# FINAL REPORT

# Stream Stabilization in Western Iowa: Structure Evaluation and Design Manual HR-385

Sponsored by
Iowa Department of Transportation, Highway Division
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Submitted by

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# Stream Stabilization in Western Iowa: Structure Evaluation and Design Manual HR-385

## Abstract


Stream degradation is the action of deepening the stream bed and widening the banks due to the increasing velocity of water flow. Degradation is pervasive in channeled streams found within the deep to moderately deep loess regions of the central United States. Of all the streams, however, the most severe and widespread entrenchment occurs in western Iowa streams that are tributaries to the Missouri River (Lohnes, 1997).

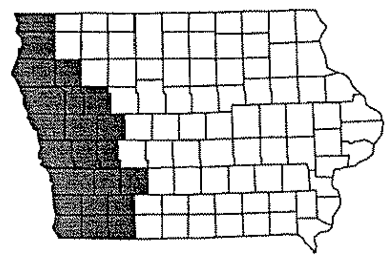
In September 1995 the Iowa Department of Transportation awarded a grant to Golden Hills Resource Conservation and Development, Inc. The purpose of the grant, HR 385 "Stream Stabilization in Western Iowa: Structure Evaluation and Design Manual," was to provide an assessment of the effectiveness and costs of various stabilization structures in controlling erosion on channeled streams. A review of literature, a survey of professionals, field observations and an analysis of the data recorded on fifty-two selected structures led to the conclusions presented in the project's publication, *Design Manual, Streambed Degradation and Streambank Widening in Western Iowa.* Technical standards and specifications for the design and construction of stream channel stabilization structures are included in the manual. Additional information on non-structural measures, monitoring and evaluation of structures, various permit requirements and further resources are also included.

Findings of the research project and use and applications of the *Design Manual* were presented at two workshops in the Loess Hills region. Participants in these workshops included county engineers, private contractors, state and federal agency personnel, elected officials and others. The *Design Manual* continues to be available though Golden Hills Resource Conservation and Development.

## Introduction and Background

Stabilization of degrading stream channels continues to be one of the most challenging problems facing western Iowa today. In the 22 counties that comprise the western Iowa loess area, an estimated $1.1 billion in bridges, roads and farmland have been damaged by the increasing speed of the channeled streams (Hadish, 1994). Fast moving streams scour the banks around bridges, expose pilings and, in some cases, cause collapse of the bridge. Rows of crops fall into stream channels, sometimes in the time it takes for the farmer to circle the field. Stream erosion has resulted in severe damage to communication and energy infrastructure including pipelines and fiber-optic lines. Without immediate and meaningful action, future costs of degradation of the main streams may run as high as $34 million. If smaller tributaries to the main streams are included, future costs escalate to more than $70 million (Hadish, 1994).

The Hungry Canyons Alliance was formed under the Loess Hills Development and Conservation Authority in 1990 to address the severe loss of land and damage to infrastructure caused by stream channel erosion in the deep loess soils region of western Iowa. Members of the Alliance represent the 22 counties in the region and include county engineers, landowners, county Boards of Supervisors, and Soil and Water Conservation Districts.



Member counties of the Loess Hills Development and Conservation Authority

Bank stabilization, upland conservation treatments and land use play important roles in inhibiting soil erosion in streams. However, the effects of these efforts are short-term if the bed of the stream remains unstable. Members of the Hungry Canyons Alliance agree that a comprehensive, long term and low maintenance approach to stream bed stabilization must include some form of grade control.

Grade control of a degrading stream can be achieved by placing structures across the streambed. A backwater affect is formed above the structure, thus slowing the flow enough to prevent further scouring of the bed and banks.

The majority of Hungry Canyons projects include hydraulic control structures. These structures generally have a raised weir section that creates an upstream backwater condition. Hydraulic control structures reduce downstream sediment flow by preventing the erosion of beds and banks. The structures also have the added benefit of trapping sediments upstream of the structures. The most commonly used stream stabilization structures in western Iowa are sheet pile, h-pile, rock sills and concrete block weirs.

## Goal and Objectives

The goal of HR 385 "Stream Stabilization in Western Iowa: Structure Evaluation and Design Manual" was to determine the optimum stream stabilization measure(s) to be utilized in a given stream setting. Results of the project are detailed in the project's publication, *Design Manual, Streambed Degradation and Streambank Widening in Western Iowa.* Following is a brief summary of the tasks and findings of the project.

*Task 1 Establish an Advisory Committee*
An Advisory Committee to the project met consistently throughout the five year period of this project. The Committee reviewed data as it became available and advised the investigators on project direction and progress. Members of the Advisory Committee consisted of engineers and professionals from federal, state, and local agencies, private consulting firms, and Iowa State University. (See Addendum A for a list of Principal Investigators and of Advisory Committee members.)

*Task 2 Selection of Stream Channel Stabilization Structures*
A survey of government and private engineers, contractors and consultants was conducted to determine key characteristics in the design and construction of stream stabilization structures. Addendum B presents a summary of responses to the survey.

Fifty-two structures were selected for detailed study based on survey results, a Geographic Information System database and field observations. The representative selection of stream stabilization structures was made based on structural and site characteristics including structure type, size of drainage area, and depth of loess soil. The structures include numerous variations in their designs including vertical drop distances at the weir, bank slope variations, size and height of the weir, the size of riprap and the use of grout and the placement of riprap on the banks and along the structure. Structures that were known to have experienced high flow events were also selected for detailed study. Addendum C presents the structures evaluated during the study.

*Task 3 Describe Site Conditions for Selected Structures*
Planning documents, survey reports, design calculations and plans were collected for all the selected stabilization structures. Additional field surveys were completed to supplement information obtained from documents.

The project found that two major questions arise when siting grade control structures. The first question asks: "Is grade control really needed in this stream?" The *Design Manual* describes the six stages of stream degradation and includes recommendations on when a structure would be effective in preventing further degradation. Predictors for the amount and rate of future degradation (see Task 8) and methods to determine cost benefits are included.

If a grade control structure is determined to be necessary, a second question must be asked: "What is the optimum location for the structure or structures?" The *Design Manual* addresses this question in detail, assisting the reader in exploring streambed and streambank characteristics, channel conditions and drainage features. The *Design Manual* offers a site evaluation procedure as wells as a site evaluation checklist. In general, the project found that the following questions regarding the site should be considered:

- Will the structure be built on a straight reach or on a meander of the stream?
- What occurs downstream of the structure?
- What are the critical hydraulic factors including downstream bed elevation, anticipated tailwater and equilibrium slope?
- What is the inflow from ditches, tile lines and/or tributaries?
- What are critical geotechnical factors including bank height, land use and geologic factors?
- What is the optimum number of structures needed to protect the facility or land?
- What is the impact of tributaries of the channel on the structure?
- What is the predicted aggradation upstream of the stabilization structure?

*Task 4 Determine Stream Flow History*

Stream flow history was estimated for the structures included in the project. The history included recorded stream discharges, daily precipitation, drainage basin conditions and stream channel characteristics. The results of this analysis were used to determine the maximum flow rate to which the selected structures were subjected.

Together, Tasks 3 and 4 provided the basis for the creation of a grade stabilization selection matrix. This matrix is included in the *Design Manual* and presents criteria for seven categories of design. By determining the design criteria that correspond to a specific channel condition, a grade stabilization structure may be selected from the four structures identified for use in western Iowa.

*Task 5 Describe Stabilization Structures*
The earliest grade control structures identified in western Iowa date from the 1940's. Until the 1970's, these structures consisted of concrete flumes having drops between 4 and 11 meters. By the late 1970's, costs for these structures ranged from between $300,000 and $1 million. (Lohnes, 1997).

Since the 1980's, grade control structures have primarily included four types of structures: sheet pile, h-pile, rock sills and concrete block weirs. These structures typically incorporate drops of 1 to 1.5 m and cost between $40,000 to $90,000. These four structures were chosen for their effectiveness in the western Iowa loess area and for the lower cost in construction. The *Design Manual* includes a detailed description of the structure types selected for the study, the range of characteristics found within and between structure types, and structure performance.

*Task 6 Stabilization Structure Performance Rating System*
A systematic evaluation was developed based on nine performance components. The resultant "Stream Channel Stabilization Structure Inventory and Evaluation Form" (See Addendum D.) was used in field evaluations of the selected stabilization structures.

*Task 7 Evaluation of Stabilization Structures*
The results of the field evaluations were combined with an analysis of structure characteristics (design discharge, riprap specifications, construction and maintenance costs) and site conditions (maximum flow rate, channel characteristics) to determine the relationship between these variables and the effectiveness of stabilization structures.

The most common problem, exhibited by 67% of the structures evaluated in the study, was in-channel movement of the riprap, barrier rails and concrete blocks. The second most common problem was erosion downstream of the stilling basin. Sixty-one percent of the selected structures experienced at least some erosion downstream. Because a significant number of structures exhibited these problems, this issue was studied thoroughly. The *Design Manual* includes a discussion of hydraulic equations for stilling basin design as well as recommendations for the quality, shape and sizing of riprap and the use of grouting.

During the summer of 1996 and again in 1998, many of the 52 study structures experienced flows that were from 100 and 500 year storms. In spite of these unusually heavy flows, 91% of the structures evaluated were in good or average condition and continue to provide grade stabilization.

*Task 8 Methods of Estimating Stream Degradation and Widening*
Predicting stream degradation allows placement of grade control structures at sites where maximum erosion is expected. Accurate prediction of stream degradation can help designers avoid constructing structures on streams where the streambed has already or will soon become stabile.

A significant amount of research has been done on describing and predicting streambed degradation in rivers and streams. Prediction models have been developed based on characteristics of flow regime and on the behavior of water in open-channel flow conditions. Other models characterize the response of a stream's longitudinal profile to the nature of the material through which the stream is flowing. Several empirical models use the decelerating nature of the degradation process over time to estimate the stable bed evaluation.

Seven streambed degradation estimation models are presented and analyzed in the *Design Manual* including the geomorphic, stratigraphic, tractive, velocity adjustment, power function, hyperbolic and the exponential model. Ease of application, amount of data required, and accuracy of the calculated degradation depth were the main reasons for recommending the exponential model.

Estimation of future streambank widening was also explored through the use of the Landvoid model, developed by Dr. Robert Lohnes, Iowa State University. The primary focus of this model is the computation of the critical height at which a vertical or sloped streambank will remain stable without collapsing or sloughing.

*Task 9 Identify Alternatives to Structural Stabilization Measures*
A review of literature and interviews with professionals have provided information regarding alternatives to structures for streambed stabilization. The *Design Manual* describes circumstances and design strategies for use of logs, boards, and channel debris, natural rock and beaver dams, and combination hard and soft structures such as k-dams, log and debris-catcher dams.

Future watershed projects for streambed stabilization may include both hard and soft structures, changing channel configurations and increasing channel roughness, adding buffer strips and encouraging farmland conservation practices.

*Task 10 Develop Procedures for Monitoring and Evaluating Stabilization Structures*
The *Design Manual* discusses features common to structures with long term stability. The features which are presented include overall height of drop of the structure, stilling basin design, slope angle of the constructed streambanks, gradation and condition of the riprap material, protection upstream of the structure, and strategies for side drainages.

A methodology for evaluating structures based on these features and a form for use in the field are presented. The "Stream Channel Stabilization Structure Inventory and Evaluation Form" can be used by those persons concerned about, and responsible for, the monitoring, evaluation and maintenance of stream channel stabilization structures.

*Task 11 Provide Training in Monitoring and Evaluation Procedures for Structures*
Each criterion presented in the "Stream Channel Stabilization Structure Inventory and Evaluation Form" suggests different elements that can affect the field performance of a structure. For example, the stability of the upstream banks and streambed suggest the structure is providing the necessary grade control, while instability of the downstream banks and streambed can infer that a headcut is moving upstream toward the structure.

The "Stream Channel Stabilization Structure Inventory and Evaluation Form" and its potential use were presented at two workshops held in western Iowa in September 1998. It is hoped that the evaluation form can be incorporated into the regular bridge inspection process. The Hungry Canyons Alliance will attempt to integrate evaluation and monitoring into its projects, and continue to review the "Stream Channel Stabilization Structure Inventory and Evaluation Form" as a tool of evaluation.

*Task 12 Develop a Design Manual for Selected Stream Channel Stabilization Measures*
The *Design Manual, Streambed Degradation and Streambank Widening in Western* was published and presented to participants of two workshops held in September 1998. A copy of the manual was distributed to 22 county members of the Loess Hills Development and Conservation Authority. Ten manuals were provided to the Natural Resource Conservation Service. Manuals were also sent to selected persons in county, state and federal agencies who provided support for the project. In addition, 25 manuals were provided to the IDOT. Manuals will continue to be available through Golden Hills RC&D. (See Addendum E for a Table of Contents of the *Design Manual.*)

*Task 13 Provide Instruction in the Use of the Design Manual*
Two workshops were held with the purpose of presenting the findings of the project and to distribute copies of the *Design Manual.* The first workshop, held in Red Oak on September 17, 1998 was attended by 30 persons. The second workshop, held in Mapleton on September 22, 1998 was attended by 33 persons. Participants included county engineers, private contractors, state and federal agency personnel, elected officials and others.

**Summary**

The project provided much-needed research and evidence of the effectiveness of streambed stabilization structures in western Iowa. While the most common problems associated with streambed structures (displacement of riprap and downstream erosion) were generally recognized by individual engineers and planners, the relationship to design principles was not always clear. The study and the resulting *Design Manual* and workshops provided an opportunity to present specific design principles and techniques that can assist engineers in creating the most effective streambed structures.

The results of the study have also shown that expensive grade control measures of the past can be effectively replaced with more economical grade control structures. Alternatives to steel or concrete, variations in the height of riprap up the sides of the bank and the circumstances under which grout is used are some techniques which may reduce the cost of structures

**Recommendations for Further Research:**

A regular review of the streams and the level of degradation taking place over time was identified as essential to the planning for and prevention of streambed degradation. Participants in the study called for a regular update (every five years) of the stages of stream channel degradation in western Iowa.

In western Iowa, glacial till or bedrock , which is resistant to erosion, underlies the highly erodible loess soils. Little data on the depths of alluvium are available. Additional mapping of the stratigraphy of the alluvial deposits and underlying materials would assist in estimating future degradation.

The protection of specific infrastructure has been and will continue to be a priority when considering the placement of streambed structures. However, the findings of this project and the experience of western Iowa professionals, call for the application of design principles to a larger system of natural and engineered forces. A systems approach to streambed degradation includes a regional review of the characteristics upstream and downstream of a given site. It also includes inspection of the entire watershed and its current and future land use. Learning more about integrating streambed structures with streambank stabilization, supporting conservation efforts on the upland and preparing for and adapting to changing land use are all considered to be critical in planning and design.

Participants in the workshops expressed a need for innovative designs for streambed structures. These designs may be used for structures placed by landowners on small tributaries to streams. By placing smaller structures on tributaries, several counties have found that severe degradation on the main streambeds can be prevented. In 1998, Hungry Canyons Alliance created a program which provides funds for these types of structures. Applicants are landowners who may work in conjunction with their County Engineer, Soil and Water Conservation District or a representative of the Natural Resource Conservation Service to develop new and innovative solutions to streambed degradation.

The classification of streams for fish habitat and corresponding structures which allow fish migration offers potential for successful designs in the western Iowa area. Protecting fish and wildlife and providing recreational opportunities for the growing populations in the counties near metropolitan areas is a growing concern. Together with the Iowa Department of Natural Resources, Hungry Canyons Alliance hopes to develop streambed stabilization structure designs which protect fish movement and habitat and may also be integrated into plans for recreational activities.

Finally, with riprap being costly and in limited supply, western Iowa engineers are looking for alternative materials. Materials such as tires, flyash or concrete from dismantled bridges, roads or other facilities offer the potential for suitable and inexpensive material.

**References**

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Addendum A

# Stream Stabilization in Western Iowa: Structure Evaluation and Design Manual HR-385

Principal Investigators

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Eldo Shornhorst, Shelby County Engineering Office
Martin Adkins, USDA Natural Resources Conservation Service

Advisory Committee Members

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Jerry Hare, Pottawattamie County Engineer, Council Bluffs
Greg Reeder, City Engineer, Council bluffs
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Jim Schnieder, USDA Natural Resources Conservation Service, Des Moines
Doug Voegele, Iowa State University, Ames

Addendum B

## Stream Stabilization in Western Iowa: Structure Evaluation and Design Manual HR-385

### Summary of Survey Responses

I. Types of stream stabilization measures identified

1. Low head steel sheet-pile weir
2. Rock sill; rock chutes
3. H-pile crib structure
4. Gabion flume
5. Reinforced-concrete flume
6. Combination structural and non-structural
7. Reinforced-concrete box culvert
8. Non-structural measures
9. Concrete block structures

II. Site conditions affecting planning, design, and construction

1. Drainage area
2. Channel characteristics: size, depth, cross-section, scour, erosion
3. Soil type, stability and erodibility
4. Anticipated channel degradation and widening
5. Channel slope (grade)
6. Stream flow rate, peak flow, volume, velocity
7. Adjacent land use
8. Existing structures, facilities and utilities to be protected
9. Other: vegetative cover and upland treatment such as conservation practices

III. Items that would benefit planning and design

1. Design guidelines
2. Tool to determine which type of structure to use under what circumstances
3. HEC-2
4. Formula to predict length of upstream protection *needed*
5. Life-time maintenance requirements and costs
6. Formula or chart for hydraulic performance
7. Economic benefit to sponsor and landowners
8. Life expectancy of existing bridge or facility
9. Grade removal range for each type of structure
10. Cost per amount of grade removed

IV. Types of infrastructure to protect

1. Bridges
2. Culverts (concrete box, pipes)
3. Utilities (public, private, gas pipelines, rural water, electric, phone)
4. Roads
5. Buildings (public and private)
6. Farmland
7. Railroad bridges

V. Most important steps and information used in planning, design and construction of stream stabilization project

1. Prediction of future stream degradation
2. Identification of "stable" grade of stream
3. Coordination with state and federal agencies
4. Identifying benefits of structure to facilities and land
5. Approval of county Board of Supervisors
6. Landowner awareness and cooperation
7. Detailed site survey including hydrology, geology, cross section, etc.
8. Determination of stream characteristics (flow, volume, velocities)
9. Predesign conference
10. Final design
11. Bid-letting
12. Award contract
13. Construction
14. Final inspection

Addendum C

**Stream Stabilization in Western Iowa: Structure Evaluation and Design Manual**

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Selected Structures

| Structure Type | County | Stream | Location | DA (sq mi) | Loess Depth (m) | Owner |
|---|---|---|---|---|---|---|
| Concr. block | Audubon | E. Nishnabotna River | 30/31 T-81N R-34W | 45 | 4-6m | COUNTY |
| Concr. block | Crawford | Paradise Creek Trib | 2 T-83N R-40W | 5.5 | 6-10m | STATE |
| Concr. block | Pottawattamie | Mosquito Creek | 25/30 T-77N R-41W | 144 | 10-20m | STATE |
| Concr. block | Woodbury | Big Whiskey | 6 T-88N R-46W | 51.4 | 6-10m | STATE |
| Gabion Flume | Pottawattamie | Keg Creek | 1 T-75N R-42W | 90 | 10-20m | COUNTY |
| H-pile | Burt, NE | Elm Creek | 10 T-23N R-10E | 23.4 | 10-20m | COUNTY |
| H-pile | Page | W. Tarkio Creek Trib | 13/14 T-68N R-39W | 5 | 6-10m | COUNTY |
| H-pile | Page | West Mill Creek | 24/25 T-67N R-38W | 25 | 6-10m | COUNTY |
| H-pile | Pottawattamie | Silver Creek | 3 T-74N R-41W | 100 | 10-20m | COUNTY |
| RCB, flume outlet | Crawford | Emigrant Creek | 23 T-84N R-41W | 12 | 10-20m | STATE |
| RCB, flume outlet | Fremont | Cooper Creek | 22 T-69N R-42W | 5.2 | >20m | COUNTY |
| RCB, flume outlet | Fremont | Honey Creek | 18/19 T-70N R-40W | 7 | 10-20m | COUNTY |
| RCB, SAF outlet | Woodbury | East Fork Wolf Creek | 21 T-87N R-44W | 28 | >20m | COUNTY |
| Rock sill | Cass | Baughman's Creek | 7 T-74N R-37W | 11 | 6-10m | COUNTY |
| Rock sill | Cass | Turkey Creek Tributary | 32 T-77N R-34W | <1 | 4-6m | COUNTY |
| Rock sill | Harrison | Pigeon Creek | 27/28 T-79N R-41W | 30 | 10-20m | COUNTY |
| Rock sill | Montgomery | Tarkio River Tributary | 20 T-71N R-37W | 5 | 6-10m | COUNTY |
| Rock sill | Shelby | Long Branch | 21/28 T-80N R-37W | 25 | 6-10m | COUNTY |
| Sheetpile | Audubon | E. Nishnabotna Trib | 13 T-81N R-35W | <1 | 4-6m | COUNTY |
| Sheetpile | Carroll | Brushy Creek | 34/35 T-83N R-35W | 40 | 4-6m | COUNTY |
| Sheetpile | Cass | Crooked Creek | 12 T-77N R-35W | 29.7 | 2-6m | COUNTY |
| Sheetpile | Cass | Troublesome Creek | 16/21 T-77N R-35W | 100 | 2-6m | COUNTY |
| Sheetpile | Crawford | East Soldier R. Trib. | 29/32 T-84N R-41W | 5 | 10-20m | COUNTY |
| Sheetpile | Crawford | Middle Soldier R. | 19 T-84N R-41W | 6.9 | 10-20m | COUNTY |
| Sheetpile | Crawford | Middle Soldier R. | 2/3 T-84N R-41W | 7.7 | 10-20m | COUNTY |
| Sheetpile | Crawford | Middle Soldier R. | 19/20 T-84N R-41W | 21.3 | 10-20m | COUNTY |
| Sheetpile | Crawford | Middle Soldier R. | 19/30 T-84N R-41W | 24 | 10-20m | COUNTY |
| Sheetpile | Harrison | Pigeon Creek | 28/33 T-79N R-41W | 32.4 | 10-20m | COUNTY |
| Sheetpile | Mills | Deer Creek | 36 T-71N R-40W | 27.7 | 10-20m | COUNTY |
| Sheetpile | Monona | Jordan Creek | 27/28 T-83N R-43W | 15 | >20m | COUNTY |
| Sheetpile | Monona | Jordan Creek | 5 T-82N R-43W | 25.5 | >20m | COUNTY |
| Sheetpile | Page | Snake Creek | 2 T-68N R-38W | 17.5 | 4-6m | COUNTY |
| Sheetpile | Pottawattamie | Graybill Creek | 16 T-75N R-39W | 35 | 6-10m | PRIVATE |
| Sheetpile | Pottawattamie | Little Walnut Creek | 4 T-75N R-38W | 8 | 6-10m | COUNTY |
| Sheetpile | Pottawattamie | Walnut Creek | 9 T-75N R-38W | 53.8 | 6-10m | COUNTY |
| Sheetpile | Pottawattamie | Walnut Creek | 3 T-75N R-38W | 44 | 6-10m | COUNTY |
| Sheetpile | Pottawattamie | Walnut Creek | 34 T-76N R-38W | 43.8 | 6-10m | COUNTY |
| Sheetpile | Pottawattamie | Walnut Creek | 27/34 T76N R-38W | 42.1 | 6-10m | COUNTY |
| Sheetpile | Shelby | Elk Creek | 7/8 T-81N R-37W | 20 | 6-10m | COUNTY |

| Structure Type | County | Stream | Location | DA (sq mi) | Loess Depth (m) | Owner |
|---|---|---|---|---|---|---|
| Sheetpile | Taylor | West Branch 102 River | 29/32 T-70N R-34W | 50.5 | 2-6m | COUNTY |
| Sheetpile | Taylor | Middle Branch 102 River | 3/4 T-69N R-34W | 43.8 | 2-6m | COUNTY |
| Sheetpile | Taylor | Middle Branch 102 River | 34 T-70N R-34W | 43 | 2-6m | COUNTY |
| Sheetpile | Woodbury | Elliot Creek | 3/10 T-88N R-46W | 34 | >20 | COUNTY |
| Sheetpile | Woodbury | Elliot Creek | 21 T-88N R-46W | 47 | >20 | COUNTY |
| Sheetpile | Woodbury | Elliot Creek | 29 T-88N R-46W | 50 | >20 | COUNTY |
| Sheetpile | Woodbury | McElhaney Creek | 27/28 T-89N R-44W | 13.5 | 10-20m | COUNTY |
| Sheetpile | Woodbury | West Wolf Creek | 35/36 T-88N R-45W | 35.3 | >20m | COUNTY |
| Sheetpile | Woodbury | West Wolf Creek | 1 T-87N R-45W | 37 | >20m | COUNTY |
| Sheetpile | Woodbury | West Wolf Creek | 1/12 T-87N R-45W | 39 | >20m | COUNTY |
| Sheetpile (derrick stone) | Shelby | Mosquito Creek | 11 T-80N R-40W | 30 | 10-20m | STATE |
| Sheetpile (double) | Monona | Jordan Creek | 33 T-83N R-43W | 19.3 | >20m | COUNTY |
| Sheetpile (triple) | Monona | Jordan Creek | 32/33 T-83N R-43W | 21.9 | >20m | COUNTY |

Addendum D

**Stream Stabilization in Western Iowa: Structure Evaluation and Design Manual**

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"Stream Channel Stabilization Structure Inventory and Evaluation Form"

Structure Description:______________________________________________ Date of Evaluation: _______

_____________________________________________________________

Stream:________________________________________ Name of Contact: ____________________

County:________________________________________ Telephone: ________________________

Location: T_____N R_____W SEC _____

Year Constructed: ______________________________

Construction Cost: $_____________________________ Design Discharge: _____ cfs

Average Annual Maintenance Costs: $_________________ Frequency: __________ -year

Maximum Estimated Discharge since Construction: ________ cfs
Date of when Maximum Discharge Occurred: ________________________
Estimated Maintenance Costs Associated with Maximum Discharge Event: $________________

Vertical Distance of Upstream Side of Bridge Deck to Channel Invert: _____ feet

Overall Height of Drop: _____ feet

Distance of Grade Control Structure from Infrastructure: _____ feet

Distance from Structure to Upstream end of Backwater Affect: _____ feet

Average Diameter of Riprap Material: _____ inches

Condition of Riprap Material (circle all that apply): no problems cracking spalling dissolving disintergrating

Streambed Material (circle all appropriate): clays silts sands gravels

| **Performance Evaluation** | good | average | poor | n/a |
|---|---|---|---|---|
| Apply Numerical Ranking to the Following Evaluation Criteria | 1-3 | 4-6 | 7-9 | X |
| Stability of upstream streambanks | | | | |
| Stability of downstream streambanks | | | | |
| Stability of upstream channel invert | | | | |
| Stability of downstream channel invert | | | | |
| Impact of structure on protecting infrastructure | | | | |
| Structural integrity of grade control structure | | | | |
| Structural integrity of upstream riprap | | | | |
| Structural integrity of downstream riprap | | | | |
| Condition of stilling basin or scour hole | | | | |
| **Performance Evaluation descriptions provided on back of this sheet** | | | | |

| Identify the Percentage of Total from the above Evaluation Criteria | 1-33% | 34-67% | 68-100% |
|---|---|---|---|
| **Overall condition of grade control structure** | | | |

Notes (observations, maintenance requirements, etc.): ______________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

# Performance Evaluation Descriptions

**Stability of upstream streambanks-**
1-3 good - appear stable with over 60% vegetative cover, no noticeable erosion
4-6 average - limited erosion along toe, 30-60% vegetative cover, minor streambank sloughing occurring
7-9 poor - significant indication of erosion along toe, 0-30% vegetative cover, active streambank sloughing
n/a - not applicable

**Stability of downstream streambanks -**
1-3 good - appear stable with over 60% vegetative cover, no noticeable erosion
4-6 average - limited erosion along toe, 30-60% vegetative cover, minor streambank sloughing occurring
7-9 poor - significant indication of erosion along toe, 0-30% vegetative cover, active streambank sloughing
n/a - not applicable

**Stability of upstream channel invert -**
1-3 good - no indication of erosion, scouring, or headcutting taking place
4-6 average - minor erosion along toe of banks, or ripples and small falls indicating minor headcutting
7-9 poor - indication of active erosion along toe of banks, and/or substantial headcutting is occurring
n/a - not applicable

**Stability of downstream channel invert -**
1-3 good - no indication of erosion, scouring, or headcutting taking place
4-6 average - minor erosion along toe of banks, or ripples and small falls indicating minor headcutting
7-9 poor - indication of active erosion along toe of banks, and/or substantial headcutting is occurring
n/a - not applicable

**Impact of structure on protecting infrastructure -**
1-3 good - all piers and abutments appear to be stable and erosion and bank widening is not noticeable
4-6 average - indication of minor erosion occurring in vicinity of piers or abutments
7-9 poor - indication of substantial erosion occurring in vicinity of piers and abutments
n/a - not applicable

**Structural integrity of grade control structure -**
1-3 good - all riprap appears to be stable and secure, sheetpile appears stable, and all concrete and grout appears intact
4-6 average - indication of minor displacement of riprap, sheetpile being flanked, minor cracks in concrete and grout
7-9 poor - substantial displacement of stone, flows flanking sheetpile, failure of concrete and grout sections
n/a - not applicable

**Structural integrity of upstream riprap -**
1-3 good - all riprap appears to be stable and well placed with no sign of cracking, spalling, or disintegration
4-6 average - minor displacement of riprap in several areas, indications of cracking, spalling, or disintegration
7-9 poor - significant displacement of riprap, severe cracking, spalling, and/or disintegration occurring
n/a - not applicable

**Structural integrity of downstream riprap -**
1-3 good - all riprap appears to be stable and well placed with no sign of cracking, spalling or disintegration
4-6 average - minor displacement of riprap in several areas, indications of cracking, spalling or disintegration
7-9 poor - significant displacement of riprap, severe cracking, spalling, and/or disintegration occurring
n/a - not applicable

**Condition of stilling basin or scour hole -**
1-3 good - no sloughing, erosion, or debris blockage of stilling basin, or widening or lengthening of scour hole occurring
4-6 average - minor sloughing, erosion, or debris blockage of basin, or minor widening and lengthening of scour hole
7-9 poor - significant sloughing, erosion, or debris blockage, or significant widening and lengthening of scour hole
n/a - not applicable

**Overall condition of grade control structure -**
1-33% good - structure appears to be stable and functioning as designed
34-67% average - minor damage to structure identified, requires minimal maintenance to repair
68-100% poor - significant operational problems occurring, requires extensive remedial measures to prevent failure

# Design Manual
## Streambed Degradation and Streambank Widening in Western Iowa

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