EROSION CONTROL FOR HIGHWAY APPLICATIONS

Phase I: Review and Synthesis of Literature

FINAL REPORT
TR-464

Principal Investigator
Marian Muste
Research Engineer, IIHR-Hydroscience & Engineering, The University of Iowa

Project Engineer
Robert Ettema, Professor of Civil Engineering and Environmental Engineering
Research Engineer, IIHR-Hydroscience & Engineering, The University of Iowa

Project Engineer
Connie Mutel
Research Scientist, IIHR-Hydroscience & Engineering, The University of Iowa

Graduate Research Assistants
Roger Gomez
Department of Geoscience, The University of Iowa
Petronela Shaffer
Henry B. Tippie College of Business, The University of Iowa
Kwonkyu Yu
Department of Civil and Environmental Engineering, The University of Iowa

Preparation of this report was financed through funds provided by the Iowa Department of Transportation through the Iowa Highway Research Board

Iowa Department of Transportation
800 Lincoln Way, Ames, IA 50010
Telephone: (515) 239-1447
Fax: (515) 239-1092

May 2002

Executive Summary

The project described herein has led to a convenient, computer-based expert system for identifying and evaluating potentially effective erosion- and sedimentation-control measures for use in roadway construction throughout Iowa and elsewhere in the Midwest. The expert system is intended to be an accessible and efficient practical resource to aid state, county, and municipal engineers in the selection of the best management practices for preventing unwanted erosion and sedimentation at roadway construction sites, during and after construction.

The expert system is based on a comprehensive review of the literature on erosion and sedimentation control methods (ESCMs). The literature includes diverse in-house manuals, information on state-DOT websites, as well as an array of publications from various agencies (state, and federal government) and industry, design manuals, federal and national guidelines, and specialized computer programs. In addition, surveys of state DOTs within the U.S. Great Plains and Upper & Middle Mississippi Valley Regions, and of Iowa County engineers were conducted. The literature review and the surveys led to the expert system, which comprises a structured synthesis of information on ESCMs. It provides information on the principal technical, implementation, economic, and operational efficiency considerations.

A notable finding of the literature review and the state DOTs survey is the identification of numerous in-house manuals developed by the various agencies directly involved with mitigating erosion and sedimentation concerns. The manuals are mainly in hardcopy format, though some are in an electronic format. The literature review and survey revealed that, although extensive ESCM literature exists, much of it is not organized to enable effective use by highway engineers. This finding motivated the project investigators to initiate and develop a contemporary, computer-based expert system.

The expert system is a comprehensive "inference engine" that will assist state, county, and municipal engineers in the selection, design, construction, inspection, and maintenance of ESCMs for a particular roadway construction situation. The expert system was designed to ensure that selected ESCMs take into account site characteristics, the lifetime of the planned method, and Iowa's Midwest environment. The expert system can be further developed by refining its database content and by adapting the current inference engine for web-based environment. Those further steps were beyond this first phase of the Project.

The project also led to a significant shortlist of ESCM research needs. Among them is the need to better take into account the impacts on ESCMs of frigid winter conditions. In this regard, a common concern is the establishment of protective vegetation to mitigate erosion and sedimentation concerns at roadway construction sites.

TABLE OF CONTENTS

LIST OF TABLES

1. INTRODUCTION

Each year, large amounts of soil are eroded from highway sites, especially from highways under construction. It usually is rather difficult to control erosion at highway construction sites because of the extent of disturbed soil and the difficulty of controlling water runoff. Though data on the overall rates of sediment transported to streams at these sites limited, erosion rates from them are typically 10 to 20 times the rates from agricultural land, some reports suggest erosion rates up to 100 times as high (e.g., Goldman et al., 1986). The eroded soil incurs severe economic costs (e.g., excavation or dredging, soil replacement, highway consolidation) and environmental impacts (e.g., deterioration of water quality in the watershed and streamside vegetation, removal of important topsoil constituents). Consequently, erosion prevention and sedimentation control are major factors in the design, construction and maintenance of highways.

Irrespective of project size and erosion-mitigation method, selection of the optimum erosion control measures for a specific situation needs to be facilitated using a comprehensive, yet straightforward plan. Besides being technically feasible, quick, and economic, the current approach in implementing an erosion control project includes compliance requirements with federal, state, and local regulations. Protecting water quality is of paramount concern in this regard. The new Phase II rules from the Environmental Protection Agency (EPA) concerning storm-water erosion and sediment control practices are scheduled to be in place by the end of 2002. Moreover, state DOT's must be ready to demonstrate how current methods, as well as new and innovative methods, will meet the water quality standards mandated by the Phase II rules.

Efficient planning for erosion control requires a comprehensive consideration of site topography, drainage pattern, rainfall data, soil data, existing vegetation, off-site features (streams, lakes, buildings), as well as available types and operational characteristics of the erosion control methods. These varied and complex considerations, commonly limit the number of problems encountered in finding feasible and economic methods to minimize erosion. Several disciplines of science and engineering are required to address erosion problems. Highway designers, project engineers, and maintenance personnel often need the advice of hydrologists, hydraulic engineers, soil engineers, soil scientists, agronomists, landscape architects, and other specialists to minimize erosion problems.

The literature regarding erosion control methods is scattered in diverse published accounts, such as guidelines or instructional manuals published by an array of agencies, such as State Department of Transportation, US Department of Agriculture (through its Agricultural Research Service and Soil Conservation Service), Environmental Protection Agency, American Association of State Highway Transportation Officials, etc. The lack of a centralized source of information has led to a variety of erosion-control designs and procedures now in use during highway construction. Therefore, engineers from state DOTs[1], counties, and municipalities are forced periodically to conduct extensive literature reviews of

[1] Department of Transportation

erosion and sediment control protection methods. The reviews can be labor intensive, requiring engineers to survey needs, and develop best management practices for erosion and sediment control, and to adapt methods to meet the climatic variations that prevail locally.

The objectives of the present project are identification and evaluation of erosion control methods utilized in highway applications in Iowa (and thereby elsewhere in the Midwest) through a literature review and assemblage of this information in a practical resource. This compilation provides assurance that the best appropriate methods for preventing erosion are being used at each site, during and after construction.

The present project entailed a comprehensive review of the literature on Erosion and Sediment Control Methods[2] (ESCM). The literature was collected through conventional means, internet search, and a survey submitted to the Great Plains and Mississippi Valley DOTs. A cursory examination of the literature shows that there are numerous guidelines for erosion and sediment control methods used in highway applications. The manuals/guidelines/standard specifications, however, vary widely in format, and often are not directly useful. The literature survey conducted for this study revealed that all the surveyed DOTs rely on guidelines assembled in hardcopy manuals comprising hundreds of pages. Manual layout commonly follows conventional arrangement of content; i.e., temporary measures, permanent measures; or, alternatively, measures for protection of soil surface, runoff control, and sediment removal. Most of the newer manuals include the provisions related to the Storm Water Pollution Prevention Plans (SWPPP), that are presented separately. Important considerations involved in the selection process, such as overall efficiency and suitability of Erosion and Sediment Control Measures (ESCM) for particular conditions are not included. It is, therefore, often difficult to use the published literature to quickly identify, assess, and efficiently select site-specific erosion control methods for temporary or permanent use.

The project sought to synthesize and structure the relevant information on erosion and sediment control in a effective meaningful way, to facilitate direct access to pertinent information regarding the ESCMs for a variety of site-specific conditions. The information is structured as an expert system designed specifically to aid engineers to select and implement erosion and sediment control methods. The expert system is a computer software that aids decision-making and design in a particular field. Input from Iowa County Engineers and Iowa DOT personnel was sought in order to ensure accessibility and utility of the expert system.

Additionally, the project identified significant needs for further research and development. The study concludes with suggestions for further development of the expert system and research suggestions to mitigate current limitations of ESCMs.

[2] Erosion and sediment control *methods* or *measures* are interchangeable used in the present report.

2. LITERATURE SURVEY

The review of literature on highway erosion and sediment control methods, included publications from diverse sources: state DOTs websites, industry, and tribal, state, and federal government publications, design manuals, federal and national guidelines, and computer programs. The list of resources used for the compilation of the expert system database is provided in Appendix A.

Particularly useful information was obtained from a survey of state DOTs in the U.S. Great Plains and Upper & Middle Mississippi Valley. The questionnaire used in the survey, the list of contacted persons, the summary of the survey responses, and specific comments are presented in Appendix B. The synthesis of survey information tabulated in Appendix B shows that the surveyed DOTs use a variety of literature sources for addressing Erosion and Sedimentation Control problems. The common characteristic for all DOTs, in this regard, is that most them have developed their own in-house compilations of manuals/guidelines, possibly to take into account specific issues related to local state conditions. The most frequently cited references are as follows:

1) International Erosion Control Association. "How To Put the BEST Back Into Your Best Management Practices (BMPs)," Short Course - Reference cited by Kansas, Oklahoma, Wyoming
2) Environmental Protection Agency (1992). Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices; Publication No. EPA-833-R-92-005; Washington, DC – Reference cited by Kansas and Missouri

These references also are primary sources of ESCM information for Iowa DOT.

The last publication appears to be the most used reference. The content of EPA Publication EPA-833-R-92-005 (EPA, 1992) is adopted in all in-house available guidelines because it refers to the development and implementation of the Storm Water Pollution Prevention Plans (SWPPP). The plans are federally mandated for construction works spanning areas larger than 5 acres (2 ha, 29,234 m^2) to regulate the discharge of pollutants. Section 402 of the Clean Water Act established the National Pollutant Discharge Elimination System (NPDES) to regulate the discharge of pollutants from point sources. SWPPP is closely related to erosion and sediment control works, as they are potential sources of pollution that reasonably may be expected to affect the quality of storm water discharge associated with roadway constructions. EPA (1992) has a useful structure that follows the steps usually incurred with ESCM design and implementation. Phase 3 of the EPA (1992) contains recommendations for the best management practices for erosion and sediment control.

The survey reveals another common feature, namely that almost every state DOT compiles its own customized set of manuals/guidelines adapting best management practices for erosion and sediment control to allow for the climatic variations that prevail in the respective state. An increasing number of these publications is available on the internet, some at no charge, some procurable at modicum prices. The availability of the literature in electronic format is advantageous because the software used for displaying the documents contains rudimentary search engines that provide increased flexibility in use. However, the search engines are general tools with limited functionality for efficient selection of an ESCM.

The literature review also searched the internet and software for information on ESCMs. Both electronic sources of information are being actively developed, and hold great promise for disseminating information on erosion and sediment control for roadway applications. However, currently these sources have not attracted independent use.

In summary, the literature and internet surveys show that there exist numerous sources of information covering aspects of ESCM design, construction, permit compliance, inspection, and removal. The existing sources are useful for design engineers, or engineers with vast experience in the area. However, the sources often are difficult to be used by practitioners with limited experience on ESCMs, such as city and county engineers with limited access to colleagues with extensive ESCM expertise. The number of information sources available in electronic format is growing, but these sources do not yet significantly aid the decision making and design.

Rather than compiling a new set of paper guidelines on ESCMs, the present study initiated the development of an expert system to aid ESCM selection. The bulk of the literature surveyed for this study now is enclosed in the expert system. The content structure and operation of the system are described next.

3. EXPERT SYSTEM FOR SELECTION AND DOCUMENTATION OF ESCMs

3.1. Expert System Concept

The work described leads to an expert system that identifies and provides specifications on erosion and sediment control measures for highway applications in Iowa (and thereby elsewhere in the Midwest). The expert system assembles pertinent literature on erosion and sediment control in an efficient, practical source that can be accessible for highway engineers of various levels of technical background. An expert system is the best choice for accomplishing this task. The role of the expert system is to identify that the appropriate methods for erosion and sediment control are used at each site, during and after construction.

An expert system (ES) is a type of computer application program that aids decision making or solving problems in a particular field by using knowledge and analytical rules defined by experts in the field. Expert systems are part of a general category of computer applications known as artificial intelligence, because these computer applications perform tasks that would otherwise be performed by a human expert. For example, there are expert systems that can diagnose human illnesses, make financial forecasts, and schedule routes for delivery vehicles. Some expert systems are designed to take the place of human experts, while others are designed to aid them. To design an expert system, one needs to study how human experts make decisions and translates the rules into terms that a computer can understand.

Human experts solve problems by using a combination of factual knowledge and reasoning ability. In an expert system, these two essentials are contained in two separate but related components, a knowledge base and an inference engine. The knowledge base provides specific facts and rules about the subject, and the inference engine provides the reasoning ability that enables the expert system to form conclusions. Expert systems also provide additional tools in the form of user interfaces and explanation facilities. User interfaces, as with any application, enable people to form queries, provide information, and otherwise interact with the system. Explanation facilities, an intriguing part of expert systems, enable the systems to explain or justify their conclusions, and they also enable developers to check on the operation of the systems themselves.

3.2. ES design principles

The expert system (ES) designed during this study is a comprehensive guide aimed at assisting state, city, and county engineers to select, design, construct, inspect, and maintain erosion-control measures. Special attention was given in the design of ES to ensure that the optimum solution for mitigation of soil erosion effects takes into account site conditions, the lifetime of the planned solution, and conditions in Iowa. The current version of the expert system is configured for PC platforms. Further development of the database, as a web-based engine, can be expanded to other user categories, i.e., associate general contractors, design engineer, consultant engineers, etc.

The present ES was developed with its users in mind. Discussions with state DOT personnel during the initial stage of ES development emphasized that primary users will be field engineers. Suggestions collected from state and county engineers prompts to development of the ES for ESCMs. The design of the ES was guided by the principles described below:

- *Comprehensive simulation of the ESCM decision-making process*. All technical elements involved in the selection of the control measures are incorporated in the ES (objectives, type, site evaluation, ESCM specifications). Permitting considerations relevant to selection of the ESCM are also included.
- *Multi-layered information*. User interfaces for each requested input or output information are contained by two or more layers: the first layer addresses general information valid for classes of ESCM, while the subsequent layers address details pertaining to specific factors or selected ESCM. Given the fact that field engineers are only occasionally implementing ESCMs, the terms of the interfaces are explained in plain language to accommodate various technical backgrounds.
- *Self-contained*. The various levels of information make the ES a comprehensive source of information that does not need additional references to guide in the selection of the appropriate ESCM for a particular situation. When needed, the user is directed to additional sources of information regarding data collection, and data interpretation and evaluation.
- *Portability*. The current design of the ES assumes user access to a personal computer (PC). Further development considers transitioning to web-based version of the ES that will allow user to access the information from any computer. Each of the steps involved in the decision making process can be printed as hardcopy containing exclusively the specifications related to the ESCM of interest.
- *Compact format and efficient navigation*. Use of the multi-layer structure allows minimization of the number of ES interfaces. Navigation rules are simple and straightforward, thereby enabling users to form queries, provide information, and efficiently interact with the ES. The ES prompts the user when input data are incomplete or the functions are not yet implemented in the engine.
- *Flexibility*. The design of the ES allows unlimited further development and upgrading of the database with minimum changes to the core ES elements.
- *Iowa specific*. Though the information assembled in the ES is collected from various state DOTs and Iowa counties, priority was given to include ESCMs evidently best suited for Iowa and to rely in principal on the literature resources available in the state.

The ES interfaces were designed using Borland C++ Builder, Version 5.0 (Borland Software Corporation). The ES database was organized using Paradox 7 (Corel Corporation).

3.3. ES knowledge base

The content of the ES is based on relevant information regarding erosion and sedimentation control methods collected from the sources described in Section 2, with special emphasis on ESCMs utilized in Iowa, Great Plains and Upper & Middle Mississippi Valley state DOTs. The review of the information was not a simple compilation of the erosion control measures used in highway applications. The review was conducted to develop a structured synthesis encompassing all the relevant elements involved in ESCM design, construction, inspection, maintenance, removal, economical considerations, and efficiency considerations. Once set in place, the ES can be updated and upgraded to include the best management practices (BMP) as they develop.

Projects that expose areas of soil to erosion, such that sediment could adversely affect operations on the highway or associated rights-of-way, could be introduced into receiving waters, or could affect adjacent properties, sensitive environmental resources need to provide ESCM. Efficient planning for ESCMs requires a comprehensive knowledge of the site to be protected, permitting requirements, as well as the available types and operational characteristics of potential ESCM. The database attempts to take into account all of the variables that impact the decision making process when one selects a BMP for ESCMs. Projects involving no clearing and grubbing, excavation, stockpiling of topsoil, borrow or construction of embankment normally will not require an ESCM. Therefore, they are not included in the ES. Examples of such actions are: installation of lighting, signing, traffic signals, guardrails, weed spraying, pavement marking, seal coating, and planting of landscaping materials.

3.3.1. *ESCM type*

For situations where ESCMs are needed, the leading principle in differentiating the methods is the type of erosion or sediment control to be undertaken:

- Quick and short-term (0-6 months) ESCMs to be applied during and immediately following highway construction (e.g., roadway grades, roadside diches, embankments, cut slopes, stream banks, drainage outlets).
- Transitional ESCMs (6-12 months)
- Long-term erosion control methods (more than 12 months)
- ESCMs for transitioning from short-term to long-term erosion control measures

3.3.2. *ESCM Purpose*

The information compiled organized in accordance with ESCM purpose. Common purposes are as follows:

- Erosion Control Method (ECM) to keep soil in its original location (e.g., temporary or permanent seeding and planting, mulching, geotextiles, chemical stabilization, sod stabilization, vegetative buffer strips, protection of trees, preservation of natural vegetation, dust control, soil retaining measures, stream bank stabilization)
- Sediment Control Method (SCM) to keep soil close to its original location (e.g., silt fence, straw bales or brush barriers, sediment trap, sediment basin, brush barrier, drainage swale, subsurface drains, pipe slope drains, level spreaders, storm drain inlet protection, rock outlet protection, reinforced soil retaining systems, gabions)

- Erosion and Sediment Control Method (ESCM) to protect typical roadway elements that combine both types of controls (e.g., road ditches, swales)
- Storm Water Management Control Method (SWMCM) to control pollutants after construction is complete (e.g., retention pond, detention pond, infiltration measures, vegetated swales).

Each of the above purposes is further categorized in terms of method functionality of the ESCM in practical situations; i.e., protection of slopes, borrow/stockpile, perimeter control, sediment trapping, water conveyance, energy dissipation structures, and retention structures.

3.3.3. ESCM *construction phasing*

An especially important consideration when selecting control methods and developing ESCM plans is to ensure that each appropriate construction phase is considered. The three phases that an ESCM plan should address are:

- initial clearing phase
- intermediate grading phase
- final stabilization of the site.

The initial phase should address the *perimeter controls* required at the initial clearing stage to prevent sediment from leaving the site. The *intermediate* phase should reflect the *controls* required during construction. The third phase of erosion control is the final stabilization of the site and installation of the *permanent controls*. Some of the most important practical means to implement these controls are summarized below.

Perimeter Controls. These controls usually are installed after the clearing and prior to any grubbing of the site. The controls are located in keeping with the natural topography of the site and the limits of construction. The purpose of these controls is to prevent off-site damage by minimizing the sediment that leaves the site. In most cases, these controls will remain in place throughout the construction of the project. Typical perimeter controls include:

- Filter barriers (silt fence, straw bales, and brush barriers)
- Diversion structures (diversion berms and channels)
- Settling structures (sediment traps and sediment basins)

Intermediate Controls. The most critical and most difficult phase of erosion control is the intermediate phase, especially during new construction. Intermediate controls are implemented as the project progresses from the grubbing stage to the final grade. This is the stage of construction when earth-moving activities are at a maximum. At this point, both the extent of exposure and the duration of exposure is greatest making the site most susceptible to erosion. Temporary erosion controls must be implemented in incremental stages as construction progresses. In addition, some permanent structural controls such as culverts, storm sewers, and some waterways are installed. Intermediate controls commonly include:

- Temporary slope drains
- Temporary channel linings
- Mulching
- Temporary and permanent turf establishment
- Checkdams
- Settling structures
- Inlet protection

Final Controls. The last phase of erosion control includes final stabilization of the slopes and waterways, stabilization of outfalls, and other disturbed areas. Most final controls are permanent, however some temporary controls may be used. Final controls include:

- Permanent turf establishment
- Channel linings
- Temporary slope drains
- Checkdams
- Outlet protection
- Curbs, gutters and downdrains (chutes)
- Road inlets

Some ESCMs actually may serve in more than one phase. For instance, filter barriers and settling structures may control sediment from the initial phase through the final slope stabilization. Also, in some reconstruction projects, the only ESCM phases required may be the initial and final controls.

The ES does not directly relate the ESCMs with the different stages of the highway construction, but the introduction section of the ES warns that developing ESCM plans might require multiple iterations through the ES database in order to address all the elements of the project (e.g., perimeter control, soil protection/stabilization, water conveyance, sediment trapping) and the different stages of roadway construction (initial, intermediate, and final phases).

3.3.4. *Erosion and water runoff estimation*

Up to this point, the ES's knowledge-ase addresses control measures in accordance with their purpose and type (short, transitional, permanent). The next ES steps concern the prediction of erosion. The ES addresses only erosion processes associated with water action, because rainfall and its associated runoff are the primary source of erosion in the United States, especially in Iowa.

The ES is designed to provide qualitative and a quantitative estimate of the erosion potential. Currently, the ES provides only qualitative erosion potential. Qualitative assessment of the factors involved in erosion prediction suffices for appropriate selection of control measures for particular site conditions. Further development of the ES will include the qualitative assessment of the erosion potential by implementing calculation engines using the available to estimate sediment yield or water runoff. This last ES capability will enable designers to efficiently select ESCMs in direct relationship with the actual sediment delivery rates.

The ES items considered herein attempt to take into account all of the variables that impact the decision making process when one selects a BMP[3] for erosion or sediment control. The following factors are incorporated in the ES knowledge base:

- Area type: the location of construction site (urban, semi-urban, rural) can raise particular issues and concerns (e.g., safety, aesthetical aspects)
- Watershed area size: this factor directly involved in evaluating the erosion and water runoff potential
- Soil type: soil type is an important factor influencing sediment yield due to the wide range of soil susceptibility to erosion
- Topography: geographic relief (slope steepness and length in principal) in the watershed is a basic item to consider in connection with erosion
- Climatic factors: these are important for soil and vegetation development and determination of erosion and runoff
- Ground cover: ground cover (e.g., vegetation, leaf litter, or rock fragments) changes the effects of rainfall and runoff on the soil surface.
- Land use: temporary or permanent reduction in the ground cover can be caused by such activities as grazing, logging, mining, fires, urbanized developments in the vicinity of the site can impact the sediment yield

3.3.5. *ESCMs*

There is a wide variety of erosion and sediment control measures and means to classify them; i.e., temporary-permanent, structural-non-structural. On-going research and implementation efforts are further dedicated to find new means to control erosion and sediment control and/or to improve the efficiency of the existing ones. The ESCMs considered in the ES refer to those currently used in ESCM day-by-day practice. The ES does not include ESCMs that are still under evaluation (e.g., compost-based ESCMs). Table 1 presents all the ESCMs contained in the ES knowledge base, listed in alphabetical order.

[3] BMP = Best Management Practice

Table 1. List of ES ESCMs

#	ESCM	Description
1	**Bench**	A slightly reverse sloping step on a back slope to reduce slope length.
2	**Berm ditches**	A temporary or permanent ridge of soil located to channel runoff water to planned location.
3	**Brush barriers**	Used in conjunction with filter fabric, filter sediment from runoff before leaving a site.
4	**Channel liners**	Control measure used to facilitate the establishment of a vegetative growth in a drainage way or as a protection prior to the placement of a permanent armoring.
5	**Channels**	A drainage way used to convey runoff through, along, or around an area. Conveying runoff in a channel that has an uninterrupted positive grade to the outlet.
6	**Check dam**	A small temporary barrier or dam constructed across a drainage ditch.
7	**Culverts**	Divert flood flows and redirect storm runoff to another area such as a basin or a trap.
8	**Detention basins**	Depressed areas that store runoff during wet weather and dry the rest of the time.
9	**Ditch checks**	Protect ditches from erosion and to filter sediment from flowing water.
10	**Diversions**	A temporary or permanent dike or berm located so water can be directed to planned location.
11	**Energy dissipaters**	An obstacle placed at the outlet of a drainage pipe or any other location that requires reduction of rapid water flow to prevent erosion.
12	**Filter berms**	A temporary ridge of porous material such as stone or gravel, that can be stabilized in rows, banks, or mounds.
13	**Filter strip**	A strip of grass planted at right angles to the flow of runoff.
14	**Flotation silt curtain**	A silt curtain used in a lake or pond to keep silt-laden water within the construction area.
15	**Infiltration trench**	A trench designed for the filtration of storm water and collection of sedimentation.
16	**Infiltration basin**	A depressed area with a vegetated bottom, similar to a dry pond. Used as storm water management designed to reduce the peak flow for a 2 to 10 year storm.
17	**Inlet protection**	Carries runoff water in an underground drainage system; used in conjunction with storm drain diversion measures.
18	**Matting**	A temporary erosion control practice used for the establishment of vegetation that helps protect seeding and increase germination.
19	**Mulching**	Applying plant residue or other suitable material to protect the soil surface.
20	**Outlet protection**	An apron or other energy dissipating device placed at the outlet of a drainage pipe.
21	**Permanent seeding**	Permanent seeding of lawn grasses and tall grass mixtures used as an effective method of controlling long term erosion.

22	**Retaining walls**	A constructed wall used to assist in the stabilization of cut or fill slopes where permissible slopes cannot be obtained without the use of a wall.
23	**Retention pond**	A permanent pool of water that has the capacity to store storm water until it is released from the structure.
24	**Revetment flume**	A device used to transport water in a structure to a lower level without erosion.
25	**Sediment basin**	A basin created by excavating and/or building a dam across a waterway. A sediment basin usually consists of a dam, a pipe outlet, and an emergency spillway.
26	**Serrated cut**	Stairstep grading used in soils containing large amounts of soft rock which may be impossible or impractical to smooth grade.
27	**Shoulder drains**	Used during fill slope construction for the purpose of conveying flow from the roadway surface level down to the toe of slope.
28	**Shrubs**	Used for the control of surface drainage and soil and wind erosion.
29	**Silt fence**	A temporary barrier of geotextile fabric used to intercept sediment on small drainage areas. This is one of the most convenient ESCM.
30	**Slope/Terrace**	Used to intercept and convey surface runoff at a non-erosive velocity to a suitable outlet and to retain runoff for moisture conservation.
31	**Sodding**	Used to cover bare soil with cut sod (usually bluegrass) in order to provide rapid ground cover and stabilization of the soil. Often used in waterways and flumes.
32	**Straw bales**	Are used to filter sediment from runoff in sheet flow applications.
33	**Surface roughening**	Used to provide a rough finish on clay soils. This procedure should generally be used after the fall seeding period has passed.
34	**Temporary sediment trap**	A depressed area in a drainage location that allows the runoff to slow and the silt to settle.
35	**Temporary seeding**	Seeding grasses and legumes planted on disturbed areas of soil. Grass cover is the most effective method of controlling erosion.
36	**Temporary slope drain**	A structure (metal or flexible pipe) used to carry runoff water from the top of a slope to the bottom.
37	**Top soiling**	Salvaged topsoil placed over subsoils that provides a growing media for establishing a cover of grass.
38	**Trees**	Used for the control of surface drainage, soil and wind erosion.
39	**Under drains**	A perforated conduit such as pipe, tubing, or tile installed beneath the ground to intercept and convey ground water.
40	**Vines and ground covers**	Used for the control of surface drainage and soil and wind erosion.

3.3.6. *ESCM Specifications*

The ES provides *in one place* all the elements needed for the user to select the best ESCM option. At this point in time, due to the limited resources available for the project, the descriptive elements regarding each ESCM are provided as citations of reference(s), including the page where the specific information can be found. Despite of the extensive literature used for compiling the present ES, the references are limited to those used by the Iowa DOT (IDOT), as well as Iowa county and municipal engineers. This limit is used because of considerations of accessibility and technical acceptance by DOT, county, and municipal engineers. Future development of the ES will include detailed Plan Notes, Special Provisions, Supplemental and Standard Specifications for each ESCM. It is envisioned that the ES will use direct links to existing internet information or may duplicate the information in an electronic format.

Each ESCM is characterized by specific considerations related to the following ESCM implementation aspects:

- Planning: developing erosion and sediment control plans requires multiple iterations through the database to address the different stages of roadway construction; i.e., initial phase, intermediate phase, final phase, and coordination with transportation and other agencies
- Design
- Construction
- Inspection/maintenance/stabilization/removal
- Efficiency (advantages/disadvantages, obstacles, field experiences); most of the input in this category stems from the Iowa County engineers survey
- Compliance requirements
- Payment unit

3.3.7. *Permitting*

The U.S. Environmental Protection Agency, under the Clean Water Act, requires that discharges of storm water from construction sites (including highways) which disturb more than 20,234 m^2 (5 acres, 2 ha) of land must be covered by a National Pollutant Discharge Elimination System (NPDES) permit. Phase II of the federal NPDES permitting process (compulsory by March 8, 2003) will reduce the size of the disturbed area to 4050m^2 (1 acre, 0.405 ha). For these projects, IDOT is responsible for preparing and implementing a Storm Water Pollution Prevention Plan (SWPPP) to be submitted to Iowa Department of Natural resources (DNR).

The six major phases for the development of a SWPPP in conjunction with ESCMs are:

- Site evaluation and design development
- Assessment
- Control selection and plan design
- Certification and notification
- Construction and implementation
- Final stabilization and discontinuation

ES's knowledge database addresses the technical aspects of ESCM selection within the framework of SWPPP development. For user convenience the ES includes the set of checklists as described in Iowa's General Permit No.2 for the development of the pollution prevention plan. All the information included in ES is needed for developing a pollution prevention plan. Currently, the ES does not include all the elements necessary for preparing SWPPP. The missing elements are runoff water quality, type of receiving body of water, and waste disposal controls. Those elements might affect the selection of an ESCM, however not as much as would the technical considerations. Runoff water quality information can be obtained from various agencies including the U.S. Geological Survey, State, or local watershed protection agencies. Identification of the name and the location of the body of water that will receive the runoff from the highway construction site is usually available from county, State, or USGS maps. Construction of roads may require the use of toxic or hazardous materials such as petroleum products, pesticides and herbicides. Proper disposal of construction-site waste must comply with the pertinent regulations (state or local waste disposal sanitary sewer or septic system regulations, control of offsite vehicle tracking, and control of allowable non-storm water discharges). The elements presently not in the ES can be added during a subsequent developmental stage, so that the ES includes all elements required by the pollution and prevention plan.

The information contained in the ES is collected from a wide variety of sources. Various documents may be referenced in the ES, but not included due to possible concerns for copyright infringement. It shall be the responsibility of the user to secure those documents as needs dictate. Note that some of the Manuals and Standard specifications referred in the database can only be obtained by purchasing. The ES knowledge base is subject to periodic revision and it shall be the responsibility of the user to ascertain the document being used is the most current edition. The ES version shown in this project contains the most current information.

3.4. ES structure and analytical rules

The ES attempts to incorporate, within its inference engine, specific rules and facts applied to the knowledge base in order to lead the user to the selection of ESCMs. The elements of the database are connected through "strings" and "logical" connections. The list of the connections in the database is provided in Table 2. That table has more than 30 logical fields. Each logical field corresponds to the selection of a step (i.e., A, B, C, etc). For example, A2 field corresponds to the selection of the second option in Step A, i.e., 'Transitional'. Therefore, if one measure can be used as a 'transitional' measure, this field should be marked 'true'. The default setting for all database cells is 'true'. As the user makes the Input selection, the program validates/cancels the default setting. Selection is based on those connections that remain "true" after the dialog.

The rules and facts are based on the literature review and analytical judgment. The following dependencies are incorporated in the ES rules:

- conventional classifications
    - Type (duration) of the ESCM
    - Purpose of ESCM
    - Erosion type
- permitting requirements are related to drainage are extent, ESCM construction, inspection, maintenance, removal
- ESCMs are related to the roadway construction phase
- slope steepness and length are related to erosion potential
- safety and aesthetical consideration are related to the area type
- control measures are related according to their nature (ECM, SCM, ESCM, SWMCM) to the appropriate analytical rules

The ES's interfaces enable users to pose queries and to interact with the ES. The interfaces provide general and detailed information in each step to facilitate understanding of interface terminology and selection justification.

Table 2. ES Rules

Parameter/Specifications	Dependencies
ES INPUT INFORMATION	**Multi-dimensional**
A. Type of erosion or sediment control	
A.1. Short term (0-6 months)	
A.2. Transitional (6-12 months)	
A.3. Permanent (> 12 months)	
A.4. Transitional and permanent (> 6 & > 12 months)	
B. Erosion control objective	
B.1. Erosion Control Measure (ECM)	
B.1.(a). Slope Protection/Stabilization	A.1, A.2, A.3, A.4
B.1.(b). Borrow and Stockpile Protection	A.1 and A.2
B.1.(c). Stream Bank Protection	A.1 and A.3
B.2. Sediment Control Measure (SCM)	
B.2.(a). Perimeter Control	A.1 and A.2
B.2.(b). Sediment Trapping	A.1 and A.3
B.2.(c). Water/Runoff Conveyance	A.1 and A.3
B.3. Erosion and Sediment Control Measure (ESCM)	A.1, A.2, A.3, A.4
B.3. (a) Roadway ditches	A.1, A.2, A.3, A.4
B3. (b) Swales	A.3
B3. (c) Energy dissipation structures	A.1, A.2, A.3, A.4
B.4. Storm Water Management Control (SWMCM)	A.3
C. Area type	
C.1. urban	As and Bs
C.2. semi-urban	As and Bs
C.3. rural	As and Bs
D. Drainage area extent	
D.1. < 20,234 m^2 (5 acres, 2 ha)	No NPDES permit
D.2. > 20,234 m^2 (5 acres, 2 ha)	NPDES permit
Quantitative parameter assessment*	Not implemented
E. Soil erodibility	
Qualitative parameter assessment*	

E.1. A	
E.1. B	
E. 1. C	
E. 1. D	
Quantitative parameter assessment	Not implemented
E. Grade slope (steepness and length)	
Qualitative assessment:	
F.1. (a) 0-3%	Low erosion potential
F.1. (b) 3-8%	Medium erosion potential
F.1. (c) > 8%	High erosion potential
Quantitative parameter assessment	Not implemented
F.1 Climate	
Qualitative assessment	Iowa climate***
Quantitative parameter assessment	Not implemented
F.3 % drainage area covered by ground/vegetation	
Quantitative parameter assessment	Not implemented
F.4 Land use	
Quantitative parameter assessment	Not implemented
G. Types of water erosion	
G.1 Sheet	B.1.(a) or B.1(b).
G.2 Splash	B.1.(a) or B.1(b).
G.3 Gully	B.2.
G.4 Rill	B.2.
G.5 Stream bank	B.1.(c)
H. Sediment yield & Water runoff estimation	
Sediment yield equation	A.1 or A.2 and B.1.(a) or B.1.(b), B.2.(a), B.2.(b) Not implemented
Water runoff equation	A.3 or A.4 and B.2. (c) or B.3 Not implemented
ES OUTPUT INFORMATION	
I. Recommended Erosion & Sediment Control Measure	ESCM(s) selected by ES based on all the above dependencies
J. ESCM Planning	- Reference(s), Page - Checklist
K. ESCM Design	- Reference(s), Page - Checklist
L. ESCM Construction	- Reference(s), Page - Checklist - Permit requirements
M. ESCM inspection/maintenance/stabilization/removal	- Reference(s), Page - Checklist - Permit Requirements
N. ESCM efficiency (advantages/disadvantages, obstacles, field experiences)	- Reference(s), Page - IA County Engineers survey input
O. ESCM Compliance requirements	List of regulatory agencies
P. Payment unit	Payment units provided

* Function to be implemented in the ES by addition of an interactive estimation engine

** Based on gross estimation of the parameter effect

*** Only ESCMs relevant to Iowa climate were included in the ES

The ES relates the type of erosion and sedimentation processes to a principle upon which an ESCM is based. For example, sediment from sheet and rill erosion can be normally controlled by land treatment measures, such as land grading and vegetation, whereas sediment derived form channel-type erosion usually requires structural measures (SCMs). The main variables involved in quantitative estimation pf the erosion and sedimentation processes are sediment yield and water runoff. Sediment yield is related to the amount of dislocated material due to erosion and subsequent transport from the site. Water runoff is an important parameter for the selection and design of the erosion structural measures. No equation presently exists whereby an erosion control planner can determine the most cost-effective solution to a specific erosion problem. There are, though, relationships to calculate sediment yield for different type of erosion processes and similar relationships for water runoff calculation.

Erosion and Sedimentation. It is important to distinguish between erosion and sediment yield. Erosion is the process by which soil particles are detached by water or wind. Sediment yield (sedimentation) is the amount of eroded sediment transported through the drainage area. Sediment yield is the most important factor for consideration, because predicted erosion rates are generally smaller due to deposition, slope change, etc. It is sediment yield, which causes off-site, water quality problems.

There are a number if approaches to determine the sediment yield from a watershed. They depend on watershed environment and the data available (IECA, 1993). A typical relationship is the Universal Soil Loss Equation, which is suitable for estimation of sheet and rill erosion processes (IECA, 1993);

$$A = R \times K \times L \times S \times C \times P$$

where A is the average annual rate of erosion (tons/acre/year), R is the rainfall factor, K is the soil erodibility factor, L is the slope length, S is the slope gradient, C is the cover factor, and P is the conservation practice. Similar predictive equations are available for estimation of gully, channel, and strembank erosion.

Water Runoff. There are several methods for estimation of storm runoff discharge. One of the most-often used methods for small drainage areas (A < 200 acres) is the *rational formula*;

$$Q = C´\ i\ ´\ A$$

where Q is the runoff discharge (acre-inch per hour $\cong$ 1 ft^3/sec), i is the rainfall intensity (inches per hour for a duration corresponding to the concentration time T_c), and A is the drainage area (acres). Tc is given by

$$T_c = \frac{0.0663 L^{0.77}}{S^{0.385}}$$

where Tc (hours), L is the slope length (kilometers), and S is the slope steepness. The runoff coefficient, C, is an estimate of the fraction of total rainfall that will appear as runoff. Runoff coefficients for sites with more than one land use are estimated by calculating a weighted average (based upon the area) of the runoff coefficients for each land use. For large areas use specialized references (Simon and Korom, 1997).

When the sediment erosion and runoff equations will be implemented, the user has to identify the sources of sediment, determine the rates of erosion from each type of source, and establish the relative contribution of each source to the total. Based on this input, the ES evaluates what ESCM treatment or mitigating approach should be recommended to reduce the sediment yield. Moreover, the ES evaluates the relative effects the mitigating measures will have in reducing sediment yield and damages. Hard numbers can be develop for some variables, but, when comparing dissimilar technologies, more subjective considerations sometime influence the decision making process.

3.5. Selection process

The ES leads the user through a step-wise process comprising the following steps and sequence:

INPUT INFORMATION

Step 1. Identify issues and concerns (regulatory environment, public opinion)
Step 2. Develop goals and objectives
Step 3. Evaluate erosion potential (area size, topography, soil erodibility, existing ground/vegetation, land use)

OUTPUT INFORMATION

Step 4. Nominate and evaluate alternative ESCMs
Step 5. Screen and select best ESCM
Step 6. ESCM Plan/design
Step 7. ESCM Construct
Step 8. ESCM Monitoring/maintenance/stabilization/removal
Step 9. Miscellaneous information (ESCM efficiency, compliance requirements, payment unit)

ES sequence: 1 – 2 – 3 – 5 – 6 - 7 – 8 – 9. As there is no universal agreement regarding what constitutes an optimal solution for a particular situation of erosion and sedimentation, selecting ESCMs from the suggested list must be based on users' judgment and experience for similar conditions. The ultimate selection of an appropriate ESCM for a particular situation is made by the user in step 4.

In addition to the suggested ESCMs made by ES in step 4, the user's final ESCM selection should consider the following objectives:

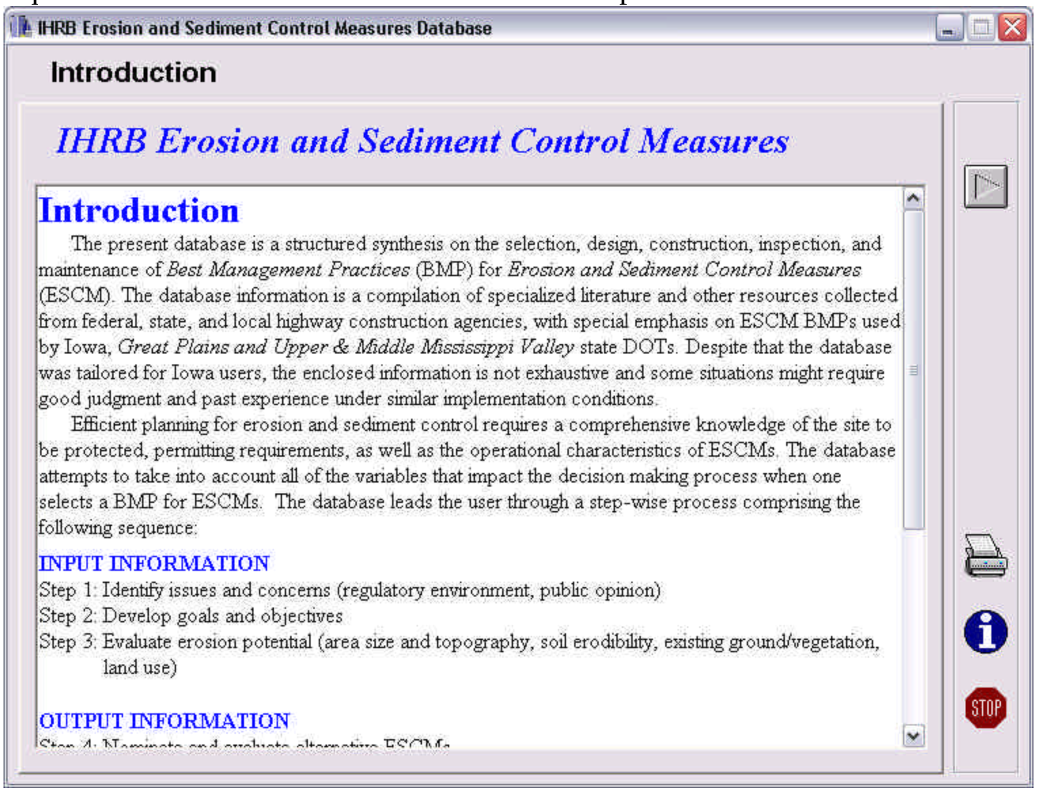
- limit both on-and off-site impacts to acceptable levels
- facilitate project construction while minimizing construction and maintenance costs
- be simple to construct
- minimize interruption to normal construction procedures and operations
- ensure safe operation of the features protected

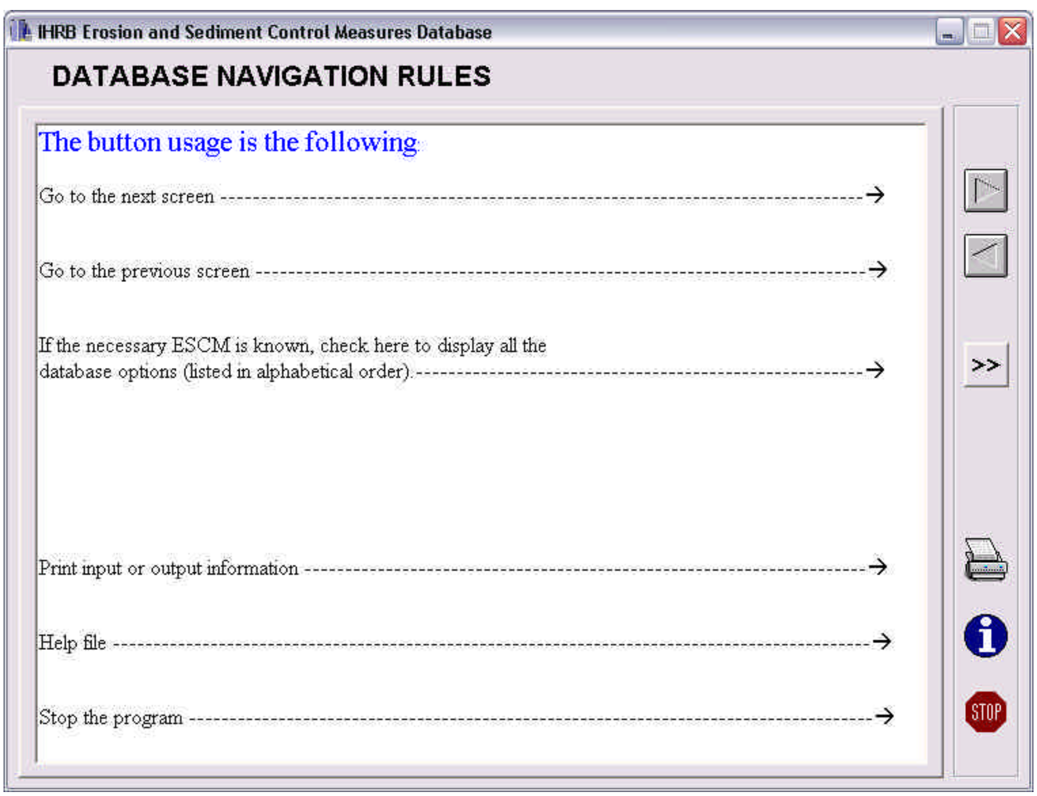
The configuration of the ES is such that Step 4 (Nominate and evaluate alternative ESCMs) is organized in one layer (interface). This feature enables the user to view all the suggested ESCMs on the same screen. Moreover, the specifications for the selected ESCM are contained in the same layer. This single-layer configuration allows quick and efficient comparison of similar specifications for the suggested ESCMs.

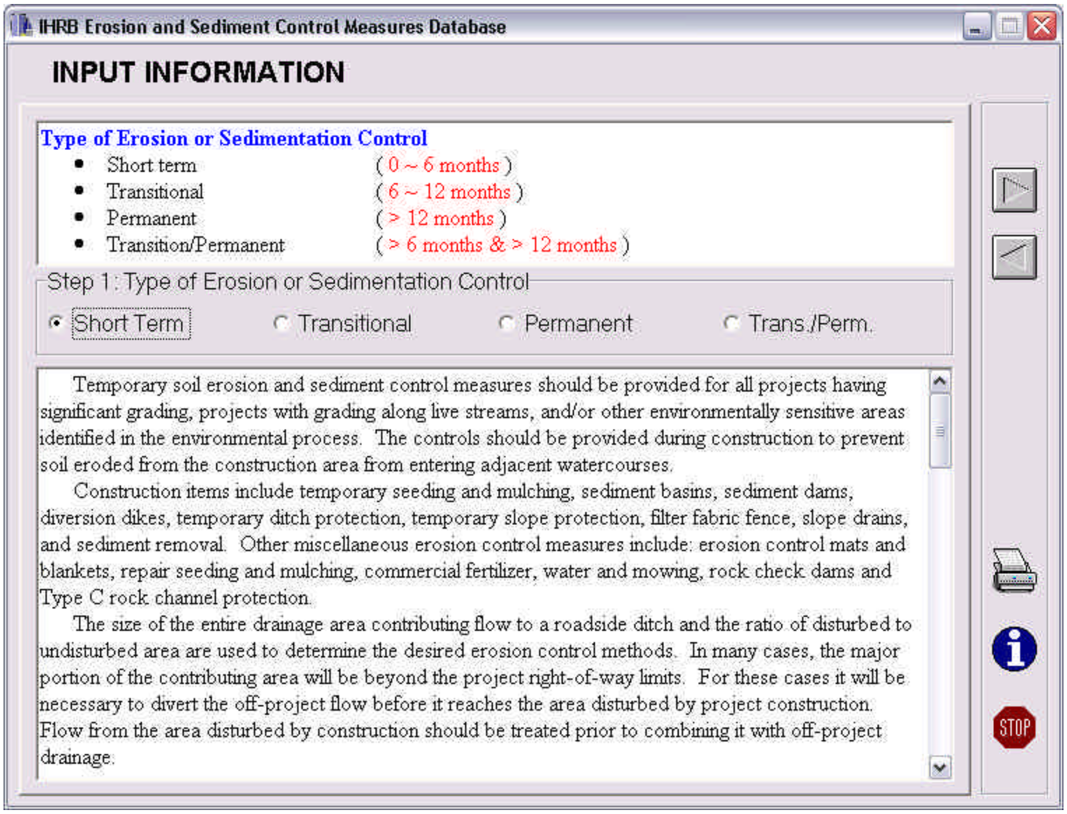
An additional feature is incorporated in the ES for experienced users. In the first steps of ES navigation, users who are knowledgeable upfront of the ESCMs likely needed for the protection project at a specific site can directly select the ESCMs necessay for their project plan. Similar to a design manual, the ES conveniently provides all the pertinent information available in the relevant literature.

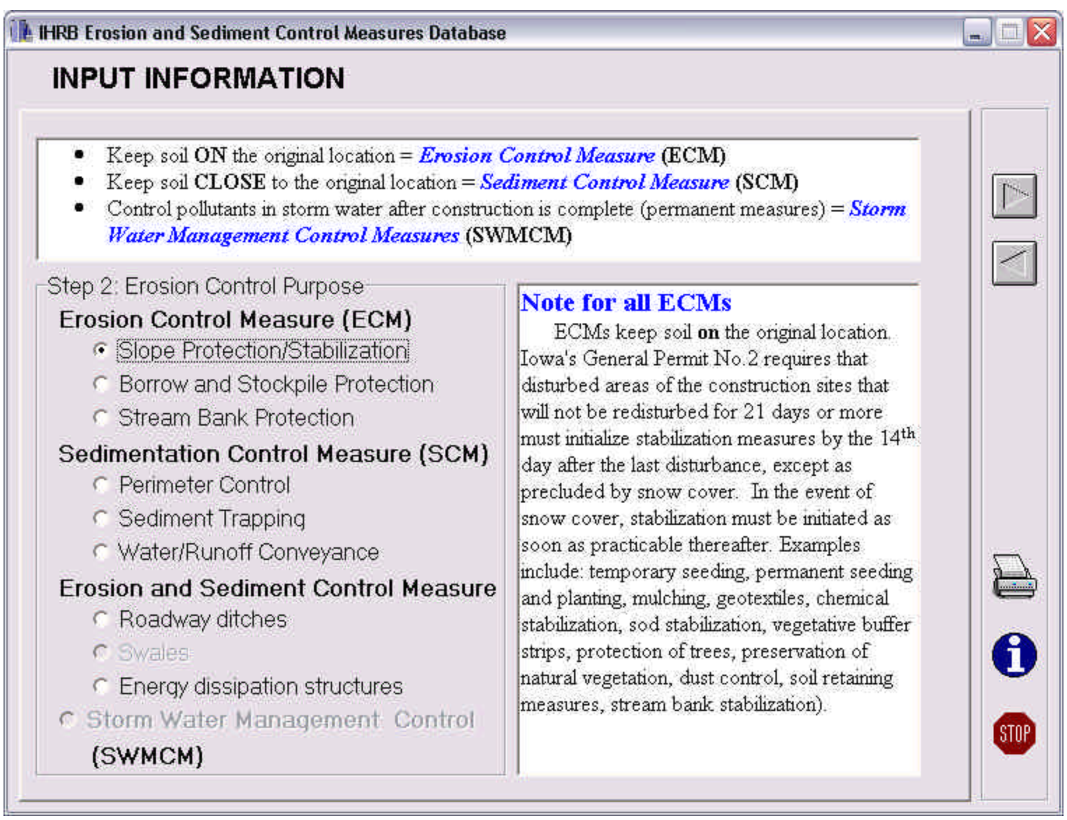
4. SAMPLE OF EXPERT SYSTEM NAVIGATION

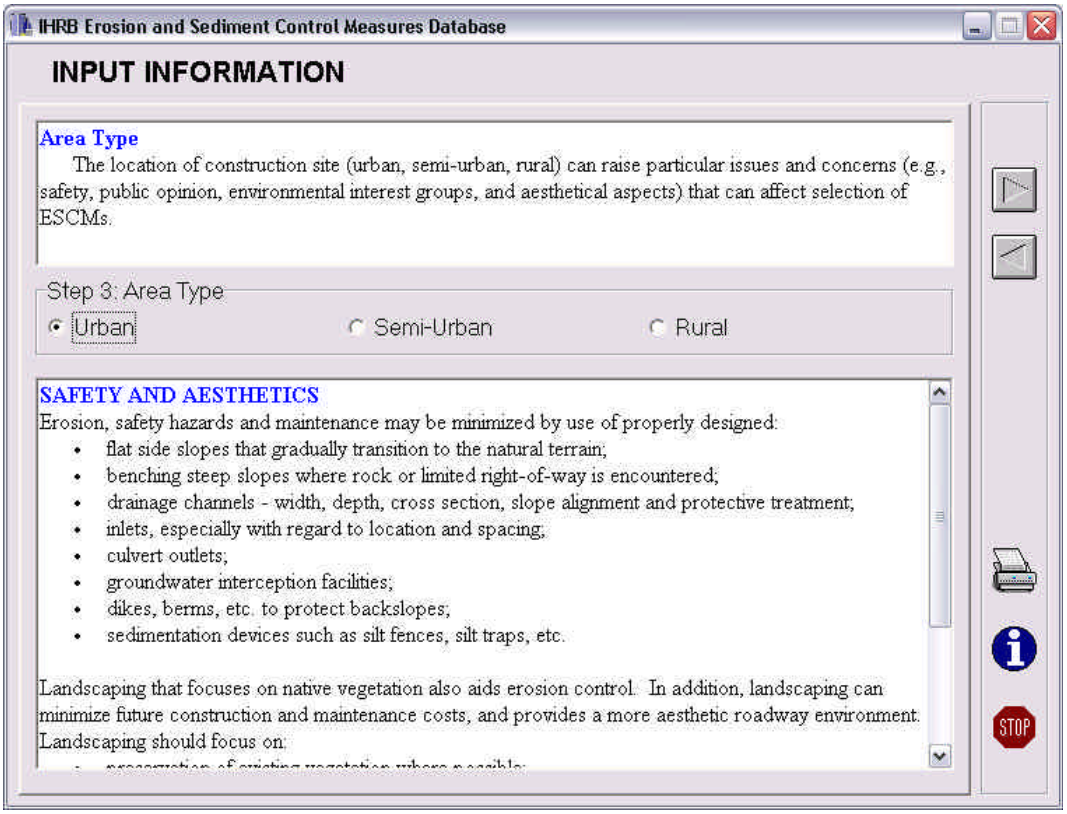
A sequence of ESCM selection and documentation is provided below:

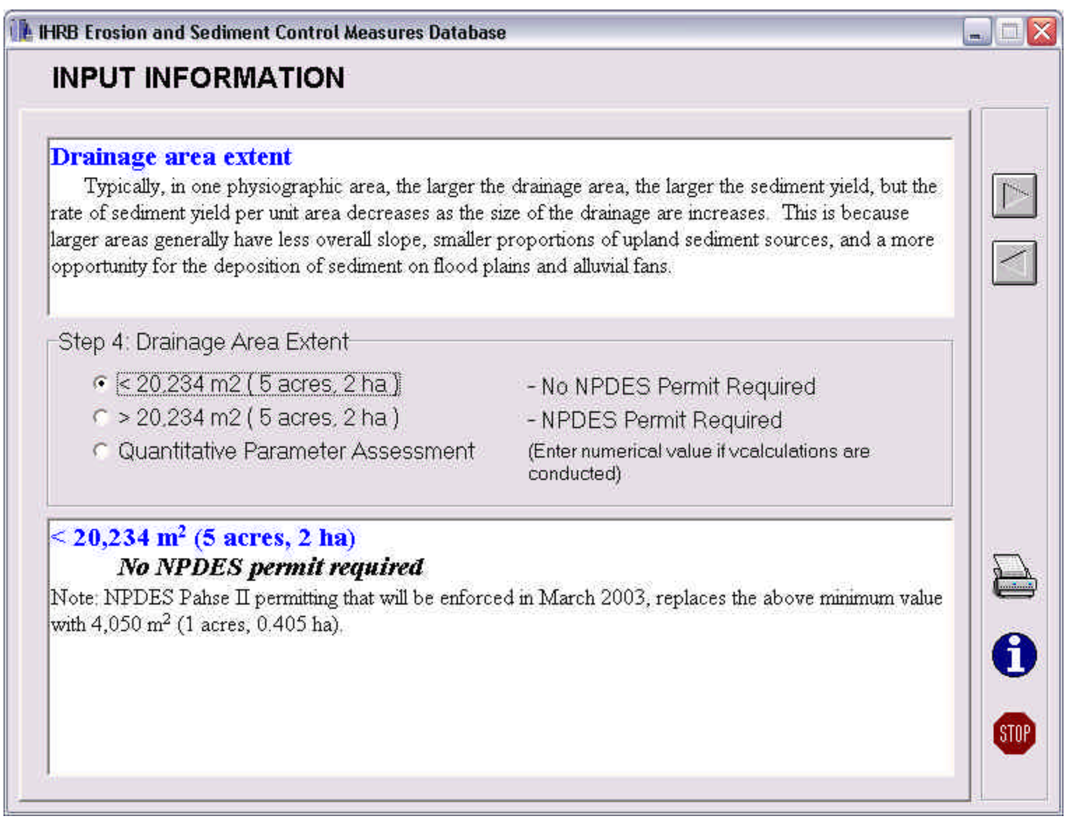


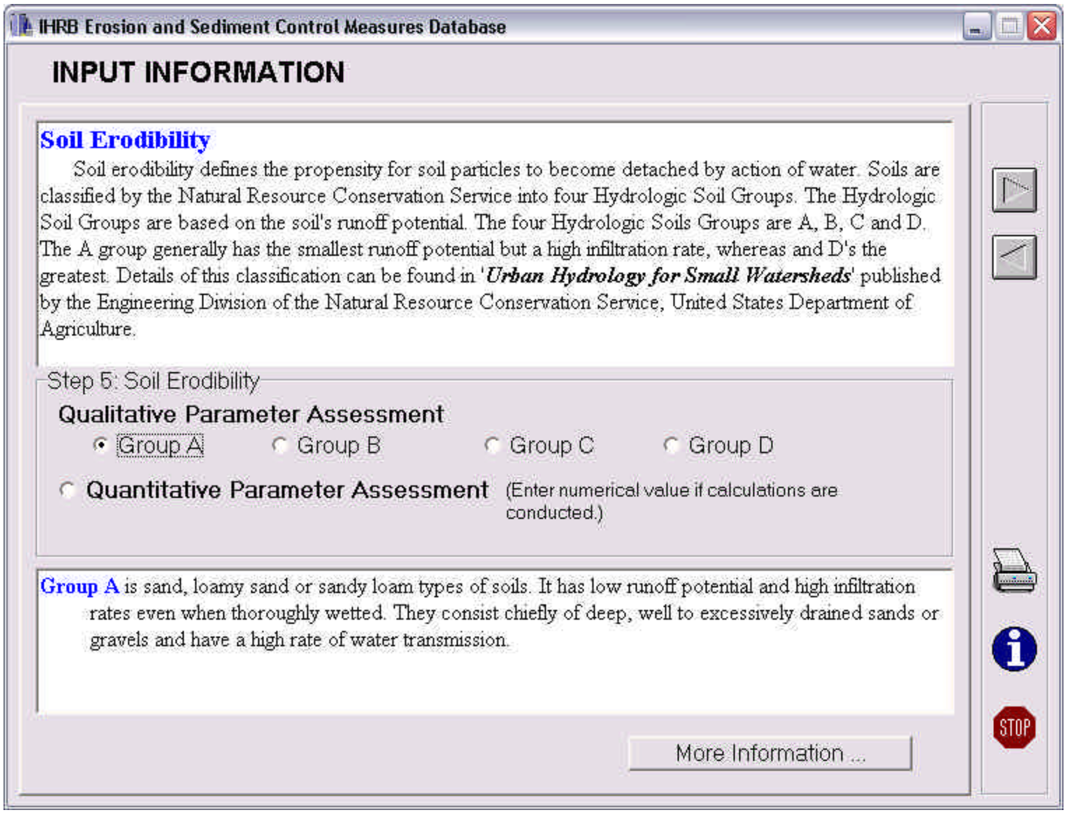


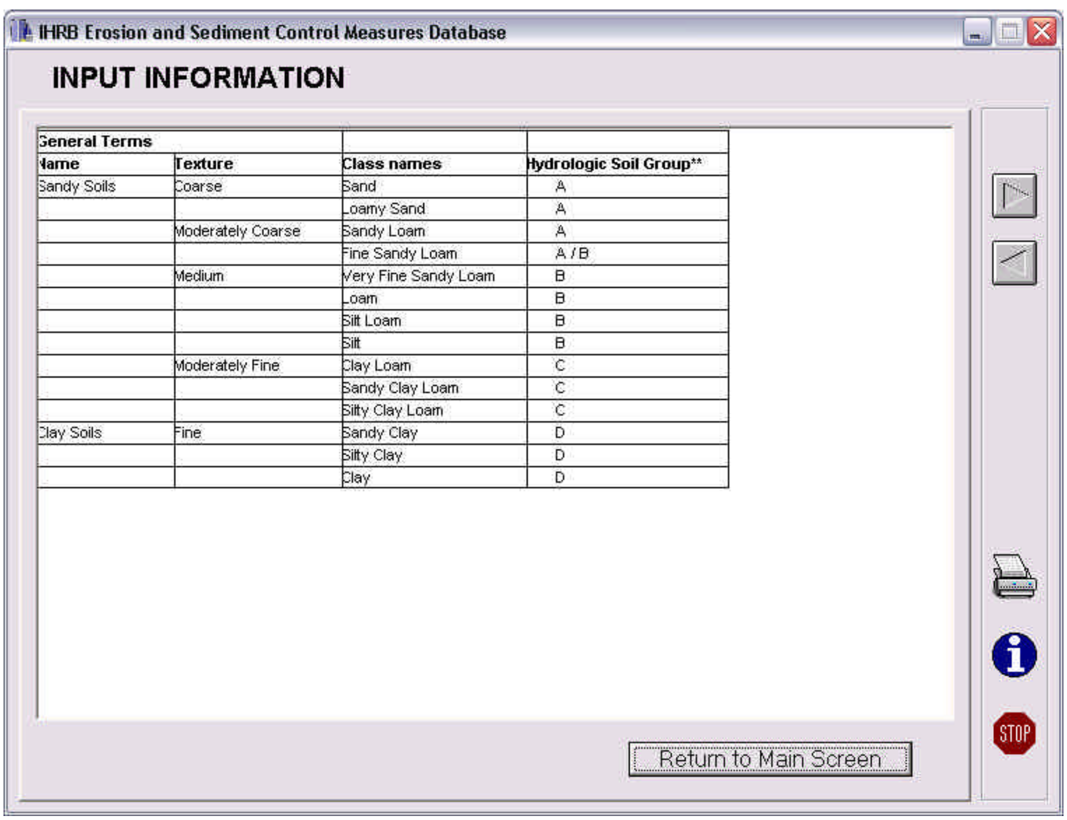

IHRB Erosion and Sediment Control Measures Database
INPUT INFORMATION
Type of Erosion or Sedimentation Control
Short term (0 ~ 6 months)
Transitional (6 ~ 12 months)
Permanent (> 12 months)
Transition/Permanent (> 6 months & > 12 months)
Step 1: Type of Erosion or Sedimentation Control
Short Term
Transitional
Permanent
Trans./Perm.
Temporary soil erosion and sediment control measures should be provided for all projects having significant grading, projects with grading along live streams, and/or other environmentally sensitive areas identified in the environmental process. The controls should be provided during construction to prevent soil eroded from the construction area from entering adjacent watercourses.
Construction items include temporary seeding and mulching, sediment basins, sediment dams, diversion dikes, temporary ditch protection, temporary slope protection, filter fabric fence, slope drains, and sediment removal. Other miscellaneous erosion control measures include: erosion control mats and blankets, repair seeding and mulching, commercial fertilizer, water and mowing, rock check dams and Type C rock channel protection.
The size of the entire drainage area contributing flow to a roadside ditch and the ratio of disturbed to undisturbed area are used to determine the desired erosion control methods. In many cases, the major portion of the contributing area will be beyond the project right-of-way limits. For these cases it will be necessary to divert the off-project flow before it reaches the area disturbed by project construction. Flow from the area disturbed by construction should be treated prior to combining it with off-project drainage.
STOP


IHRB Erosion and Sediment Control Measures Database
INPUT INFORMATION
Keep soil ON the original location = Erosion Control Measure (ECM)
Keep soil CLOSE to the original location = Sediment Control Measure (SCM)
Control pollutants in storm water after construction is complete (permanent measures) = Storm Water Management Control Measures (SWMCM)
Step 2: Erosion Control Purpose
Erosion Control Measure (ECM)
Slope Protection/Stabilization
Borrow and Stockpile Protection
Stream Bank Protection
Sedimentation Control Measure (SCM)
Perimeter Control
Sediment Trapping
Water/Runoff Conveyance
Erosion and Sediment Control Measure
Roadway ditches
Swales
Energy dissipation structures
Storm Water Management Control (SWMCM)
Note for all ECMs
ECMs keep soil on the original location. Iowa's General Permit No.2 requires that disturbed areas of the construction sites that will not be redisturbed for 21 days or more must initialize stabilization measures by the 14th day after the last disturbance, except as precluded by snow cover. In the event of snow cover, stabilization must be initiated as soon as practicable thereafter. Examples include: temporary seeding, permanent seeding and planting, mulching, geotextiles, chemical stabilization, sod stabilization, vegetative buffer strips, protection of trees, preservation of natural vegetation, dust control, soil retaining measures, stream bank stabilization).
STOP

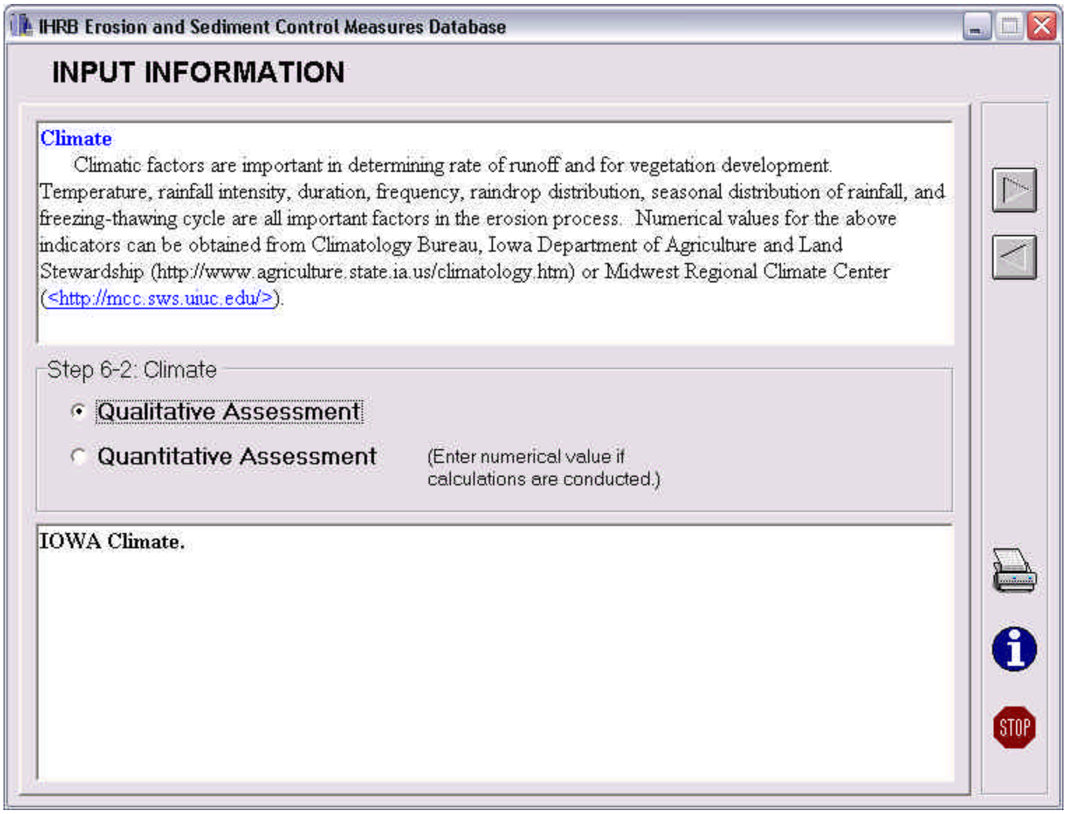

IHRB Erosion and Sediment Control Measures Database
INPUT INFORMATION
Area Type
The location of construction site (urban, semi-urban, rural) can raise particular issues and concerns (e.g., safety, public opinion, environmental interest groups, and aesthetical aspects) that can affect selection of ESCMs.
Step 3: Area Type
Urban
Semi-Urban
Rural
SAFETY AND AESTHETICS
Erosion, safety hazards and maintenance may be minimized by use of properly designed:
• flat side slopes that gradually transition to the natural terrain;
• benching steep slopes where rock or limited right-of-way is encountered;
• drainage channels - width, depth, cross section, slope alignment and protective treatment;
• inlets, especially with regard to location and spacing;
• culvert outlets;
• groundwater interception facilities;
• dikes, berms, etc. to protect backslopes;
• sedimentation devices such as silt fences, silt traps, etc.
Landscaping that focuses on native vegetation also aids erosion control. In addition, landscaping can minimize future construction and maintenance costs, and provides a more aesthetic roadway environment.
Landscaping should focus on:
STOP

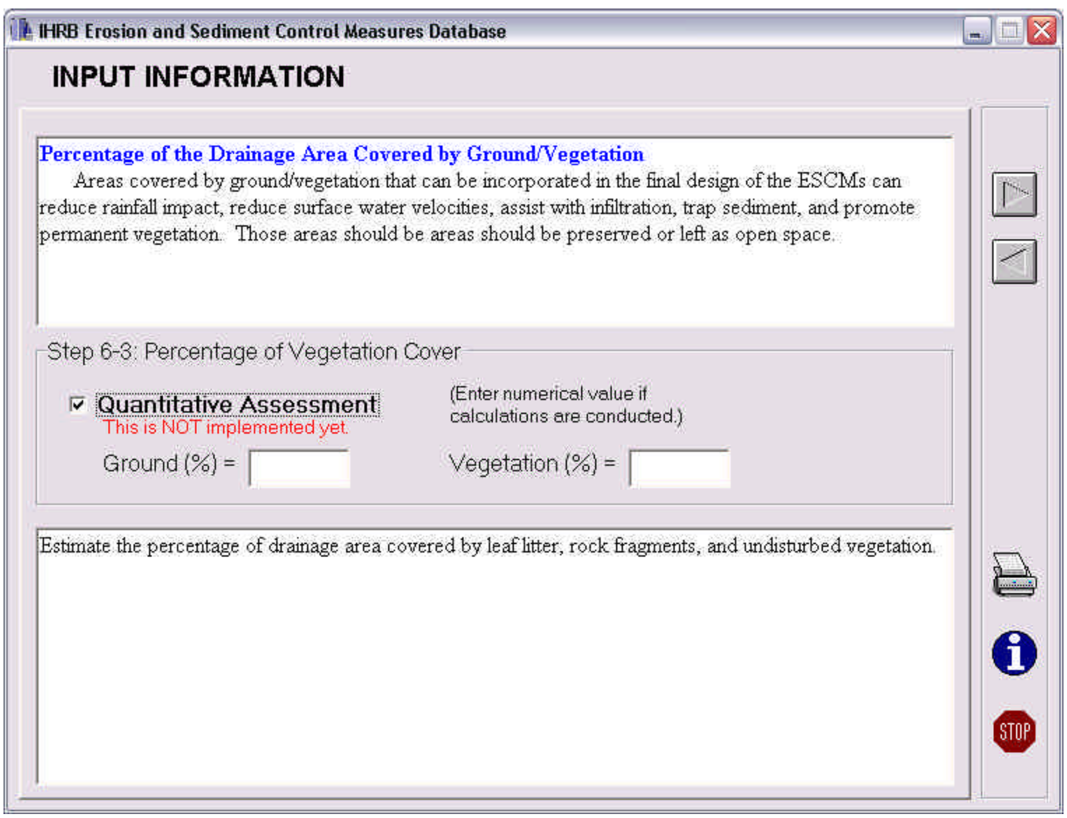

IHRB Erosion and Sediment Control Measures Database
INPUT INFORMATION
Drainage area extent
Typically, in one physiographic area, the larger the drainage area, the larger the sediment yield, but the rate of sediment yield per unit area decreases as the size of the drainage are increases. This is because larger areas generally have less overall slope, smaller proportions of upland sediment sources, and a more opportunity for the deposition of sediment on flood plains and alluvial fans.
Step 4: Drainage Area Extent
< 20,234 m2 (5 acres, 2 ha)
- No NPDES Permit Required
> 20,234 m2 (5 acres, 2 ha)
- NPDES Permit Required
Quantitative Parameter Assessment
(Enter numerical value if vcalculations are conducted)
< 20,234 m² (5 acres, 2 ha)
No NPDES permit required
Note: NPDES Pahse II permitting that will be enforced in March 2003, replaces the above minimum value with 4,050 m² (1 acres, 0.405 ha).
STOP

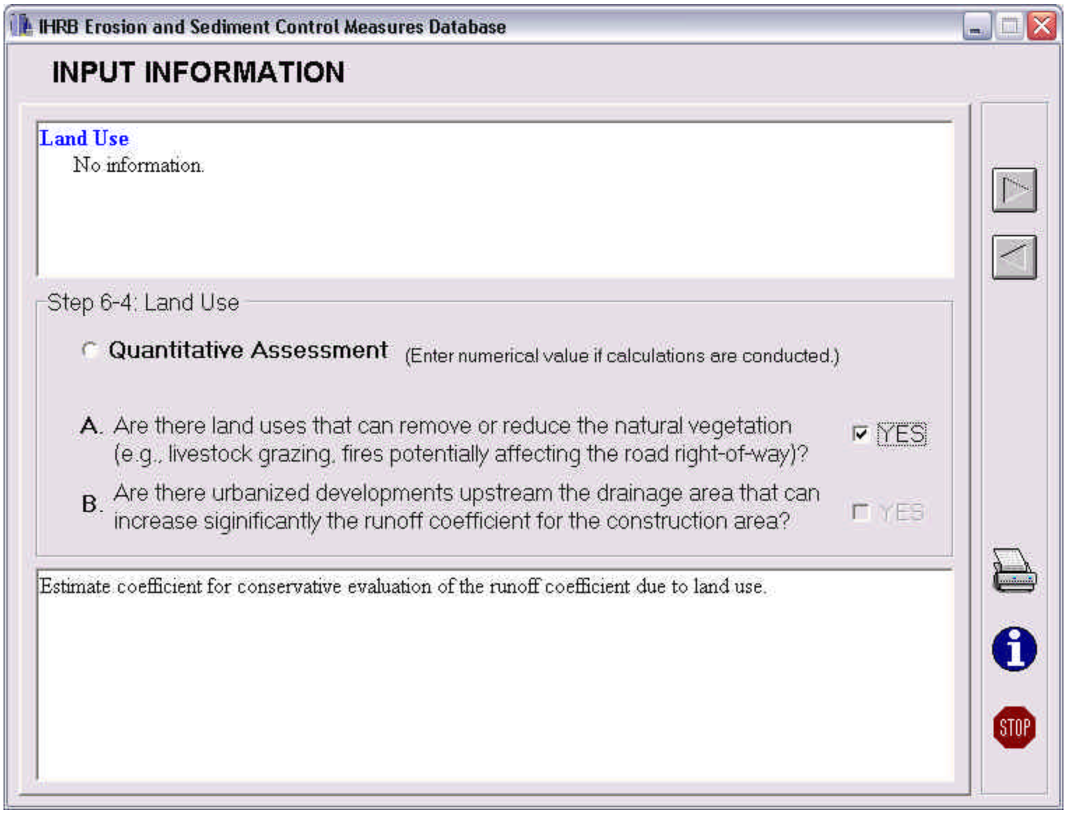


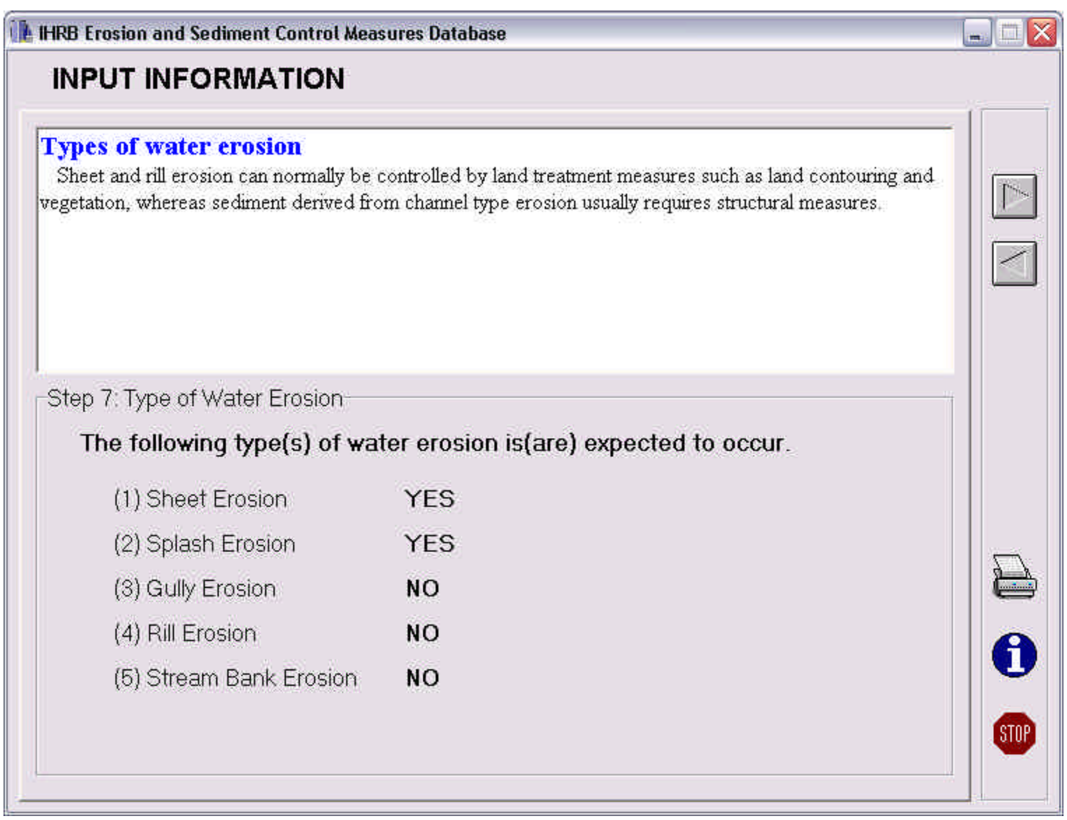


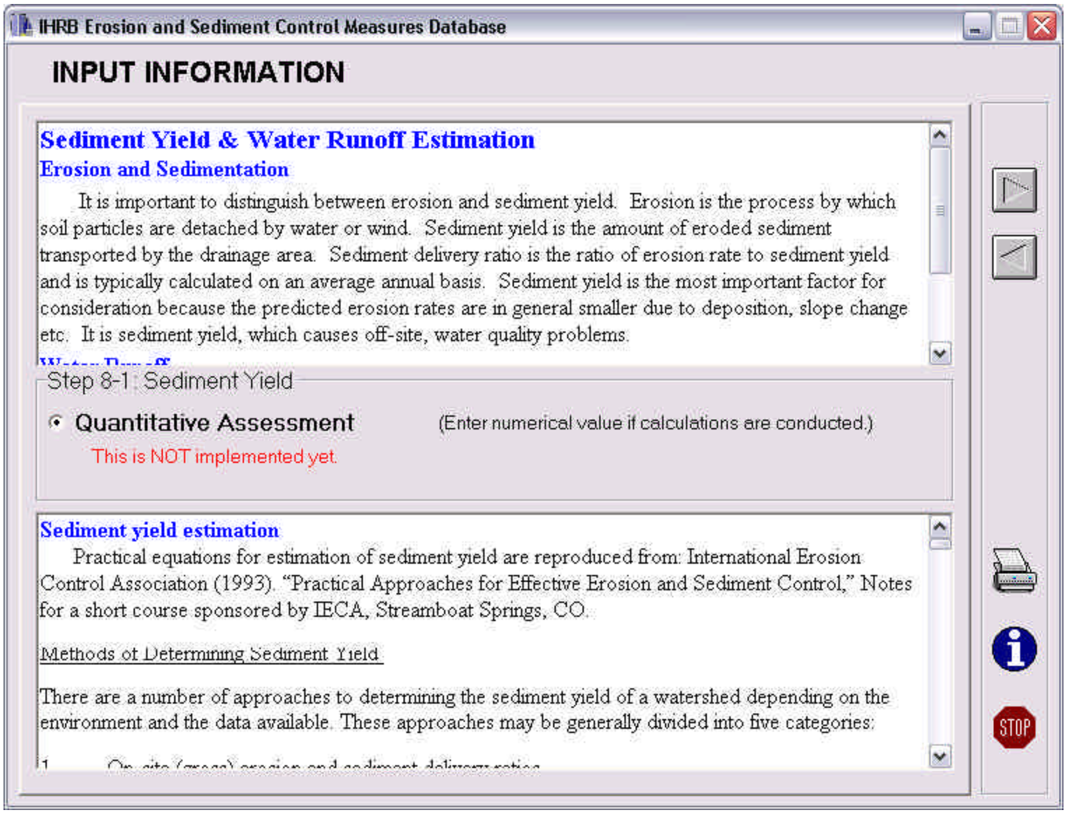
General Terms			
Name	Texture	Class names	Hydrologic Soil Group**
Sandy Soils	Coarse	Sand	A
		Loamy Sand	A
	Moderately Coarse	Sandy Loam	A
		Fine Sandy Loam	A / B
	Medium	Very Fine Sandy Loam	B
		Loam	B
		Silt Loam	B
		Silt	B
	Moderately Fine	Clay Loam	C
		Sandy Clay Loam	C
		Silty Clay Loam	C
Clay Soils	Fine	Sandy Clay	D
		Silty Clay	D
		Clay	D

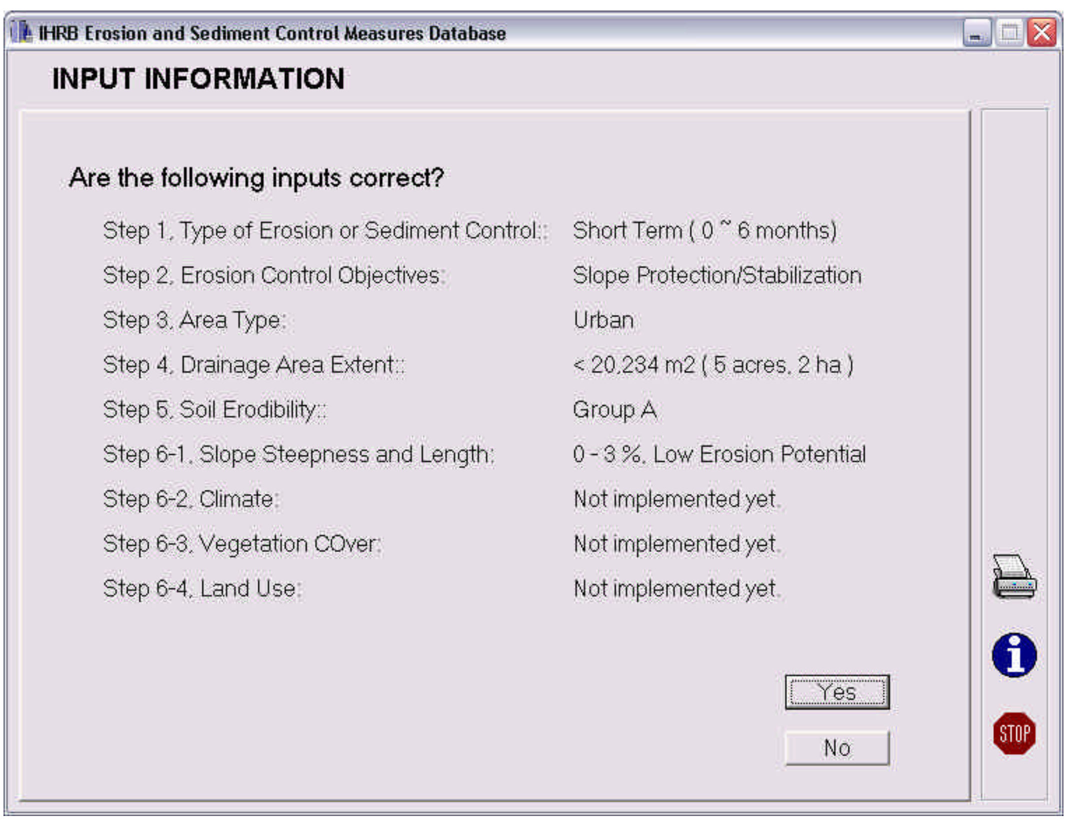

IHRB Erosion and Sediment Control Measures Database
INPUT INFORMATION
Climate
Climatic factors are important in determining rate of runoff and for vegetation development. Temperature, rainfall intensity, duration, frequency, raindrop distribution, seasonal distribution of rainfall, and freezing-thawing cycle are all important factors in the erosion process. Numerical values for the above indicators can be obtained from Climatology Bureau, Iowa Department of Agriculture and Land Stewardship (http://www.agriculture.state.ia.us/climatology.htm) or Midwest Regional Climate Center (<http://mcc.sws.uiuc.edu/>).
Step 6-2: Climate
Qualitative Assessment
Quantitative Assessment
(Enter numerical value if calculations are conducted.)
IOWA Climate.
STOP

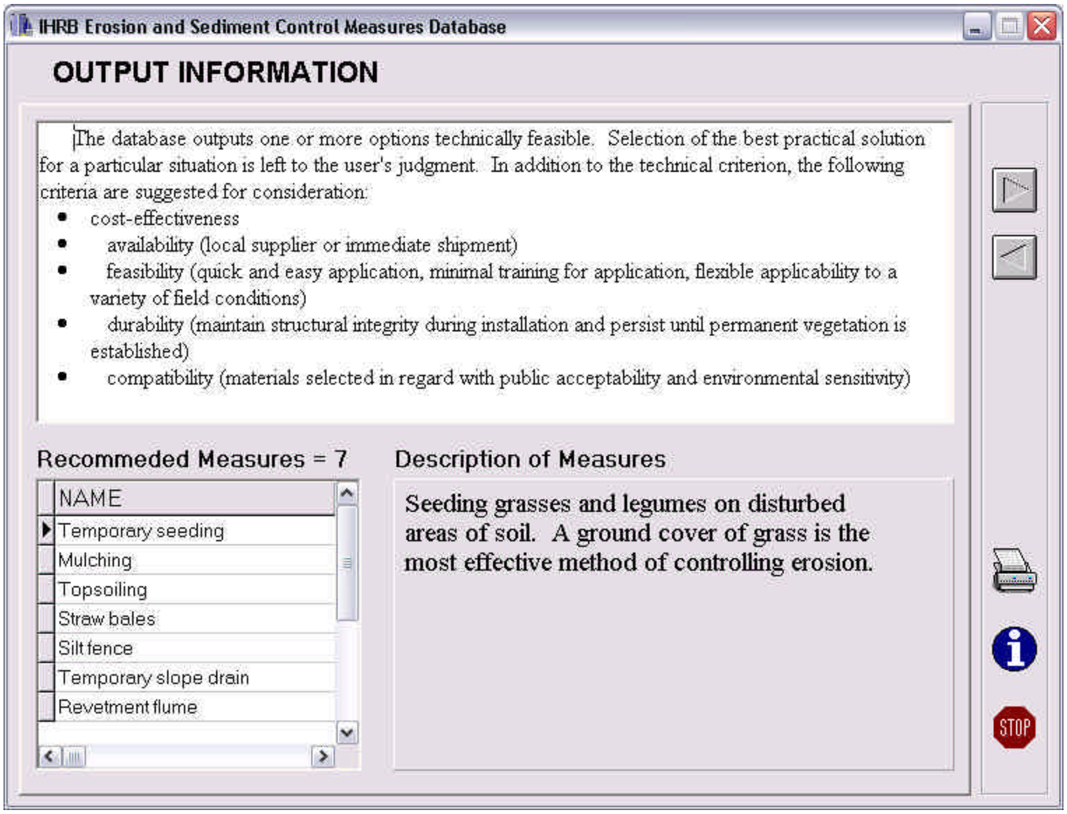

IHRB Erosion and Sediment Control Measures Database
INPUT INFORMATION
Percentage of the Drainage Area Covered by Ground/Vegetation
Areas covered by ground/vegetation that can be incorporated in the final design of the ESCMs can reduce rainfall impact, reduce surface water velocities, assist with infiltration, trap sediment, and promote permanent vegetation. Those areas should be areas should be preserved or left as open space.
Step 6-3: Percentage of Vegetation Cover
Quantitative Assessment
This is NOT implemented yet.
(Enter numerical value if calculations are conducted.)
Ground (%) =
Vegetation (%) =
Estimate the percentage of drainage area covered by leaf litter, rock fragments, and undisturbed vegetation.
STOP

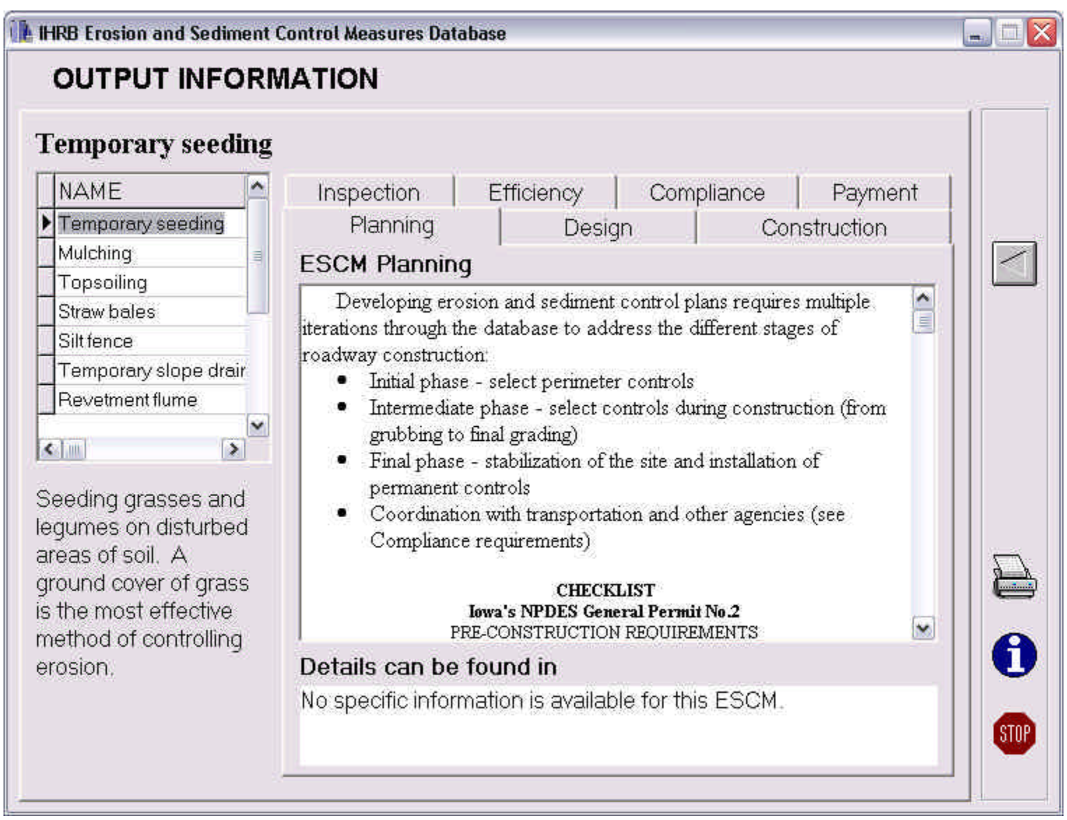

IHRB Erosion and Sediment Control Measures Database
INPUT INFORMATION
Land Use
No information.
Step 6-4: Land Use
Quantitative Assessment
(Enter numerical value if calculations are conducted.)
A. Are there land uses that can remove or reduce the natural vegetation (e.g., livestock grazing, fires potentially affecting the road right-of-way)?
YES
B. Are there urbanized developments upstream the drainage area that can increase siginificantly the runoff coefficient for the construction area?
YES
Estimate coefficient for conservative evaluation of the runoff coefficient due to land use.
STOP

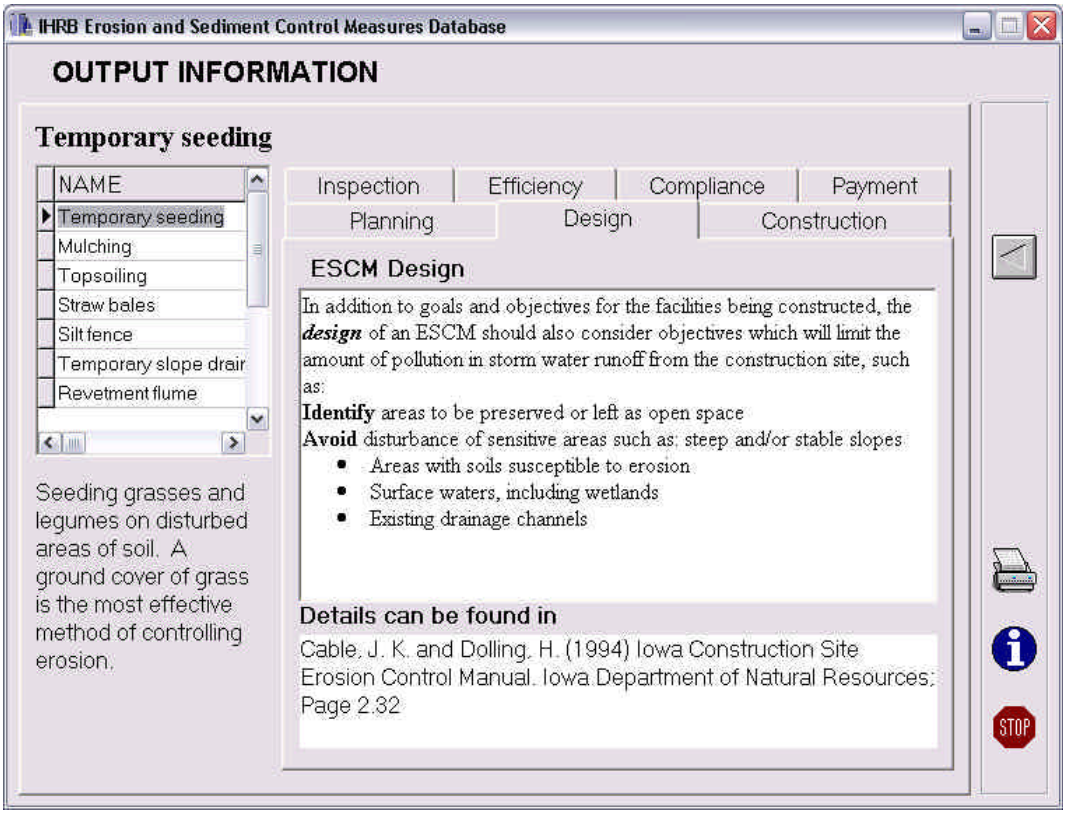

IHRB Erosion and Sediment Control Measures Database
INPUT INFORMATION
Types of water erosion
Sheet and rill erosion can normally be controlled by land treatment measures such as land contouring and vegetation, whereas sediment derived from channel type erosion usually requires structural measures.
Step 7: Type of Water Erosion
The following type(s) of water erosion is(are) expected to occur.
(1) Sheet Erosion YES
(2) Splash Erosion YES
(3) Gully Erosion NO
(4) Rill Erosion NO
(5) Stream Bank Erosion NO
STOP

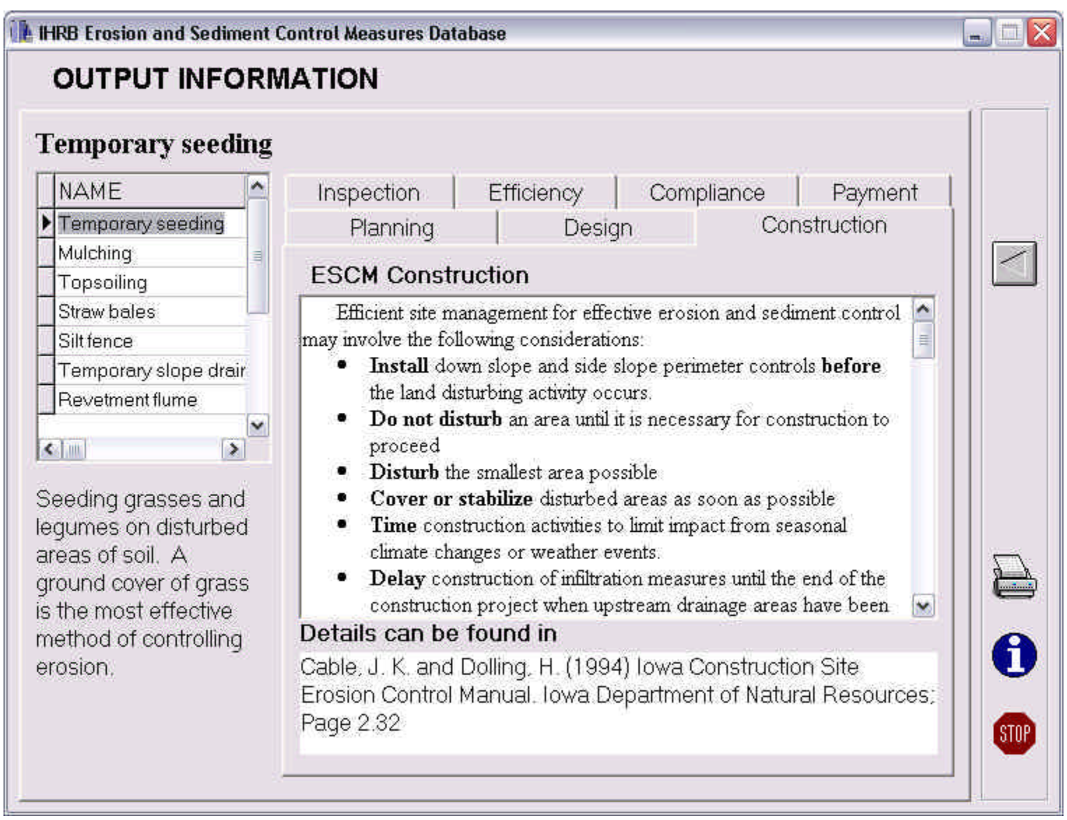

IHRB Erosion and Sediment Control Measures Database
INPUT INFORMATION
Sediment Yield & Water Runoff Estimation
Erosion and Sedimentation
It is important to distinguish between erosion and sediment yield. Erosion is the process by which soil particles are detached by water or wind. Sediment yield is the amount of eroded sediment transported by the drainage area. Sediment delivery ratio is the ratio of erosion rate to sediment yield and is typically calculated on an average annual basis. Sediment yield is the most important factor for consideration because the predicted erosion rates are in general smaller due to deposition, slope change etc. It is sediment yield, which causes off-site, water quality problems.
Step 8-1: Sediment Yield
Quantitative Assessment
(Enter numerical value if calculations are conducted.)
This is NOT implemented yet.
Sediment yield estimation
Practical equations for estimation of sediment yield are reproduced from: International Erosion Control Association (1993). "Practical Approaches for Effective Erosion and Sediment Control," Notes for a short course sponsored by IECA, Streamboat Springs, CO.
Methods of Determining Sediment Yield
There are a number of approaches to determining the sediment yield of a watershed depending on the environment and the data available. These approaches may be generally divided into five categories:
STOP

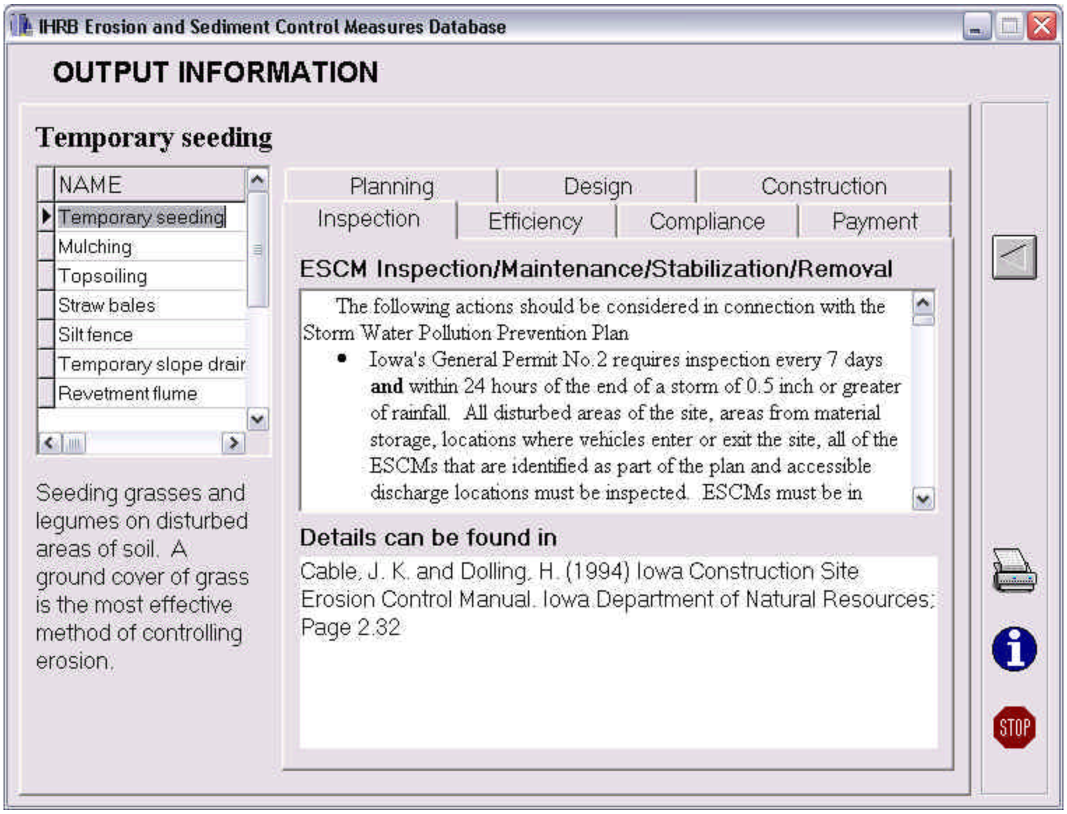

IHRB Erosion and Sediment Control Measures Database
INPUT INFORMATION
Are the following inputs correct?
Step 1. Type of Erosion or Sediment Control:: Short Term (0 ~ 6 months)
Step 2. Erosion Control Objectives: Slope Protection/Stabilization
Step 3. Area Type: Urban
Step 4. Drainage Area Extent:: < 20,234 m2 (5 acres, 2 ha)
Step 5. Soil Erodibility:: Group A
Step 6-1. Slope Steepness and Length: 0 - 3 %, Low Erosion Potential
Step 6-2. Climate: Not implemented yet.
Step 6-3. Vegetation COver: Not implemented yet.
Step 6-4. Land Use: Not implemented yet.
Yes
No
STOP

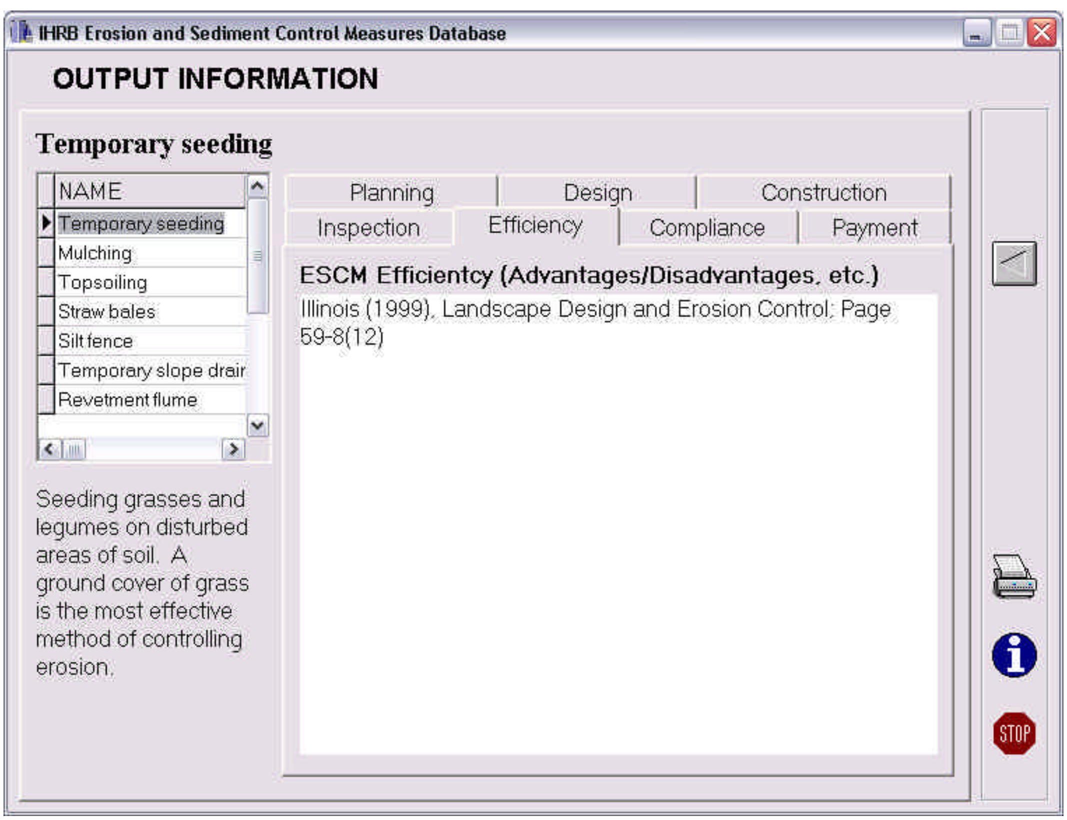

IHRB Erosion and Sediment Control Measures Database
OUTPUT INFORMATION
The database outputs one or more options technically feasible. Selection of the best practical solution for a particular situation is left to the user's judgment. In addition to the technical criterion, the following criteria are suggested for consideration:
• cost-effectiveness
• availability (local supplier or immediate shipment)
• feasibility (quick and easy application, minimal training for application, flexible applicability to a variety of field conditions)
• durability (maintain structural integrity during installation and persist until permanent vegetation is established)
• compatibility (materials selected in regard with public acceptability and environmental sensitivity)
Recommeded Measures = 7
NAME
Temporary seeding
Mulching
Topsoiling
Straw bales
Silt fence
Temporary slope drain
Revetment flume
Description of Measures
Seeding grasses and legumes on disturbed areas of soil. A ground cover of grass is the most effective method of controlling erosion.
STOP

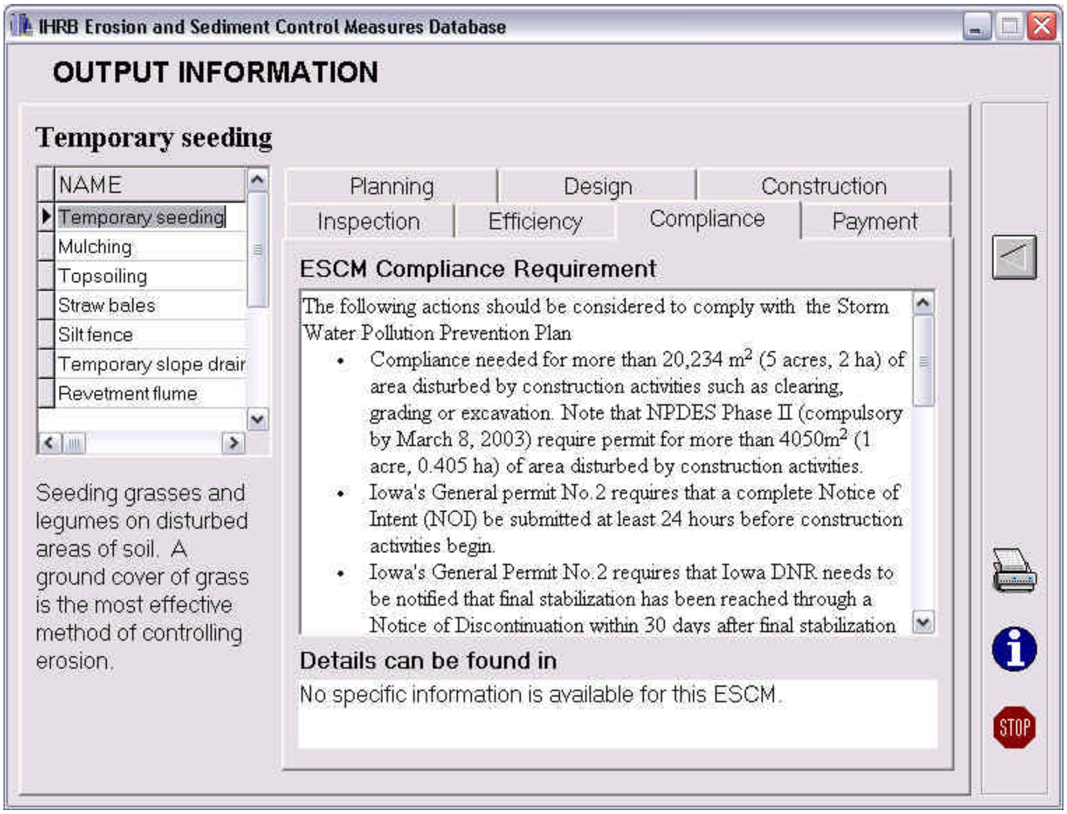

IHRB Erosion and Sediment Control Measures Database
OUTPUT INFORMATION
Temporary seeding
NAME
Temporary seeding
Mulching
Topsoiling
Straw bales
Silt fence
Temporary slope drair
Revetment flume
Seeding grasses and legumes on disturbed areas of soil. A ground cover of grass is the most effective method of controlling erosion.
Inspection
Efficiency
Compliance
Payment
Planning
Design
Construction
ESCM Planning
Developing erosion and sediment control plans requires multiple iterations through the database to address the different stages of roadway construction:
• Initial phase - select perimeter controls
• Intermediate phase - select controls during construction (from grubbing to final grading)
• Final phase - stabilization of the site and installation of permanent controls
• Coordination with transportation and other agencies (see Compliance requirements)
CHECKLIST
Iowa's NPDES General Permit No.2
PRE-CONSTRUCTION REQUIREMENTS
Details can be found in
No specific information is available for this ESCM.
STOP

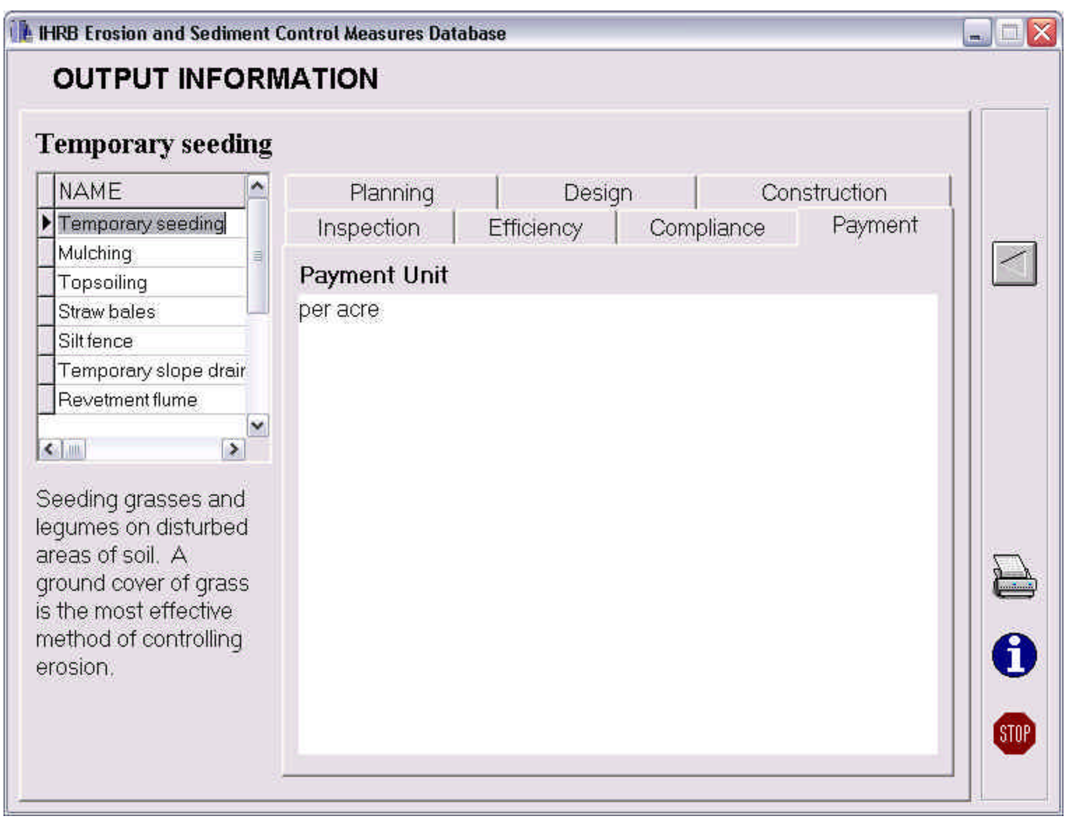

IHRB Erosion and Sediment Control Measures Database
OUTPUT INFORMATION
Temporary seeding
NAME
Temporary seeding
Mulching
Topsoiling
Straw bales
Silt fence
Temporary slope drair
Revetment flume
Seeding grasses and legumes on disturbed areas of soil. A ground cover of grass is the most effective method of controlling erosion.
Inspection
Efficiency
Compliance
Payment
Planning
Design
Construction
ESCM Design
In addition to goals and objectives for the facilities being constructed, the design of an ESCM should also consider objectives which will limit the amount of pollution in storm water runoff from the construction site, such as:
Identify areas to be preserved or left as open space
Avoid disturbance of sensitive areas such as: steep and/or stable slopes
• Areas with soils susceptible to erosion
• Surface waters, including wetlands
• Existing drainage channels
Details can be found in
Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; Page 2.32
STOP


IHRB Erosion and Sediment Control Measures Database
OUTPUT INFORMATION
Temporary seeding
NAME
Temporary seeding
Mulching
Topsoiling
Straw bales
Silt fence
Temporary slope drair
Revetment flume
Seeding grasses and legumes on disturbed areas of soil. A ground cover of grass is the most effective method of controlling erosion.
Inspection
Efficiency
Compliance
Payment
Planning
Design
Construction
ESCM Construction
Efficient site management for effective erosion and sediment control may involve the following considerations:
• Install down slope and side slope perimeter controls before the land disturbing activity occurs.
• Do not disturb an area until it is necessary for construction to proceed
• Disturb the smallest area possible
• Cover or stabilize disturbed areas as soon as possible
• Time construction activities to limit impact from seasonal climate changes or weather events.
• Delay construction of infiltration measures until the end of the construction project when upstream drainage areas have been
Details can be found in
Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; Page 2.32
STOP


IHRB Erosion and Sediment Control Measures Database
OUTPUT INFORMATION
Temporary seeding
NAME
Temporary seeding
Mulching
Topsoiling
Straw bales
Silt fence
Temporary slope drair
Revetment flume
Seeding grasses and legumes on disturbed areas of soil. A ground cover of grass is the most effective method of controlling erosion.
Planning
Design
Construction
Inspection
Efficiency
Compliance
Payment
ESCM Inspection/Maintenance/Stabilization/Removal
The following actions should be considered in connection with the Storm Water Pollution Prevention Plan
Iowa's General Permit No.2 requires inspection every 7 days and within 24 hours of the end of a storm of 0.5 inch or greater of rainfall. All disturbed areas of the site, areas from material storage, locations where vehicles enter or exit the site, all of the ESCMs that are identified as part of the plan and accessible discharge locations must be inspected. ESCMs must be in
Details can be found in
Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; Page 2.32
STOP


IHRB Erosion and Sediment Control Measures Database
OUTPUT INFORMATION
Temporary seeding
NAME
Temporary seeding
Mulching
Topsoiling
Straw bales
Silt fence
Temporary slope drair
Revetment flume
Seeding grasses and legumes on disturbed areas of soil. A ground cover of grass is the most effective method of controlling erosion.
Planning
Design
Construction
Inspection
Efficiency
Compliance
Payment
ESCM Efficientcy (Advantages/Disadvantages, etc.)
Illinois (1999), Landscape Design and Erosion Control; Page 59-8(12)
STOP


IHRB Erosion and Sediment Control Measures Database
OUTPUT INFORMATION
Temporary seeding
NAME
Temporary seeding
Mulching
Topsoiling
Straw bales
Silt fence
Temporary slope drair
Revetment flume
Seeding grasses and legumes on disturbed areas of soil. A ground cover of grass is the most effective method of controlling erosion.
Planning
Design
Construction
Inspection
Efficiency
Compliance
Payment
ESCM Compliance Requirement
The following actions should be considered to comply with the Storm Water Pollution Prevention Plan
• Compliance needed for more than 20,234 m2 (5 acres, 2 ha) of area disturbed by construction activities such as clearing, grading or excavation. Note that NPDES Phase II (compulsory by March 8, 2003) require permit for more than 4050m2 (1 acre, 0.405 ha) of area disturbed by construction activities.
• Iowa's General permit No.2 requires that a complete Notice of Intent (NOI) be submitted at least 24 hours before construction activities begin.
• Iowa's General Permit No.2 requires that Iowa DNR needs to be notified that final stabilization has been reached through a Notice of Discontinuation within 30 days after final stabilization
Details can be found in
No specific information is available for this ESCM.
STOP


IHRB Erosion and Sediment Control Measures Database
OUTPUT INFORMATION
Temporary seeding
NAME
Temporary seeding
Mulching
Topsoiling
Straw bales
Silt fence
Temporary slope drair
Revetment flume
Seeding grasses and legumes on disturbed areas of soil. A ground cover of grass is the most effective method of controlling erosion.
Planning
Design
Construction
Inspection
Efficiency
Compliance
Payment
Payment Unit
per acre
STOP

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Project summary

The objectives of this project are to evaluate the literature on erosion and sediment control measures, to synthesize the best management practices relevant to Iowa conditions in an efficient format, and to formulate further research lines that significantly improve current practices in erosion and sediment control applied to roadway construction.

The project involved a comprehensive literature review on highway erosion and sediment control methods, including specialized publications, state DOTs websites, industry, various publications (tribal, state, and federal government), design manuals, federal and national guidelines, and computer programs. Particularly useful in the review were two surveys. One survey was of state DOTs in the U.S. Great Plains and Upper & Middle Mississippi Valley. The second survey was of Iowa County Engineers.

The state DOTs survey revealed that the current practice for documentation of erosion and sediment control methods (ESCMs) is the preparation of and periodical upgrading of in-house manuals, disseminated in hardcopy or electronic format. The most cited references for direct use (or otherwise assimilated in the manuals) are EPA (1992) and IECA (1993). The literature review also revealed that, though extensive ESCM literature exits, much of it is not configured for convenient use by highway engineers. This finding directed the project to develop a contemporary, computer-based expert system for use by highway engineers seeking guidance on ESCMs.

The expert system designed in the study is a comprehensive inference engine aimed at assisting state, county, and municipal engineers in the selection, planning and implementation of ESCMs. It is developed to ensure that the selected ESCMs take into account site characteristics, the lifetime of the planned solution, and Iowa's Midwest environment. The expert system suggests potential ESCMs for a particular situation, and provides general and detailed information on the technical elements involved in ESCM design, construction, inspection, maintenance, removal, economical considerations, and efficiency.

The expert system developed during this project is the first of this kind for ESCM purposes. The system potentially can serve other state, county, and municipal engineers beyond Iowa. Given that this first version of the expert system is PC based and addresses limited user categories, it is anticipated that by further refining the level of detail of the knowledge database and by transitioning to a web-based platform, the expert system can be considerably enhanced.

In parallel with the literature synopsis and the development of the expert system, the study identified further research needs regarding methods and materials for erosion control, and methods for transitioning temporary methods to permanent ones. A valuable input in this direction was assembled through the survey collected from the Iowa County Engineers. Next section summarizes future developmental directions as indicated by the present study.

5.2. Recommendations

5.2.1. *Expert system development Phase II*

The current version of the expert system is fully functional and improves the ability of engineers to efficiently select ESCMs. An ES better helps selection of ESCMs than does the present diverse array of published articles. However, the initial stage (betha version) of the ES was built for PC platforms, and, due to limited resources, is limited in the level of detail of the ESCM specifications. Substantial additional benefits can be gained by further developing the current expert system database content, and by adapting the current inference engine to a web-based environment.

The main objectives of a Phase II of work for the project would be to accomplish the following tasks:

1. Review the ES database to ensure it includes IDOT in-house expertise in ESCMs. This step entails close collaboration with IDOT personnel to add specifications contained in Plan Notes, Special Provisions, Supplemental and Standard Specifications for each ESCM. During Phase I of work, several sources were inaccessible to the project investigators (e.g., files in Microstation format). Also, the available resources did not readily facilitate preparation of specific materials in electronic format (through scanning).
2. Implement the quantitative assessment part of the ES. Table 2, column 2 illustrates the other potential capabilities of the ES that are not yet implemented. The addition of a inference engine for the quantitative assessment will extend the functionality of the ES to additional user categories (e.g., design engineers, consultant engineers, etc)
3. Transition the ES from PC to web-based platforms. The current synthesized literature review on ESCMs is a valuable tool for users, but it was not built using state-of-the-art information transfer technologies. The PC-based ES developed by this study can be adapted for web-based environment to take advantage of important capabilities of the web-based tools, such as:

   – centralized management of the ES knowledge base
   – efficient and quick upgrading of the database (in matters of hours the database can incorporate the latest updates deemed necessary and ready for users)
   – quick dissemination
   – avoidance of conflicts in installation due to the large variety of user PC hardware and software
   – minimum maintenance
   – efficient use of links to other relevant sources of information available on internet

4. Evaluate the relationship between ESCM planning and implementation and the permitting regulations and restructuring of the database to include this relationship. Although the ES was developed with the regulatory framework in mind, the current literature review and ES development mainly focused on the technical aspects of the ESCM selection. Further development of ES can include all the considerations

required by the implementation of the Storm Water Pollution Prevention Plans that successfully and efficiently integrate technical aspects with regulatory agencies requirements.

5. Develop a training program, including an instructor's manual, and deliver training for users. The ES was designed in a simple format with user-friendly interfaces to be easily utilized. However, training sessions would be good opportunities to speed up product implementation/dissemination. Moreover, a training program could foster, through hands-on demonstrations and direct interaction with the users, further actions to enhance the functionality and content of the ES.

5.2.2. *Research needs in the area of ESCMs*

Temporary and long-term erosion-control measures have been subject of extensive research, evaluation, and continuous improvement. However, significant unresolved issues remain, especially for erosion control of areas subject to difficult environments (e.g., steep slope, or frigid winter conditions). Phase I of the project led to the following research priorities:

1. Investigate frigid temperature effects on the underlying erosion processes (sheet, splash, rill, gully)
2. Assess impacts of frigid weather on the effectiveness of ESCMs, especially those methods including establishment of protective vegetation
3. Evaluate current practices for stream bank protection and their monitoring
4. Investigate erosion control efficiency during transitioning from cool season grasses to warm season grasses
5. Evaluate Iowa specific soil erosion processes in relationship with rainfall characteristics (intensity and duration, droplet size, storm patterns, average soil temperatures, frost-free days)

The research needs identified during Phase I of work should be assessed through a survey of other state DOTs to determine how other agencies successfully and efficiently resolved similar concerns. The survey can efficiently provide directions and practical approaches in conducting the proposed research issues.

6. ACKNOWLEDGMENTS

The writers thank Mark Dunn, David Heer, Mark Masteller, and Ole Skaar, Jr. of Iowa Department of Transportation for guidance and continuous interaction during the conduct of this study. The writers also thank Stacie Johnson from Chamness Technology, Inc. for providing information on the use of compost. Student Vlad Muste, Cornell University, assisted in the final stage of development of the expert system.

7. REFERENCES

Environmental Protection Agency (1992). Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices; Publication No. EPA-833-R-92-005; Washington, DC

Goldman, S.J., Jackson, K., and Bursztynsky, T.A. (1986). *Erosion & Sediment Control Handbook*, McGraw-Hill, Inc., New York, NY.

International Erosion Control Association (1993). "Practical Approaches for Effective Erosion and Sediment Control," *Notes* for a short course sponsored by IECA, Streamboat Springs, CO.

APPENDIX A.
REFERENCES USED FOR COMPILATION OF THE EXPERT SYSTEM

A.1. REFERENCES PROCURED THROUGH LIBRARY SEARCH AND STATE DOTS SURVEY

1. Arkansas State Highway and Tranportation Deprtment (2001). Erosion and Sediment Control, Design and Construction Manual
2. American Excelsior Company (1995). "ErosionWorks," *Reference Manual*, AEC, Arlington, TX
3. American Association of State Highway and Transportation Officials (AASHTO) Guidelines for Erosion and Sediment Control in Highway Construction (1992) Volume III, Prepared by the Task Force on Hydrology and Hydraulics AASHTO Highway Subcommittee on Design
4. AASHTO Model Drainage Manual, Chapter 16, *Erosion and Sediment Contro*l
5. ASCE (1977). "Soil Erosion and Sedimentation," *Proceedings* of the National Symposium on Soil Erosion and Sedimentation by Water, ASCE, Chicago, IL.
6. California Department of General Services, *Soil Conservation Guidelines/Standards,* Document published at: http://www.resd.dgs.ca.gov/PSB/ESS/Hollister-Hills-SVRA/Part-II/Part%20II-Appendix-C.asp
7. Dolling, H. and Cable, J. (1994). "Iowa Construction Site Erosion Control Manual" *Report* prepared for the Iowa Department of Natural Resources.
8. Illinois Department of transportation (1999). BDE Manual & Construction Memorandum 00-60, Chapter 59: Landscape Design and Erosion Control.
9. Illinois Department of Transportation (2002). Erosion and Sediment Control, Standard Specifications for Road and Bridge Construction, Short Course Notes
10. International Erosion Control Association (1993). "Practical Approaches for Effective Erosion and Sediment Control," *Notes* for a short course sponsored by IECA, Streamboat Springs, CO.
11. Iowa DOT Design Manual, Chapter 10 Roadside Development and Erosion Control, Document published on: http://www.dot.state.ia.us/design/desman.htm
12. Iowa DOT Design Manual, Standard Road Plans, RC Series, Erosion Control, Roadside Development, Fencing; Document published on: http://www.dot.state.ia.us/design/stdplnrc.htm
13. Iowa DOT Design Manual, Standard Road Plans, RL Series, Excavation, Embankment, Soils and Associated Work; Document published at: ftp://165.206.203.34/design/stdrdpln/metric/mrl09.pdf
14. Iowa DOT, Road Design Details (Green Book), Office of Design, IDOT, Ames, IA, Document published at:
15. http://www.msp.dot.state.ia.us/road_design/eng_typ_frame.htm
16. Iowa DOT Standard Specifications, Division 26. Roadside development, Iowa Department of Transportation, Ames, IA.
17. Iowa Department of Natural Resources (1997). "Storm Water Discharge Associated with Industrial Activity for Construction Activities" General Permit No.2, Des Moines, IA

18. Iowa Department of Natural Resources (1997). "A Brief Guide to Developing Pollution Prevention Plans and Best Management Practices," Summary Guidance for Application of General Permit No. 2., Des Moines, IA.
19. Iowa State Highway Commission (1972). "Inspection on Erosion Control," Inspector's Handbook, Ames, IA.
20. Kansas Department of Transportation (1997) A Guide for the Design, Installation, Inspection, and Maintenance of Temporary Erosion-Control Measures in Kansas
21. Lancaster, T., Nelsen, R.J. (1998). "North American Green Erosion Control Materials Design Software," North American Green, Inc.
22. Nebraska Department of Roads (2002). "Roadway Design Manual", Chapter 5: Erosion and Sedimentation Control.
23. North Dakota Department of Transportation (1997). Standard Specifications for Road and Bridge Construction, Section 708, Erosion control – Document published at: http://www.state.nd.us/dot/docs/spec1tag.pdf
24. Ohio Department of Transportation (2000). Handbook for Sediment and Erosion Control, Office of Construction Administration, Document published at: http://www.dot.state.oh.us/construction/OCA/Manuals/Docs/Erosion/Erosion%20 Control.pdf
25. Smoot, J.L. and Smith, R.D. (1992). *Soil Erosion Prevention & Sediment Control*, Prepared for Tennessee Department of Transportation and Tennessee Department of Environment and Conservation, Nonpoint Source Program
26. South Dakota Department of Transportation, Erosion Control, Prepared by the Dot Material Testing & Inspection Certification Program Training Group and the Bureau of Personnel (2000) – Document published at: http://www.sddot.com/docs/manuals/ErosionControlCoverandTableofContents.pdf; http://www.sddot.com/docs/manuals/ErosionControlManual.pdf
27. U.S. Army Corps of Engineers (1998). "Streambed Degradation and Streambank Widening in Western Iowa," *Design Manual* prepared by Golden Hills RC&D), Oakland, IA
28. U.S. Environmental Protection Agency, *Erosion, Sediment, and Runoff Control for Roads and Highways*, Document published at: http://www.epa.gov/OWOW/NPS/education/runoff.html
29. U.S. Department of transportation (1995). "Best Management Practices for Erosion Control Manual" *Report* No. FHWA-FLP-94-005, Federal Highway Administration, Sterling, VA.
30. U.S. Department of Transportation, Federal Highway Administration (1996). "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects," Division 600: Incidental Construction, U.S. Government Printing Office, Washington D.C., Document published on: http://www.wfl.fha.dot.gov/design/specs/fp96.pdf
31. West Virginia DOT (1993). "Erosion & Sediment Control Manual,' *Report* prepared by Roadway Design Division, Technical Services Section, WVDOT
32. Yu, S.L. and Kaighn, R.J. (1991). "VDOT Manual of Practice for Planning Stormwater Management," Virginia Transportation Research Council, Charlottesville, VA.

A.2. REFERENCES PROCURED THROUGH INTERNET SURVEY OF GREAT PLAINS AND UPPER & MIDDLE MISSISSIPPI VALLEY STATE DOTS WEBSITES

Arkansas http://www.ahtd.state.ar.us/

Standard Specifications for Highway Construction 1996
http://www.ahtd.state.ar.us/contract/progcon/general/stdspecs.htm
Supplemental Specifications to Arkansas' 1996 Standard Specifications for Highway Construction:

- Contains information for seeding and geotextile fabric applications

http://www.ahtd.state.ar.us/Contract/ProgCon/General/SUPPSPEC.HTM

Illinois http://www.dot.state.il.us/

1. Erosion and Sediment Control Procedures and Practices for Construction Sites, Northeastern Illinois Planning Commission, 1993, (video tape, 18 min.). Demonstrates practices and procedures to follow at construction sites to control erosion and sediment.

2 (filed)[1]. Illinois Department of Transportation, Highway Standards – drawings available at:
http://www.dot.state.il.us/desenv/hwystds/rmdgn.html

3. Standard Specifications, BDE Special Provisions and Highway Standards

- Including: Earthwork, Landscaping, and Erosion control

http://www.dot.state.il.us/desenv/hwyspecs.html

4. Environmental Reviews for a particular location; relevant erosion control procedures,
http://www.dot.state.il.us/desenv/rt67impact/start.pdf

Indiana http://www.ai.org/dot/

1 (filed). Indiana DOT standard, Section 205: http://www.ai.org/dot/TS/standards/book/mar/2-1999.pdf
available from Indiana Department of Transportation Technical Services – see sample

Kansas http://www.ink.org/public/kdot/

No available references (KDOT Temporary Soil Erosion and Sediment Control, 1997 – can be purchased)

Kentucky http://www.ktc.uky.edu/ktctmb.html

1. (filed) Kentucky Transportation Cabinet (1998). Standard Specifications and Standard Drawings Erosion Control for Highway Construction; at: http://www.kytc.state.ky.us/design/memos/8-98.htm

2. Video catalog: Design, Structure, materials, environment, etc.
http://www.ktc.uky.edu/tx/Video2001.pdf

Michigan http://www.mdot.state.mi.us/

No available references (MDOT Soil Erosion and Sediment Control Manual, May 2000 – can be purchased)

1. Road Design Manual:
a) Environmental Chapter
http://www.mdot.state.mi.us/design/englishroadmanual/erdm10.pdf
b) Grades and Earth Chapter
http://www.mdot.state.mi.us/design/englishroadmanual/erdm02.pdf

[1] The document is available in hardcopy

2. Soil Erosion and Sedimentation Control Program: Training manuals, county agencies, permits, applications
http://www.deq.state.mi.us/lwm/water%5Fmgmt/soils/soils.html

Minnesota http://www.dot.state.mn.us/

1. Road Design Manual, Section 8-5.02.
2. Erosion Control Plans - http://www3.dot.state.mn.us/sampleplan/english/erosion.htm
3. (filed). Design Scene, Chapeter 13: Turf Establishment published at: http://www.dot.state.mn.us/tecsup/scene/chapters/scene_13.html
4. Seeding Manual from the Office of Environmental Services, Turf Establishment and Erosion control Unit:
   http://www.dot.state.mn.us/environment/seeding_manual/Manual2000.pdf

Missouri http://www.modot.state.mo.us/

1 (filed).General Special Provisions and Supplemental Specifications to 1999 Missouri Standard Specifications for Highway Construction, Missouri Highways and Transportation Commission, Jefferson City, Missouri (7/1/2000):
http://www.modot.state.mo.us/design/stdplan/metric_images/m80610d.pdf

2. Missouri Standard Specifications for Highway Construction, Missouri Highways and Transportation Commission,
Jefferson City, Missouri (1999) – available only through purchase

3. General Construction Manual http://www3.modot.state.mo.us/coman.nsf/

Nebraska http://www.dor.state.ne.us/

1 (filed). NDOR Construction Manual: http://www.dor.state.ne.us/ref-man/cman-toc.htm
Division 800 - Roadside Development and Erosion Control

2 (filed). NDOR Standard Specifications: http://www.dor.state.ne.us/ref-man/spece.htm

Oklahoma http://www.okladot.state.ok.us/

Fabric Forms for Erosion Control, Oklahoma DOT, 1980, (videotape, 15 min.). This video shows uses for geotextile fabric forms in erosion control

Ohio http://www.dot.state.oh.us/

1 (filed). Item 207 Temporary Soil Erosion and Sediment Control; published at: http://www.dot.state.oh.us/spec/207.htm

2 Environmental services http://www.dot.state.oh.us/oes/

Tennessee http://www.tdot.state.tn.us/

1. (filed)Tennessee Department of Transportation (1995). Standard Specifications for Road and Bridge Construction, Division II – Construction Details; found at: http://www.tdot.state.tn.us/construction/specbook/95sec800.pdf

Wyoming http://wydotweb.state.wy.us/

No available references

A.3. REFERENCES PROCURED THROUGH INTERNET SURVEY OF OTHER THAN GREAT PLAINS AND UPPER & MIDDLE MISSISSIPPI VALLEY STATE DOTS WEBSITES

A.3.1. *State DOTs*

California

1. Construction Manual (2001). 4-20 Erosion Control and Highway Planting California Department of Transportation, pdf document published at:
http://www.dot.ca.gov/hq/construc/manual2001/chapter4/chp4_20.pdf

Florida

No available references

New Hampshire

1. New Hampshire Department of transportation (1997) Standard Specifications for Road and Bridge Construction, Section 645, published as pdf document at:
http://webster.state.nh.us/dot/specifications/specifications.htm

Washington

1.Highway Runoff Manual:
http://www.wsdot.wa.gov/fasc/EngineeringPublications/Manuals/Highway.pdf
2. Erosion Control Manual- not published but refered at:
http://www.wvdot.com/10%5Fcontractors/10b2_manualform.htm

A.3.2. *Federal agencies*

Comments:

- FHWA adopts in 1994 Vol. III AASHTO (1992) as guidelines.
- DOT has "The BMP for Erosion and Sediment Control" 1995

AASHTO

No available references

FHWA

1. (filed) Document (1994) stating that FHWA adopts Vol III AASHTO Highway Drainage Guidelines 1992
2. Federal Highway Administration (1994). Erosion and Sediment Control on Highway Construction Projects – published at (only references to other documents):
http://204.29.171.50/framer/1000/default.asp?realname=Federal+Highway+Administration&cc=US&lc=en%2DUS&frameid=1565&providerid=112&url=http%3A%2F%2Fwww%2Efhwa%2Edot%2Egov%2F

NCHRP

Available through purchase from the TRB library (http://nationalacademies.org/trb/bookstore/)
1. Israelsen, CE; Clyde, CG; Fletcher, JE; Israelsen, EK; Haws, FW; Packer, PE; Farmer, EE. (1980). "EROSION CONTROL DURING HIGHWAY CONSTRUCTION--MANUAL ON PRINCIPLES AND PRACTICES. " NCHRP Report 221
2. A companion document (NCHRP Report 220) describes the research that was conducted as background for preparation of the manual above: Israelsen, CE; Clyde, CG; Fletcher, JE; Israelsen, EK; Haws, FW; Packer, PE; Farmer E.E. (1980). "EROSION CONTROL DURING HIGHWAY CONSTRUCTION--RESEARCH REPORT," NCHRP Report 220.

U.S. DOT

1. U.S. Department of Transportation**,** Bureau of Transportation Statistics, National Transportation Library: has list of articles and other publications sorted in chronological order – good for looking for new technologies:
http://199.79.179.82/sundev/search.cfm

A.3.3. *Other sources*

Erosion Control Technology Council
http://www.ectc.org/about/index.html#top

International Erosion Control Association: no publications available (documents provided with short courses)

Minnesota Erosion Control Association (2001). Erosion & Sediment Control Certification & Eteam Training Program Manual, published as pdf at: http://www.mnerosion.org/tmman.pdf

Erosion Control Headquarters: synthesis of news at: http://www.constr.com/erosion/products.htm

Compost (contact person: Stacie Johnson, Chamness Technology Inc.)

1. (filed) M., Risse, B. Faucette (last accessed 2002). "Compost Utilization for Erosion Control", Cooperative Extensive Service, The University of Georgia College of Agricultural and Environmental Sciences, internet address: http://www.ces.uga./pubcd/B1200.htm
2. (filed) U.S. Environmental Protection Agency (1997). "Innovative Uses of Compost-Erosion Control, Turf Remediation, and Landscaping," EPA530-F-97-043
3. (filed) California Environmental Protection Agency (2000). "Use of Compost and Co-Compost as a Primary Erosion Control Material," Report on the Demonstration Project, Placer County, CA.

APPENDIX B

GREAT PLAINS AND UPPER & MIDDLE MISSISSIPPI VALLEY DOTS SURVEY

B.1. SURVEY FORMAT

The survey below was sent out on March 3, 2002. On April 3, and May 1, additional requests were sent out to Tennessee and Kentucky DOTs.

Dear Madam/Sir:

IIHR-Hydroscience and Engineering is conducting a project work for Iowa Highway Research Board on the topic "Erosion and Sedimentation Control". Among the project objectives is the review of the most relevant references regarding Best Management Practices for erosion prevention and sediment control for highway applications.

We would greatly appreciate if you could help us directly or forward this message to the appropriate contact person in … DOT to find these references. Specifically, we would like to obtain a list of NOT MORE THAN FIVE MOST RELEVANT publications that are used in the design of the erosion and sedimentation control measures during and after highway construction.

Please specify if the mentioned publications can be loaned, bought, or are available at no charge (perhaps on the DOT website in electronic format).

Please respond to the e-mail address indicated below. Thank you in advance for your collaboration.

Best regards,

MARIAN MUSTE, PhD, PE
Research Engineer
IIHR-Hydroscience & Engineering
323E Hydraulics Laboratory
The University of Iowa
Iowa City, IA 52242-1585
Phone: 319-384-0624
Fax: 319-335-5238
e-mail: marian-muste@uiowa.edu
web page addresses:
http://webdev.iihr.uiowa.edu/database/details.php?id=27

B.2. LIST OF STATE DOT PERSONNEL CONTACTED IN GREAT PLAINS AND UPPER & MIDDLE MISSISSIPPI VALLEY AREAS FOR ASSEMBLY OF LITERATURE REVIEW

	State	Contact	Office	Phone no.	e-mail address
1	**Arkansas**		Programs and Contracts Division	(501) 569-2261	pcd@ahtd.state.ar.us
2	**Illinois**	J.Rowley	Agriculture Specialist/Project Coordinator	(217) 785-2834	ROWLEYJL@nt.dot.state.il.us
3	**Indiana**	T. Duncan	Environmental Engineer	(317) 232-5512	tduncan@indot.state.in.us
4	**Kansas**	W. C. Leek	Landscape Architect, Bureau of Design, Environmental Services Section	(785) 296-0853	leek@ksdot.org
5	**Kentucky**	T. Hopwood	Manager, Transportation Center, University of Kentucky	(859) 257-2501	thopwood@engr.uky.edu
6	**Michigan**	J. Rios	Construction and Technology Division	(517) 322-5874	riosj@michigan.gov
7	**Minnesota**	L. Belz	Erosion Control Specialist, Soil conservation Biologist	(651) 284-3757	lori.belz@dot.state.mn.us
8	**Missouri**	M. Fritz	Soils and geology	(573) 526-4345	fritzm@mail.modot.state.mo.us
9	**Nebraska**	P.TenHulzen	Design Standards Engineer, Roadway Design Division	(402) 479-3951	ptenhulz@dor.state.ne.us
10	**Oklahoma**	M. Graham	Environmental Assessments Customer Service Dept	(405) 702-1000	Margaret.Graham@deq.state.ok.us
11	**Ohio**	T. Linkous	Assistant Environmental Administrator	(614) 466-5075	Thomas.Linkous@dot.state.oh.us
12	**Tennessee**	W. H. Brode	Environmental Technical Studies Environmental Specialist – Ecology	(615) 741-6834	wbrode@mail.state.tn.us
13	**Wyoming**	J. Samson	Agronomist	(307) 777-4488	John.Samson@dot.state.wy.us

B.3. SUMMARY OF SURVEY RESPONSES

	State	Response	Recommended literature resources	Comments
1	**Arkansas**	Yes	1) Arkansas State Highway and Transportation Department (2001). "Erosion and Sediment Control, Design and Construction Manual,"	Procured (hardcopy)
2	**Illinois**	Yes	1) Illinois DOT Standard Specifications for Road and Bridge Construction (2002). Section 280, (www.dot.state.il.us/ 2) Illinois NRCS Urban Manual (www.il.nrcs.usda.gov) 3) In-stream Sediment Control Techniques, Field Implementation Manual, Nest Field Guide FG-007, Oct. 1997 (http://www.borealscience.on.ca) 4) Training texts developed for both Program Development and Specific Task Training	Procured (hardcopy) Available on internet Available on internet Procured (hardcopy)
3	**Indiana**	Yes	1) Indiana DOT (2002). "Design Manual, Chapter 37, In-house published document	Procured (electronic)
4	**Kansas**	Yes	1) Federal Highway Administration (1996). HYDRAIN: Integrated Drainage Design Computer System Workbook; National Highway Institute Course; G.Young, M. Stein, J. Krolak,, T. Atayee; Publication No. FHWA-HI-96-031; Washington, DC 2) International Erosion Control Association (2000). "How To Put the BEST Back Into Your Best Management Practices (BMPs)," Professional Development Short Course; J. McCullah, Steamboat Springs, CO 3) American Association of State Highway and Transportation Officials (1992). Highway Drainage Guidelines; Washington, DC 4) Federal Highway Administration (1996). Evaluation and Management of Highway Runoff Water Quality; Federal Highway Administration; Publication No. FHWA-PD-96-03; Washington, DC 5) Environmental Protection Agency (1992). Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices; Publication No. EPA-833-R-92-005; Washington, DC	
5	**Kentucky**	No		
6	**Michigan**	Yes	1) Michigan DOT, Soil Erosion and Sedimentation Control Manual – In-house publication	

7	**Minnesota**	Yes	1) Minnesota DOT, Standard Specifications for Construction Books (http://www.dot.state.mn.us/tecsup), Specifications: 2373, 1803.5, 2577 3882, 3883, 3884, 3885, 3886, 3887, 3888, 3889, 3891, 3892, 3892, 3894, 3895 2) P. Quinn, D. Stenlund (2001). "Erosion & Sediment Control Certification & ETEam Training Program Manual," (http://www.dot.state.mn.us/environment/whatsnew/TrnManCl.pdf) 4) Minnesota DOT Environmental Memos (http://www.dot.state.mn.us/environment/links/environmental_technical_memos.html) 5) Minnesota DOT Manual (2000). Road Design Ch.8 Erosion Control "Protecting Water Quality in Urban Areas-BMP's for Dealing with Storm Water Runoff from Urban, Suburban Developing Areas of Minnesota" Minn. Pollution Control Agency	Available on internet Available on internet Available on internet
8	**Missouri**	Yes	1) Project Development Manual; Missouri Department of Transportation. In-house publication. 2) Federal Highway Administration (1995). Best Management Practices for Erosion and Sediment Control; Report No. FHWA-FLP-94-005 3) Missouri Department of Natural Resources (1998). Protecting Water Quality; The St. Charles County Soil and Water Conservation District, St. Charles, Missouri, and the Dam and Reservoir Safety Program, Division of Geology and Land Survey, Rolla, Missouri; PUB000488. 4) U. S. Environmental Protection Agency (1992). Developing Pollution Prevention Plans and Best Management Practices; EPA 833-R-92-001	
9	**Nebraska**	Yes	1) Nebraska Department of Roads Roadway Design Manual; Chapter Five: Erosion and Sedimentation Control (January 2002 Draft)	Procured (electronic)
10	**Oklahoma**	Yes	1) "ODOT's Standard Specifications for Highway Construction," In-house publication 2) "Storm Water Management Guidelines for Design and Construction Activities," In-house publication 3) International Erosion Control Association "Practical Approaches for Effective Erosion and Sediment Control" IECA 4) "How to put the BEST back in Best Management	

			Practices" by J. McCullah with Salix Applied Care of Redding, CA 5) "Erosion Draw, Erosion and Sediment Control manual for Computer-Aided Drafting," In-house publication	
11	**Ohio**	Yes	1) Ohio Department of Transportation (2000). Handbook for Sediment and Erosion Control, Office of Construction Administration (http://www.dot.state.oh.us/construction/OCA/Manuals/Docs/Erosion/Erosion%20Control.pdf) 2) Location & Design Manual, Volume 2 Drainage Design, Chapters 1112 and 1113, In-house publication (http://www.dot.state.oh.us/se/hy/LD2/LD2TOC.htm) 3) Hydraulic Standard Construction Drawings (http://www.dot.state.oh.us/se/standard/Hydraulic/index.htm) 4) Construction and Material Specifications, In-house publication, Earthwork chapter, Section 207 (http://www.dot.state.oh.us/construction/OCA/Specs/ReWrite/Docs/207101901fnl.htm)	Available on internet Available on internet Available on internet Available on internet
12	**Tennessee**	No		
13	**Wyoming**	Yes	1) J. Fifield (2001). Designing for Effective Sediment & Erosion Control on Construction Sites, Forester Communications. Santa Barbara, CA 2) J. Fifield (2002). Field Manual on Best management Practices for Contractors and Inspectors,. Forester Communications. Santa Barbara, CA 3) International Erosion Control Association (1997). Erosion and Sediment Control Practices for Construction Activities at Water Crossings. A. Bruce, IECA Short Course, 1997, Nashville, TN. , Steamboat Spgs., CO	

Some of the answers contain additional relevant information regarding the resources and the DOT implementation policy. Presented herein are the most substantial answers.

Illinois

Thank you for your inquiry. My name is John Rowley, and among my duties, serve as co-instructor for the Department's Erosion and Sediment Control classes and as a member of our Department's Erosion and Sediment Control Committee. There are several references available which discuss 'Best Management Practices for erosion and sediment control for highway applications, and I would speak to what is commonly used by our IDOT Offices.

Before I list these few References, I would quote our Committee Chairman Rich Nowack who aptly stated in a previous inquiry regarding BMP''s, etc.: * "We do not allow the contractor to design the erosion control plan. The plan is prepared by IDOT staff and or its consultants. Our policies require that erosion control needs to be addressed beginning in phase 1 (environmental and project report documents) and continuing through all the project phases. In Illinois the NPDES permit defines IDOT as the owner of the project so we prepare the plans. The contractor and his agents must certify that they will implement the plan.

* All projects with a few exceptions must have an erosion plan with pay items or the project does not go to letting. The contractors like this also because they know what they are bidding on and what they are expected to do; and most importantly how they need to schedule their work to meet the NPDES requirements. Since we have been preparing the plans and putting them in bid documents (the last 3 years) our costs to implement erosion control have dropped significantly running on average about 1% of the total contract. In addition, we have also implemented a deficiency deduction against the contractor for failure to implement and maintain the plan and associated practices. Our approach is that we pay the contractor to put the plan is place, pay him to maintain and pay him to take it out. IDOT staff is responsible for performing weekly inspection and provides the contractor and subs with required maintenance via a written form.

* we have developed an extensive training program for IDOT staff, consultants and contractors in this area. We can send you a copy of the book which contains all our policies, requirement, pay items, etc."

* For further information contact Rich Nowack at (217) 782-2984 or John Rowley at (217) 785-2834. Let me know if you want our book. I have mentioned these above items due to the fact that BMP's have always been available and that the best of the BMP's cannot achieve, without proper implementation, an 'engineered solution' to the erosion and sediment control problems encountered by so many.

Kansas

We also have researched what other states and federal agencies are doing regarding erosion and sedimentation control, and "surf the web" for information from numerous sources, including organizations such as the International Erosion Control Association.

APPENDIX C
IOWA COUNTY ENGINEERS SURVEY

C.1. SURVEY FORMAT

The survey below was sent out on March 29, 2002. Due to the poor response, On April 22, 2002 the survey was sent out again. Eventually, 27 out of 99 Iowa County Engineers responded.

QUESTIONAIRE

As the research engineers for this project, we are preparing a database (expert system) to assist Iowa DOT personnel and Iowa County Engineers in the design, construction, inspection, and maintenance of erosion and sedimentation control measures (ESCM) associated with roads. The end product of the research will be a user-friendly guide aiding the user for selection of the Best Management Practices (BMP) in erosion and sedimentation control. The database will be available widely to the Iowa County Engineers.

The aim of the present survey is to gather past and current information from Iowa County Engineers regarding experiences/problems related to ESCM during and after highway/road construction. Your input is essential for shaping the content and structure of the database to County Engineers' needs. We ask that you provide the information sought on the Table below. Thanks indeed for your help and contribution to this project.

Robert Ettema, Professor and Chair, Department of Civil and Environmental Engineering, University of Iowa, Iowa City, IA 52242, robert-ettema@uiowa.edu

Marian Muste, Research Engineer, IIHR- Hydroscience & Engineering, The University of Iowa, Iowa City, IA 52242, marian-muste@uiowa.edu

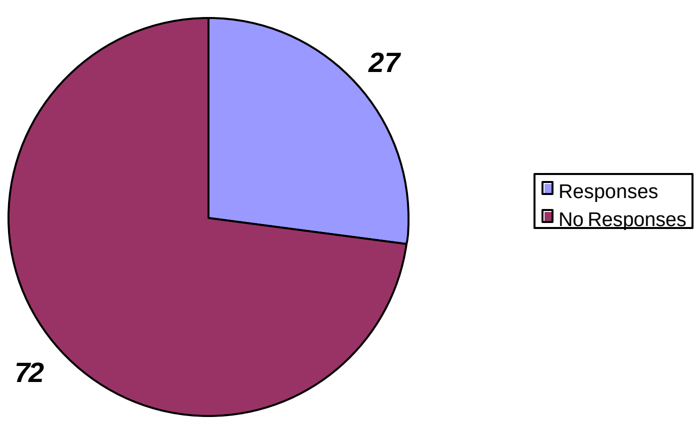
Connie Mutel, Research Scientist, IIHR- Hydroscience & Engineering, The University of Iowa, Iowa City, IA 52242, connie-mutel@uiowa.edu

MARIAN MUSTE, PhD, PE
Research Engineer & Adjunct Assistant Professor Mechanical Engineering
IIHR-Hydroscience & Engineering
323E Hydraulics Laboratory
The University of Iowa
Iowa City, IA 52242-1585
Phone: 319-384-0624
Fax: 319-335-5238
e-mail: marian-muste@uiowa.edu

No	Question	Answer
1	Engineer Name	
2	County	
	Years of experience as county engineer	
3	Please list up to five most-often used references/resources for ESCMs design/construction/maintenance/inspection.	
4	Are the available resources sufficient to conduct ESCM works?	
5	What are the most often encountered difficulties in obtaining the information about ESCMs?	
6	What are the most difficult issues/concerns/parameters to deal with in selection of an ECSM?	
7	Would you benefit from an easy-to-use guideline for ESCMs?	
8	What format would you prefer for ECSM references/resources (hardcopy, pocket sized manual, computer-based)?	
9	Do you consider that a training program on ECSMs would help your current activity?	
10	Are public opinion and aesthetics factors you consider when you design/construct/maintain/inspect ESCMs?	
11	What is in your opinion the most important ESCM selection criteria (please rank in order of importance, from 1 to 6):	
	Durability	
	Constructability	
	Effectiveness	
	Availability	
	Maintainability	
	Cost-effectiveness	
12	Give examples of successful ESCMs (list them in order)	
13	Give examples of unsuccessful ESCMs (list them in order) and provide potential failure causes.	
14	List the newest ESCM practices used in your activity (e.g., geotextiles, compost)	
15	List obstacles/problems associated with ESCMs that you consider that need further attention/research.	

C.2. LIST OF IOWA SURVEYED COUNTY ENGINEERS

No	County	Name	e-mail address
1	Adams	Eldon Rike	erike@mddc.com
2	Black Hawk	Richard King	rking@co.black-hawk.ia.us
3	Buchanan	Brian Keierleber	bcengineer@trxinc.com
4	Calhoun	Ron Haden	hadenr@hotmail.com
5	Carroll	David Paulson	cacoengr@thewebunwired.com
6	Cedar	Donald Torney	ccengr@netins.net
7	Clarke	Richard McKnight	clarke@pionet.net
8	Crawford	Paul Assman	cracoeng@hotmail.com
9	Dallas	Jim George	jgeorge@co.dallas.ia.us
10	Dickinson	Dan Eckert	deckert@co.dickinson.ia.us
11	Emmet	Roger R. Patocka	emmeteng@ncn.net
12	Fayette	Dennis Edgar	edgar@co.fayette.ia.us
13	Fremont	Daniel R. Davis	fremontcoeng@sidney.heartland.net
14	Hamilton	Dennis Short	dshort@hamiltoncounty.org
15	Iowa	Vince Ehlert	iacoeng@netins.net
16	Keokuk	Christy Van Buskirk	cvanbuskirk@lisco.com
17	Kossuth	Richard Schiek	kosseng@ncn.net
18	Marion	Roger Schletzbaum	rschletzbaum@co.marion.ia.us
19	Monroe	John Goode	goode@albia.com
20	Osceola	Thomas Snyder	tsnyder@osceolacoia.org
21	Pocahontas	Steven Camp	pokyengr@ncn.net
22	Poweshiek	Thomas Andersen	powcoeng@netins.net
23	Taylor	Don Turner	engineer@bedford.heartland.net
24	Wapello	Brian Moore	wapcoeng@pcsia.net
25	Winnebago	Jim Witt	jwitt@wctatel.net
26	Winneshiek	Lee Bjerke	lbjerke@co.winneshiek.ia.us
27	Woodbury	Richard Storm	dstorm@sioux-city.org

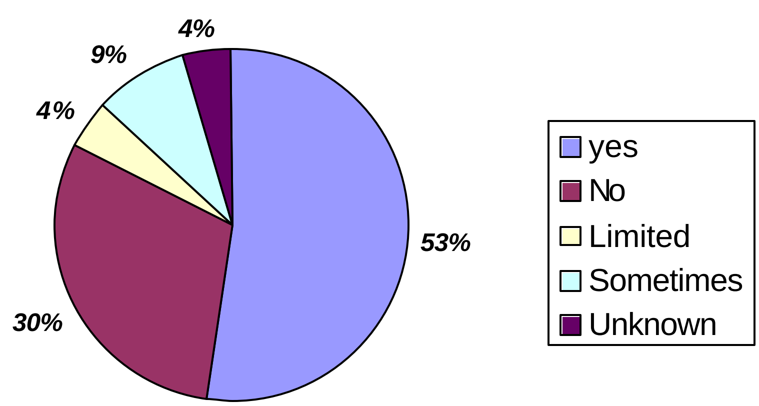


C.3. SUMMARY OF SURVEY RESPONSES

Question 3: List up to five most-often used references/resources for ESCM design/construction/maintenance/inspection.

No	Source	Responses
1	IDOT Design Manual/Std. Specs	14
2	Design Manual for Streambed Degradation and Stream Bank in West Iowa	4
3	Other Engineers	5
4	Product literature/personnal	14
5	NRCS Specs	3
6	Internet	2
7	Experience	2
8	DOT and Construction Site Std. Plans	6
9	Trade Magazines	2
10	Other	11

Question 4: Are the available resources sufficient to conduct ESCM works?



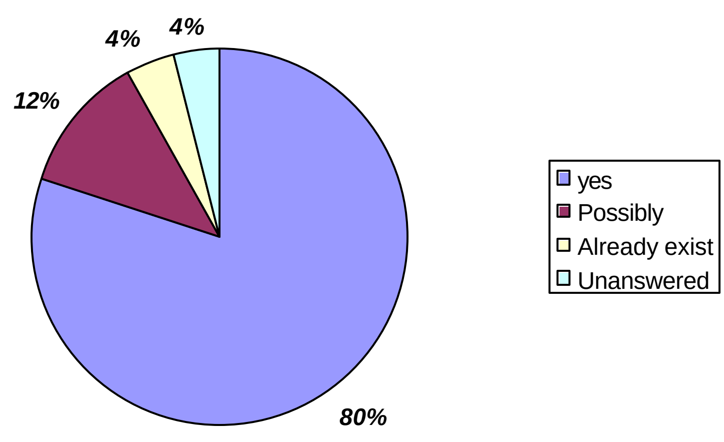
Question 5: What are the most often encountered difficulties in obtaining the information about ESCMs?

No	Comment
1	There is no standardized reference.
2	ESCM ratings
3	Lack of innovative and cost effective examples
4	Information is scattered throughout various resourses
5	Quick source material
6	Performance data
7	Keeping up with new technologies and products
8	Which ones actually seem to work and under what circumstances.
9	It would be nice if everything would be in one place.
10	I haven't had any trouble obtaining information; if anything there might be too much information. That is, every jurisdiction seems to have their favorite BMP, etc. Sometimes, it can be difficult sorting through all the possible options.
11	We tend to only address erosion problems after the fact
12	Not enough detail given to design/choose method
13	One Stop Reference; experience in Applications
14	Applications vary and suppliers have very general information which we must apply to a specific situation
15	Do not know where to look and there's no evaluation as to functionality or application to site-specific circumstances.
16	I, personally, do not know where it is
17	No standard guidelines
18	Lack of knowledge of using the
19	I have not had difficulty in finding what I was needing

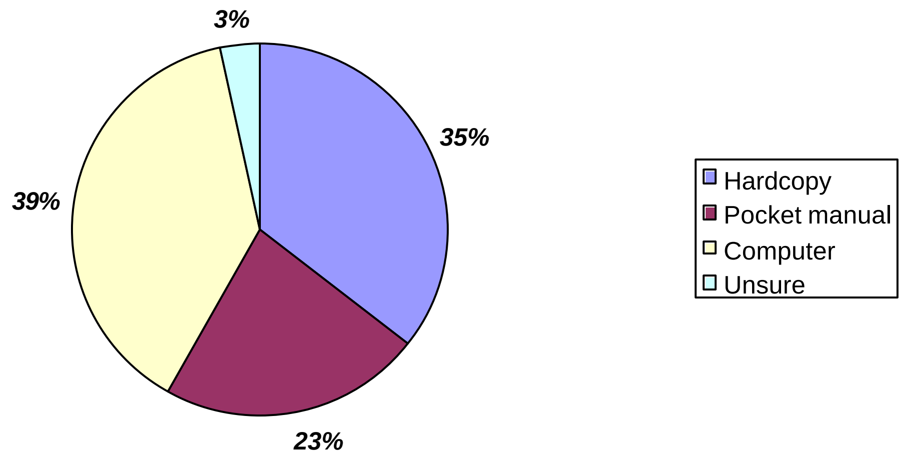
Question 6: What are the most difficult issues/concerns/parameters to deal with in selection of an ECSM?

No	Issues/concerns/parameters	Responses
1	Cost	11
2	Effectiveness/Site Specificity	10
3	Resource availability	2
4	Land acquisition/access	2
5	Regulations	1
6	Future Maintenance	2
7	Seasonal changes	1
8	Other	6

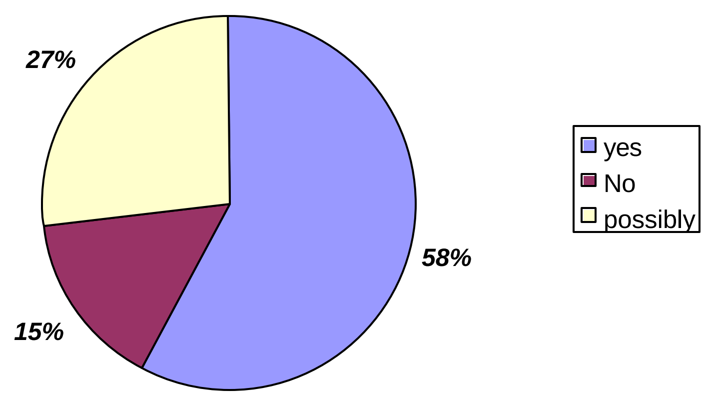
Question 7: Would you benefit from an easy-to-use guideline for ESCMs?



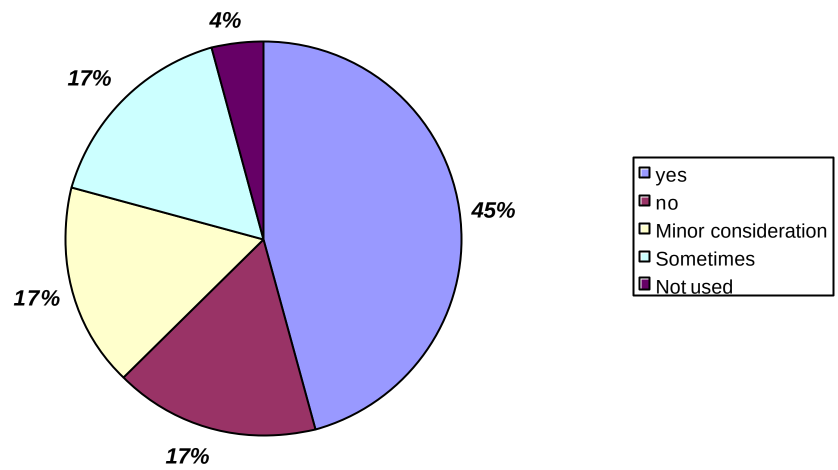
Question 8: What format would you prefer for ECSM references/resources (hardcopy, pocket sized manual, computer-based)?



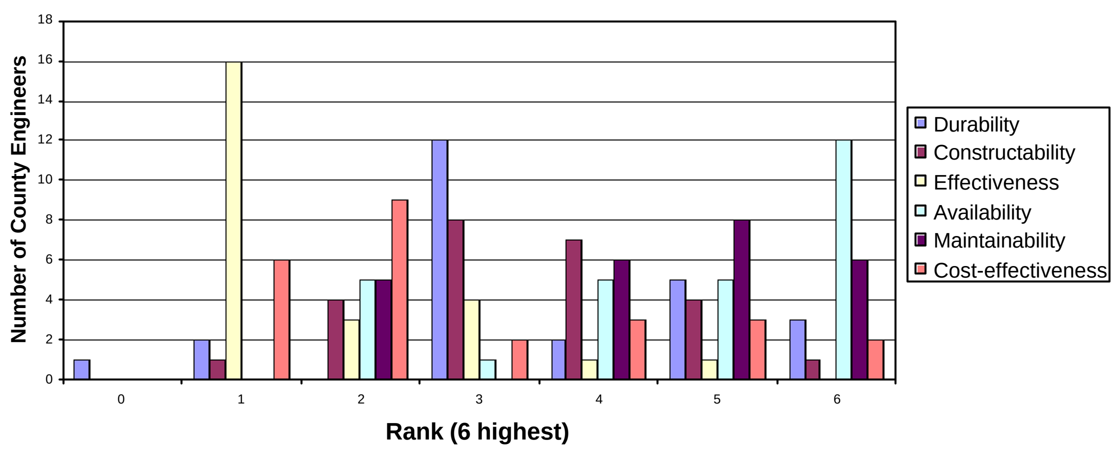
Question 9: Do you consider that a training program on ECSMs would help your current activity?



Question 10: Are public opinion and aesthetics factors you consider when you design/construct/maintain/inspect ESCMs?

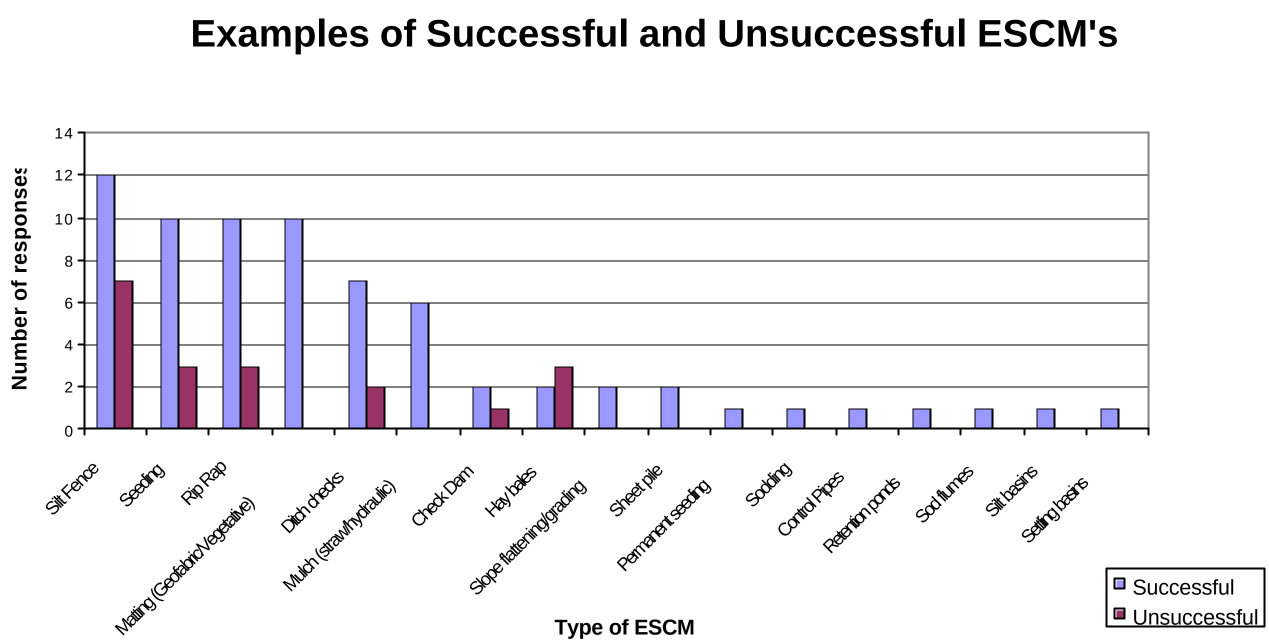


Question 11: What is in your opinion the most important ESCM selection criteria (please rank in order of importance, from 1 to 6):



Question 12: Give examples of successful ESCMs (list them in order)

Question 13: Give examples of unsuccessful ESCMs (list them in order) and provide potential failure causes.



Question 14: List the newest ESCM practices used in your activity (e.g., geotextiles, compost**)**

No	ESCM	No of responses
1	Geotextile	3
2	Hydromulching	2
3	Mats (Wood Excelsior/coconut)	2
4	Straw blankets	1
5	BFM's	1
6	Compost (Hydroposting /Filtrexx)	1
7	Settling basins	1
8	Covers (paper/mesh)	1
9	Tensor	1
10	Geoweb	1
11	ECRM 40	1

Question 15: List obstacles/problems associated with ESCMs that you consider that need further attention/research.

No	Comment
1	Easier and cost effective short term construction alternatives
2	I don't know that much about the products available
3	Costs, the laws min efforts required
4	Cost and getting employees to implement ESCM
5	Need to protect from insect infestation. Settling basins are desirable in most developments due to the attraction of bugs, mostly mosquitoes
6	The biggest problem is getting the grass to grow before all the work you have done gets washed away.
7	All have inherent problems when you deal with our soils, no matter how good it appears. A large rain event always shows weaknesses in all types.
8	The need for education of new materials and practices
9	Easy reference for various applications
10	Cost and the DOT
11	Trash from agriculture fields
12	Appropriate seed types
13	Cost effectiveness
14	Cost and maintenance issues
15	Efficacy of hydroposting (we will be testing this this year) and compost products in general (great potential). There are so many products it is difficult to be knowledgeable about all of them and know which are suitable to your site.

APPENDIX D
EXPERT SYSTEM INTERFACES

The following document contains the structure and the content of the information enclosed in the Expert System interfaces. Header numbering relates interfaces with the database structure. The framed text shows information on displayed interfaces. Marked text has the following significance:

Info about database connections
Info about the interfaces

INPUT DATA

Introduction

The present database is a structured synthesis on the selection, design, construction, inspection, and maintenance of best management practices (BMP) for erosion and sediment control measures (ESCM). The database information is a compilation of specialized literature and other resources collected from federal, state, and local highway construction agencies, with special emphasis on ESCM BMPs used by Iowa, Great Plains and Upper & Middle Mississippi Valley state DOTs. Even though the database was tailored for Iowa users, the enclosed information is not complete and some situations might require good judgment and past experience.

Efficient planning for erosion and sediment control requires a comprehensive knowledge of the site to be protected, permitting requirements, as well as the operational characteristics of ESCMs. The database attempts to take into account all of the variables that impact the decision making process when one selects a BMP for ESCMs. The database leads the user through a step-wise process comprising the following sequence:

INPUT INFORMATION

Step 1. Identify issues and concerns (regulatory environment, public opinion)
Step 2. Develop goals and objectives
Step 3. Evaluate erosion potential (area size and topography, soil erodibility, existing ground/vegetation, land use)

OUTPUT INFORMATION

Step 4. Nominate and evaluate alternative ESCMs
Step 5. Screen and select best ESCM
Step 6. ESCM Planning/design
Step 7. ESCM Construction
Step 8. ESCM Monitoring/maintenance/stabilization/removal
Step 9. ESCM Compliance requirements

Erosion is likely to occur at any concentration of flow; however, it occurs most severely in high flow concentrations. Erosion most commonly occurs:

- on slopes of more than 1,000 ft (300 m) (and less depending on the percent slope and soil type);
- on the outer banks of curved channels;
- at a culvert outlet or inlet;
- where the longitudinal slope of the ditch exceeds 2.5%;
- where there is sheet flow over a foreslope or backslope.

An especially important consideration when selecting controls and developing erosion control plans is to ensure that each appropriate construction phase is considered. The three phases that an erosion control plan should address are: the initial clearing phase, the intermediate grading phase, and the final stabilization of the site. The first phase should address the *perimeter controls* required at the initial clearing stage to prevent sediment from leaving the site. The *intermediate* phase should reflect the *controls* required during construction. The third phase of erosion control is the final stabilization of the site and installation of the *permanent controls*.

Perimeter Controls. These controls are usually installed after the clearing and prior to any grubbing of the site. The controls are located to keep with the natural topography of the site and the limits of construction. The purpose of these controls is to prevent off-site damage by minimizing the sediment that leaves the site. In most cases, these controls will remain in place throughout the construction of the project. Typical perimeter controls include:

- Filter barriers (silt fence, straw bales, and brush barriers)
- Diversion structures (diversion berms and channels)
- Settling structures (sediment traps and sediment basins)

Intermediate Controls. The most critical and most difficult phase of erosion control is the intermediate phase, especially in new construction. Intermediate controls are implemented as the project progresses from the grubbing stage to the final grade. This is the stage of construction when earth-moving activities are at a maximum. At this point, both the extent and duration of exposure is greatest in making the site most susceptible to erosion. Temporary erosion controls must be implemented in incremental stages as construction progresses. In addition, some permanent structural controls such as culverts, storm sewers, and some waterways are installed. Intermediate controls commonly consist of the following methods:

- Temporary slope drains
- Temporary channel linings
- Mulching
- Temporary and permanent turf establishment
- Checkdams
- Settling structures
- Inlet protection

Final Controls. The last phase of erosion control includes final stabilization of the slopes and waterways, stabilization of outfalls, and other disturbed areas. Most final controls are permanent, however some temporary controls may be used. Final controls include the following methods:

- Permanent turf establishment
- Channel linings
- Temporary slope drains
- Checkdams
- Outlet protection
- Curbs, gutters and downdrains (chutes)
- Road inlets

Some controls may actually serve in more than one phase. For instance, filter barriers and settling structures may control sediment from the initial phase through the final slope stabilization. Also, in some reconstruction projects, the only erosion control phases may be the initial and final controls. ES does not directly relate the erosion control methods with the different stages of the highway construction. Developing ESCM planning might require multiple iterations through the database to address all the elements of the project (perimeter control, soil protection/stabilization, sediment trapping) and the different stages of roadway construction (initial, intermediate, and final phases).

Summary of the navigating instructions

A. Type of erosion or sediment control

Choices for the user:

A.1 Short term (0-6 months)*
A.2. Transitional (6-12 months)*
A.3. Permanent (> 12 months)**
A.4. Transitional and permanent (> 6 months & > 12 months)**

* When these options are selected the following text shows up

Temporary soil erosion and sediment control measures should be provided for all projects having significant grading, projects with grading along live streams, and/or other environmentally sensitive areas identified in the environmental process. The controls should be provided during construction to prevent soil eroded from the construction area from entering adjacent watercourses.

Construction items include temporary seeding and mulching, sediment basins, sediment dams, diversion dikes, temporary ditch protection, temporary slope protection, filter fabric fence, slope drains, and sediment removal. Other miscellaneous erosion control measures include: erosion control mats and blankets, repair seeding and mulching, commercial fertilizer, water and mowing, rock check dams and Type C rock channel protection.

The size of the entire drainage area contributing flow to a roadside ditch and the ratio of disturbed to undisturbed area are used to determine the desired erosion control methods. In many cases, the major portion of the contributing area will be beyond the project right-of-way limits. For these cases it will be necessary to divert the off-project flow before it reaches the area disturbed by project construction. Flow from the area disturbed by construction should be treated prior to combining it with off-project drainage.

Method Selection

A. For drainage areas less than one acre [0.4 hectares, 4046 m^2], filter fabric fence ditch checks, shall be specified with small pits excavated behind them. The specific size and location of these controls need not be shown on the plan. Their use should be directed by plan note. Ditch checks should be spaced so that no check is within the backwater of a downstream check. A ditch check should be provided at all significant changes in ditch grade.

B. For drainage areas between 1 and 5 acres [0.4 and 2 hectares; 4046 m^2 and 20234 m^2] and where greater than two-thirds of the contributing drainage area is disturbed by construction, sediment basins are more effective and should generally be specified. Where less than two-thirds of the total contributing drainage area is disturbed by construction, a temporary ditch, dike and/or slope drain should be provided to divert flow from undisturbed areas away from the new ditch to reduce sediment basin size, or necessitate ditch checks only for the remainder of the flow. If more appropriate for the specific site (e.g. fill areas in lieu of cut areas) the roadway or toe of slope ditch should be stabilized immediately upon construction, and a bale dike or filter fabric fence place at the bottom of the disturbed slope. Rock check dams may be used to prevent ditch erosion until the permanent stabilization has been established. The specific size and location of these controls shall be shown on the plans.

C. For drainage areas between 5 and 20 acres [2 and 8 hectares; 20234 m^2 and 80937 m^2], sediment dams or a series of sediment basins should be specified. It is desirable to locate temporary controls within the permanent right-of-way. However, it may be necessary to purchase a temporary easement to provide an adequate ditch control. For areas between 5 and 10 acres [2 to 4 hectares; 20234 m2 and 10117 m^2] where less than one-half of the contributing drainage area is disturbed by construction, a temporary ditch, dike and/or slope drains or ditch stabilization and bale dikes should be provided. For areas of 10 to 20 acres [4 to 8 hectares; 10117 m^2 and 80937 m^2] where less than one-third of the contributing drainage area is disturbed by construction a temporary ditch, dike and/or slope drains or ditch stabilization and bale dikes should be provided. The specific size and location of these controls should be shown on the plans. Sediment basins, ditch checks, etc. should be clearly shown in the roadway ditch prior to the receiving or crossing watercourse. These items should not be shown within the receiving or crossing watercourse.

D. When the contributing drainage area exceeds 20 acres [8 hectares; 80937 m^2], the off-project drainage should be diverted or the following method should be specified. The channel carrying the flow shall be stabilized immediately by a permanent or temporary lining and a filter fabric fence dike shall be placed between the disturbed project area and the stabilized ditch. Rock check dams should be provided to prevent channel erosion until permanent channel stabilization has been established.

E. Where project drainage is not intercepted by a project ditch, a straw bale dike or other approved filter dike or fence should be placed at the construction limits. The specific size and location of these controls should be shown on the plans. Filter Fabric Fence shall be placed just beyond the toe of slope of all sheet flow areas adjacent to live streams or other environmentally sensitive areas identified in the environmental documents regardless of the amo unt of grading involved.

F. Filter fabric fence should be placed around all catch basins and manholes.

G. Filter fabric fence or sediment basins shall be used to isolate the project from any adjacent live streams.

H. For highly erodible soil areas identified in the environmental documents, any area cleared shall be brought to grade immediately and permanent erosion control measures called for on the plans shall be applied.

Required Size of Sediment Basins

Sediment basins or dams shall provide a storage volume of 67 cubic yards per acre [130 cubic meters per hectare] of total contributing drainage area, which is 0.5 inches [13 millimeters] of runoff or approximately a two-year frequency. The volume should be increased where discharge from the basin empties onto an environmentally sensitive area as identified in the environmental documents. Should the failure of a sediment dam pose a significant danger to downstream property, the spillway should be checked to assure safe passage of a 50-year frequency storm.

(Ohio Department of Transportation, Location & Design Manual – Volume 2 Drainage Design, http://www.dot.state.oh.us/se/hy/LD2/1112.htm.)

** When these options are selected the following text shows up

The selection of permanent erosion control measures is based on the following:

- location of installation (urban, rural, rest stop, recreation area, etc.);
- economic analysis of suitable alternatives;
- agronomic principles;
- site-specific requirements;
- availability of construction materials;
- future maintenance requirements;
- wetlands protection.

B. Erosion control objective

- Keep soil **on** the original location **= Erosion Control Measure (ECM)**
- Keep soil **close** to the original location = **Sediment Control Measure (SCM)**
- Control pollutants in storm water after construction is complete (permanent measures) = **Storm Water Management Control Measures (SWMCM)**

B.1. Erosion Control Measure (ECM)
- B.1.(a). Slope Protection/Stabilization (can be A.1, A.2, A.3, A.4)
- B.1.(b). Borrow and Stockpile Protection (can be A.1 and A.2)
- B.1.(c). Stream Bank Protection (can be A.1 and A.3)

B.2. Sediment Control Measure (SCM)
- B.2.(a). Perimeter Control (can be A.1 and A.2)
- B.2.(b). Sediment Trapping (can be A.1 and A.3)
- B.2.(c). Water/Runoff Conveyance (can be A.1 and A.3)

B.3. Erosion and Sediment Control Measure (ESCM)
- B.3. (a) Roadway ditches (can be A.1, A.2, A.3, A.4)
- B3. (b) Swales (can be only A.3)
- B3. (c) Energy dissipation structures (can be A.1, A.2, A.3, A.4)

B.4. Storm Water Management Control (SWMCM) (can be only A.3)

Note for all ECMs: ECMs keep soil **on** the original location. Iowa's General Permit No.2 requires that disturbed areas of the construction sites that will not be redisturbed for 21 days or more must initialize stabilization measures by the 14th day after the last disturbance, except as precluded by snow cover. In the event of snow cover, stabilization must be initiated as soon as practicable thereafter. Examples: temporary seeding, permanent seeding and planting, mulching, geotextiles, chemical stabilization, sod stabilization)

Note for all SCMs: SCMs keep soil **close** to the original location. Iowa's General Permit No.2 requires that the pollution prevention plan includes structural practices to divert flows away from disturbed areas, to store flows, or to limit the discharge of pollutants from the site to the degree attainable. Examples: earth dike, silt fence, sediment trap, sediment basin, brush barrier, drainage swale, subsurface drains, pipe slope drains, level spreaders, storm drain inlet protection, rock outlet protection, reinforced soil retaining systems, gabions.

Iowa's General Permit requires that, where it is attainable, a temporary or permanent sediment basin be installed in any drainage location where more than 10 acres in the upstream drainage area are disturbed at one time. The sediment basin must provide at least 3,600 cubic feet of storage for every acre of land which it drains (flow from upland areas that are undisturbed may be diverted around the basin). For drainage locations with 40,468 m^2 (10acres or 4.05ha) or fewer disturbed acres, sediment traps, filter fences, or equivalent measures must be installed along the downhill boundary of the construction site. Where such a sediment basin is not attainable, other structural sediment control, providing equivalent effectiveness, are required for all side slope and down slope boundaries of the construction areas.

Note for all ESCMs: ESCMs have the role to protect typical roadway elements that combines both types of controls (e.g., road ditches, swales)

Note for all SWMCMs: SWMCMs are constructed to **prevent or control pollution** of storm after the construction is completed. The selected SWMCSM should remove 80 % of the total suspended solids resulting from the construction project. When selecting the SWMCM for a development project, consider the impacts of these measures on the environmental media (e.g., land, air, and ground water). In addition to pollutant removal, the SWMCM must address velocity dissipation at discharge location. Iowa's General Permit No.2 requires that velocity dissipation devices be placed along the length of any outfall where the discharge from the developed area may erode the channel so that the natural physical and biological characteristics and functions are maintained and protected. Examples: retention pond, detention pond, infiltration measures, vegetated swales and natural depressions.

C. Area type

The location of construction site (urban, semi-urban, rural) can raise particular issues and concerns (e.g., safety, public opinion, environmental interest groups, and aesthetical aspects) that can affect selection of ESCMs.

C.1. urban (all of the As and Bs)
C.2. semi-urban (all of the As and Bs)
C.3. rural (all of the As and Bs)

SAFETY AND AESTHETICS

Erosion, safety hazards and maintenance may be minimized by use of properly designed:

- flat side slopes that gradually transition to the natural terrain;
- benching steep slopes where rock or limited right-of-way is encountered;
- drainage channels - width, depth, cross section, slope alignment and protective treatment;
- inlets, especially with regard to location and spacing;
- culvert outlets;
- groundwater interception facilities;
- dikes, berms, etc. to protect backslopes;
- sedimentation devices such as silt fences, silt traps, etc.

Landscaping that focuses on native vegetation also aids erosion control. In addition, landscaping can minimize future construction and maintenance costs, and provides a more aesthetic roadway environment. Landscaping should focus on:

- preservation of existing vegetation where possible;
- transplantation of existing vegetation if necessary and feasible;
- planting of new vegetation native to the area;
- selective clearing and thinning;

regeneration of native plant species.

D. Drainage area extent

Typically, in one physiographic area, the larger the drainage area, the larger the sediment yield, but the rate of sediment yield per unit area decreases as the size of the drainage increases. This occurs because larger areas generally have less overall slope, smaller proportions of upland sediment sources, and a more opportunity for the deposition of sediment on flood plains and alluvial fans.

D.1. < 20,234 m^2 (5 acres, 2 ha)* – No NPDES permit required

Note: NPDES Phase II permitting that will be enforced in March 2003, replaces the above minimum value with 4050m^2 (1 acre, 0.405 ha).

D.2. > 20,234 m^2 (5 acres, 2 ha) – NPDES permit required

Note: for more than 40,468 m^2 (10 acres, 4 ha) – need to establish temporary sediment basin

Quantitative parameter assessment (enter numerical value if calculations are conducted):

E. Soil erodibility

Soil erodibility defines the propensity for soil particles to become detached by action of water. Soils are classified by the Natural Resource Conservation Service into four Hydrologic Soil Groups. The Hydrologic Soil Groups are based on the soil's runoff potential. The four Hydrologic Soils Groups are A, B, C and D. The A group generally has the smallest runoff potential but a high infiltration rate, whereas and Ds the greatest. Details of this classification can be found in 'Urban Hydrology for Small Watersheds' published by the Engineering Division of the Natural Resource Conservation Service, United States Department of Agriculture.

Group A is sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission.

Group B is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

Group C soils are sandy clay loam. They have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.

Group D soils are clay loam, silty clay loam, sandy clay, silty clay or clay. This HSG has the highest runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.

General Terms			
Name	**Texture**	**Class names**	**Hydrologic Soil Group****
Sandy Soils	Coarse	Sand	A
		Loamy Sand	A
	Moderately Coarse	Sandy Loam	A
		Fine Sandy Loam	A/B
	Medium	Very Fine Sandy Loam	B
		Loam	B
		Silt Loam	B
		Silt	B
	Moderately Fine	Clay Loam	C
		Sandy Clay Loam	C
		Silty Clay Loam	C
Clay Soils	Fine	Sandy Clay	D
		Silty Clay	D
		Clay	D

***Numerical values can be found from local Soil Conservation Service and Cooperative Extension Office.*

Qualitative parameter assessment:

E.1. A
E.1. B
E. 1. C
E. 1. D

Quantitative parameter assessment (enter numerical value of if calculations are conducted):

F. Other factors influencing erosion

F. 1 Slope steepness and length

A gross estimation of the erosion potential is indicated by the slope steepness:

		Slope length should not exceed
0-3%:	Low erosion potential	300 ft
3-8%:	Medium erosion potential	150 ft
Over 8%:	High erosion potential	75 ft

Qualitative assessment:

F.1. (a) 0-3%: Low erosion potential
F.1. (b) 3-8%: Medium erosion potential
F.1. (c) Over 8%: High erosion potential

General principles for assessing flow path length and slope effects

- The effect of flow path length is not as great as effect of slope angle
- Long slopes and especially, long steep slopes, should not be constructed
- Long slopes should be shortened by creating contour diversion or benches
- Convex slope magnifies slope base erosion
- Concave slope reduces base erosion

Quantitative parameter assessment (enter numerical value of if calculations are conducted):

Slope Steepness: ______

Slope Length: ______

F.2 Climate

Climate is a Blind Item. A Blind Item is a database item displayed but not operational. An engine will be implemented at a later stage. The Blind Item is not involved selection of the outputs.

Climatic factors are important in determining rate of runoff and for vegetation development. Temperature, rainfall intensity, duration, frequency, raindrop distribution, seasonal distribution of rainfall, and freezing-thawing cycle are all important factors in the erosion process. Numerical values for the above indicators can be obtained from Climatology Bureau, Iowa Department of Agriculture and Land Stewardship (http://www.agriculture.state.ia.us/climatology.htm) or Midwest Regional Climate Center (http://mcc.sws.uiuc.edu/).

Qualitative assessment: Iowa climate

Quantitative parameter assessment (enter numerical value if calculations are conducted)

F.3 Percentage of the drainage area covered by ground/vegetation

Drainage area is a Blind Item. A Blind Item is a database item displayed but not operational. An engine will be implemented at a later stage. The Blind Item is not involved selection of the outputs.

Areas covered by ground/vegetation that can be incorporated in the final design of the ESCMs can reduce rainfall impact, reduce surface water velocities, assist with infiltration, trap sediment, and promote permanent vegetation. Those areas should be areas should be preserved or left as open space.

Quantitative parameter assessment (enter numerical values if calculations are conducted):

Estimate the percentage of drainage area covered by leaf litter, rock fragments, and undisturbed vegetation.

Ground %

Vegetation %

F.4. Land use

Land use is a Blind Item. A Blind Item is a database item displayed but not operational. An engine will be implemented at a later stage. The Blind Item is not involved selection of the outputs.

Land use has a variable impact on sediment yield. Activities such as agriculture, urban development, and road construction, may remove the vegetative cover for parts of the year or even permanently. Reduction in the cover can be caused by such activities as grazing, logging, mining, fires, urbanized developments in the vicinity of the site.

When the user chooses C.2. or C.3, selection 'a' below will either be highlighted or displayed alone for the user. Also, if the user chooses C.1 or C.2, selection 'b' below will then be highlighted or displayed alone for the user.

a. Are there land uses that can remove or reduce the natural vegetation (e.g., livestock grazing, logging, fires potentially affecting the road right-of- way)?
b. Are there urbanized developments upstream the drainage area that can increase significantly the runoff coefficient for the construction area?

Quantitative parameter assessment (enter numerical value of if calculations are conducted):
Estimate coefficient for conservative estimation of the runoff coefficient due to land use:

G. Types of water erosion

Erosion type is a Blind Item. A Blind Item is a database item displayed but not operational. An engine will be implemented at a later stage. The Blind Item is not involved selection of the outputs.

Sheet and rill erosion can normally be controlled by land treatment measures such as land contouring and vegetation, whereas sediment derived from channel type erosion usually requires structural measures.

The following type of water erosion is expected to occur

G.1 Sheet
G.2 Splash. The above two selections will be displayed if user selects B.1.(a) or B.1(b).
G.3 Gully
G.4 Rill. The above two selections will be displayed if user selects B.2.
G.5 Stream bank This selection will be displayed if the user selects B.1.(c)

G.1, G.2, G.3, G.4 are displayed for B.3(a), B.3(b)

H. Sediment yield & water runoff estimation

Erosion and Sedimentation

It is important to distinguish between erosion and sediment yield. Erosion is the process by which soil particles are detached by water or wind. Sediment yield is the amount of eroded sediment transported by the drainage area. Sediment delivery ratio is the ratio of erosion rate to sediment yield and is typically calculated on an average annual basis. Sediment yield is the most important factor for consideration because the predicted erosion rates are in general smaller due to deposition, slope change etc. It is sediment yield, which causes off-site, water quality problems.

Water Runoff

Iowa's General Permit No.2 requires that the runoff coefficient of the site needs to be determined after construction is complete. The runoff coefficient "c" is an estimate of the fraction of total rainfall that will appear as runoff. Runoff coefficients for sites with more than one land use are estimated by calculating a weighted average (based upon the area) of the runoff coefficients for each land use.

- If the user selects A.1 or A.2 and B.1.(a) or B.1.(b) or B.2.(a) or B.2.(b) then the Sediment Yield frame will show up
- If the user selects A.3 or A.4 and B.2. (c) or B.4 the Water Runoff frame will show up
- If user selects A.3 or A.4 and B.3(a), and B.3(b) the Sediment Yield frame will show up
- If user selects A.1, A.2, A.3, or A.4 and B.3(c) the Water Runoff frame will show up

Sediment yield estimation

Practical equations for estimation of sediment yield are reproduced from: International Erosion Control Association (1993). "Practical Approaches for Effective Erosion and Sediment Control," *Notes* for a short course sponsored by IECA, Streamboat Springs, CO.

Scanned document using information from: 22-pp. 17- 24

Quantitative parameter assessment (enter numerical value of if calculations are conducted)

Water runoff estimation

There are several methods for estimation of storm runoff discharge. Below is presented one of the most-often used method for small drainage areas (A < 200 acres):.the *rational formula*. For large areas use specialized references [Simon, A. L. and Korom, S.F. (1997). *Hydraulics*, Prentice-Hall, Inc. Columbus, OH]

Runoff equation

For drainage areas, $A < 200$ acres

$Q = CiA$

where Q is the runoff discharge (acre-inch per hour $\cong$ 1 ft^3/sec), i is the rainfall intensity (inches per hour for a duration corresponding to the concentration time T_c), and A is the drainage area (acres). Tc is given by

$$T_c = \frac{0.0663L^{0.77}}{S^{0.385}}$$

where Tc (hours), L is the slope length (kilometers), and S is the slope steepness.
Typical values for the runoff coefficients are provided in the table below

Scanned document: compilation of information using the data from (19 – p.11-table 1 + 22. table B-p.38)

Quantitative parameter assessment (enter numerical value of if calculations are conducted)

OUTPUT DATA

I. Recommended erosion & sediment control measure

The database outputs one or more options that are technically feasible. Selection of the best practical solution for a particular situation is left to the user's judgment. In addition to the technical criterion, the following criteria are suggested for consideration:

- cost-effectiveness
- availability (local supplier or immediate shipment)
- feasibility (quick and easy application, minimal training for application, flexible applicability to a variety of field conditions)
- durability (maintain structural integrity during installation and persist until permanent vegetation is established)
- compatibility (materials selected in regard with public acceptability and environmental sensitivity)
-

From this point on the user obtains specifics for individual ESCMs.

Name of the ESCMs	Short description of the ESCM
Name of the ESCMs	Short description of the ESCM

Etc….

Insert the name of the selected ESCM based on the INPUT info

J. ESCM planning

Developing erosion and sediment control plans requires multiple iterations through the database to address the different stages of roadway construction:

- Initial phase – select perimeter controls
- Intermediate phase – select controls during construction (from grubbing to final grading)
- Final phase – stabilization of the site and installation of permanent controls
- Coordination with transportation and other agencies (see Compliance requirements)

For more info please click here
Scanned document using info from: 19- p. 24 and 24- p.VI-1

Details can be found in:

Reference(s) …. page

Insert the name of the selected ESCM based on the INPUT info

K. ESCM design

In addition to goals and objectives for the facilities being constructed, the ***design*** of an ESCM should also consider objectives which will limit the amount of pollution in storm water runoff from the construction site, such as:

Identify areas to be preserved or left as open space

Avoid disturbance of sensitive areas such as: steep and/or stable slopes

- o Areas with soils susceptible to erosion
- o Surface waters, including wetlands
- o Existing drainage channels

Details can be found in:

Reference(s) …. page

Insert the name of the selected ESCM based on the INPUT info

L. ESCM construction

Efficient site management for effective erosion and sediment control may involve the following considerations:

- **Install** down slope and side slope perimeter controls **before** the land disturbing activity occurs.
- **Do not disturb** an area until it is necessary for construction to proceed
- **Disturb** the smallest area possible
- **Cover or stabilize** disturbed areas as soon as possible
- **Time** construction activities to limit impact from seasonal climate changes or weather events.
- **Delay** construction of infiltration measures until the end of the construction project when upstream drainage areas have been stabilized
- **Do not remove** temporary perimeter controls until **after** all upstream areas are finally stabilized

Button displaying Permit Requirements and insert the box below

In addition, the following actions should be considered to comply with in connection with the Storm Water Pollution Prevention Plan

- Iowa's General permit No.2 requires that a complete Notice of Intent (NOI) be submitted at least 24 hours before construction activities begin. The NOI links a particular storm water discharge with the terms and conditions found in the general permit.
- The major soil disturbing activities during highway construction are: clearing, excavation and stockpiling, rough grading, final or finish grading, preparation for seeding and planting, excavation of trenches, demolition. Iowa's General Permit No.2 requires that disturbed areas of the construction sites for temporary and permanent ECSMs that will not be re-disturbed for 21 days or more must be stabilized by the 14th day after the last disturbance, except as precluded by snow cover. In the event of snow cover, stabilization must be initiated as soon as practicable thereafter.
- Because construction activities may handle certain hazardous substances over the course of the project, spills of these substances may create a "hazardous condition" and are required to be reported. Iowa law requires that as soon as possible but not less than 6 hours after the onset of a "hazardous condition" the IDNR and local sheriff's office of the affected county be notified. The storm water pollution prevention plan must be modified with 14 calendar days of a "hazardous condition".
- Iowa's General Permit No.2 requires updates in the construction plans if the operator observes that it the selected solution is not effective in minimizing the erosion or sediment entrapment or changes to original plans are made from other considerations. Permittees shall have 7 days after notification to make the necessary changes.
- Iowa law requires that copies of the Storm Water Pollution Prevention Plan and all other reports required by the permit, as well as all of the data used to complete the Notice of Intent, be retained for 3 years after the completion of final site stabilization.

Button displaying For more info please click here and insert the text below
Scanned document with info from: 19- p. 26

Details can be found in:

Reference(s) …. page

Insert the name of the selected ESCM based on the INPUT info

M. ESCM inspection/maintenance/stabilization/removal

The following actions should be considered in connection with the Storm Water Pollution Prevention Plan

- Iowa's General Permit No.2 requires inspection every 7 days **and** within 24 hours of the end of a storm of 0.5 inch or greater of rainfall. All disturbed areas of the site, areas from material storage, locations where vehicles enter or exit the site, all of the ESCMs that are identified as part of the plan and accessible discharge locations must be inspected. ESCMs must be in good operating condition until construction activity is complete and final stabilization has been reached. (Note: this text does not apply to permanent ESCMS).
- Iowa's General Permit No.2 defines final stabilization as the time when all soil stabilization activities at the site have been completed and that a uniform perennial vegetative cover with a density of 70% of the cover for unpaved areas not covered by permanent structures has been established or equivalent permanent stabilization measures (such as rip rap, gabions, or geotextiles) have been employed. A Notice of Discontinuation has to be submitted within 30 days from the final stabilization to Iowa DNR.

Button displaying For more info please click here and insert the text below
Scanned document with info from: 19- p. 27, 15-p.51-54, 23-p.87-89

Insert the name of the selected ESCM based on the INPUT info

N. ESCM efficiency (advantages/disadvantages, obstacles, field experiences)

Details can be found in:

Reference(s) …. page +
input from Iowa County Engineer's survey

Insert the name of the selected ESCM based on the INPUT info

O. ESCM compliance requirements

The following actions should be considered to comply with the Storm Water Pollution Prevention Plan

Compliance needed for more than 20,234 m^2 (5 acres, 2 ha) of area disturbed by construction activities such as clearing, grading or excavation. Note that NPDES Phase II (compulsory by March 8, 2003) require permit for more than 4050m^2 (1 acre, 0.405 ha) of area disturbed by construction activities.

Iowa’s General permit No.2 requires that a complete Notice of Intent (NOI) be submitted at least 24 hours before construction activities begin.

Iowa’s General Permit No.2 requires that Iowa DNR needs to be notified that final stabilization has been reached through a Notice of Discontinuation within 30 days after final stabilization has been reached.

Summary of other agencies/regulations that might require permits for ESCMs:

Federal:

1. U.S. Environmental Protection Agency (1992). “Storm Water Management for Construction Activities, Developing Pollution Prevention Plans and Best Management Practices” EPA Office of Water, EPA 832-R-92-005 (Federal- Summary of NPDES General Permits: 15-p.5, 17-p.1.7)
2. Federal Water Pollution Control Act (1977). Clean Water Act, Sections 401, 402, 402(p), 404.
3. Federal Endangered Species Act
4. Clean Air Act
5. Code of Federal Regulations (23 CFR 650.307)
6. Federal Farmland Protection Act

State of Iowa (see also 17-p.1.10, 18; Virginia criteria: 23-p.3)

1. Iowa Department of Natural Resources (1997). “Storm Water Management for Construction Activities,” General Permit No. 2, Summary Guidance, IDNR, Des Moines, IA (ref #19 in IIHR references)
2. State of Iowa Statutory Requirements Pertaining to Erosion Control Plans: 467A.54 Code of Iowa
3. State Wetlands Act
4. State Nature Preserves Act

Local Ordinances

Details can be found in:

Reference(s) …. page

Insert the name of the selected ESCM based on the INPUT info

P. Payment unit

Provide data

APPENDIX E
EXPERT SYSTEM DATABASE

TABLE FOR DATABASE
TEMPORARY AND PERMANENT EROSION CONTROL MEASURES

Temporary ECMs

Vegetative measure

			A. Type of Control 0-6 months, 6-12, >12, >6 & >12 months	B. Objective (ECM, SCM, SWMCM)	C. Area type urban, semi-urban, rural	D. Drainage area extent <5 acres or >5 acres	E. Soil erodibility Groups A, B, C, and/or D	F. Other factors influencing erosion (Slope steepness, Climate, % of the drainage area, Land use) F.2 Climate		F.3 Percent of the drainage area	F.4 Land use	G. Types of water erosion Sheet, splash, gully, rill, stream bank	H. Sediment yield
1	Temporary seeding	Seeding grasses and legumes planted on disturbed areas of soil. Grass cover is the most effective method of controlling erosion.	A.1, A.2.	B.1.(a),B.1.(b),B.2.(b),B.3.(a), B.3.(b)	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2,G.3,G.4	
2	Channel liners	Control measure used to facilitate the establishment of a vegetative growth in a drainage way or as a protection prior to the placement of a permanent	A.1, A.2.	B.1.(c)	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.5	
3	Vegetative filter strip	A strip of grass planted at right angles to the flow of runoff.	A.1,A.2, A.3,A.4	B.1.(a),B.2.(a),B.3.(a),B.3.(b)	C.1.,C.2., C.3.	D.1.	E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2,G.3,G.4	
4	Mulching	Applying plant residue or other suitable material to protect the soil surface.	A.1, A.2., A.3,A.4	B.1.(a),B.1.(b),B.3.(a),B.3.(	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2	
5	Sodding	Used to cover bare soil with cut sod (usually bluegrass) in order to provide rapid ground cover and stabilization of the soil. Often used in waterways and	A.1,A.2,A.3,A.4	B.1.(a),B.3.(a)	C.1.,C.2., C.3.	D.1.	E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2	
6	Matting	A temporary erosion control practice used for the establishment of vegetation that helps protect seeding and increase germination.	A.1, A.2	B.1.(a),B.1.c,B.3.(a)	C.1.,C.2., C.3.	D.1.	E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2,G.5	
7	Surface roughening	Used to provide a rough finish on clay soils. This procedure should generally be used after the fall seeding period has passed.	A.1,A.2,A.3,A.4	B.1.(a)	C.1.,C.2., C.3.	D.1.	E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2	
8	Topsoiling	Salvaged topsoil placed over subsoils that provides a growing media for establishing a cover of grass.	A.1,A.2, A.3,A.4	B.1.(a),B.1.(b),B.2.(a),	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2,G.3,G.4	

Sediment Barriers

1	Straw bales	Are used to filter sediment from runoff in sheet flow applications.	A.1, A.2	B.1.(a),B.2.(a),B.2.(b),B.3.(a)	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2,G.3,G.4	
2	Silt fence	A temporary barrier of geotextile fabric used to intercept sediment on small drainage areas. This is one of the most convenient ESCM.	A.1, A.2., A.3., A.4.	B.1.(a),B.1.(b),B.2.(a),B.2.(b),B.3.(b)	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b)				G.1,G.2,G.3,G.4	
3	Brush barrier	Used in conjunction with filter fabric, filter sediment from runoff before leaving a site.	A.1, A.2	B.1.(a),B.2.(a), B.3.(a)	C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2	
4	Berm ditches	A temporary or permanent ridge of soil located to channel runoff water to planned location.	A.1, A.2, A.3., A.4.	B.1.(a)	C.1.,C.2., C.3.	D.1., D.2.	E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2	
5	Filter berms	A temporary ridge of porous material such as stone or gravel, that can be stabilized in rows, banks, or mounds.	A.1, A.2	B.1.(a), B.2.c	C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2, G.5	
6	Ditch checks	Protect ditches from erosion and to filter sediment from flowing water.	A.1, A.2., A.3., A.4.	B.1.(a),B.1.(c),B.2.(b),B.3.(a),B.3.(b)	C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2, G.3,G.4,G.5	

Water Conveyance

1	Diversions	A temporary or permanent dike or berm located so water can be directed to planned location.	A.1, A.2., A.3., A.4.	B.1.(a),B.2.(a),B.3.(a)	C.1.,C.2., C.3.	D.1.	E.3, E.4	F.1.(a),F.1(b)				G.1,G.2,G.3,G.4	
2	Infiltration trench	A trench designed for the filtration of storm water and collection of sedimentation	A.3.	B.2.(b), B.4	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b)				G.3,G.4	
3	Temporary slope drain	A structure (metal or flexible pipe) used to carry runoff water from the top of a slope to the bottom.	A.1, A.2., A.3., A.4.	B.1.(a),B.2.(a),B.2.(b),B.3.(a)	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2,G.3,G.4	
4	Check dam	A small temporary barrier or dam constructed across a drainage ditch.	A.1, A.2	B.2(b),B.3.(a)	C.1.,C.2., C.3.	D.1.	E.3.,E.4	F.1.(a),F.1(b)				G.3,G.4	
5	Outlet protection	An apron or other energy dissipating device placed at the outlet of a drainage pipe.	A.1, A.2.	B.1.(a)	C.1.,C.2., C.3.	D.1.	E.3.,E.4	F.1.(a),F.1(b)				G.1,G.2	
6	Inlet protection	Carries runoff water in an underground drainage system; used in conjunction with storm drain diversion measures.	A.3., A.4.	B.1(c),B.2(b),B.3.(a)	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.3,G.4	
7	Energy dissipators	An obstacle placed at the outlet of a drainage pipe or any other location that requires reduction of rapid water flow to prevent erosion.	A.1, A.2., A.3., A.4.	B.1(c)	C.1.,C.2., C.3.	D.1., D.2.	E.1,E.2,E.3	F.1.(a),F.1(b),F.1.(c)				G.5	
8	Revetment flume	A device used to transport water in a structure to a lower level without erosion.	A.1, A.2.	B.1.(a)	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2	

Sediment detention ponds and basins

1	Temporary Sediment trap	A depressed area in a drainage location that allows the runoff to slow and the silt to settle.	A.1, A.2	B.2(b)	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b)				G.3,G.4	
2	Infiltraton basin	A depressed area with a vegetated bottom, similar to a dry pond. Used as storm water management designed to reduce the peak flow for a 2 to 10 year	A.1, A.2 , A.3	B.2(b), B.4	C.1.,C.2., C.3.	D.1., D.2.	E.1,E.2,E.3.,E.4	F.1.(a)				G.3,G.4	
3	Sediment basin	A basin created by excavating and/or building a dam across a waterway. A sediment basin usually consists of a dam, a pipe outlet, and an emergency spillway	A.1, A.2.	B.2(b),B.2(a),	C.1.,C.2., C.3.	D.1.	E.2,E.3.,E.4	F.1.(a),F.1(b)				G.3,G.4	
4	Flotation silt curtain	A silt curtain used in a lake or pond to keep silt-laden water within the construction area.	A.1, A.2.	B.1.(c)	C.1.,C.2., C.3.	D.1., D.2.	E.1,E.2,E.3.,E.4	F.1.(a), F.1(b),F.1.(c)				G.5	

Permanent ECMs

1	Permanent seeding	Permanent seeding of lawn grasses and tall grass mixtures used as an effective method of controlling long term erosion.	A.3., A.4.	B.1.(a),B.1.(b),B.2.(b),B.3.(a), B.3.(b)	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2,G.3,G.4	
2	Trees	Used for the control of surface drainage, soil and wind erosion.	A.3., A.4.	B.1.(a),B.1.(b),B.2.(a),B.3.(a)	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2,G.3,G.4	
3	Shrubs	Used for the control of surface drainage and soil and wind erosion.	A.3., A.4.	B.1.(a),B.1.(b),B.2.(b)	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2,G.3,G.4	
4	Vines and ground covers	Used for the control of surface drainage and soil and wind erosion.	A.3., A.4.	B.1.(a),B.1.(b),B.2.(b)	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2,G.3,G.4	
5	Slope/Terrace	Used to intercept and convey surface runoff at a non-erosive velocity to a suitable outlet and to retain runoff for moisture conservation.	A.3., A.4.	B.1.(a),B.1.(b), B.2.c	C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2,G.3,G.4	
6	Serrated cut	Stairstep grading used in soils containing large amounts of soft rock which may be impossible or impractical to smooth grade.	A.3	B.1.(a)	C.1.,C.2., C.3.	D.1.	E.3.,E.4	F.1.(a)				G.1,G.2	
7	Bench	A slightly reverse sloping step on a back slope to reduce slope length.	A.3., A.4.	B.1.(a),B.1.(b)	C.1.,C.2., C.3.	D.1.	E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2	
8	Channels	A drainage way used to convey runoff through, along, or around an area. Conveying runoff in a channel that has an uninterrupted positive grade to the	A.3	B.2.(a),B.2.(c)	C.2., C.3.	D.1., D.2	E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2	
9	Shoulder drains	Used during fill slope construction for the purpose of conveying flow from the roadway surface level down to the toe of slope.	A.3	B.1.(a),B.1.c, B.2.c	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.3	F.1.(a),F.1(b),F.1.(c)				G.1,G.2,G.3,G.4,G.5	
10	Retaining walls	A constructed wall used to assist in the stabilization of cut or fill slopes where permissible slopes cannot be obtained without the use of a wall.	A.3.	B.1.(a),B.2.(a), B.3.(a)	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b)				G.1,G.2,G.3,G.4	
11	Culverts	Divert flood flows and redirect storm runoff to another area such as a basin or a trap.	A.3.	B.1.(a),B.2.(a),B.2.c,B.3.(a),B.3.(b),B.4	C.2., C.3.	D.1.	E.1,E.2,E.3.,E.5	F.1.(a),F.1(b),F.1.(c)				G.1,G.2,G.3,G.4, G.5	
12	Underdrains	A perforated conduit such as pipe, tubing, or tile installed beneath the ground to intercept and convey ground water.	A.3., A.4.	B.1.(a),B.2.(a),B.2.(c),B.3.(a)	C.1.,C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.1,G.2,G.3,G.4	
13	Detention basins	Depressed areas that store runoff during wet weather and dry the rest of the time.	A.3.	B.2.(c), B.4	C.2., C.3.	D.1.	E.1,E.2,E.3.,E.4	F.1.(a),F.1(b),F.1.(c)				G.3,G.4	
14	Retention pond	A permanent pool of water that has the capacity to store storm water until it is released from the structure.	A.3.	B.2(b)	C.1.,C.2., C.3.	D.2	E.3.,E.4	F.1.(a)				G.3,G.4	

TABLE FOR OUTPUT

TEMPORARY AND PERMANENT EROSION CONTROL MEASURES

Temporary ECMs

Vegetative measure | **Description**

	Vegetative measure	Description	I. Recommended Erosion & sediment Control Measure	J. ESCM Planning	K. ESCM Design	L. ESCM Construction	M. ESCM inspection/maintenance/stabilization/removal	N. ESCM efficiency (advantages/disadvantages, obstacles, field experiences)	O. ESCM Compliance requirements	P. Payment Unit
1	Temporary seeding	Seeding grasses and legumes planted on disturbed areas of soil. Grass cover is the most effective method of controlling erosion.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.32**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa	Illinois (1999), Landscape Design and Erosion Control; **Page 59-8(12)**		per acre
2	Channel liners	Control measure used to facilitate the establishment of a vegetative growth in a drainage way or as a protection prior to the placement of a permanent armoring.			AASHTO Model Drainage Manual, Chapter 16: Erosion and Sediment Control; **Page 16-14**	AASHTO Model Drainage Manual, Chapter 16: Erosion and Sediment Control; **Page 16-**	AASHTO Model Drainage Manual, Chapter 16: Erosion and Sediment Control; **Page 16-12**			per acre
3	Vegetative filter strip	A strip of grass planted at right angles to the flow of runoff.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 51**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa			per acre
4	Mulching	Appying plant residue or other suitable material to protect the soil surface.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.27**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources;	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.27**			
5	Sodding	Used to cover bare soil with cut sod (usually bluegrass) in order to provide rapid ground cover and stabilization of the soil. Often used in waterways and flumes.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.41**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources;	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.42**			sq ft.
6	Matting	A temporary erosion control practice used for the establishment of vegetation that helps protect seeding and increase germination.			Smoot, J. L. and Smith, R.D. Soil Erosion Prevention & Sediment Control. (1999) The University of Tennessee, Knoxvillle, Water Resources, Civil & Environmental Engineering; **Page 55**	Smoot, J. L. and Smith, R.D. Soil Erosion Prevention & Sediment Control. (1999) The University of Tennessee, Knoxvillle, Water	Smoot, J. L. and Smith, R.D. Soil Erosion Prevention & Sediment Control. (1999) The University of Tennessee, Knoxvillle, Water			
7	Surfacing roughening	Used to provide a rough finish on clay soils. This procedure should generally be used after the fall seeding period has passed.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.47**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources;	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.47**			per acre
8	Topsoiling	Salvaged topsoil placed over subsoils that provides a growing media for establishing a cover of grass.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.49**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa			

Sediment Barriers

	Sediment Barriers	Description	I. Recommended Erosion & sediment Control Measure	J. ESCM Planning	K. ESCM Design	L. ESCM Construction	M. ESCM inspection/maintenance/stabilization/removal	N. ESCM efficiency (advantages/disadvantages, obstacles, field experiences)	O. ESCM Compliance requirements	P. Payment Unit
1	Straw bales	Are used to filter sediment from runoff in sheet flow applications.			Federal Highway administration (1995) BMP for Erosion and sediment Control Report No. FHWA-FLP-94-005; **Page 64**	Federal Highway administration (1995) BMP for Erosion and sediment Control Report No. FHWA-FLP-94-005; **Page 64**	Federal Highway administration (1995) BMP for Erosion and sediment Control Report No. FHWA-FLP-94-005; **Page 64**			
2	Silt fence	A temporary barrier of geotextile fabric used to intersept sediment on small drainage areas. One of the most convient control measures to use on all projects.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.35**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources;	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.35**			linear foot
3	Brush barrier	Used in conjunction with filter fabric, filter sediment from runoff before leaving a site.			AASHTO Model Drainage Manual, Chapter 16: Erosion and Sediment Control; **Page 16.20**	AASHTO Model Drainage Manual, Chapter 16: Erosion and Sediment Control; **Page**	Federal Highway administration (1995) BMP for Erosion and sediment Control Report No. FHWA-	Illinois (1999), Landscape Design and Erosion Control; **Page 59-8(6)**		
4	Berm ditches	A temporary or permanent ridge of soil located to channel runoff water to planned location.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.60**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa			linear foot
5	Filter berms	A temporary ridge of porous material such as stone or gravel, that can be stabilized in rows, banks, or mounds.			Task Force on Hydrology and Hydraulics, AASHTO Highway Subcommittee on Design (1992): AASHTO Guidelines for erosion and sediment control in highway construction; **Page 8**	Task Force on Hydrology and Hydraulics, AASHTO Highway Subcommittee on Design (1992): AASHTO Guidelines for erosion and	Task Force on Hydrology and Hydraulics, AASHTO Highway Subcommittee on Design (1992): AASHTO Guidelines for erosion and			
6	Ditch checks	Protect ditches from erosion and to filter sediment from flowing water.			A Guide for the Design, Installation, Inspection, and Maintenance of Temporary Erosion-Control Measures in Kansas (1997). Kansas	A Guide for the Design, Installation, Inspection, and Maintenance of Temporary	A Guide for the Design, Installation, Inspection, and Maintenance of Temporary Erosion-Control	Illinois (1999), Landscape Design and Erosion Control; **Page 59-8(14)**		

Water Conveyance

	Water Conveyance	Description	I. Recommended Erosion & sediment Control Measure	J. ESCM Planning	K. ESCM Design	L. ESCM Construction	M. ESCM inspection/maintenance/stabilization/removal	N. ESCM efficiency (advantages/disadvantages, obstacles, field experiences)	O. ESCM Compliance requirements	P. Payment Unit
1	Diversions	A temporary or permanent dike or berm located so water can be directed to planned location.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.60**	Cable, J. K. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of	Cable, J. K. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural	Illinois (1999), Landscape Design and Erosion Control; **Page 59-8(8)**		-linear ft (small) -cu yd (larger)
2	Infiltration trench	A trench designed for the filtration of storm water and collection of sedimentation			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.72**	Cable, J. K. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of	Cable, J. K. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural	Illinois (1999), Landscape Design and Erosion Control; **Page 59-8(10)**		
3	emporary slope drai	A structure (metal or flexible pipe) used to carry runoff water from the top of a slope to the bottom.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.60**	Cable, J. K. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of	Cable, J. K. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural	Illinois (1999), Landscape Design and Erosion Control; **Page 59-8(8)**		-linear ft (small) -cu yd (larger)
4	Check dam	A small temporary barrier or dam constructed across a drainage ditch.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.64**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa	Illinois (1999), Landscape Design and Erosion Control; **Page 59-8(9)**		Riprap: per ton; Silt fence: ft.; Straw bales:
5	Outlet protection	An apron or other energy dissipating device placed at the outlet of a drainage pipe.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.64**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa			
6	Inlet protection	Carries runoff water in an underground drainage system; used in conjunction with storm drain diversion measures.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.86**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa	Illinois (1999), Landscape Design and Erosion Control; **Page 59-8(14)**		sq. ft.
7	Energy dissipators	An obstacle placed at the outlet of a drainage pipe or any other location that requires reduction of rapid water flow to prevent erosion.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.75**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa	Illinois (1999), Landscape Design and Erosion Control; **Page 59-8(13)**		Riprap: per ton
8	Revetment flume	A device used to transport water in a structure to a lower level without erosion.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.75**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa			Sod: per sq.; Riprap: per ton

Sediment detention ponds and basins

1	Temporary Sediment trap	A depressed area in a drainage location that allows the runoff to slow and the silt to settle.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.117**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa			Silt fence: linear ft.; Crushed rock: per ton
2	Infiltration basin	A depressed area with a vegetated bottom, similar to a dry pond. Used as storm water management designed to reduce the peak flow for a 2 to 10 year storm.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.140**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa			individually charged
3	Sediment basin	A basin created by excavating and/or building a dam across a waterway. A sediment basin usually consists of a dam, a pipe outlet, and an emergency spillway			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.114**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa	Illinois (1999), Landscape Design and Erosion Control; **Page 59-8(13)**		
4	Flotation silt curtain	A silt curtain used in a lake or pond to keep silt-laden water within the construction area.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.78**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa			linear ft.

Permanent ECMs

1	Permanent seeding	Permanent seeding of lawn grasses and tall grass mixtures used as an effective method of controlling long term erosion.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.34**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa			per acre
2	Trees	Used for the control of surface drainage, soil and wind erosion.			A Guide for the Design, Installation, Inspection, and Maintenance of Temporary Erosion-Control Measures in Kansas (1997). Kansas	A Guide for the Design, Installation, Inspection, and Maintenance of Temporary	A Guide for the Design, Installation, Inspection, and Maintenance of Temporary Erosion-Control			
3	Shrubs	Used for the control of surface drainage and soil and wind erosion.			A Guide for the Design, Installation, Inspection, and Maintenance of Temporary Erosion-Control Measures in Kansas (1997). Kansas	A Guide for the Design, Installation, Inspection, and Maintenance of Temporary	A Guide for the Design, Installation, Inspection, and Maintenance of Temporary Erosion-Control			
4	Vines and ground covers	Permanent seeding of lawn grasses and tall grass mixtures used as an effective method of controlling long term erosion.			A Guide for the Design, Installation, Inspection, and Maintenance of Temporary Erosion-Control Measures in Kansas (1997). Kansas	A Guide for the Design, Installation, Inspection, and Maintenance of Temporary	A Guide for the Design, Installation, Inspection, and Maintenance of Temporary Erosion-Control			
5	Slope/Terrace	Used for the control of surface drainage, soil and wind erosion.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.137**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa	Illinois (1999), Landscape Design and Erosion Control; **Page 59-8(9)**		linear ft.
6	Serrated cut	Used for the control of surface drainage and soil and wind erosion.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.146**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa			
7	Bench	A slightly reverse sloping step on a back slope to reduce slope length.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.54**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa	Illinois (1999), Landscape Design and Erosion Control; **Page 59-8(9)**		Included in grading
8	Channels	A drainage way used to convey runoff through, along, or around an area. Conveying runoff in a channel that has an uninterrupted positive grade to the outlet.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.18**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa			sq. ft.
9	Shoulder drains	Used during fill slope construction for the purpose of conveying flow from the roadway surface level down to the toe of slope.								
10	Retaining walls	A constructed wall used to assist in the stabilization of cut or fill slopes where permissible slopes cannot be obtained without the use of a wall.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.101**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa			
11	Culverts	Divert flood flows and redirect storm runoff to another area such as a basin or a trap.						Illinois (1999), Landscape Design and Erosion Control; **Page 59-8(13)**		
12	Underdrains/Subsurface Drainage	A perforated conduit such as pipe, tubing, or tile installed beneath the ground to intercept and convey ground water.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.132**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa			
13	Detention basins	Depressed areas that store runoff during wet weather and dry the rest of the time.			Yu, S. L. and Kaighn, R. J. (1992) Virginia DOT Manual of Practice for Planning Stormwater Management. Virginia Transportation Research		Yu, S. L. and Kaighn, R. J. (1992) Virginia DOT Manual of Practice for Planning Stormwater	Illinois (1999), Landscape Design and Erosion Control; **Page 59-8(8)**		
14	Retention pond	A permanent pool of water that has the capacity to store storm water until it is released from the structure.			Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa Department of Natural Resources; **Page 2.143**	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual.	Cable, J. K. and Dolling, H. (1994) Iowa Construction Site Erosion Control Manual. Iowa	Illinois (1999), Landscape Design and Erosion Control; **Page 59-8(8)**		variable