National Pollutant Discharge Elimination System (NPDES) program?**

   ☐ **yes** ☐ **no**

2. Temporary Seeding and Mulching

a. Do you have field experience with temporary seeding and mulching for control of erosion from slopes? (If no, skip to #3.) ☐ **yes** ☐ **no**

b. Under what conditions (e.g., slope geometry, soil, weather, season) are temporary seeding and mulching effective?

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c. Under what conditions are temporary seeding and mulching ineffective?

d. Can you suggest any changes to KDOT's current standards that might make temporary seeding and mulching more effective or less costly?

3. Temporary Slope Barriers: Straw or Hay Bales

a. Do you have field experience with temporary slope barriers constructed of straw or hay bales? (If no, skip to #4.) ☐ **yes** ☐ **no**

b. Under what conditions are hay-bale slope barriers effective?

c. Under what conditions are hay-bale slope barriers ineffective?

d. Can you suggest any changes to KDOT's current standards that might make hay-bale slope barriers more effective or less costly?

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4. Temporary Slope Barriers: Silt Fence

a. Do you have field experience with temporary slope barriers constructed of silt fence? (If no, skip to #5.) ☐ **yes** ☐ **no**

b. Under what conditions are silt-fence slope barriers effective?

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c. Under what conditions are silt-fence slope barriers ineffective?

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d. Can you suggest any changes to KDOT's current standards that might make silt-fence slope barriers more effective or less costly?

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5. Temporary Ditch Checks: Straw or Hay Bales

a. Do you have field experience with temporary ditch checks constructed of straw or hay bales? (If no, skip to #6.) ☐ **yes** ☐ **no**

b. Under what conditions are hay-bale ditch checks effective?

c. Under what conditions are hay-bale ditch checks ineffective?

d. Can you suggest any changes to KDOT's current standards that might make hay-bale ditch checks more effective or less costly?

6. Temporary Ditch Checks: Silt Fence

a. Do you have field experience with temporary ditch checks constructed of silt fence? (If no, skip to #7.) ☐ **yes** ☐ **no**

b. Under what conditions are silt-fence ditch checks effective?

c. Under what conditions are silt-fence ditch checks ineffective?

d. Can you suggest any changes to KDOT's current standards that might make silt-fence ditch checks more effective or less costly?

7. Temporary Berms

a. Do you have field experience with temporary berms for diversion of runoff to stabilized slopes or temporary slope drains? (If no, skip to #8.) ☐ **yes** ☐ **no**

b. Under what conditions are temporary berms effective?

c. Under what conditions are temporary berms ineffective?

d. Can you suggest any changes to KDOT's current standards that might make temporary berms more effective or less costly?

8. Temporary Slope Drains

a. Do you have field experience with temporary slope drains? (If no, skip to #9.) **☐ yes ☐no**

b. Under what conditions are temporary slope drains effective?

c. Under what conditions are temporary slope drains ineffective?

d. Can you suggest any changes to KDOT's current standards that might make temporary slope drains more effective or less costly?

9. Temporary Sediment Basins

a. Do you have field experience with temporary sediment basins? (If no, skip to #10.)
☐ yes ☐no

b. Under what conditions are temporary sediment basins effective?

c. Under what conditions are temporary sediment basins ineffective?

d. Can you suggest any changes to KDOT's current standards that might make temporary sediment basins more effective or less costly?

10. Any ideas for temporary erosion-control measures other than those in questions 2-9?

11. **To what extent, if any, do temporary erosion-control measures interfere with construction activities?**

12. **Aside from impairment of downstream water quality, what negative effects, if any, do erosion and sedimentation have on the construction process?**

Your name and title: ____________________

Your address: ____________________

Your telephone number: (   ) _____ - ________

Best time to call you: ____________________

Thank you for completing this questionnaire. Please mail to:

Dennis Weinrich, P.E.
Field Construction Engineer
Bureau of Construction and Maintenance
Kansas Department of Transportation
Topeka, Kansas 66612-1568

1. Are you aware that every KDOT project that disturbs 5 or more acres is required to submit a Storm Water Pollution Prevention Plan (SWPPP) to KDHE as part of the federally mandated National Pollutant Discharge Elimination System (NPDES) program (answer yes or no)?

Of the 28 KDOT personnel who responded to this questionnaire, 20 answered yes to this question, and 8 answered no.

2. Temporary Seeding and Mulching

- Temporary seeding and mulching is effective for 6:1 slopes or less steep.
- Temporary seeding and mulching is effective for fall and spring weather conditions.
- Use emulsified asphalt for mulch cover in highly erodable areas.
- Water the temporary seed areas.
- Need to add bid item for watering seed in summer time to get it to germinate. No point in seeding if it won't germinate.
- Mulch can't be punched into frozen soil.
- The only way that the 17 acre rule for temporary seeding can be achieved is to require the grading subcontractor to have his own drill and mulcher, and do his own seeding. The seeding contractors are too busy to get to each project in a timely fashion.
- Temporary seeding and mulching is ineffective during prolonged dry periods and winter conditions.
- Don't till the seed in—drill it.
- KDOT should use more ryegrass seed with fescue or bromegrass seed mixed in. KDOT should also make provisions on long term projects, in the contract, to seed more than once.
- Seed between March 1st and October 1st.
- Temporary seeding and mulching is effective for 3:1 slopes or less steep.
- Temporary seeding and mulching is ineffective at edges of paved areas due to sheetflow from road surface.
- Require a dirt contractor to finish ditches and slopes before moving on to another area. Immediately seed the slopes and ditches. Use erosion-control blankets on all finished areas susceptible to erosion. Install all rock and concrete ditch lining before moving on. Water the seed and get it started before rain can wash it out.
- Certain temporary drainage conditions would benefit from temporary mulching and no seeding. Seed would not have time to germinate before being disturbed again.
- Use temporary mulch only when good judgment says seeding will be ineffective.

- Silt ponds could be an inexpensive alternative to seed that either washes away or never germinates.
- Sometimes when slopes are near vertical and rocky, it is best to use vegetation (e.g., Crown Vetch).
- Since KDOT allows by permit the harvesting of hay on the right of way by private individuals, they should be able to retain a certain percentage of the harvest for KDOT use and perhaps for contract use.
- Summer weather is hard on ryegrass.
- Straw mulch has a negative effect on the growth of ryegrass.
- Prairie hay has seed of other native grasses in with it and these seeds germinate and establish excellent erosion control.
- Apply fertilizer with drill or e-z flow.
- Agricultural broadcast spreaders are designed to broadcast fertilizer on open flat fields, not 3:1 or 4:1 slopes.
- Take soil samples of soils used in embankments and cut sections, may need micro-nutrients to promote vegetation growth.
- Some slopes are too steep to get equipment on to—these areas must be worked by hand making it difficult to work mulch into the soil. In a case like this, the contractor usually blows mulch on the slope without punching it in. Use soil guard in this type of area—it won't be less costly, but it will help seed germinate.
- I've heard some seeding contractors suggesting that we use different types of seed for different regions and seasons throughout the state. Is sorghum an alternative?
- Temporary seeding and mulching is ineffective for shale and class C soils.
- Do away with liming on temporary seeding.
- Add wheat to annual rye seed mixture for temp seeding.
- Use hydro mulch (seed, binder, fertilizer).

3. Temporary Slope Barriers: Straw and Hay Bales

- Temporary slope barriers don't work well on loose slopes.
- Don't bury the bales as deep; this shortens their useful life.
- Leave the stakes out; bury the bales at least ¾ of a bale deep.
- Temporary slope barriers are not effective on steep slopes.
- Temporary slope barriers can't be staked into rock.
- Temporary slope barriers work better if they're placed before erosion begins.
- Hay bales are more effective than silt fence for slope barriers because the hay bale stands up to concentrated flows better.
- Barriers get washed away during high water at bridge berms.
- Wrap the bales in excelsior blankets for a more long-term solution.

- Temporary slope barriers are not effective for “high velocity runoff”.
- Silt level must be kept down behind barriers.
- Start bidding temporary slope barriers with a reasonable number of linear feet in the plans. For a long time, we had to negotiate a price. I would like to see the designers be able to approximate better. Also state that a barrier damaged due to the contractor’s negligence, including lack of maintenance, shall be repaired at their cost.
- When you have prolonged periods of rain, it’s hard to get in and remove silt or repair a barrier without creating more of a problem.
- Run bales in straight line not more than 300 ft at approximately 5 degrees towards the steepest slope, generally not towards a traveled lane. This forms a levee type run of water which at these intervals water pressure is allowed to be released and controlled run-off into ditches or basins which are protected with further bale of silt fence installations.

4. Temporary Slope Barriers: Silt Fence

- Large flows can knock silt-fence slope barriers down.
- Look at the overall cost of silt fence; it may be cheaper to use hay bales.
- Temporary slope barriers must be spaced properly on slope.
- Temporary slope barriers must be properly trenched and backfilled.
- Can’t stake temporary slope barriers in on rocky slopes.
- Use 2”x2” oak stakes with metal cleat strips instead of staples.
- On highly erodable slopes, temporary slope barriers can’t handle the amount of silt being displaced.
- Good for keeping silt out of adjacent farm fields.
- Use other alternatives; don’t spend any money on silt fence at all.
- Silt fence is easily damaged by high intensity rains and/or wind.
- Start bidding temporary slope barriers with a reasonable number of linear feet in the plans. For a long time, we had to negotiate a price. I would like to see the designers be able to approximate better. Also state that barrier damaged due to contractors negligence, including lack of maintenance, shall be repaired at their cost.
- I would like to see the spacing of wood stakes decreased. The silt fence tends to sag in the middle even after being placed tight.

5. Temporary Ditch Checks: Straw or Hay Bales

- Temporary ditch checks are effective in ditches that don’t drain large basins.

- When a bale check rots out, it leaves a trench.
- Checks hold water which makes the seed die upstream of the check.
- Need to have something to combat the scour hole down stream of the check. Possibly use some type of erosion-control mat on the downstream side of the check.
- Don't use stakes—if properly placed, the bales will not move.
- Dig bales into the soil by at least ½ of a bale height.
- Hay-bale ditch checks should be installed with no more than a foot elevation grade change between checks.
- Hay-bale ditch checks must be cleaned out regularly.
- Make hay bales a set price per bale with 2 stakes, not by the foot. Also give an estimated quantity for a grading job. The bale size needs to be stated on the plans for length because you can get them in any length.
- Some contractors tend to run bales too high up the ditch slopes. The last several bales would never back water up if placed.
- Use hay; don't use straw.
- Start bidding temporary ditch checks with a reasonable number of linear feet in the plans. For a long time, we had to negotiate a price. I would like to see the designers be able to approximate better. Also state that barrier damaged due to contractors negligence, including lack of maintenance, shall be repaired at their cost.
- Use sod instead ditch checks.
- It might be more cost effective to install permanent ditch lining (rip rap or concrete) in the beginning.
- Use soil dams with pipes for drainage.

6. Temporary Ditch Checks: Silt Fence

- Temporary ditch checks work in areas where there is little or no silt.
- Water runs under silt-fence ditch checks.
- Silt-fence ditch checks work okay in ditches with less than a 1.0% grade line.
- Silt fence will help to level out segments of the ditch which will allow vegetation to get a start.
- Start bidding silt-fence ditch checks with a reasonable number of linear feet in the plans. For a long time, we had to negotiate a price. I would like to see the designers be able to approximate better. Also state that barrier damaged due to contractors negligence, including lack of maintenance, shall be repaired at their cost.
- It's more difficult to remove silt from than hay bales.

7. Temporary Berms

- Temporary berms are ineffective if not built large enough to do the job.
- If the berm is properly placed so as to contain all runoff, it's effective.
- Berms should be in the plans so KDOT doesn't have to pay out of the Force Account to install them.
- Temporary berms must be tall enough—if not, water overtops them and washes them out.
- Doesn't necessarily need to be a berm, this can be done with a "V" ditch made with a simple pass of a motor grader with his blade cocked.
- Temporary berms are good for diverting water to slope drains.
- Temporary berms are usually never on the plans; placement is usually a field decision.
- Temporary berms are ineffective if the problem will exist in permanent condition.

8. Temporary Slope Drains

- Slope drains need to be buried.
- Concrete slope drains are the best for high velocity flows.

9. Temporary Sediment Basins

- Temporary sediment basins are effective when the pipe is installed at the channel bottom.
- Temporary sediment basins are ineffective when inadequate storage is provided to slow volume flowing into basin.
- The pipe outlet should be at the flowline to prevent wash. Rock protection may also be required.
- Allow overflow to run around berm and onto grass or rock; this would eliminate the pipe requirement.
- Usually not enough room to properly install a sediment basin.
- Temporary sediment basins must be cleaned out regularly.
- Put known locations for temporary sediment basins in the plans so it is a requirement that they be built.
- Establish prices for cleaning out temporary sediment basins.
- Provide for cost sharing if topsoil stockpiling is incorporated in sediment basins or soil erosion control. Obtain temporary easements necessary for sediment basins. Pay for construction on private land where sediment basin is constructed, used, and left for a farm pond at completion of project.

- Purchase easements where necessary in known locations where the right of way is inadequate.

10. Any ideas for temporary erosion-control measures other than those in questions 2-9?

- Contractors need to complete permanent erosion control as they proceed on a project.
- Use erosion-control blankets for permanent erosion control.
- Give the inspector more authority to install rock, concrete ditch liner, or erosion-control blanket where needed.
- Use more rock ditch lining.
- If erosion-control blankets are called for, put them on the project plans instead of the seeding plans.
- Toe ditches used to direct runoff to areas where erosion-control devices are present can be built very cheaply and quickly. These can eliminate the need for more devices by maximizing the ones already in place.
- Use Quik-Crete bags for ditch checks.
- Use ditch checks made of rock. They work well in steep ditches.
- Come up with a new way of anchoring ditch checks in areas with a shallow soil mantle.
- Need to train both KDOT and contractors when and where to use each type of erosion-control measure. Silt fence and hay bales are easy but the others we don't use because we are unsure how/where to do so.

11. To what extent, if any, do temporary erosion-control measures interfere with construction activities?

- If not properly coordinated, grading contractors have a hard time finishing on the project. Many checks are destroyed needlessly.
- If measures are installed too soon, contractor can't finish final grading.
- It's difficult to permanent seed with measures in place.
- The 17 acre limitation causes problems.
- The contractor does not appreciate our efforts to control erosion on the project. We are in a constant struggle between keeping up with erosion control and progressing with the project.
- Seeding around devices is difficult.
- Our present KDOT policies require additional documentation. Documentation can interfere with the time delegated to inspection.
- Measures must be relocated as project progresses.

- Sometimes measures retain water and prolong the muddy state.
- When installed before slope and drainage have been established, measures get in the way.
- Contractors are willing to gear up and do initial installation of erosion control, but efforts decrease as the project continues.
- Diligence in repairing existing erosion control is lacking.

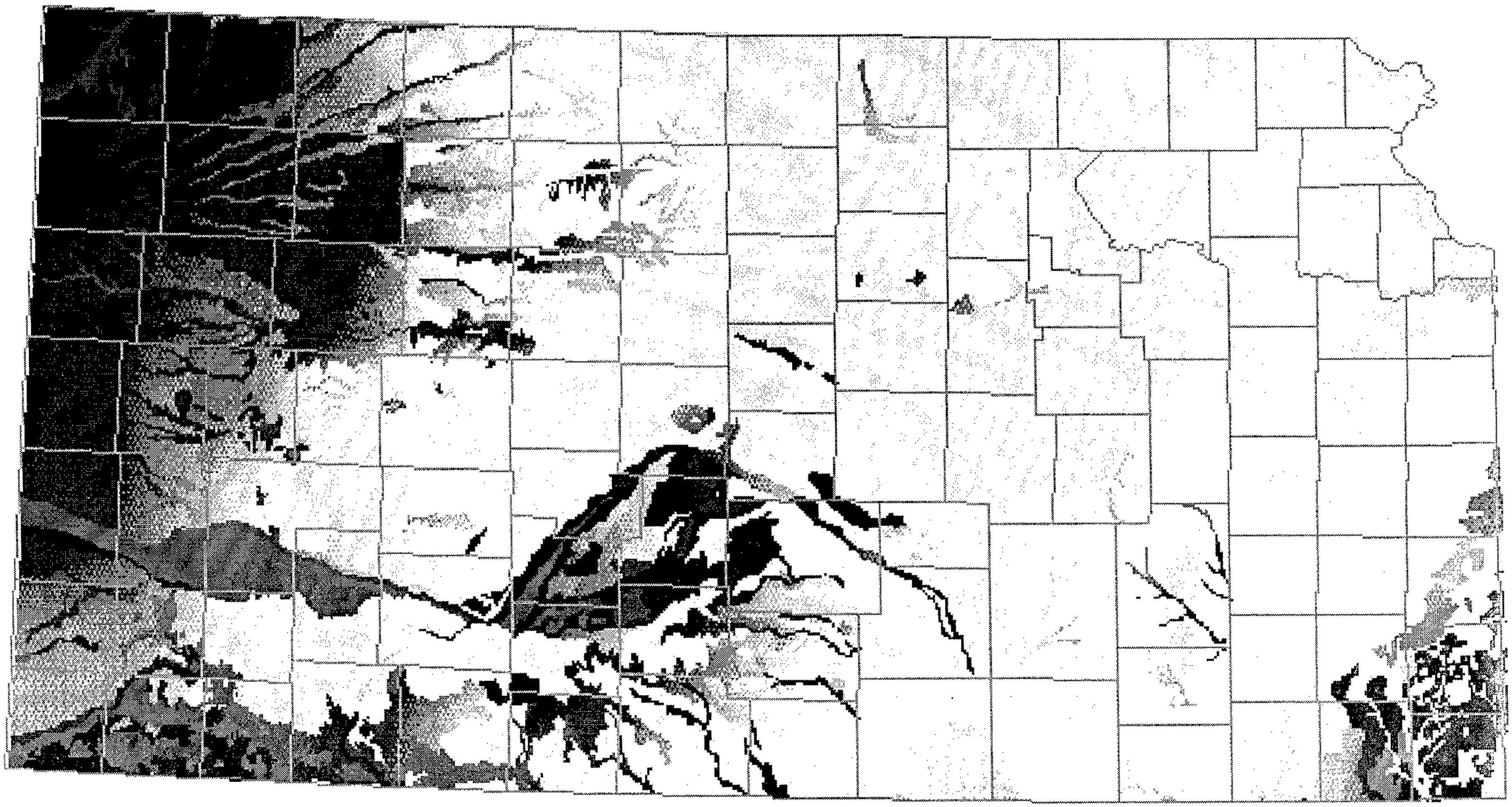
12. Aside from impairment of downstream water quality, what negative effects, if any, do erosion and sedimentation have on the construction process?

- Erosion requires ditches and slopes to be refinished and repaired to an acceptable condition which takes extra resources.
- Erosion at the edge of the asphalt roadway creates a drop-off condition and deteriorates the edge of the roadway. Maintenance of highway mowers is effected over the long term.
- Erosion and sedimentation create difficulties with final grading and permanent seeding.
- Siltation of farm fields contaminates crops.
- Silting into RCB bases before construction is completed.
- The aesthetic look of the project is compromised.
- The worst problem is that in construction, they want you to establish drainage first. You do this but no one wants to put temporary erosion control on ditches that are not finished. This is because they don't want to have to remove the bales. Then if you don't make them put up erosion control until ditches are finished, you have more than the allowable amount of acres opened up.
- Contractor many times has to regrade a slope or ditch.
- Relations between inspector and construction personnel are sacrificed. With incentive type contracts, the contractor does not appreciate the significance of erosion control and at times, instead of complying with KDOT's wishes, they would rather resist.
- Rills and gullies are a rough ride for maintenance mowers.
- Ditches that wash late in the project are difficult to repair.
- Re-shouldering is sometimes necessary prior to reseeding and mulching operations.

Appendix B

KDOT Temporary Erosion-Control Manual and Kansas Erosion Potential Map

Kansas Erosion Potential Map



Erosion Potential Index

90	80	75	60	55	40	25

The erosion potential index is the product of the soil erodability factor and the rainfall intensity factor in the universal soil loss equation. The other factors in the universal soil loss equation are site-specific. The universal soil loss equation provides an estimate of annual soil loss in tons per acre. *Note: white areas are water bodies.*

This map was created for the Kansas Department of Transportation, as part of K-TRAN Research Project KU-97-2, by Brian J. Treff and Bruce M. McEnroe, Department of Civil and Environmental Engineering, University of Kansas.