ILLINOIS SCIENTIFIC SURVEYS JOINT REPORT 1

CONCEPTUAL MODELS OF EROSION AND SEDIMENTATION IN ILLINOIS

Volume II. level II models, model interactions, keywords, and bibliography

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Nancy R. Black • David L. Gross • Timothy W. Sipe • Paul G. Risser

Prepared in cooperation with the Research Section,
Illinois Department of Energy and Natural Resources

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FOREWORD

Natural processes of soil erosion and sedimentation have been drastically impacted by human activities. Topsoil is being lost from farms, stream banks are being eroded away, lakes and reservoirs are being silted, and excessive erosion and sedimentation are significantly affecting the water quality and biological productivity of lakes and streams. Actions that may be taken collectively to minimize these problems must be based on sound scientific knowledge and accurate information.

In 1982, the Illinois Department of Energy and Natural Resources allocated research funds to the Board of Natural Resources and Conservation for projects vital to the State of Illinois. This research project on the development of "Conceptual Models of Erosion and Sedimentation in Illinois" is one such project that has been sponsored by my department. Scientists and engineers from the Water Survey, Geological Survey, and Natural History Survey were involved in this multidisciplinary effort in which questions on soil erosion and sedimentation were addressed in a systematic manner. The eleven "Conceptual Models" on erosion and sedimentation, the extensive bibliography, and the summary of data gaps and research needs represent the most complete analyses that have ever been done for the State of Illinois in this subject area, and show where we should direct our efforts to solve the problems of soil erosion and sedimentation.

Michael B. Witte, Director
Illinois Department of Energy
and Natural Resources
Chairman, Board of Natural Resources
and Conservation

ABSTRACT

Erosion and sedimentation are natural processes that can neither be stopped nor eliminated. However, human activities have been instrumental in drastically accelerating these processes. Presently excessive amounts of soil loss from the watershed are impacting productivity of farms, changing the natural balance of the stream-watershed environment by aggrading stream beds and lakes, and altering the biological and geological continuity of the system. This complex process of erosion and sedimentation with its multi-dimensional facets can be examined in a coherent manner only by the development and interpretation of a set of conceptual models covering the total erosion and sedimentation phenomenon.

A set of eleven conceptual models has been developed consisting of a single Level I model and ten Level II models. The Level I model is a general model but it identifies the major subdivisions of the environment and the important natural and human factors that influence erosion and sedimentation processes. The Level II models each specifically depict one system or sub-system of the environment. These systems are: agriculture, grassland, forest, mining, urban, construction, streams and rivers, permanent wetland, seasonal wetland, and lakes and reservoirs. Detailed descriptions of each interaction within each model have also been developed. On the basis of an extensive review of the literature, discussion and active participation by various state and federal agencies, and workshop inputs, a list of data gaps and research needs has been developed and is included in the report.

The report has been divided into two volumes. Volume I contains the project summary, including a brief description of all the models and the list of information and data gaps. Volume II contains a detailed description of all Level II models and model interactions, listings of the related citations for each interaction for all the ten Level II models, a list of more than 500 keywords, and a bibliography with over 700 entries. Descriptions of the process of interpreting the Level II models and of the generation of the exhaustive list of citations are also included.

Keywords: Erosion, Sedimentation, Illinois, Conceptual Models, Rivers, Lakes, Agriculture, Forest, Urban, Construction, Upland, Wetland, Research Needs, Data Gaps

ACKNOWLEDGMENTS

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Staff members who contributed substantially are Rodger Adams and Cheryl Peterson from the Water Survey, Mary Krick and Marjorie Eastin from the Geological Survey, and Monica Lusk, Carla Heister, and Faith Wetzel from the Natural History Survey. Typists who prepared the camera ready-copy are Kathleen Brown and Pamela Lovett from the Water Survey. Gail Taylor, Water Survey, edited the final copy of the report, and the graphics were prepared by the graphics personnel from the Water Survey under the supervision of John Brother. Lastly, we would like to thank Marcia Nelson, former Water Survey librarian, who assisted extensively in the preparation and the operation of the "Biblio" computer program used to enter, store, and sort the bibliographical references.

Printing was done at the State Geological Survey under the supervision of Dennis Reed.

REPORT FORMAT

This report has been divided into two volumes. Volume I is a summary of the project, describing the technical approach and some highlights of the results. An appendix to Volume I lists the participants in the workshop on the project that was held at Allerton House.

Volume II describes all the models in detail, lists and describes the interactions between various parameters for each model, and lists the bibliographical references that are closely related to each of the model interactions. It also lists the 513 keywords used for this project with the numerical codes relating them to the various models. It then presents the bibliography containing a total of 795 entries, including pertinent keywords.

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(Concluded on next page)

CONTENTS (Concluded)

VOLUME II. LEVEL II MODELS, MODEL INTERACTIONS, KEYWORDS, AND BIBLIOGRAPHY

INTRODUCTION

This report has been divided into two volumes. Volume I contains the project summary describing objectives, procedures followed for the literature review, the survey of agencies and agency responsibilities, the Level I and Level II models, the workshop at Allerton House, and important information gaps and research needs. Volume I thus gives a very broad overview of the total project content and its multidimensional facets. Volume I was not meant to give detailed descriptions of the important interrelationships of the ten Level II conceptual models.

Volume II, on the other hand, contains the bulk of the technical analyses performed in the development of the Level II models. This volume includes a description of each of the Level II models and model interactions, along with the bibliographical references that are closely related to the interactions for each model. It also contains a list of the keywords, and a large bibliography.

An extensive list of keywords was selected and utilized in this project. Selection of the keywords was based on an extensive review of pertinent literature encompassing a broad spectrum of subjects and disciplines. All the keywords have been arranged in alphabetical order and numbered in ascending order. Each model component shown inside each box within the model(s) is also a keyword or keywords, and the appropriate number(s) is(are) shown within the respective boxes. All the keywords are given on pages 227-231.

LEVEL II MODELS

Background

The Level II conceptual models are the central component of this project. They represent a unified approach to identifying and explaining the dynamics and interactive nature of erosion and sedimentation processes in all parts of the landscape at a useful intermediate level of detail. They also bind together all other elements of the project in a coherent manner.-

The general model given as the Level I model (shown on page 3) identifies the Level II models. The Level I model breaks the landscape into six major systems recognized by the U.S. Fish and Wildlife Service in their classification of wetland and deep water habitats (Cowardin et al., 1979).*

Four of these systems apply directly to Illinois (Upland, Riverine, Palustrine, and Lacustrine), and two (Estuarine and Marine) are included in the Level I model (but not modeled at Level II) because they represent the ultimate sinks of sediment and adsorbed materials eroded and transported from Illinois. The Upland System is divided here into six subsystem models and the Palustrine System is divided into two subsystem models (Table II-1). The Riverine and Lacustrine Systems are represented by one model each. All Level II model components and interactions for specific models will be identified subsequently by the key letters shown in Table II-1.

The level of resolution chosen for Level II models is a useful compromise between (1) gross generality that does not address detailed problems and (2) explicit complexity of actual mechanisms that does not provide a manageable perspective. The components of each model, and across all models, are on roughly the same order of resolution.

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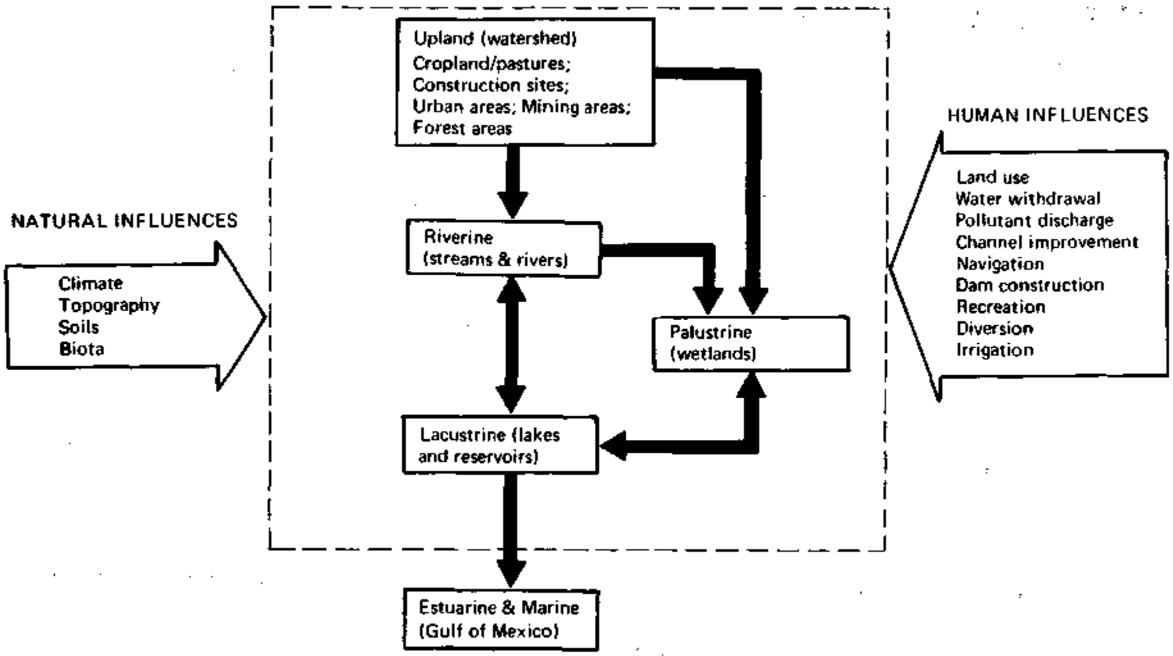
*Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of Wetlands and Deep Water Habitats of the United States. U.S. Department of Interior, Fish and Wildlife Service, Biological Services Program, FWS/OBS-79/31.



Level I model; a conceptual model for the transport of sediment, biota, nutrients, and chemical pollutants by water in Illinois

(Major sources and sinks of sediment and organic and inorganic matter are represented by the boxes. The flow of material from one environment to another is shown by the arrows. The natural and human influences are represented by two switches acting on the whole system representing the state of Illinois.}

Table II-1. Level II Models and the Corresponding Abbreviations Used in the Interaction Codes

Name	Abbreviation
Upland System	
Agriculture Subsystem	A
Grassland Subsystem	G
Forest Subsystem	F
Mining Subsystem	M
Urban Subsystem	U
Construction Subsystem	C
Riverine System	R
Palustrine System	
Permanent Wetland Subsystem	p
Seasonal Wetland Subsystem	S
Lacustrine System	L

Interpretation of Level II Models

The Level II models depict the complex interrelationships between various capture mechanics, sources and sinks', cause and effect relations, external constraints, and impacts of one segment of the landscape on an adjoining or distant segment or segments. Thus it is imperative that readers realize and understand this significant difference between the Level II models and other models that depict only one process within a landscape. These models, given in Figures I-2 through I—11, Volume I, and repeated in Figures II-1 and II-8 through II-16, show the relationships between various components of the models. Each model not only depicts the correlation among various components (keywords) but also demonstrates the erosion and sedimentation processes within a specified area of the landscape. The. keyword(s) within each model component will enable the reader to identify the important contribution of the specified component and how it may be related to other components.

An explanation of how to interpret the Level II models and the meaning of the interactions can be given easily by selecting one of the Level II models and giving a step-by-step demonstration of its use.

Figure II-1 shows the Level II model of the Agriculture Subsystem. A brief description of this model has already been given in Volume I. The model can be subdivided into five categories from left to right: economic and management factors, management influences, physical and natural characteristics of the watershed, external physical constraints and the resultant erosion and sedimentation, and export of materials.

The components shown within the model are interconnected with one-way and two-way arrows. An explanation of the keywords (components) and interactions is given in Figure II-2. The interactions shown in Figure II-2 are

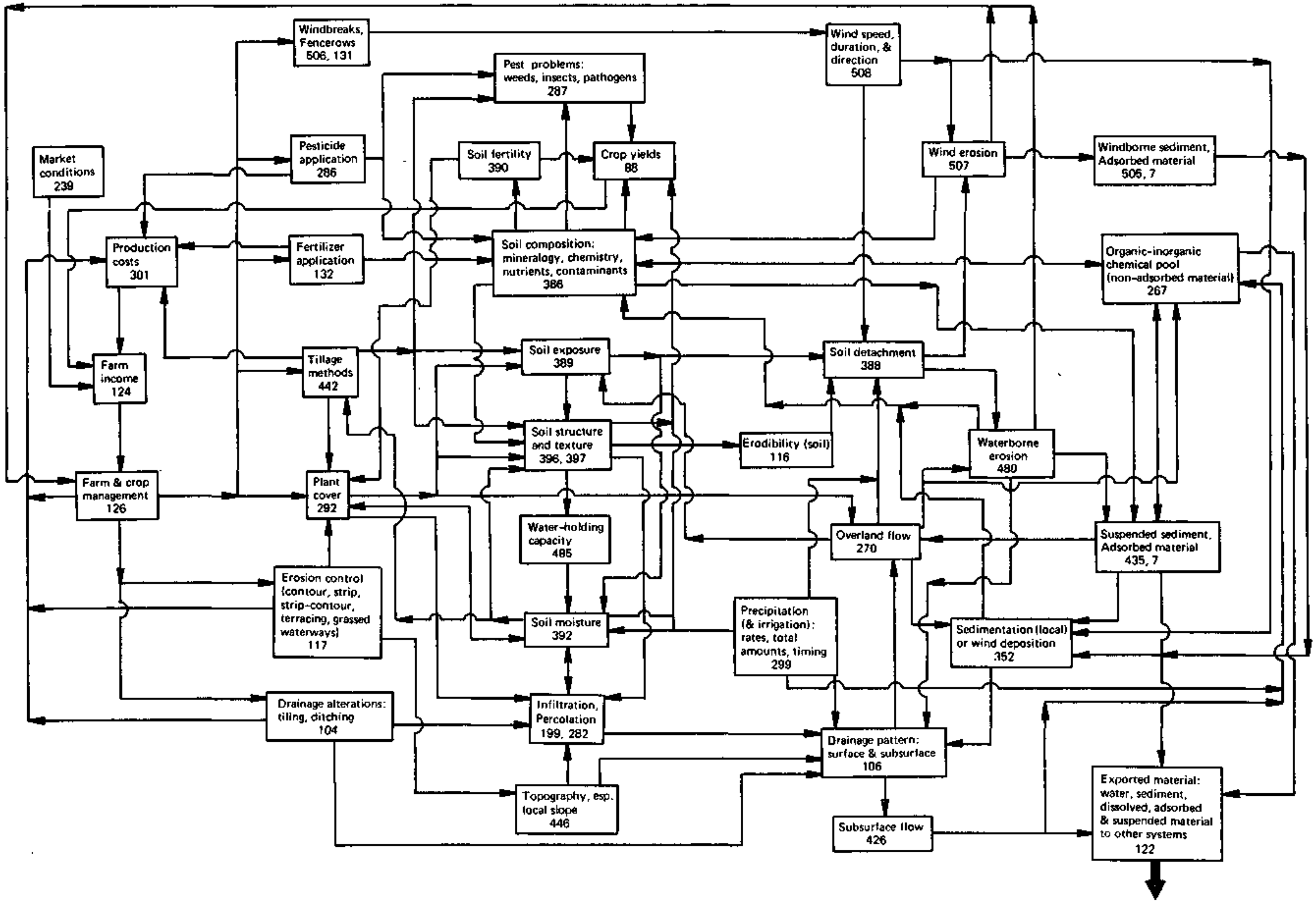


Figure II-1. Level II model for the Agriculture Subsystem

Components in the model are identified by keywords and an assigned number:

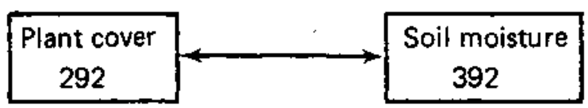
Component	Number
Tillage methods	442
Soil exposure	389

Interactions between components are identified by pairs of numbers:

The code 442-389 refers to the interaction,

Interactions can also be identified by two way arrows:

The codes 292-392, 392-292 refer to the interactions,



In some cases, a model component is composed of two keywords.
For example,

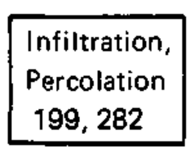


Figure II-2. Examples of keywords, model components, and interactions, Agriculture Subsystem model on the first-order level. Figure II-3 illustrates first- and second-order interactions, showing the effects of tillage method on infiltration and percolation through soil structure. Figures II-4 through II-6 show, respectively, the economic and management factors, "management influences," and the physical and natural factors of watersheds. Similar partitioning of the remaining components can easily be done.

The versatility of the Level II models can further be demonstrated by showing how farm income (Box A124) is related to exported material (Box A122), following a route through farm and crop management (Box A126), erosion control (Box A117), topography (Box A446), drainage pattern (Box A106), overland flow (Box A270), non-adsorbed organic-inorganic chemical pool (Box A267), and exported material (Box A122). This interrelationship between any two, three, or more components is explained diagrammatically in Figure II-7.

It must be remembered that the use of these models depends on a clear understanding of the model components, keywords, and interrelationships between the components, and on a systematic interpretation of the models. Readers who closely follow Figures II-2 through II-7 can have a better understanding of this complex but easily interpretable model. The examples shown are for the Agriculture Subsystem model only; however, similar cross-relationships exist within each of the other nine Level II models.

For each Level II model, a brief description and a diagram of the model are provided. These are followed by detailed descriptions of the model interactions, with related bibliographical references given for each interaction. These related references are discussed in the next section.

The effects of tillage methods on infiltration/percolation through soil structure would be coded as,

442-(396, 397); (396, 397)-(199, 282)

and represented in the models as,

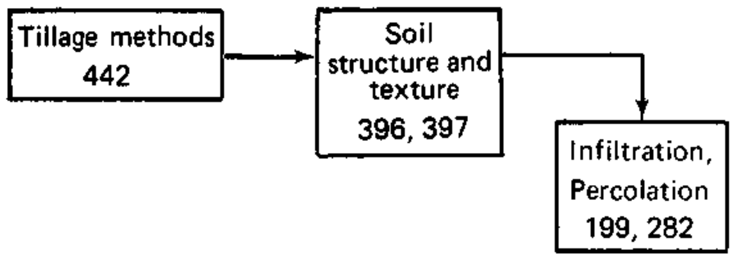


Figure II-3. First— and second-order interactions, Agriculture Subsystem model

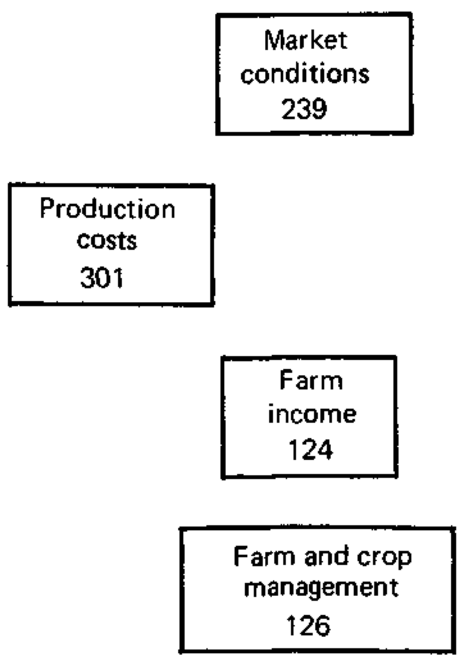


Figure II-4. Economic and management factors, Agriculture Subsystem model

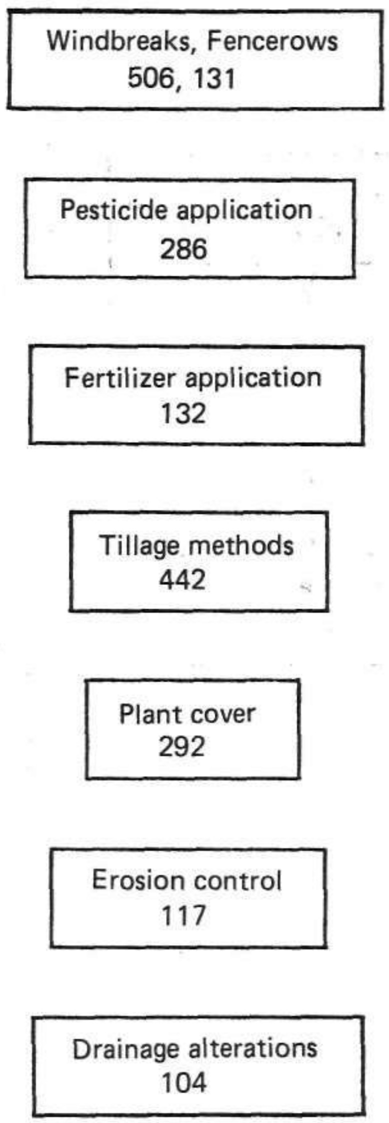


Figure II-5. Management influences, Agriculture Subsystem model

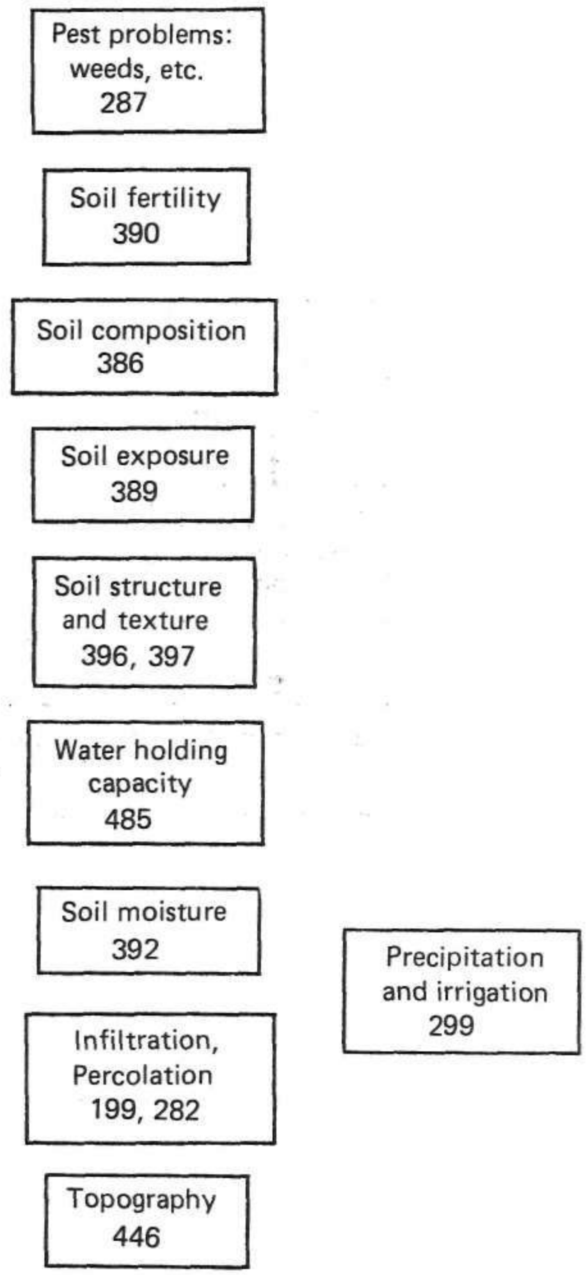


Figure II-6. Physical and natural factors, Agriculture Subsystem model

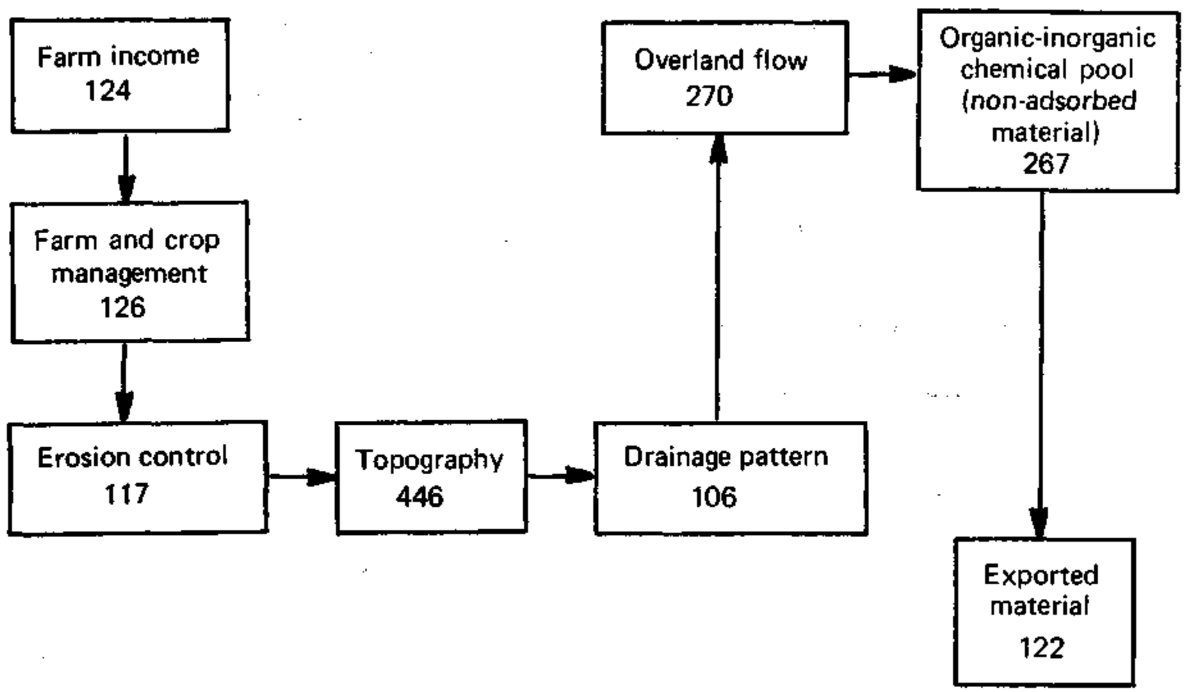


Figure II-7. Effect of farm income on exported material, Agriculture Subsystem model

RELATED REFERENCES FOR MODEL INTERACTIONS

It is essential that the bibliographical references assembled for this project and given in subsequent sections be interrelated with the individual model interactions. Utilizing the keywords listed with each reference and the keywords used for each component of each model, a computer search was made to identify the related references. For "example, in the Agriculture Subsystem Level II model (Figure II-1), if the effects of erosion control (A117) on plant cover (A292) are considered, it will be of significant value if a determination is made of the number of references that have been listed which specifically address this particular interaction. Since all the references and the keywords were listed and kept in a computer file, it was fairly easy to make a computer search of all the references where the keywords erosion control (117) and plant cover (292) appeared. This technique was followed for all the interactions for each of the Level .II models. (Additional related words were also used in conjunction with the keywords.) This searching not only identified the related and available references, but it also showed the areas where significant research or data collection have not yet been done.

The related references for each interaction for each Level II model are given in Tables II-2 through II-11. These references are listed (by numbers only) with each interaction. Thus in Table II-2, the first interaction is A88-124 relating crop yields to farm income. The numbers given after the interaction description refer to the specific bibliographic citings.listed in the bibliography on pages 234 to 359. Thus, a reader can specifically choose one of the models, identify a specified interaction, and then pick up the related references,without going through all of the references. This information should be of considerable value to researchers, planners, and research administrators in identifying the areas where a serious gap in our knowledge still persists or where significant bibliographical information is available.

DESCRIPTIONS OF LEVEL II MODELS AND MODEL INTERACTIONS

All the Level II models fall under four basic systems. These are the Upland System containing Agriculture, Grassland, Forest, Mining, Urban, and Construction Subsystems; the Riverine (Streams and Rivers) System; the Palustrine System containing Permanent and Seasonal Wetland Subsystems; and the Lacustrine (Lakes and Reservoirs) System. Obviously, significant similarities exist between subsystem models under the same main "system." Brief descriptions for each of the Level II models are included in Volume I of this report. Some additional descriptions are given in the following pages.

Upland System

Agriculture Subsystem

Model Description and Model Interactions. This model is shown in Figure II-1. A fairly detailed explanation of this model has been given in the subsection on "Interpretation of Level II Models." Some additional interpretation follows.

The Agriculture Subsystem model describes all intensively cultivated lands, including all row-cropped acreage, cultivated nurseries, truck crop acreage, and small grain crops. Hayfields are placed in the Grassland Subsystem (G) because of their similarity to permanent pastures and other grasslands. This means that under crop rotation (e.g., corn followed by alfalfa), the same field may be considered as being in the Agriculture Subsystem in one year and in the Grassland Subsystem in a second year.

Fields producing small grain crops (wheat, oats, sorghum) or soybeans that are sown broadcast instead of in rows are included in the Agriculture Subsystem even though continuous plant cover in healthy crops is similar to both hayfields and pastures. The reason for this placement is that the production of small grains requires soil preparation steps that are distinct from hayfield and pasture management.

Large intensively cultivated nurseries and truck crop fields resemble row crop production and are included here. Mature orchards are usually grassed and hence are included in the Grassland Subsystem.

Erosion and sedimentation are considered to be the results of multiple sequences of both natural and human-influenced causes and effects. The interacting variables are ultimately soil, water, and wind; hence any influence on this triumvirate may affect erosion and sedimentation processes. The following discussion of factors related to erosion is based on the Agriculture Subsystem model (Figure II-1), but it is also valid for the other Upland Subsystems.

In all the Upland Subsystems, waterborne erosion (A480) and wind erosion (A507) result from the convergence of conditions that allow detachment of soil particles and transport of the particles in the downstream direction by the moving water or wind. For waterborne erosion this convergence is shown in the center of the right half of the Upland Subsystem models by the arrows connecting overland flow (A270), soil detachment (A388), and waterborne erosion (A480). The corresponding relationships for wind erosion are the arrows between wind speed, duration, and direction (A508), soil detachment (A388), and wind erosion (A507).

Working backward from these convergences, note that overland flow (A270) is one part of the overall drainage pattern (A106) which in itself is the result of numerous soil and water variables. Wind speed/duration/direction is less complicated since it depends little on soil properties. Soil detachment is also affected by soil and water variables. Soil exposure (A389) and erodibility (A116), when combined with either precipitation (A299), overland flow (A270), or wind speed (A508), will result in the dislodgement of soil particles.

Both exported material (A122) and local sedimentation by wind or water (A352) depend on two properties: the amount and nature of waterborne (A435) or windborne (A505) sediment and the ability of the transport agent--wind speed (A508) or overland flow (A270)--to keep the soil particles in transit.

The relationships between the soil variables in the third column are generally clear. Soil composition (A386) is a composite component that includes all physical and chemical characteristics of the soil particles themselves, from particle size to pH to contaminants. Thus all chemical inputs, outputs, and exchanges are processed through the soil composition component. These include inputs from fertilizer application (A132-386) or pesticide application (A286-386); inputs through precipitation (A299-267); outputs related to pesticides to eliminate pest problems (A386-287) or nutrients to alter soil fertility (A386-390); and exchanges, including soil composition to/from non-adsorbed organic-inorganic chemical pool (A386-267 and A267-386) and soil moisture to/from infiltration, percolation (A392-(199,282) and A(199,282)-392).

Of the management influences shown in the second column of components, the bottom four are the most important: tillage methods (A442), plant cover (A292), erosion control (A117), and drainage alterations (A104). They form the composite link between farm practices and soil and water variables. Pesticide (A286) and fertilizer (A132) application are added due to their effects on suspended sediment and adsorbed materials and non-adsorbed chemical pools (A(435, 7) and A267, respectively).

The management strategy pursued by an individual farmer will depend on many forces both internal and external to his operation. Most are channeled through farm income (A124), which is the net result of the opposing economic forces of production costs (A301), crop yields (A88), and market conditions (A239). The reason for this channelization through farm income is that. decisions to implement any particular management technique, including erosion control practices, are motivated in the final analysis by concern for financial gain or loss-

Detailed model interactions between interrelated parameters have been developed. These interactions are described in Table II-2.

Table II-2.' Descriptions of Interactions for the Agriculture Subsystem Model

Interaction code	Description
A88-124	Crop yields - Farm income: This represents the effects of crop yields on farm income, as influenced by production costs and market conditions. Related References: 84,165,431,602,665,666
A104-106	Drainage alterations - Drainage pattern: This represents the effects of drainage alterations implemented by the farmer on existing field drainage (surface and subsurface), either enhanced, retarded, or some combination of both. Related References: 163,580,599
A104-(199,282)	Drainage alterations - Infiltration, Percolation: The effects of drainage alterations on infiltration and percolation are usually due to subsurface tilling, which accelerates removal of water and thus speeds percolation. Related References: none
A104-301	Drainage alterations - Production costs: The implementation of drainage systems is usually done with an eye toward crop yields, and hence may be considered a component of production costs. Related References: 580,599
A106-270	Drainage pattern - Overland flow: As used in this model, drainage is divided into surface (runoff) and subsurface flows. The surface flow is called overland flow. Related References: 9,32,561,633
A106-426	Drainage pattern - Subsurface flow: Subsurface flow is one component of the total drainage pattern (as discussed in 106-270 above) and includes both natural and artificial (e.g., tile system) subsurface water movement. Related Reference: 538

A116-388 Erodibility (soil) - Soil detachment:
Soil detachment is the convergence of two variables: soil characteristics suitable for dislodgment and a dislodging force. The former is summarized here as soil erodibility; the latter may be wind, precipitation, or overland flow.

Related References: 18,38,40,174,187,194,237,239,241,453,460, 462,582,646,678,726,752

A117-292 Erosion control - Plant cover:
One major category in erosion control practice is the use of plant cover to reduce soil exposure, soil detachment, runoff velocity, etc. This may be accomplished through grassed waterways, strip cropping, winter cover crops, and other means.

Related References: 6,7,11,1 4,29,31,39,50,85,86,109,130,141,207, 236,239,245,279,286,298,299,331 ,363,436,458, 503,554,561,628,637,664,737,778

A117-301 Erosion control - Production costs:
The implementation of erosion control measures contributes to farm operation costs, even though the benefits may be delayed and. returned only over the long run.

Related References: 5,165,202,272,274,511,580,655

A117-446 Erosion control - Topography (especially local slope):
Several erosion control techniques alter effective local slope, such as terracing, contour farming (where the slope alteration is on the scale of individual crop rows), and more direct measures involving actual grade manipulation.

Related References: 6,39,40,85,120,128,129,141,157,162,165,211, 241 ,270,296,331,363,381,430,462,472,528,662, 666,726,727,755,777,778

A124-126 Farm income - Farm management:
This represents the powerful effect of farm income on all farm management decisions.

Related References: 74,84,156,260,271,431,510,511,524,602,665

A126-104 Farm management - Drainage alterations:
Farm management decisions to alter field drainage for faster or slower movement of water off fields may include improved drainage of low ground, heavy soils, or soils with subsurface barriers to water movement. Alterations to slow water movement off fields may involve reducing runoff velocity, reducing slope length, or trapping sediment.

Related References: 484,687

A126-117 Farm management - Erosion control:
This represents farm management decisions to implement any of several erosion control techniques, as influenced by current erosion losses and crop management, farm income, and projected costs and benefits of the erosion control projects.

Related References: 6,43,74,152,201,260,271,399,400,431,461,510, 511,717,739,755

A126-132 Farm management - Fertilizer application:
This represents farm management decisions to apply fertilizer (timing, rates, total amounts, fertilizer type, and method of application) based on considerations regarding crop yields, farm income, and fertilizer costs.

Related References: 84,271,510,517,717

A126-286 Farm management - Pesticide application:
This represents farm management decisions to apply pesticides (time, rates, total amounts, pesticide type, and method of application) based on considerations regarding projected crop yield reduction by pests, pesticide costs, and farm income.

Related References: 84,260,517

A126-292 Farm management - Plant cover:
This represents the effects of farm management decisions on plant cover in cultivated fields, and consequently on soil exposure and infiltration. This involves both live (winter cover crops, rotation legume crops, soybean sowing vs. row-cropping, etc.) and dead (crop residues, either intact or partially incorporated) plant material. This may also include the existence and management of grassed waterways or greenbelts along drainage draws, ditches, streams, or fencerows.

Related Reference: 6

A126-301 Farm management - Production costs:
This interaction includes all other farm operation costs not directly indicated by other arrows in the model (e.g., equipment operation and repair).

Related References: 84,201,511,602

A126-442 Farm management - Tillage methods:
This represents farm management decisions concerning choice of tillage system, as influenced by soil characteristics and existing soil erosion, pest problems, crop yields, and farm income.

Related References: 84,107,201,431,484,511,524,602,717,739

A126-(506,131) Farm management - Windbreaks, Feneerows:
This represents farm management decisions regarding the use of windbreaks and/or the retention of fencerows to reduce wind speed and offset wind erosion.

Related Reference: 107

A132-301 Fertilizer application - Production costs:
The contribution of fertilizer costs to total production costs is included here.

Related References: 84,599,617,655

A132-386 Fertilizer application - Soil composition:
This represents alteration of soil composition, and thus enhancement of soil fertility, through fertilizer application. This involves fertilizer type, timing, rates, application method, and associated soil and water variables.

Related References: 84,244, 433,447,517,649,688,694,717

A(199,282)-106 Infiltration, Percolation - Drainage pattern:
The relationships between infiltration and percolation, as influenced by many other soil and water variables and existing field drainage patterns, is represented here. The latter includes surface and subsurface flows and their spatial and temporal patterns.

Related References: 145,538,743

A(199,282)-392 Infiltration, Percolation - Soil moisture:
Soil moisture at any point in time is the composite result of several soil and water variables, including infiltration and percolation, which influence how quickly water moves into and through (or over) the soil.

Related References: 6,124,176,219,331,463,471,766

A239-124 Market conditions - Farm income:
The effects of market conditions, primarily commodity prices, on farm income, as influenced by crop yields and production costs, is represented here.

Related Reference: 165

A267-122 Organic-inorganic chemical pool (non-adsorbed) - Exported material:
This represents the contribution of non-adsorbed chemicals in the water column to total exported materials, through either surface or subsurface flow.

Related References: 26,269,476,555

A267-386 Organic-inorganic chemical pool (non-adsorbed) - Soil composition:
Exchanges of chemical species between the water column and the soil, either in standing water or as a result of transport from one part of the land surface to another, are represented here.

Related References: 8,27,30,102,139,140,230,260,265,268,269,286, 318,370,371,372,373,420,433,435,436,447,465, 466,476,483,559,576,577,597,600,630,661 ,670, 688,715,757

A267-(435,7) Organic-inorganic chemical pool (non-adsorbed) - Suspended sediment, Adsorbed material:
This represents exchange of chemical species between non-adsorbed and adsorbed pools in either soil water or overland flow, as influenced by a variety of physical and chemical variables (such as water temperature, pH, etc.)

Related References: 89,98,113,234,322,388,457,534,550,600,690

A270-267 Overland flow - Organic-inorganic chemical pool (non-adsorbed):
This represents the contribution of overland flow and materials transported by runoff to total non-adsorbed chemical pools in waters draining agricultural fields.

Related References: 26,39,69,81,124,194,472,555,577

A270-352 Overland flow - Sedimentation or wind deposition:
Spatial and temporal patterns of field drainage (especially runoff velocity and slope) may result in local ponding. Sedimentation may occur in conjunction with suspended sediments from waterborne sheet, rill, and gully erosion and from wind erosion.

Related Reference: 194

A270-388 Overland flow - Soil detachment:
Moving water may detach erodible soil particles and initiate the overall process of erosion. This depends on runoff velocity, soil composition, critical slope, and other variables.

Related References: 143,174,192,194,288,412,460,543,561,577,671 , 749,752

A270-389 Overland flow - Soil exposure:
In sufficient quantities, overland flow may actually shield an otherwise exposed soil from raindrop impact, thus retarding soil detachment due to this latter force.

Related Reference: 749

A270-480 Overland flow - Waterborne erosion:
Erosion is the detachment and transport of soil particles. The influence of overland flow on detachment has been discussed above (270-388); clearly, overland flow provides a transport mechanism.

Related Reference: 472

A286-287 Pesticide application - Pest problems:
This interaction represents the direct effect of pesticides on weeds or insects, i.e., effects not requiring residence of the pesticide in the soil. Pesticides that operate through incorporation in the soil are described through 286-386-287.

Related References: 84,244,260,268,316,317,377,517,579,593,607, 617,650,651 ,655,686,728

A286-301 Pesticide application - Production costs:
the contribution of pesticides and their application to total production costs are represented here.

Related References: 84,617,655

A286-386 Pesticide application - Soil composition:
This represents the effects of pesticide (herbicide or insecticide) application on soil composition. This is either intentional (pesticides that require incorporation into the soil for proper action) or unintentional (caused by rain washing pesticides off plants and into the soil).

Related References: 84,244,260,268,517,607

A287-88 Pest problems - Crop yields:
The detrimental effects of weeds and insects on crop yields, through either competition for water and minerals or herbivory, are represented here.

Related References: 185,244

A292-(199,282) Plant cover - Infiltration, Percolation:
This represents the effects of plant cover on infiltration (raindrop interception, reduced input to the ground surface, reduced momentum and impact of drops reaching the ground, etc.) and percolation (enhanced through root channels, whose extent is correlated with above-ground plant cover).

Related References: 6,219,331,746

A292-270 Plant cover - Overland flow:
Both live and dead plant material may form obstructions to movement of runoff. The results are reduced velocity, sedimentation, reduced detachment, and consequently reduced erosion.

Related References: 6,130,503,582

A292-389 Plant cover - Soil exposure:
This represents the relationship between plant cover and soil exposure, as influenced by any of the practices discussed in 126-292 above. The timing of plant cover/soil exposure and the condition of the soil surface are most important.

Related Reference: 586

A292-392 Plant cover - Soil moisture:
Through transpiration, above ground plant cover may significantly lower soil moisture, particularly in the lower depths of the rooting zone.

Related References: 6,41,130,219,298,331,432,626

A292-(396,397) Plant cover - Soil structure and texture:
The influences of the plants on soil structure are primarily due to root channelization and aeration by living plants, and to contribution of organic material to the soil.

Related References: 6,41,130,219,298,331,432,626

A299-106 Precipitation - Drainage pattern:
For any given precipitation event, the total quantities and rates of precipitation will influence the balance between surface and subsurface flows. Other interacting variables are soil texture and structure, water holding capacity, and infiltration/percolation. In addition, antecedent moisture content will influence the response of the drainage pattern to a new event. -

Related References: 9,14,32,63,88,132,145,146,163,383,385,438, 538,561,586,633,648,679,680,737,743,767,768, 789,790

A299-267 Precipitation - Organic-inorganic chemical pool (non-adsorbed):
Materials dissolved or adsorbed to particles in rainwater will contribute to the non-adsorbed chemical pool in surface and subsurface waters.

Related References: 8,37,39,47,81,88,132,145,150,159,232,234, 245,286,331,389,396,433,459,483,520,559,572, 586,591,651,661,715,767

A299-388 Precipitation - Soil detachment:
Precipitation variables responsible for raindrop impact and soil particle dislodgement (velocity, drop size, etc.) affect subsequent erosion rates.

Related References: 38,141,143,190,239,288,380,382,446,453,460, 462,471,474,483,485,561,582,645,646,748,749, 752,765

Table II-2. Continued

A299-392 Precipitation - Soil moisture:
Precipitation patterns will influence soil moisture at any point in time, as regulated by drainage pattern and other soil characteristics.

Related References: 38,107,331,463,471,539,734,766

A301-124 Production costs - Farm income:
This represents the effects of fixed and flexible costs on farm income, as balanced against crop yields and market conditions.

Related References: 84,165,511,580,602,655

A352-106 Sedimentation or wind deposition - Drainage pattern:
This represents the potential alteration of the drainage pattern (especially overland flow) by local sedimentation due to ponding, ditch filling, etc.

Related References: 63,69,81,88,143,153,194,259,412,421,438,530, 567,577,679,680,749,767

A352-386 Sedimentation or wind deposition - Soil composition:
Sediments deposited by water or wind may alter the character of the soil surface to which they are added. This alteration may be in physical (texture) or chemical (pH, nutrients, contaminants) properties.

Related References: 8,24,27,114,153,206,211,269,318,323,340,348, 381 ,396,405,426,458,465,466,467,482,483,535, 565,577,582,600,603,607,658,670,679,688,712, 718,746,748

A386-88 Soil composition - Crop yields:
This represents the influences of soil composition on crop yields, other than through soil fertility (390-88) or pest reduction (386-287-88). Examples would be soil pH, herbicides or other toxins, and excessive salts.

Related References: 84,124,182,244,427,517,743

A386-267 Soil composition - Organic-inorganic chemical pool (non-adsorbed):
This represents the contribution of soil composition to the non-adsorbed chemical pool in soil water and drainage waters (surface and subsurface).

Related References: 8,18,145,269,286,433,436,447,466,572,577,661

A386-287 Soil composition - Pest problems:
This interaction represents the transition through the soil of pesticides (herbicides or insecticides) that are incorporated into the soil for proper action against pests. Compare this to the direct effects of applied pesticides (286-287).

Related References: 50,84,94,244,517,625,637,743

A386-390 Soil composition - Soil fertility:
Soil fertility is one aspect of soil composition, related to the total quantities, availabilities, and exchange rates of essential macro- and micronutrients. Also included here would be all factors affecting nutrient adsorption/exchange surfaces, such as clay mineralogy and soil pH, moisture, texture, and structure.

Related References: 20,50,84,94,503,626,637

A386-(396,397) Soil composition - Soil structure and texture:
Soil composition affects soil structure and texture through mineralogy, particle size, and chemical constituents, both organic and inorganic.

Related References: 38,41 ,124,219 ,244,340,426,432,517,626,673

A386-(435,7) Soil composition - Suspended sediment, Adsorbed material:
The characteristics of suspended sediments moving off agricultural land surfaces via erosion will depend to a great extent on their nature before detachment and transport. All aspects of soil composition will affect suspended sediments, soil texture and structure will determine the particle size distribution of the suspended sediments, and the nature of adsorbed materials in runoff will reflect their constitution before erosion.

Related Reference: 269

A388-480 Soil detachment - Waterborne erosion:
Erosion is the detachment and transport of soil particles. A transport agent is not effective in erosion unless soil is detached. Thus soil detachment and overland flow converge in this model to yield waterborne erosion.

Related References: 392,394,706

A388-507 Soil detachment - Wind erosion:
Wind erosion requires the detachment and transport of soil particles by wind, and the model interactions reflect this convergence of forces.

Related References: 40,323,392,394,706

A389-388 Soil exposure - Soil detachment:
Detachment of soil particles is accelerated by exposure of the soil surface and retarded by any factor that decreases exposure, such as plant cover (292-389) or overland flow (270-389). The effect of exposure may be modified by the timing of exposure and the condition of the exposed soil, which are in turn affected by farm management decisions regarding tillage methods, plant cover, and erosion control.

Related References: 130,529,546,582,749

A389-392 Soil exposure - Soil moisture:
An exposed soil will lose more moisture to evaporation than an unexposed soil due to higher temperatures, lower relative humidity, and removal of water vapor by wind.

Related References: none

A389-(396,397) Soil exposure - Soil structure and texture:
In certain soils, prolonged exposure may alter the surface structure and thus infiltration, erodibility, etc.

Related References: 130,298

A390-88 Soil fertility - Crop yields:
This represents the influence of soil fertility on crop yields, as modified by soil composition, precipitation, drainage patterns, soil moisture, weed problems, and the application of fertilizers.

Related References: 84,201,377,431

A390-287 Soil fertility - Pest problems:
Weed growth may be enhanced by good soil fertility, particularly if fertilizer is applied.

Related Reference: 776

A390-292 Soil fertility - Plant cover:
The amount of plant biomass per unit area will depend largely on soil fertility, in addition to other factors such as soil moisture and pest problems.

Related References: 6,7,20,39,45,48,50,94,134,207,285,304,331, 341,359,368,369,403,503,519,541,548,587,588, 589,590,622,625,626,637,663,746,754,792

A392-88 Soil moisture - Crop yields:
This represents the influence of soil moisture availability (as affected by several soil and water variables) on crop yields, which may be either positive (retention of available water into drought periods) or negative (too much water, and reduced crop performance).

Related References: 124,617

A392-(199,282) Soil moisture - Infiltration, Percolation:
The existing soil moisture status will partially determine infiltration and percolation rates. Clearly a saturated soil mass will exhibit minimal additional infiltration, while a dry soil will exhibit maximum rates of vertical movement.

Related References: 124,463,766

Table II-2. Continued

A392-292 Soil moisture - Plant cover:
In conjunction with soil fertility and other soil variables, soil moisture patterns (spatial and temporal) will determine the amount of plant biomass per unit area.

Related References: 363,586

A392-(396,397) Soil moisture - Soil structure and texture:
This interaction refers to the long-term effects of soil moisture on the development of soil structure, particularly in soils subject to marked expansion/contraction cycles in response to fluctuating moisture. The effect is most noticeable (and most important for erosion) in the upper layers of the soil profile.

Related References: 38,124,517

A392-442 Soil moisture - Tillage methods:
Soil moisture patterns due to weather or land variables may affect farm management decisions regarding choice of tillage methods. This is true for both extremes of soil moisture status: tillage methods may be chosen to conserve moisture or in response to excessive moisture.

Related References: 107,121,440

A(396,397)-88 Soil structure and texture - Crop yields:
The direct effect of soil structure on crop yields is through favorability to root growth. Indirect effects are through soil moisture and variables affecting soil moisture.

Related Reference: 124

A(396,397)-116 Soil structure and texture - Erodibility (soil):
The texture and structure of a given soil will in a large part determine its erodibility in response to wind, precipitation, or overland flow detachment agents.

Related References: 38,556

A(396,397)-(199,282) Soil structure and texture - Infiltration, Percolation:
Infiltration and percolation potentials are initially set by soil texture and structure, since these latter variables alter the ability of water to move vertically in the soil in response to gravity.

Related References: 6,124,176,219,331,471

A(396,397)-485 Soil structure and texture - Water holding capacity:
The ability of a soil to hold water depends partly on its mineralogical composition, but primarily on its texture and structure, which regulate surface area for water adhesion, pore space size, and routes of movement in response to ped aggregation.

Related References: none

A426-122 Subsurface flow - Exported material:
Water, suspended sediment and adsorbed materials, and non-adsorbed chemicals are carried in subsurface drainage flows through tiles and pipes; they may be exported from the Agriculture Subsystem.

Related References: none

A426-267 Subsurface flow - Organic-inorganic chemical pool (non-adsorbed):
Non-adsorbed chemicals in subsurface waters will contribute to the total pool of non-adsorbed materials in water draining agricultural lands. This interaction is distinguished from that between subsurface flow and exported material (426-122) since chemicals may be transported below the surface in non-adsorbed form from one part of a field to another, to interact there with the soil composition and associated adsorbed pools.

Related References: 39,224,311,414,731

A(435,7)-122 Suspended sediment, Adsorbed material - Exported material:
A major fraction of the material exported from agricultural lands will consist of suspended sediments and adsorbed chemicals.

Related References: 393,596,693,759

A(435,7)-267 Suspended sediment, Adsorbed material - Organic-inorganic chemical pool (non-adsorbed):
This interaction represents the loss of adsorbed materials from suspended sediments to non-adsorbed pools in the water column, as affected by many physical and chemical variables (such as water temperature, water pH, etc.)

Related References: 4,8,26,27,30,44,47,59,69,77,80,81,88,89,98, 100,102,129,135,139,140,159,166,174,175,176, 189,194,200,203,209,220,223,224,245,260,268, 269,272,311,314,315,316,318,322,331,333,342, 346,347,352,356,364,371,372,373,396,409,417, 420,445,457,465,466,472,475,476,483,544,549, 550,555,559,572,575,576,577,586,591 ,597,600, 623,629,630,634,641,651,655,657,659,667,670, 685,686,688,690,691,692,713,715,720,721,722, 724,756,757,767,776,780,786, 791 ,792

A(435,7)-270 Suspended sediment, Adsorbed material - Overland flow:
The quantities and characteristics of suspended sediments will alter the makeup of surface waters draining agricultural fields.

Related References: 2,9,26,32,69,81,143,152,153,174,192,194,253, 259,288,404,412,421,472,530,543,555,564,577, 749

A(435,7)-352 Suspended sediment, Adsorbed material - Sedimentation or wind deposition:
In conjunction with suitable overland flow velocities and slope conditions, suspended sediments may be deposited through local ponding or general reduction in runoff velocity. Wind may also deposit sediment.

Related References: 4,8,26,27,30,44,47,59,69,77,80,81,88,89,98, 100,102,129,135,139,140,159,166,174,175,176, 189,194,200,203,209,220,223,224,245,260,268, 269,272,311,314,315,316,318,322,331,333,342, 346,347,352,356,364,371,372,373,396,409,417, 420,445,457,465,466,472,475,476,483,544,549, 550,555,559,572,575,576,577,586,591,597,600, 623,629,630,634,641,651,655,657,659,667,670, 685,686,688,690,691,692,713,715,720,721,722, 724,756,757,767,776,780,786, 791,792

A442-287 Tillage methods - Pest problems:
Crop residues may serve as refugia for insects or pathogens, and weeds respond differentially to various types of cultivation.

Related Reference: 244

A442-292 Tillage methods - Plant cover:
This represents the direct effects of tillage methods on plant cover during the entire year, involving the amounts of residue or non-crop plant growth, the type and frequency of cultivation, the condition of the soil following full- or reduced-tillage in terms of erodibility, and the application of herbicides (which eliminate weeds but reduce plant cover).

Related References: 7,298

A442-301 Tillage methods - Production costs:
Tillage systems vary in their direct (equipment operation) and indirect (pesticide application) production costs. Note that crop yields are also affected by different tillage techniques.

Related References: 5,84,201,202,274,511,602,655

A442-389 Tillage methods - Soil exposure:
Related to the direct effects of tillage on plant cover, this interaction involves the effects of tillage on soil exposure, primarily through the amount of surface area exposed by the different tillage techniques and the frequency and timing of such exposure. This interaction becomes particularly important when the tillage system under use precludes the establishment or retention of any significant plant cover.

Related Reference: 298

A442-(396,397) Tillage methods - Soil structure and texture:
This represents the effects of different tillage methods on soil structure, including compaction, disaggregation, hardpan formation, etc. The timing of soil manipulation required by a given tillage system is important here, since working a wet soil greatly magnifies the effects on soil structure over working a moist or dry soil.

Related References: 124,244,298

A446-106 Topography (especially local slope) - Drainage pattern:
This represents the effects of local slope, natural or modified, on existing surface and subsurface field drainage, other than through infiltration and percolation (see 382-(199,282)).

Related References: 132,248,586,648,679,768

A446-(099,282) Topography (especially local slope)- Infiltration, Percolation:
This represents the influence of effective local slope on rates of water penetration and vertical versus horizontal movement in the soil. This eventually affects the drainage pattern.

Related References: 6,162,331,453,746

A480-106 Waterborne erosion - Drainage pattern:
On a small scale, the surface drainage network may be altered by rill and gully erosion, which create routes of water movement. Of course, a small-scale rill may become an enormous gully with time.

Related References: none

A480-126 Waterborne erosion - Farm management:
This represents the influence of soil losses or sedimentation due to waterborne erosion on farm management decisions regarding crop production and erosion control, as influenced by considerations of farm income.

Related References: 43,558

A480-386 Waterborne erosion - Soil composition:
Removal of soil particles and adsorbed materials may change physical and chemical aspects of soil composition.

Related Reference: 392

A480-(435,7) Waterborne erosion - Suspended sediment, Adsorbed material:
Waterborne erosion, represented here as the convergence of soil detachment and transport, directly regulates the characteristics of eroded materials put in suspension.

Related References: 43,317,377,392,394

A485-392 Water holding capacity - Soil moisture:
As affected by soil composition, soil texture and soil structure, water holding capacity will partially determine soil moisture status at any given point in time.

Related References: none

A(505,7)-122 Windborne sediment, Adsorbed material - Exported material:
This represents the contribution of windborne sediment to material exported from the Agriculture Subsystem.

Related References: none

A(505,7)-352 Windborne sediment, Adsorbed material - Sedimentation or wind deposition:
This represents deposition of sediment by wind as a function of wind speed and quantities of sediment being transported.

Related References: 269,317,377,494,7^7

A(506,131)-508 Windbreaks, Fencerows - Wind speed, duration, and direction:
The effects of windbreaks in reducing wind speed and detachment, and promoting sedimentation, are represented here.

Related Reference: 107

A507-126 Wind erosion - Farm management:
This represents the influences of soil losses or deposition due to wind erosion on farm management decisions regarding erosion control practices and crop management, as influenced by considerations of farm income.

Related References: 43,107,558

A507-386 Wind erosion - Soil composition:
Removal of soil particles and adsorbed materials may change physical and chemical aspects of soil composition.

Related References: 8,40,392,427

A507-(505,7) Wind erosion - Windborne sediment, Adsorbed material:
This represents the contribution of wind erosion in the Agriculture Subsystem to windborne sediment and adsorbed materials.. Variables affecting detachment and transport (such as wind speed) will also determine the characteristics of the transported sediment.

Related References: 107,317,377

Table II-2. Concluded

A508-352 Wind speed, duration, and direction - Sedimentation or wind deposition:
Deposition of sediment, by wind requires suitable combinations of wind speed and airborne sediments. Wind speed is affected by both natural (topography, natural vegetation) and managed (planted windbreaks, fencerows) factors.

Related References: 33,454

A508-388 Wind speed, duration, and direction - Soil detachment:
Wind erosion requires both the detachment and transport of soil particles. Given suitable characteristics of the soil surface (exposure, erodibility, etc.), wind may dislodge soil particles, setting the stage for transport.

Related References: none

A508-507 Wind speed, duration, and direction - Wind erosion:
Wind serves as both the detachment force and the transport mechanism for wind erosion. The velocity and duration of suitable winds will affect total quantities of transported materials, and the distances they are moved.

Related Reference: 107

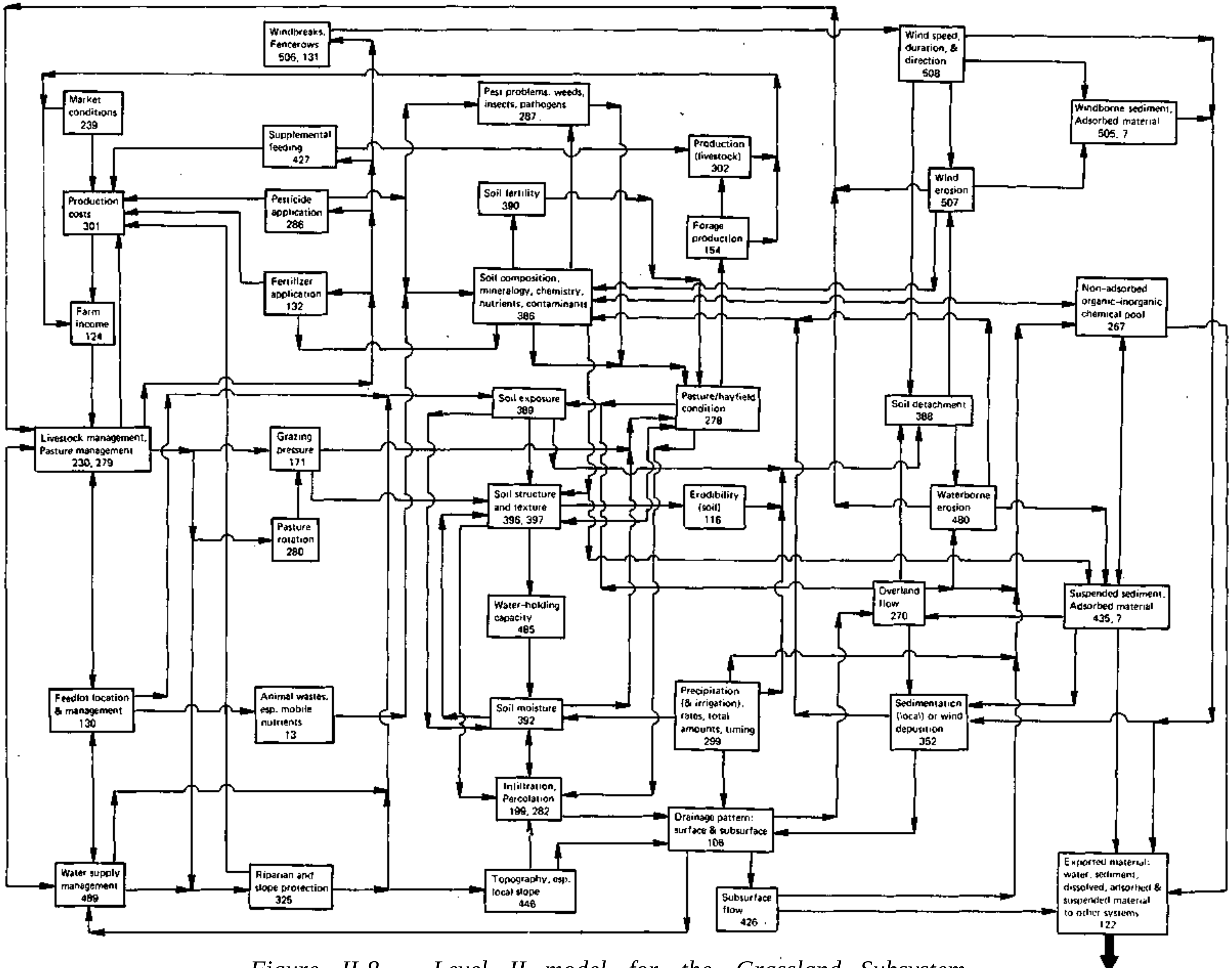


Figure II-8. Level II model for the Grassland Subsystem

Grassland Subsystem

Model Description and Model Interactions. Figure II-8 shows the Level II model for the Grassland Subsystem. The major interrelationships between the most important variables have already been described for the Agriculture Subsystem model.

The Grassland Subsystem includes natural grasslands, pastures, hayfields, orchards, highway right-of-ways (those not in shrub or forest cover), urban and rural lawns, parks, etc.

Small grain crops (wheat, oats, sorghum) and broadcast soybeans are placed in the Agriculture Subsystem due to the seasonal pattern of soil preparation and exposure. However, fields sown to these crops resemble hayfields (from the perspective of erosion) when a continuous plant cover is established. Thus for discrete erosion events, rather than annual averaging, fields in these types of crops may be considered as grasslands if desired.

Since pastures and hayfields represent the most extensive categories of grasslands in Illinois, the model component terminology is geared to these land uses. However, any of the remaining land use categories above can easily fit the model by slight alterations of component terms or selective removal of non-applicable components. For example, an orchard grower would change livestock and pasture management (G230,279) to "orchard management" and would probably ignore the components that deal with feedlot management (G130), animal wastes (G13), supplemental feeding (G427), forage production (G154), and livestock production (G302).

The Grassland Subsystem differs from the Agriculture Subsystem in four principal ways. These are:

1) Livestock are present on pastured grasslands and have effects on management decisions and on soils.

2) The role of plant cover and vigor, represented as pasture condition (G278), is relatively more important here, since tillage effects are reduced or absent.

3) The effects of slope are generally more significant in the Grassland Subsystem since pastures are often located on steeper terrain.

4) Riparian zones are more influential, since pastures frequently contain streams or ponds that are accessible to livestock.

Discussions of this model will be confined to management decisions and methods since soil and water variables have already been described for the Agriculture Subsystem.

Pasture/hayfield condition (G278) replaces plant cover in the Agriculture Subsystem (A292) and directly affects two components that have similarly replaced crop yields (A88)--forage production (G154) and livestock production (G302). Forage here means plant material either grazed directly or removed (baled or put in silo) for later consumption. These three components (G278, G154, and G302) jointly affect farm income, as balanced against production costs (G301) and market conditions (G239). Again, most management decisions, including erosion control efforts, are ultimately affected by production costs (fixed and variable) and farm income (G124).

Livestock and pasture management (G230,279) are connected to two other management components: feedlot management (G130) and water supply management (G489). The former is important due to the potential concentration of animal wastes and contaminated runoff. The latter is related to the use of in-pasture water sources, particularly streams, and livestock access to these water supplies.

Grazing pressure (G171) refers to the ratio between livestock numbers (and forage demands) and pasture acreage. Grazing pressure and pasture rotation (G280), as modified by management decisions, represent both the intensity of direct soil disruption by livestock and the effects of varying levels of pressure on pasture condition.

Examples of important higher-order interactions are as follows. The effects of feedlot management (G130) on non-adsorbed organic-inorganic chemical pool (G267) are represented by G130→13→386→267. The effects of pest problems (G287) on pesticide application (G286) are represented by G287→278→154→302→124→(230,279)→286.

Table II-3 gives the detailed descriptions of the model interactions.

Table II-3. Descriptions of Interactions for the Grassland Subsystem Model

Interaction code	Description
G1 3-386	Animal wastes - Soil composition: This represents the influences of animal wastes on pasture or near-feedlot soil composition, either through direct deposition by livestock or mechanical spreading of solid or liquid manure. Related References: 521,688,712,714,715
G106-270	Drainage pattern - Overland flow: (same as A106-270) Related References: 9,32,561,633
G106-426	Drainage pattern - Subsurface flow: (same as A106-426) Related Reference: 538
G106-489	Drainage pattern - Water supply management: Existing drainage patterns in pastures will affect decisions on the use of in-pasture streams, the location of man-made ponds, etc. Related References: 633,743
G116-388	Erodibility (soil) - Soil detachment: (same as A116-388) Related References: 18,38,40,174,194,237,239,241,453,460,462, 582,646,678,726,752
G124-(230,279)	Farm income - Livestock management, Pasture management: This represents the powerful influence of farm income, as the result of the balancing forces of production costs, production rates, and market conditions, on livestock and pasture/hayfield management decisions. Of particular interest here are decisions which divert resources to erosion and/or sedimentation control. Related References: 580,595
G130-13	Feedlot management - Animal wastes: This represents the influence of feedlot management decisions on the location, quantity, character, and handling of animal wastes. Related Reference: 677

G130-(230,279) Feedlot management - Livestock management, Pasture management:
This and the reverse interaction represent the interplay between feedlot and pasture management decisions.

Related References: none

G130-389 Feedlot management - Soil exposure:
This represents the effects of feedlot location and livestock density on soil exposure in and around the feedlot, plus travel corridors between pasture, feedlot, buildings, and/or water supplies.

Related References: none

G130-489 Feedlot management - Water supply management:
This and the reverse interaction represent the interplay between feedlot and water supply management decisions.

Related References: none

G132-301 Fertilizer application - Production costs:
This represents the contribution of fertilizer costs to total livestock-related production costs on the farm.

Related References: 84,599,617,655

G132-386 Fertilizer application - Soil composition:
(same as A132-386)

Related References: 84,244,433,447,517,649,688,694,717

G154-124 Forage production - Farm income:
This represents the contribution to farm income by forage produced and sold - i.e., forage not consumed on the same farm, which would influence farm income through livestock production (154-302-124).

Related References: none

G154-302 Forage production - Production (livestock):
This represents the effects of forage production on livestock production rates, as influenced by pasture or hayfield condition, the handling of the forage (grazing, baling, silo storage, etc.), herd size, and supplemental feeding strategies.

Related References: none

G171-278 Grazing pressure - Pasture or hayfield condition:
The effects of grazing pressure on pasture condition are primarily a function of the herd size: pasture size ratio and the amount of time spent in the pasture by the livestock. Pasture condition refers principally to plant cover and vigor and is a function of soil structure, soil composition, and water-related variables as well as grazing pressure.

Related References: none

Gl71-(396,397) Grazing pressure - Soil structure and texture:
Direct trampling by livestock is particularly acute along trails and in congregation areas, and is aggravated if steep slopes are involved. Note that grazing pressure may have an indirect effect on soil structure by decreasing plant vigor and root growth; the latter has a major impact on soil structure.

Related References: none

G(199,282)-106 Infiltration, Percolation - Drainage pattern:
(same as A(199,282)-106)

Related References: 145,538,7^3

G(199,282)-392 Infiltration, Percolation - Drainage pattern:
(same as A(199,282)-392)

Related References: 6,124,176,219,331,463,471,766

G(230,279)-130 Livestock management, Pasture management - Feedlot management:
This and the reverse interaction represent the interplay between livestock/pasture management and feedlot management.

Related References: none

G(230,279)-132 Livestock management, Pasture management - Fertilizer application:
The pasture condition and the projected benefits of increasing forage production and hence livestock production will influence decisions on the application of fertilizer.

Related References: 593,595,776

G(230,279)-171 Livestock management, Pasture management - Grazing pressure:
This interaction represents all management decisions concerning grazing pressure, involving several variables: market conditions, livestock production rates, farm income due to the livestock component, herd size in relation to pasture size, feed and supplement costs, the potential for pasture rotation, demand for row-crop acreage and consequent reduction of pasture acreage, and pasture condition.

Related References: none

Table II-3. Continued

G(230,279)-280 Livestock management, Pasture management - Pasture rotation:

This represents management decisions regarding pasture rotation, if the option exists, as influenced by market conditions, production rates, farm income due to livestock production, erosion, and especially pasture condition.

Related References: none

G(230,279)-286 Livestock management, Pasture management - Pesticide application:

This represents pasture management decisions to apply insecticides or herbicides to control insects and weeds, in response to pasture or hayfield alteration by pests (and hence projected forage production).

Related Reference: 593

G(230,279)-301 Livestock management, Pasture management - Production costs:

This represents livestock and pasture management decisions concerning production costs, as outcomes of previous interplays between market conditions, livestock production rates, production costs, and farm income. "Production costs" here includes erosion or sedimentation controls implemented by the farmer and subject to management under the influence of on-farm and off-farm economic, legal, and social forces.

Related Reference: 580

G(230,279)-325 Livestock management, Pasture management - Riparian and slope protection:

This represents management decisions to implement (or retain) riparian or slope protection measures, resulting primarily in reduced soil exposure. This may be accomplished through restricted livestock access to slopes and riparian zones or by establishing plant cover on vulnerable slopes. These decisions are influenced by pasture characteristics and water supply management.

Related References: none

G(230,279)-427 Livestock management, Pasture management - Supplemental feeding:

This represents management decisions concerning the use of feed and supplements beyond those produced on the farm. The decisions are influenced by a host of variables, among which are market conditions (for buying the supplemental feed), pasture condition and forage production, herd size and livestock production rates, and reduction of pasture acreage due to row-crop acreage demand.

Related References: none

G(230,279)-489 Livestock management, Pasture management - Water supply management:
This and the reverse interaction represent the interplay between livestock/pasture and water supply management, particularly in-pasture streams and ponds, and livestock access to water supplies.

Related References: none

G(230,279)-(506,131) Livestock management, Pasture management - Windbreaks, Fencerows:
This represents management decisions regarding the use of windbreaks and/or the retention of natural barriers to wind movement, in an effort to reduce wind speed and offset wind erosion.

Related References: none

G239-124 Market conditions - Farm income:
This represents the effects of market conditions, primarily livestock commodity prices and supplemental feed prices, on farm income, as balanced against production costs and livestock production rates.

Related Reference: 165

G239-301 Market conditions - Production costs:
This interaction represents the effect of market conditions on total livestock production costs through the prices of supplemental feeds, feeder calves, heifers, etc. .

Related References: 165,599

G267-122 Organic-inorganic chemical pool (non-adsorbed) - Exported material:
(same as A267-122)

Related References: 26,269,476,555

G267-386 Organic-inorganic chemical pool (non-adsorbed) - Soil composition:
(same as A267-386)

Related References: 8,27,30,102,139,140,230,260,265,268,269,286, 318,370,371,372,373,420,433,435,436,147,465, 466,476,483,559,576,577,597,600,630,661 ,670, 688,715,757

G267-(435,7) Organic-inorganic chemical pool (non-adsorbed) - Suspended sediment, Adsorbed material:
(same as A267-(435,7))

Related References: 89,98,113,234,322,388,457,534,550,600,690

Table II-3. Continued

G270-267 Overland flow - Organic-inorganic chemical pool (non-adsorbed):
(same as A270-267)

Related References: 26,39,69,81,174,194,472,555,577

G270-352 Overland flow - Sedimentation or wind deposition:
(same as' A270-352)

Related Reference: 194

G270-388 Overland flow - Soil detachment:
(same as A270-388)

Related References: 143,174,192,194,288,412,460,543,561,577,671, 749,752

G270-389 Overland flow - Soil exposure:
(same as A270-389)

Related Reference: 749

G270-480 Overland flow - Waterborne erosion:
(same as A270-480)

Related Reference: 472

G278-154 Pasture or hayfield condition - Forage production:
This represents the effects of pasture or hayfield condition (plant cover and vigor) on the quality and quantity of forage production.

Related References: none

G278-(199,282) Pasture or hayfield condition - Infiltration, Percolation:
This represents the effects of pasture condition, specifically plant cover/soil exposure and root growth and activity, on infiltration and percolation, respectively. The results are a decrease in the rate of water entry into the soil (and soil detachment) by foliage interception, and often an increase in percolation due to old and new root channels. The attainment of field saturation and maximum runoff discharge may be delayed by the first of these effects.

Related References: none

G278-270 Pasture or hayfield condition - Overland flow:
The amount of plant cover, including both live and dead materials, may form obstructions to the movement of runoff. The results are reduced velocity, increased sedimentation, reduced detachment, and consequently reduced erosion. Thus a pasture or hay field in good condition retards soil erosion in several ways.

Related References: none

G278-389 Pasture or hayfield condition - Soil exposure:
Plant cover and soil exposure are the reciprocals of each other from the perspective of erosion. Plant cover may significantly decrease infiltration, soil detachment, and overland flow rates, and consequently waterborne erosion. Thus all factors affecting pasture or hayfield condition are intimately tied to eventual erosion rates.

Related References: none

G278-392 Pasture or hayfield condition - Soil moisture:
Pasture plants may affect soil moisture through infiltration and percolation, as discussed above (278-(199,282)). However, plants may greatly reduce soil moisture levels through transpiration; hence better pasture conditions with greater amounts of foliage may result in lower soil moisture levels through this process. This is partially offset by plant shading of the soil surface and lowered surface temperatures, but the effect is still significant, particularly in the removal of water from lower rooting depths in the soil profile.

Related References: none

G278-(396,397) Pasture or hayfield condition - Soil structure and texture:
The influences of plants on soil structure are due to channelization and increased aeration by living plants, and contribution of organic matter to the soil.

Related References: none

G280-171 Pasture rotation - Grazing pressure:
This represents the effects of pasture rotation on grazing pressure, and hence on pasture condition, forage and livestock production rates, and waterborne erosion.

Related References: none

G286-287 Pesticide application - Pest problems:
(same as A286-287)

Related References: 84,244,260,268,316,317,377,517,579,593,607, 617,650,651,655,686,728

G286-301 Pesticide application - Production costs:
(same as A286-301)

Related References: 84,617,655

G286-386 Pesticide application - Soil composition;
(same as A286-386)

Related References: 84,244,260,268,517,607

G287-278 Pest problems - Pasture or hayfield condition:
This represents the detrimental effects of weeds or insects on pasture/hayfield condition, forage production, and livestock production. This is due either to competition from weeds for water and minerals, or to herbivory and disease by insects and pathogens.

Related References: none

G299-106 Precipitation - Drainage pattern:
(same as A299-106)

Related References: 9,14,32,63,88,132,145,146,163,383,385,438, 538,561,586,633,648,679,680,735,743,767,768, 789,790

G299-267 Precipitation - Organic-inorganic chemical pool (non-adsorbed):
(same as A299-267)

Related References: 8,37,39,47,81,88,132,145,150,232,234,245, 286,331,389,396,433,459,483,520,559,572,586, 591,651,661,715,767

G299-388 Precipitation - Soil detachment:
(same as A299-388)

Related References: 38,141,143,190,239,288,380,382,446,453,460, 462,471,474,483,485,561,582,645,646,748, 749,752,765

G299-392 Precipitation - Soil moisture:
(same as A299-392)

Related References: 38,107,331,463,471,539,734,766

G301-124 Production costs - Farm income:
This represents the effects of fixed and flexible costs on farm income, as balanced against forage and livestock production rates and market conditions.

Related References: 84,165,511,580,602,655

Table II-3. Continued

G302-124 Production (livestock) - Farm income:
This represents the effects of livestock production rates (meat, milk, wool, feeder calves, etc.) on farm income, as balanced against production costs and market conditions.

Related References: none

G325-389 Riparian and slope protection - Soil exposure:
This represents the beneficial effects of slope and/or riparian protection on soil exposure and ultimately on soil erosion, through reduced trampling and sod disruption by livestock. This may involve restricted access to riparian zones and vulnerable slopes.

Related Reference: 296

G325-446 Riparian and slope protection - Topography, (especially local slope):
This represents protection of riparian zones and/or slopes from waterborne erosion through direct manipulation of slope characteristics (reducing grade on livestock travel corridors, etc.)

Related References: 131,162,296,430

G352-106 Sedimentation or wind deposition - Drainage pattern:
(same as A352-386)

Related References: 63,69,81,88,143,153,194,259,412,421,438,530, 567,577,679,680,749,767

G352-386 Sedimentation or wind deposition - Soil composition:
(same as A352-386)

Related References: 8,24,27,114,153,206,211,269,318,323,340,348, 381,396,405,426,458,465,466,467,482,483,535, 565,577,582,600,603,607,658,670,679,688,712, 718,746,748

G386-267 Soil composition - Organic-inorganic chemical pool (non-adsorbed):
(same as A386-267)

G386-278 Soil composition - Pasture or hayfield condition:
This represents the influences of soil composition on pasture condition (plant cover and vigor), other than through soil fertility (390-278) or pest reduction (386-287-278). Examples would be soil pH, herbicides or other toxins, or excessive salt concentrations.

Related References: none

G386-287 Soil composition - Pest problems:
(same as A386-287)

Related References: 50,84,94,244,517,625,637,743

G386-390 Soil composition - Soil fertility:
(same as A386-390)

Related References: 20,50,84,94,503,626,637

G386-(396,397) Soil composition - Soil structure and texture:
(same as A386-(396,397))

Related References: 38,41,124,219,244,340,426,432,517,626,673

G386-(435,7) Soil composition - Suspended sediment, Adsorbed material:
(same as A386-(435,7))

Related References: 269

G388-480 Soil detachment - Waterborne erosion:
(same as A388-480)

Related References: 392,394,706

G388-507 Soil detachment - Wind erosion:
(same as A388-507)

Related References: 40,323,392,394,706

G389-388 Soil exposure - Soil detachment:
Detachment of soil particles is accelerated by exposure of the soil surface and retarded by any factor that decreases exposure, such as plant cover (292-389) or overland flow (270-389). The effect of the exposure is modified by the timing of the exposure and the condition of the exposed soil, which are in turn affected by farm management decisions regarding grazing pressure, pasture rotation, fertilizer application, and farm income.

Related References: 130,529,546,582,749

G389-392 Soil exposure - Soil moisture:
(same as A389-392)

Related References: none

G389-(396,397) Soil exposure - Soil structure and texture:
(same as A389-(396,397))

Related References: 130,298

G390-278 Soil fertility - Pasture or hayfield condition:
Pasture or hayfield condition is determined by total cover and vigor of desirable forage species. The amount of plant biomass per unit area, and possibly the species composition and dominance rankings, will depend on soil fertility, in addition to other factors such as soil moisture and pest problems.

Related References: none

G390-287 Soil fertility - Pest problems:
(same as A390-287)

Related Reference: 776

G392-(199,282) Soil moisture - Infiltration, Percolation:
(same as A392-(199,282))

Related References: 124,463,766

G392-278 Soil moisture - Pasture or hayfield condition:
This interaction represents the influence of temporal and spatial patterns of soil moisture availability (as affected by numerous soil and water variables) on pasture or hayfield condition. The influence may be either positive (retention of available water into drought periods) or negative (too much water, and reduced plant performance).

Related References: none

G392-(396,397) Soil moisture - Soil structure and texture:
(same as A392-(396,397))

Related References: 38,124,517

G(396,397)-116 Soil structure and texture - Erodibility (soil):
(same as A(396,397)-116)

Related References: 38,556

G(396,397)-(199,282) Soil structure and texture - Infiltration, Percolation:
(same as A(396,397)-(199,282))

Related References: 6,124,176,219,331,471

G(396,397)-278 Soil structure and texture - Pasture or hayfield condition:
The direct effects of soil structure on pasture plant performance are through favorability to root growth. Indirect effects are through soil moisture and all variables that affect soil moisture.

Related References: none

G(396,397)-485 Soil structure and texture - Water holding capacity:
(same as A(396,397)-485)

Related References: none

G426-122 Subsurface flow - Exported material:
Water, suspended sediment and adsorbed materials, and non-adsorbed chemicals are carried in subsurface drainage flows through tiles or pipes; they may be exported from the Grassland Subsystem.

Related References: none

G426-267 Subsurface flow - Organic-inorganic chemical pool (non-adsorbed):
(same as A426-267)

Related References: 39,224,311,414,731

G427-301 Supplemental feeding - Production costs:
This represents the contribution of supplemental feeding costs to total livestock production costs, as affected by market prices for such feed.

Related References: none

G427-302 Supplemental feeding - Production (livestock):
This represents the effects of supplemental feeding (forage, grains, or supplements) on livestock production rates, as influenced by pasture or hayfield condition, grazing pressure, and the rate of gain by livestock on pasture-derived forages alone.

Related References: none

G(435,7)-122 Suspended sediment, Adsorbed material - Exported material:
(same as A(435,7)-122)

Related References: 393,596,693,759

G(435,7)-267 Suspended sediment, Adsorbed material - Organic-inorganic chemical pool (non-adsorbed):
(same as A(435,7)-267)

Related References: 4,8,26,27,30,44,47,59,69,77,80,81,88,89,98, 100,102,129,135,139,140,159,166,174,175,176, 189,194,200,203,209,220,223,224,245,260,268, 269,272,311,314,315,316,318,322,331,333,342, 346,347,352,356,364,371,372,373,396,409,417, 420,445,457,465,466,472,475,476,483,544,549, • 550,555,559,572,575,576,577,586,591,597,600, 623,629,630,634,641,651,655,657,659,667,670, 685,686,688,690,691,692,713,715,720,721,722, 724,756,757,767,776,780,786, 791,792

G(435,7)-270 Suspended sediment, Adsorbed material - Overland flow:
(same as A(435,7)-270)

Related References: 2,9,26,32,69,81 ,143,152,153,174,192,194,253, 259,288,404,412,421,472,530,543,555,564,577, 749

G(435,7)-352 Suspended sediment, Adsorbed material - Sedimentation or wind deposition:
(same as A(435,7)-352)

Related References: 3,4,7,8,21,24,25,27,42,44,45,48,49,54,60,61, 62,63,65,66,67,69,73,75,76,77,78,80,81,87, 88,89,90,92,93,96,98,106,108,109,111,114, 115,117,119,126,127,128,129,130,135,136,138, 141,143,147,149,153,166,167,168,169,170,172, 173,175,180,188,193,194,198,203,204,205,206, 211,218,220,224,239,242,248,250,251,256,259, 263,269,272,276,277,281,282,283,287,302,306, 309,310,313,314,315,317,318,319,320,321,323, 327,328,332,333,334,335,338,339,340,346,347, 348,349,350,351,352,354,365,366,375,377,381, 394,396,398,399,400,401,402,405,406,409,412, 417,421,426,437,438,439,441,446,448,449,450, 451,454,457,458,465,466,467,469,479,482,483, 488,489,490,492,493,494,495,496,497,498,499, 507,512,515,524,526,529,530,532,535,537,541, 542,544,546,547,552,557,562,563,564,565,568, 570,577,582,596,600,602,603,607,614,615,618, 623,638,639,640,641,643,644,645,646,647,651, 654,658,662,667,668,670,674,678,679,680,681, 682,685,686,688,691,692,693,699,700,702,703, 704,707,709,712,718,724,727,732,733,742,746, 747,748,749,759,760,762,763,767,771 ,775,781 , 785,787,792

G446-106 Topography (especially local slope) - Drainage pattern:
(same as A446-106)

Related References: 132,248,586,648,679,768

G446-(199,282) Topography (especially local slope) - Infiltration, Percolation:
(same as A446-(199,282))

Related References: 6,162,331,453,746

G480-106 Waterborne erosion - Drainage pattern:
(same as A480-106)

Related References: none

G480-(230,279) Waterborne erosion - Livestock management, Pasture management:
This represents the influence of soil losses or sedimentation due to waterborne erosion on livestock and pasture management decisions regarding grazing pressure, pasture condition, and erosion control, as modified by considerations of farm income.

Related References: none

G480-386 Waterborne erosion - Suspended sediment, Adsorbed material:
(same as A480-386)

Related Reference: 392

G480-(135,7) Waterborne erosion - Suspended sediment, Adsorbed material:
(same as A480-(435,7))

Related References: 43,317,377,392,394

G485-392 Water holding capacity - Soil moisture:
(same as A485-392)

Related References: none

G489-130 Water supply management - Feedlot management:
This and the reverse interaction represent the interplay between water supply and feedlot management.

Related References: none

G489-(230,279) Water supply management - Livestock management, Pasture management:
This and the reverse interaction represent the interplay between decisions regarding water supplies and livestock access, the location of water sources (natural or man-made) in pastures, travel corridors to waters, and riparian or slope protection.

Related References: none

G489-325 Water supply management - Riparian and slope protection:
Livestock access to in-pasture natural or man-made water sources may heavily affect soil exposure, structure, and erodibility. This interaction represents decisions to implement or retain riparian or slope protection as directly influenced by water access routes.

Related References: none

G489-389 Water supply management - Soil exposure:
In-pasture natural or man-made water sources are often the most serious sources of erosion in grasslands, due to livestock trampling and sod disruption, especially on streambanks. Water management decisions regarding livestock access thus have direct bearing on soil erodibility and waterborne erosion rates.

Related References: none

G(505,7)-122 Windborne sediment, Adsorbed material - Exported material:
This represents the contribution of windborne sediment to material exported from the Grassland Subsystem.

Related References: none

G(505,7)-352 Windborne sediment, Adsorbed material - Sedimentation or wind deposition:
(same as A(505,7)-352)

Related References: none

G(506,131)-508 Windbreaks, Fencerows - Wind speed, duration, and direction:
(same as A(506,131)-508)

Related Reference: 107

G507-386 Wind erosion - Soil composition:
(same as A507-386)

Related References: 8,40,392,127

G507-(505,7) Wind erosion - Windborne sediment, Adsorbed material:
This represents the contribution of wind erosion in the Grassland Subsystem to windborne sediment and adsorbed materials. Variables affecting detachment and transport, such as wind speed, will also determine the characteristics of the transported material.

Related Reference: 107

G508-352 Wind speed, duration, and direction - Sedimentation or wind deposition:
(same as A508-352)

Related References: 334,454

G508-388 Wind speed, duration, and direction - Soil detachment:
(same as A508-388)

Related References: none

Table II-3. Concluded

G508-507 Wind speed, duration, and direction - Wind erosion: (same as A508-507)

Related Reference: 107

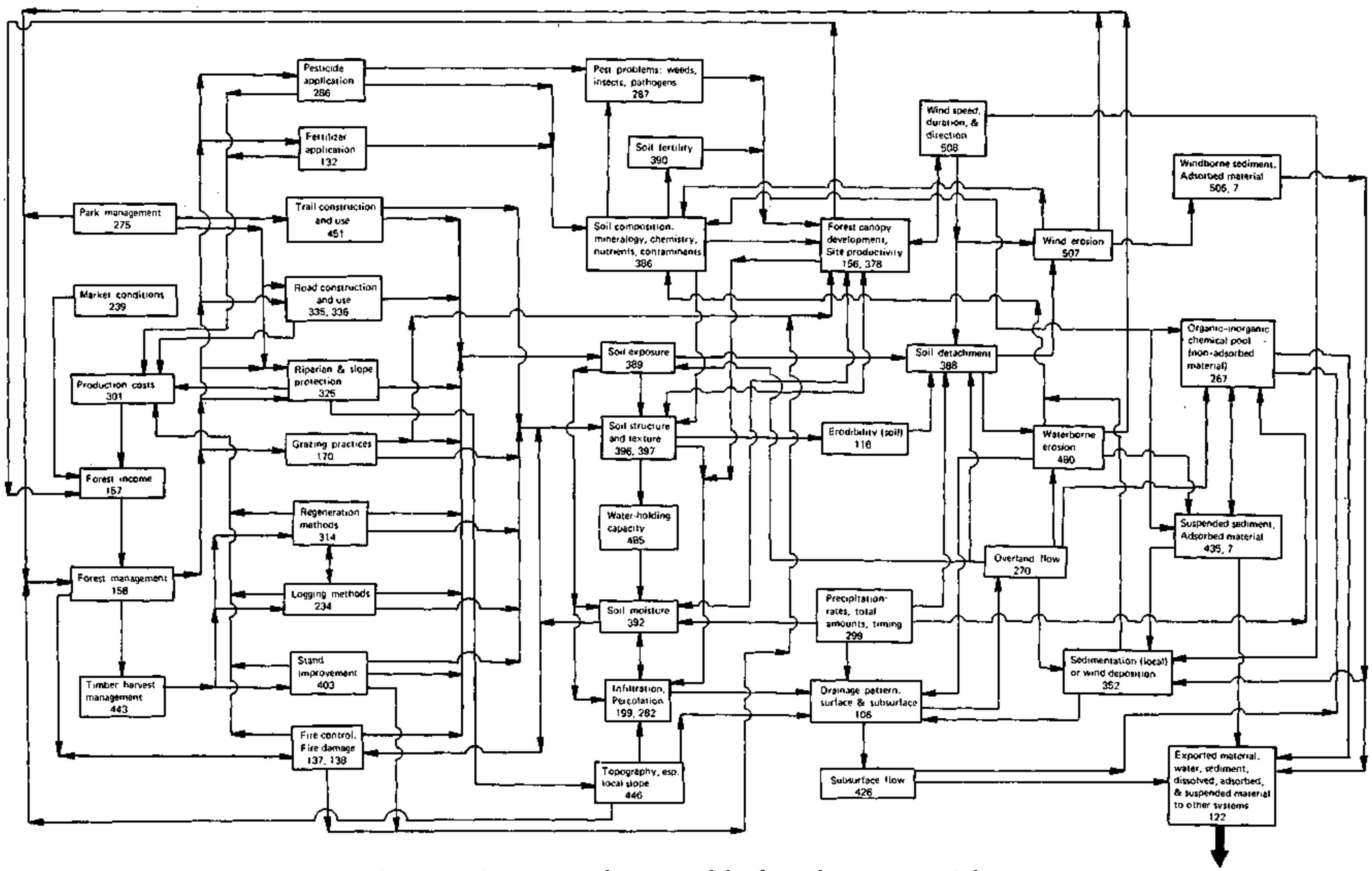


Figure II-9. Level II model for the Forest Subsystem

Forest Subsystem

Model Description and Model Interactions. The Level II model for the Forest Subsystem is given in Figure II-9. The- Forest Subsystem includes state and national forests, forested portions of state and local parks, forest plantations (except for intensively cultivated nurseries), and all other sites with continuous forest canopy, except sites that reasonably belong in other systems or subsystems.

An explanation concerning continuous forest canopy for the Forest Subsystem is needed. Many city parks and suburban lawns may possess a nearly continuous canopy. The important features distinguishing the Forest Subsystem are that 1) the continuous canopy is usually composed of several layers and significantly buffers the soil from the detachment power of precipitation, and 2) the forest floor is neither intensively cultivated nor characterized by extensive grass-forb production typical of pastures or hayfields. In addition, it is widely recognized that forest soils (and attendant humus and litter layers) serve extended water storage and gradual release functions that contrast with those of non-forested sites.

The soil and water variables and the major processes of detachment and transport are the same as in the Agriculture and Grassland Subsystems, and are not discussed here. The Forest Subsystem differs from the previous two subsystems in the following three areas:

1) Roads and trails, both during construction and use, have significant erosional impacts in the forest (park).
2) Fire, both unintended (natural) and intended for management purposes, can alter erosion potential dramatically through increased soil exposure. In addition, fire prevention or control may involve soil disruption (e.g., building firebreaks).

3) A wider variety of uses is typically made of forests, particularly farm woodlots. These include a) logging, either on a small-scale selective basis, as in firewood gathering or periodic culling, or in infrequent major cuts; b) recreation, usually hiking, camping, or horseback riding; and c) grazing by livestock.

There are useful analogies that can be made between the Forest Subsystem and the Agriculture and Grassland Subsystems discussed previously. For example, crop yield (A88), replaced by forage production (G154) and livestock production (G302) in the Grassland Subsystem model, is now replaced by forest canopy development and site productivity (F156,378). Pesticide (F286) and fertilizer (F132) application, riparian and slope protection (F325), grazing practices (F170), market conditions (F239), production costs (F301), and forest income (F157) all interact with other components here in the same way as in the other models.

The suite of forest management techniques in the second column of components (F335,336; F314; F234; F403; F137,138) influence erosion primarily through increased soil exposure and disruption. This is most often due to equipment activity, log removal, and perhaps seedbed preparation.

Grazing by livestock (F170) is usually detrimental to forest productivity and certainly retards *or* eliminates regeneration. In the worst cases, grazing and trampling by livestock in woodlands seriously increase erosion through soil exposure and disruption. Tree death and foliage elimination may result, allowing rainfall to pass unintercepted and detach the exposed soil.

Extensive use of park trails can lead to accelerated soil loss unless precautions are taken in the form of 1) proper trail location, construction, and hiking directions, 2) restricted access, and/or 3) enforcement of hiking regulations.

Road construction and use are often major contributors to soil erosion since roads are typically built for the short-term purpose of timber removal, with little regard for their acceleration of soil loss. This is acutely true in steeper terrain.

Table II-4 provides detailed descriptions of the model interactions for the Forest Subsystem.

Table II-4. Descriptions of Interactions for the Forest Subsystem Model

Interaction code	Description
F106-270	Drainage pattern - Overland flow: (same as A106-270) Related References: 9,32,561,633
F106-426	Drainage pattern - Subsurface flow: (same as A106-426) Related Reference: 538
F116-388	Erodibility (soil) - Soil detachment: (same as AH 6-388) Related References: 38,40,194,237,239,241,453,460,462
F(137,138)-(156,378)	Fire control, Fire damage - Forest canopy development, Site productivity: This represents the effects of fire on forest growth, both detrimental (uncontrolled fire damage to foliage, stems, and roots) and beneficial (controlled burning of accumulated fuel or undesirable competition, and release of nutrients, especially nitrogen). Related References: none
F(137,138)-301	Fire control, Fire damage - Production costs: This interaction represents the direct contribution of fire control measures to forest production costs. It does not include such items as regeneration plantings following fire. Related References: none
F(137,138)-389	Fire control, Fire damage - Soil exposure: Under either controlled or uncontrolled burning, but particularly due to intensive cases of the latter, soil exposure may be excessive. This will range in severity from light litter removal to complete canopy-through-humus removal, and the latter can have devastating effects on erosion rates because of the highly erodible nature of most exposed forest soils. Related References: none

F(156,378)-157 Forest canopy development, Site productivity - Forest income:
This represents the contribution of forest products, as determined by site productivity (often called site index), to forest-derived income. This is balanced against production costs and market prices for forest products.

Related References: none

F(156,378)-(199,282) Forest canopy development, Site productivity - Infiltration, Percolation:
This represents the influences of forest canopy condition on infiltration, through rainfall interception, delayed release, reduced raindrop velocity, and streamflow. Percolation is also affected by root growth and channel development.

Related References: none

F(156,378)-392 Forest canopy development, Site productivity - Soil moisture:
Through transpiration, forest foliage may significantly lower moisture levels in the soil, particularly in the lower depths of the rooting zone.

Related References: none

F(156,378)-(396,397) Forest canopy development, Site productivity - Soil structure and texture:
Addition of organic matter and root activity by forest plants affects soil texture and structure. Thus overall forest condition, as measured by the total cover and vigor of the forest vegetation, significantly affects soil characteristics.

Related References: none

F(156,378)-403 Forest canopy development, Site productivity - Stand improvement:
The condition of the forest canopy and projected products will interact with all parts of the forest and timber harvest management plan, possibly indicating the need for stand improvement.

Related References: none

F(156,378)-508 Forest canopy development, Site productivity - Wind speed, duration, and direction:
The condition of the forest will affect its capabilities as a reducer of wind velocities and hence soil detachment and wind erosion. Of particular importance would be the density of the forest foliage at all levels in the vertical profile from the top of the canopy to the forest floor, and the width of the forested subsystem.

Related References: none

F157-158 Forest income - Forest management:
This represents the influence of income due to forest-derived products or amenities on forest management plans. This may range from occasional firewood removal and sale from small farm woodlots to major timber harvest on private or public forested lands. It may also include non-wood products, such as wildlife-related fees (hunting, hiking, etc). The income will be the result of the balance between production costs and amount of products yielded.

Related References: none

F158-132 Forest management - Fertilizer application:
This represents management decisions on the type, timing, amounts, and frequency of fertilizer application, particularly during regeneration.

Related Reference: 317

F158-(137,138) Forest management - Fire control, Fire damage:
This represents management decisions on controlled burning or response to uncontrolled fires. Interacting variables include projected loss of forest-related products and income, availability of fire control equipment, and the costs of control or controlled burning.

Related References: none

F158-170 Forest management - Grazing practices:
This represents forest management decisions to allow or prohibit grazing, particularly by livestock on farm woodlots, and control over the intensity of such grazing.

Related References: none

F158-286 Forest management - Pesticide practices:
This represents management decisions on the type, timing, amount, method, and frequency of pesticide application, in response to pest problems (weeds, insects, or pathogens) and projected loss of forest products.

Related Reference: 317

F158-325 Forest management - Riparian and slope protection:
This represents forest management decisions to protect slopes and riparian zones from erosion through restricted access, erosion control structures, greenbelt retention or establishment, etc. This is especially important during road construction and timber harvest.

Related References: none

F158-(335,336) Forest management - Road construction and use:.
This represents road construction plans and methods as part of the overall forest management plan, often due to timber harvest.

Related Reference: 716

F158-443 Forest management - Timber harvest management:
This represents timber harvest plans as part of the overall forest management plan, including the projected effects of timber harvest on other activities.

Related References: 317,455,716

F132-301 Fertilizer application - Production costs:
This represents the contribution of fertilizer costs to total production costs.

Related References: 84,599,617,655

F132-386 Fertilizer application - Soil composition:
(same as A132-386)

Related References: 84,244,433,447,517,649,688,694,717

F170-(156,378) Grazing practices - Forest canopy development, Site productivity:
This represents the influences of grazing on forest canopies and site productivity other than through soil structure and composition, primarily due to browsing and bark damage. Mortality or reduced growth of reproductive size classes (seedlings, saplings) can be extensive, and damage to bark of mature trees may facilitate entry of pathogens.

Related References: none

F170-389 Grazing practices - Soil exposure:
This represents increased exposure of forest soils due to livestock trampling, rooting, and travel corridors. This can be severe on heavily used woodlots.

Related References: none

F170-(396,397) Grazing practices - Soil structure and texture:
The effects of livestock on soil structure are due to trampling and rooting. Note that these are direct effects, and that livestock may indirectly cause other changes in soil texture and structure through their influence on forest plants (170-156,378-(396,397)).

Related References: none

F(199,282)-106 Infiltration, Percolation - Drainage pattern:
(same as A(199,282)-106)

Related References: 145,538,743

F(199,282)-392 Infiltration, Percolation - Soil moisture:
(same as A(199,282)-392)

Related References: 6,124,176,219,331,463,471,766

F234-301 Logging methods - Production costs:
This represents the effect of specific logging methods on total production costs.

Related References: none

F234-314 Logging methods - Regeneration methods:
This represents the interplay between logging and regeneration techniques, primarily based on the dichotomy between natural versus artificial restocking, the conditions best suited to each, and how logging affects such conditions.

Related References: none

F234-389 Logging methods - Soil exposure:
This represents the effects of different logging methods on soil exposure, primarily through log removal and heavy equipment operation, as well as slash management.

Related References: none

F234-(396,397) Logging methods - Soil structure and texture:
This represents the effects of different logging methods on soil structure, through treefall and uprooting, log removal, heavy equipment operation, etc.

Related References: none

F239-158 Market conditions - Forest management:
This represents the effect of market prices for forest products on forest management plans.

Related References: none

F267-122 Organic-inorganic chemical pool (non-adsorbed) - Exported material:
(same as A267-122)

Related References: 26,269,476,555

F267-386 Organic-inorganic chemical pool (non-adsorbed) - Soil composition:
(same as A267-386)

Related References: 8,27,30,102,139,140,230,260,265,268,269, 286,318,370,371.372,373,420,133,435,436, 447,465,466,476,483,559,576,577,597,600, 630,661,670,688,715,757

F267-(435,7) Organic-inorganic chemical pool (non-adsorbed) - Suspended sediment, Adsorbed material:
(same as A267-(435, 7))

Related References: 89,98,113,234,322,388,457,534,550,600,690

F270-267 Overland flow - Organic-inorganic chemical pool (non-adsorbed):
This represents the contribution of overland flow and materials transported by runoff to total non-adsorbed chemical pools in waters draining forested lands.

Related References: 26,39,69,81,174,194,472,555,577

F270-352 Overland flow - Sedimentation or wind deposition:
Spatial and temporal patterns of forest drainage (especially runoff velocity) may result in local ponding. In conjunction with suspended sediment from waterborne erosion, sedimentation may occur.

Related Reference: 194

F270-388 Overland flow - Soil detachment:
(same as A270-388)

Related References: 143,174,192,194,288,412,460,543,561,577,671 , 749,752

F270-389 Overland flow - Soil exposure:
(same as A270-389)

Related Reference: 749

F270-480 Overland flow - Waterborne erosion:
(same as A270-480)

Related Reference: 472

F275-158 Park management - Forest management:
In situations where recreational areas or nature preserves contain forested tracts, this interaction refers to that part of a park management plan that deals specifically with forest management. This may involve cutting of existing forest, establishment of new forest, protection of existing areas, etc.

Related References: none

F275-325 Park management - Riparian and slope protection:
This represents park management decisions to protect slopes and riparian zones from erosion by restricted access, erosion control structures, greenbelt retention or establishment, etc.

Related References: none

F275-(335,336) Park management - Road construction and use:
This represents park management decisions involving road construction and use and, in particular, efforts to reduce erosion through slope management or other measures.

Related References: none

F275-451 Park management - Trail construction and use:
This represents park management decisions on the construction and maintenance of hiking or riding trails, including regulations for their use.

Related References: none

F286-287 Pesticide application - Pest problems:
(same as A286-287)

Related References: 84,244,260,268,316,317,377,517,579,593,607, 617,650,651,655,686,728

F286-301 Pesticide application - Production costs:
(same as A286-301)

Related References: 84,617,655

F286-386 Pesticide application - Soil composition:
(same as A286-386)

Related References: 84,214,260,268,517,607

F287-(156,378) Pest problems - Forest canopy development, Site productivity:
This represents the effects of defoliation, vascular disruption, and competition by plant competitors, insects, and pathogens on forest canopy condition and growth. Pest damage during regeneration may be most acute.

Related References: none

F299-106 Precipitation - Drainage pattern:
(same as A299-106)

Related References: 9,14,32,63,88,132,145,146,163,383,385,438, 538,561,586,633,648,679,680,737,743,767,768, 789,790

F299-267 Precipitation - Organic-inorganic chemical pool (non-adsorbed):
(same as A299-267)

Related References: 8,37,39,47,81,88,132,145,150,159,232,234, 245,286,331,389,396,433,459,483,520,559, 572,586,591,651,661,715,767

F299-388 Precipitation - Soil detachment:
(same as A299-388)

Related References: 38,141,143,190,239,288,380,382,446,453,460, 462,471,474,483,485,561,582,645,646,748, 749,752,765

F299-392 Precipitation - Soil moisture:
(same as A299-392)

Related References: 38,107,331,463,471,539,734,766

F301-157 Production costs - Forest income:
This represents the effects of fixed and flexible costs on forest-derived income, as balanced against site productivity and market conditions for forest products.

Related References: none

F314-234 Regeneration methods - Logging methods:
This represents the interplay between regeneration plans and logging techniques, as discussed under F234-314 above.

Related References: none

F314-301 Regeneration methods - Production costs:
This represents the contribution of regeneration costs to total production costs.

Related References: none

F314-389 Regeneration methods - Soil exposure:
This represents the effects of different forms of regeneration on soil exposure following timber harvest, stand improvement, or fire. Regeneration may cause minimal increases under natural restocking or major increases under intensive seedbed preparation.

Related References: none

F314-(396,397) Regeneration methods - Soil structure and texture:
The same factors that relate regeneration techniques to soil exposure (314-389) affect soil structure and texture.

Related References: none

F325-301 Riparian and slope protection - Production costs:
The beneficial effects of riparian or slope protection measures require a monetary investment, and they contribute to total production costs.

Related References: none

F325-389 Riparian and slope protection - Soil exposure:
This represents beneficial reduction of soil exposure through certain types of slope and riparian protection involving plant cover (or cover by artificial or semi-artificial materials, such as bark chips on trails).

Related Reference: none

F(335,336)-301 Road construction and use - Production costs:
This represents the contribution of road construction and maintenance costs to total forest production costs or park management costs.

Related References: none

F(335,336)-389 Road construction and use - Soil exposure:
Road construction generally increases soil exposure, with the most severe effects taking place on steeper terrain unless proper precautions are used. Unpaved roads represent continually exposed soil unless protected.

Related References: none

F(335,336)-(396,397) Road construction and use - Soil structure and texture:
The same variables that influence soil exposure during road construction also affect soil texture and structure. Texture is affected if extensive soil movement scrambles the soil profile or if fill material is added from outside sources. Structure is altered by soil movement, compaction, etc.

Related References: none

F352-106 Sedimentation or wind deposition - Drainage pattern:
(same as A352-106)

Related References: 63,69,81,88,143,153,194,259,412,421,438,530, 567,577,679,680,749,767

F352-386 Sedimentation or wind deposition - Soil composition:
(same as A352-386)

Related References: 8,24,27,114,153,206,211,269,318,323,340,348, 381,396,405,426,458,465,466,467,482,483,535, 565,577,582,600,603,607,658,670,679,688,712, 718,746,748

F386-(156,378) Soil composition - Forest canopy development, Site productivity:
This represents the influences of soil composition on forest health and growth, other than through soil fertility (390-057,378)) *or* pest reduction (386-287-(156,378)). Examples would be soil pH, herbicides, or other toxins (during regeneration, for example), or other contaminants (such as heavy metals).

Related References: none

F386-267 Soil composition - Organic-inorganic chemical pool (non-adsorbed):
(same as A386-267)

Related References: 8,18,145,269,286,133,436,117,466,572,577,661

F386-287 Soil composition - Pest problems:
(same as A386-287)

Related References: 50,84,94,244,517,625,637,743

F386-390 Soil composition - Soil fertility:
(same as A386-390)

Related References: 20,50,84,94,503,626,637

F386-(396,397) Soil composition - Soil structure and texture:
(same as A386-(396,397))

Related References: 38,41,124,219,244,340,426,432,517,626,673

F386-(435,7) Soil composition - Suspended sediment, Adsorbed material:
(same as A386-(435,7))

Related Reference: 269

F388-480 Soil detachment - Waterborne erosion:
(same as A388-480)

Related References: 392,394,706

F388-507 Soil detachment - Wind erosion:
(same as A388-507)

Related References: 40,323,392,394,706

F389-(199,282) Soil exposure - Infiltration, Percolation:
The absence of plant cover or other surface materials (litter, paved road, etc.) normally hastens infiltration, unless prolonged exposure has altered surface conditions (389-(396,397)). This interaction deals with plant cover at ground level, in contrast to the effects of the forest canopy on infiltration and percolation ((156,378)-(199,282)).

Related References: none

F389-270 Soil exposure - Overland flow:
This interaction refers principally to the presence or absence of live or dead plant material on the forest floor, and the reduction in runoff velocities that such materials may promote. This interaction is included as "Plant cover - Overland flow" in the Agriculture Subsystem and "Pasture or hayfield condition-Overland flow" in the Grassland Subsystem. The converse of plant cover — soil exposure — is used here since there is no separate component that represents just ground level plant cover.

Related Reference: 749

F389-388 Soil exposure - Soil detachment:
Detachment of soil particles is accelerated by exposure of the soil surface and retarded by any factor that decreases exposure, such as erosion control materials (mulches on roadsides, or bark chips on rails) or overland flow. The effect of exposure is modified by the timing of exposure and the condition of the exposed soil, which are in turn influenced by forest management decisions regarding timber harvest, stand improvement,.road construction, regeneration, and erosion control.

Related References: 130,529,546,582,749

F389-392 Soil exposure - Soil moisture:
(same as A389-392)

Related References: none

F389-(396,397) Soil exposure - Soil structure and texture:
(same as A389-(396,397))

Related References: none

F390-(156,378) Soil fertility - Forest canopy development, Site productivity:
This represents the effects of soil fertility on forest health and growth, as influenced by natural fertility, fertilizer application, and soil characteristics.

Related References: none

F390-287 Soil fertility - Pest problems:
Weed growth may be enhanced by good soil fertility, particularly if fertilizer is applied. This may be most important during regeneration.

Related Reference: 776

F392-(137,138) Soil moisture - Fire control, Fire damage:
Soil moisture is a natural or applied regulator for fire protection and lessened susceptibility of the forest to damage.

Related References: none

F392-(156,378) Soil moisture - Forest canopy development, Site productivity:
This represents the effects of spatial and temporal patterns of soil moisture on forest condition and growth, as modified by soil characteristics and canopy status. The effects may be either beneficial (retention of available moisture into drought periods) or detrimental (too much water, and reduced growth).

Related References: none

F392-(199,282) Soil moisture - Infiltration, Percolation:
(same as A392-(199,282))

Related References: 6,124,176,219,331,471

F392-(396,397) Soil moisture - Soil structure and texture:
(same as A392-(396,397))

Related References: 38,124,517

F(396,397)-116 Soil structure and texture - Erodibility (soil):
(same as A(396,397)-116)

Related References: 38,556

F(396,397)-(156,378) Soil structure and texture - Forest canopy development, Site productivity:
This represents the direct effect of soil texture and structure on forest growth, primarily through favorability to root growth. Note that soil texture and structure indirectly affect forest growth through other components such as water holding capacity.

Related References: none

F(396,397)-(199,282) Soil structure and texture - Infiltration, Percolation:
(same as A(396,397)-(199,282))

Related References: 6,124,176,219,331,471

F(396,397)-485   Soil structure and texture - Water holding capacity:
(same as A(396,397)-485)

Related References: none

F403-(156,378)   Stand improvement - Forest canopy development, Site productivity:
Stand improvement measures affect forest growth in many ways, including temporary reduction of canopy density, alteration of composition toward more desirable species, and acceleration of growth rates of remaining trees. Site productivity is increased. Culling of poorly formed and diseased trees may indirectly affect canopy condition and growth by reducing refuges for pathogens and other pests.

Related References: none

F403-301   Stand improvement - Production costs:
This represents the contribution of stand improvement to long-term production costs for forest products.

Related References: none

F403-389   Stand improvement - Soil exposure:
Stand improvement techniques usually involve timber cutting and removal. Thus the timber harvest variables that affect soil exposure (234-389) apply here, though-perhaps on a smaller scale.

Related References: none

F403-(396,397)   Stand improvement - Soil structure and texture:
Again, timber harvest methods and their effects on soil texture and structure are applicable on a. smaller scale to stand improvement. This parallels the effects of stand improvement on soil exposure.

Related References: none

F426-122   Subsurface flow - Exported material:
Water, suspended sediment and adsorbed materials, and non-adsorbed chemicals are carried in subsurface drainage flows in tiles and pipes; they may be exported from the Forest Subsystem.

Related References: none

F426-267 Subsurface flow - Organic-inorganic chemical pool (non-adsorbed):
Non-adsorbed chemicals in subsurface waters will contribute to the total pool of non-adsorbed materials in water draining forested lands. This interaction is distinguished from that between subsurface flow and exported material (426-122) since chemicals may be transported from one area to another below the surface without leaving the forest.

Related References: 39,224,311,414,731

F(435,7)-122 Suspended sediment, Adsorbed material - Exported material:
This represents the contribution of suspended sediments and adsorbed materials to all materials leaving the forest subsystem.

Related References: 393,596,693,759

F(435,7)-267 Suspended sediment, Adsorbed material - Organic-inorganic chemical pool:
(same as A(435,7)-267)

Related References: 4,8,26,27,30,44,47,59,69,77,80,81,88,89,98,
100,102,129,135,139,140,159,166,174,175,176,
189,194,200,203,209,220,223,224,245,260,268,
269,272,311,314,315,316,318,322,331,333,342,
346,347,352,356,364,371,372,373,396,409,417,
420,445,457,465,466,472,475,476,483,544,549,
550,555,559,572,575,576,577,586,591,597,600,
623,629,630,634,641,651,655,657,659,667,670,
685,686,688,690,691,692,713,715,720,721,722,
724,756,757,767,776,780,786, 791,792

F(435,7)-270 Suspended sediment, Adsorbed material - Overland flow:
The quantities and characteristics of suspended sediments contained in overland flow may alter characteristics of that flow.

Related References: 4,8,26,27,30,44,47,59,69,77,80,81 ,88,89,98.,
100,102,129,135,139,140,159,166,174,175,176,
189,194,200,203,209,220,223,224,245,260,268,
269,272,311,314,315,316,318,322,331,333,342,
346,347,352,356,364,371,372,373,396,409,417,
420,445,457,465,466,472,475,476,483,544,549,
550,555,559,572,575,576,577,586,591,597,600,
623,629,630,634,641,651,655,657,659,667,670,
685,686,688,690,691,692,713,715,720,721,722,
724,756,757,767,776,780,786, 791,792

F(435,7)-352 Suspended sediment, Adsorbed material - Sedimentation or wind deposition:
(same as A(435,7)-352)

Related References: 3,4,7,8,21 ,24,25,27,42,44,45,48,49,54,60,61 , 62,63,65,66,67,69,73,75,76,77,78,80,81,87, 88,89,90,92,93,96,98,106,108,109,111 ,114, 115,117,119,126,127,128,129,130,135,136,138, 141,143,147,149,153,166,167,168,169,170,172, 173,175,180,188,193,194,198,203,204,205,206, 211,218,220,224,239,242,248,250,251 ,256,259, 263,269,272,276,277,281,282,283,287,302,306, 309,310,313,314,315,317,318,319,320,321,323, 327,328,332,333,334,335,338,339,340,346,347, 348,349,350,351,352,354,365,366,375,377,381 , 39 4,396,398,399,400,401,402,405,406,409,412, 417,421,426,437,438,439,441,446,448,449,450, 451,454,457,458,465,466,467,469,479,482,483, 488,489,490,492,493,494,495,496,497,'498,499, 507,512,515,524,526,529,530,532,535,537,541, 542,544,546,547,552,557,562,563,564,565,568, 570,577,582,596,600,602,603,607,614,615,618, 623,638,639,640,641,643,644,645,646,647,651, 654,658,662,667,668,670,674,678,679,680,681, 682,685,686,688,691,692,693,699,700,702,703, 704,707,709,712,718,724,727,732,733,742,746, 747,748,749,759,760,762,763,767,771,775,781, 785,787,792

F443-234 Timber harvest management - Logging methods:
This represents harvest management decisions on the use of particular logging methods as influenced by market conditions, production costs, site productivity, topography, forest condition, and erosion potential.

Related References: none

F443-314 Timber harvest management - Regeneration methods:
This represents timber harvest management decisions that influence regeneration techniques and that are not specifically related to logging methods, such as post-logging soil preparation, planting techniques, etc.

Related References: none

F443-403 Timber harvest management - Stand improvement:
This represents stand improvement measures as one component of the overall harvest management plan.

Related References: none

Table II-4. Continued

F446-106 Topography (especially local slope) - Drainage pattern:
(same as A446-106)

Related References: 132,248,586,648,679,768

F446-158 Topography (especially local slope) - Forest management:
Site topography and local slope affect many aspects of forest management, including road construction, timber harvest, fire control, and erosion control.

Related References: none

F446-(199,282) Topography (especially local slope) - Infiltration, Percolation:
(same as A446-(199,282))

Related References: 6,162,331,453,746

F451-389 Trail construction and use - Soil exposure:
This represents the effects of trail construction and use (particularly overuse and abuse) on soil exposure, particularly on sloping terrain *or* in riparian zones.

Related References: none

F451-(396,397) Trail construction and use - Soil structure and texture:
This represents the effects of trail management on soil texture and structure, involving compaction and attempts to control structural alteration (such as the use of bark chip covering).

Related References: none

F480-106 Waterborne erosion - Drainage pattern:
(same as A480-106)

Related References: 43,558

F480-158 Waterborne erosion - Forest management:
This represents the effects of waterborne erosion or sedimentation rates on forest management decisions to implement erosion control measures.

Related Reference: 317

F480-386 Waterborne erosion - Soil composition:
(same as A480-386)

Related Reference: 392

Table II-4. Continued

F480-(435,7) Waterborne erosion - Suspended sediment, Adsorbed material:
(same as A480-(435,7))

Related References: 43,317,377,392,394

F485-392 Water holding capacity - Soil moisture:
(same as A485-392)

Related References: none

F(505,7)-122 Windborne sediment, Adsorbed material - Exported material:
This represents the contribution of windborne sediment and adsorbed materials to substances exported from the Forest Subsystem.

Related References: none

F(505,7)-352 Windborne sediment, Adsorbed material- Sedimentation or wind deposition:
(same as A(505,7)-352)

Related References: none

F507-386 Wind erosion - Soil composition:
(same as A507-386)

Related References: 8,40,392,427

F507-(505,7) Wind erosion - Windborne sediment, Adsorbed material:
This represents the contribution of wind erosion in the Forest Subsystem to windborne sediment and adsorbed materials. Variables affecting detachment and transport (such as wind speed) will also determine the characteristics of the transported material (such as particle size).

Related Reference: 107

F508-(156,378) Wind speed, duration, and direction - Forest canopy development, Site productivity:
Significant winds influence forest condition in several ways, chiefly through dessication or mechanical breakage. This is particularly important for forest stands that are narrow and for the margins of any stand.

Related References: none

Table II-4. Concluded

F508-388 Wind speed, duration, and direction - Soil detachment: (same as A508-388)

Related References: none

F508-507 Wind speed, duration, and direction - Wind erosion: (same as A508-507)

Related Reference: 107

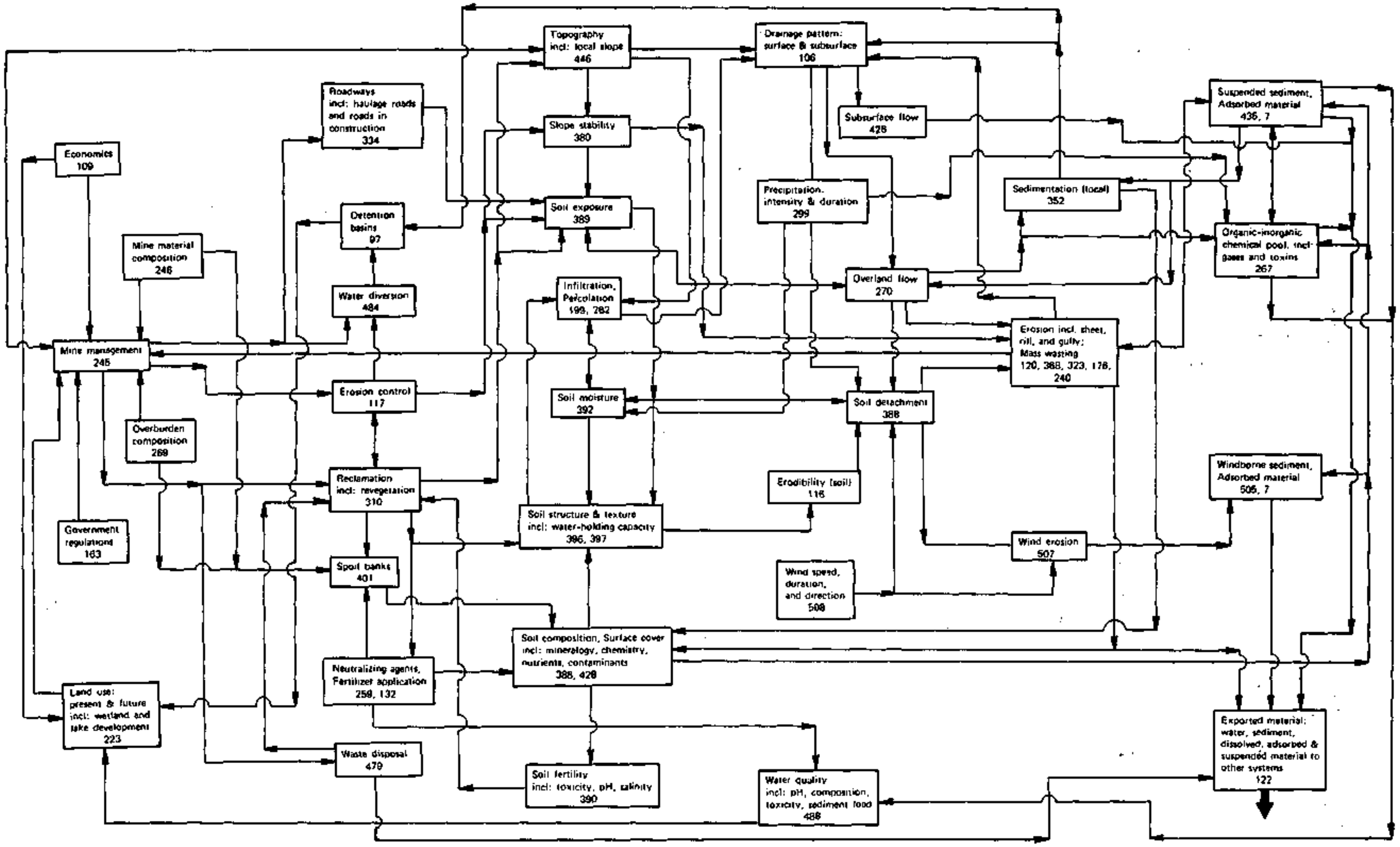


Figure II-10. Level II model for the Mining Subsystem

Mining Subsystem

Model Description and Model Interactions. The Mining Subsystem (Figure II-10) describes the influence that mining (surface or subsurface) and reclamation have on the sediment budget, water quality, soil and water composition, and surface features of a particular site or area. Although the emphasis of the model is on the impact of coal mining on sedimentation and erosion, efforts have been made to ensure application to other mining activities in Illinois (such as sand, gravel, limestone, and dolomite quarrying and mining for fluorspar, tripoli, and metals).

The model can be broken into five major categories from left to right: 1) factors influencing management decisions on mining and reclamation, 2) methods and types of modifications of the land surface (these are directly influenced by mine management), 3) physical characteristics of the land surface (soil and slope) as affected by natural or human-induced influences, 4) factors directly influencing material transport (including drainage, flow, precipitation, and surface erodibility) and the resulting erosion and sedimentation, and 5) the quantity and composition of material involved in sedimentation and erosion from mined land.

Mine management decisions are influenced by a number of factors (as indicated by the arrows directed toward management), including government regulations, economics and cost/benefit choices, material to be mined (ore grade, distribution, etc.), overburden composition and characteristics, local and regional topography, and sediment budget of the watershed. Management decisions, in turn, initiate specific types of modifications to the land surface through reclamation choices, erosion control measures, building of roadways, and use of fertilizers or neutralizers on spoil banks or back-fill pits.

As illustrated in the model, there are many possible scenarios which describe the effect these activities have on the land surface. One such example is as follows: reclamation decisions to use neutralizing agents on a spoil bank result in modification of the soil composition. Neutralization of toxic elements in the surface material decreases soil toxicity and raises the potential for revegetation. Revegetation reduces soil exposure to wind and rain, and modifies the texture and structure of soil or surface material. The texture and structure of the surface material (as influenced by existing soil moisture, vegetation, soil composition, and exposure) determine soil erodibility. Soil texture and structure influence infiltration and percolation, which have a direct influence (in conjunction with slope) on drainage and overland flow. These two factors, erodibility and drainage, in conjunction with precipitation, wind, and textural nature of suspended material, determine detachment and erosion of surface material.

Table II-5 offers detailed descriptions of all the interactions for the Mining Subsystem model.

Table II-5. Descriptions of Interactions for the Mining Subsystem Model

Interaction code	Description
M97-223	Detention basins - Land use: Detention basins are used to reduce the sediment load to receiving streams. These basins can be used for future wildlife and recreation areas if appropriately reclaimed. Related References: 90,150,777
M106-270	Drainage pattern - Overland flow: Overland flow is the main component of drainage that is of concern with regard to erosion. The factors which influence drainage (rainfall rates and intensity, infiltration and percolation properties of the soil, and topography) influence overland flow through this interaction. Related References: 9,32,561,633
M106-426	Drainage pattern - Subsurface drainage: Subsurface drainage through pipes and tiles is an important component of drainage with regard to the transport of material (dissolved or suspended contaminants) both within and outside the system. In all the upland systems where no subsurface pipes or drainage tiles are used, this component of natural drainage is primarily controlled by substrate or soil characteristics (especially the infiltration and percolation capabilities) and the intensity and duration of rainfall. Related References: none
M109-223	Economics - Land use: Economics influences the cost/benefit tradeoffs of reclaiming disturbed lands to their original state or to some other use. Economic considerations regarding reclamation may limit the future potential of the land. Without government regulations to control reclamation, many mined lands would be left as unreclaimed sites. Related References: 8,14,34,35,53,70,83,93,97,112,155,209,219, 231,271,272,273,282,321,324,361,362,377, 383,391,465,466,468,482,483,484,512,514, 566,580,592,599,632,637,663,697,699,700, 709,737,741,764,772,776

M109-245 Economics - Mine management:
Activities associated with a mining operation are first translated into economic terms so that investment decisions can be made regarding such matters as the scale of operations and methods of reclamation to be used. This includes capital and labor costs, and royalty payments.

Related References: 11,121,144,284,420,484,501,566,602,612, 625,663

M116-388 Erodibility (soil) - Soil detachment:
Each type of soil has its own inherent susceptibility to soil dislodgement and erosion due to its composition, structure, and texture (these factors influence infiltration/percolation and water-holding capacities). Large grained materials are not easily transported, while fine grained materials are easily transported. This in conjunction with other factors such as vegetative or other cover, and rainfall intensity, control the dislodgement of soil particles. It is only in conjunction with overland flow that erosion (or transportation of dislodged material) can occur.

Related References: 18,38,40,174,187,194,237,239,241 ,453,460, 462,582,646,678,726,752

M117-310 Erosion control - Reclamation:
This describes the use of erosion control measures for reclamation purposes. Provision of plant cover is included within the reclamation component.

Related References: 9,29,31,39,86,127,130,239,241,245,270,279, 286,331,340,497,503,568,637,664,737,770

M117-380 Erosion control - Slope stability:
Erosion control methods, including grading, terracing, mulches, or vegetative cover, directly influence the stability of the slope. Slope stability is also controlled by gradient and by surface and substrate characteristics (especially the cohesive strength).

Related References: 162,662

M117-389 Erosion control - Soil exposure:
Erosion control techniques reduce soil exposure to wind and rain through the use of mulches, gravel cover, cement, or plastic overlying mine waste piles, or the use of revegetation as discussed above.

Related References: 8,130,296,298,503,546

M117-484 Erosion control - Water diversion:
Erosion control needs determine the appropriate type and use of water diversion, as well as the location of channels and detention basins, for sediment trapping. Water diversion (especially sediment trapping by detention basins) provides a mechanism for detainment of chemically polluted mine waters, and for the prevention of polluted waters and sediment from entering streams and rivers.

Related References: 279,568,580

M(120,368,323,176,240)-106 Sheet, rill, and gully erosion; Mass wasting - Drainage pattern:
This represents the influence of erosion on the drainage pattern. Continued erosion modifies the flow of water by modifying local relief features.

Related References: 9,14,63,88,146,163,212,383,385,438,538,561, 767,768

M(120,368,323,176,240)-122 Sheet, rill, and gully erosion; Mass wasting - Exported material:
The transport of material out of the system is represented here.

Related References: 2,3,4,5,6,7,8,9,10,17,18,21,22,25,30,31,34, 35,38,39,40,43,44,45,52,55,56,60,63,66,74, 80,81,82,88,92,93,95,97,103,106,107,109,110, 114,115,116,117,119,125,127,128,129,130,131, 135,136,137,138,140,141,143,144,146,152,159, 162,163,174,175,177,179,80,181,187,188,189, 190,192,193,197,202,206,211,212,213,220,221, 223,224,229,236,237,238,239,241,242,243,244, 245,251,252,253,256,257,258,259,260,263,264, 267,270,271,272,274,278,279,281,282,283,287, 297,298,299,301,302,303,304,305,306,307,312, 313,314,315,316,317,318,319,320,321,323,329, 331,332,335,339,340,341,342,346,347,352,357, 359,360,362,367,368,377,381,382,383,385,390, 392,394,397,398,399,400,402,403,404,406,410, 411,412,413,415,416,418,420,421,426,429,437, 438,439,442,446,450,452,453,455,456,458,461, 462,472,473,474,475,479,480,482,483,485,488, 491,492,493,495,497,505,507,510,511,512,516, 517,520,523,525,529,530,532,537,538,539,540, 541,543,544,545,546,547,548,551,552,558,560, 561,562,564,568,569,570,574,577,579,582,583, 597,598,600,601,602,604,605,607,608,615,622, 627,628,630,631,638,641,642,644,645,646,649, 652,653,654,655,656,662,669,670,671,672,674, 678,681,682,686,688,692,693,696,699,700,703, 706,707,709,710,712,714,715,716,717,718,724, 726,727,728,729,732,734,736,741,742,744,745, 746,747,748,749,750,751,755,760,762,763,764, 765,767,768,771,772,773,777,778,792

M(120,368,323,176,240)-245 Sheet, rill, and gully erosion; Mass wasting - Mine management:
The influence of erosion rates on mine management decisions to implement various reclamation procedures for limiting sediment discharge is included here.

Related References: 30,109,110,144,223,296,331,357,385,394,420, 546,566,602,718,728,744,747,760

M(120,368,323,176,240)-(386,428) Sheet, rill, and gully erosion; Mass wasting - Soil composition, Surface cover:
The removal of surface material by erosion results in a modification of surface material composition.

Related References: 2,8,18,30,38,40,41,74,79,84,86,95,110,114, 140,152,160,181,182,206,211,236,244,260, 286,318,323,340,341,363,380,381,383,392, 404,411,420,426,427,436,452,458,474,482, 483,503,517,553,577,582,597,600,607,630, 637,642,649,656,670,673,688,712,714,715, 716,718,746,748,752

M(120,368,323,176,240)-(435,7) Sheet, rill, and gully erosion; Mass wasting - Suspended sediment, Adsorbed material:
Suspension of material through erosive action of water (dislodgement of soil or other material by sheet, rill or gully erosion, which is then carried within the water column) is included here.

Related References: 9,30,60,80,81,125,143,152,159,175,177,181, 212,245,253,287,317,346,347,360,377,398, 442,462,488,525,540,562,579,597,600,607, 630,693,707,716,747,767

M163-245 Government regulations - Mine management:
This represents government regulations regarding mine management decisions involving reclamation, waste disposal, water diversion, erosion control, and land use. Changes in government regulations result in different allowable methods for, and location of, waste disposal. In situations where regulations change, current methods for waste disposal may become unsatisfactory, and operation is halted until new disposal methods are implemented.

Related References: 14,74,110,144,165,271,274,300,320,357,361, 362,368,484,504,505,510,511,512,520,532, 551,601,605,607,608,612,669,712,741,742, 744

M(199,282)-106 Infiltration, Percolation - Drainage pattern:
The infiltration/percolation characteristics of the surface soil or material influence drainage (in conjunction with rainfall intensity and duration, and slope). On flat lying areas the rate of infiltration is one of the major controls on the amount of water carried in overland flow. On steeper slopes, the percolation characteristics become more important and allow more water to be carried on the surface. The nature of flow and its contribution to erosion of surface material depend upon the physical properties of the surface material, the amount of vegetative cover, and the rate and duration of rainfall.

Related References: 145,538,743

M(199,282)-392 Infiltration, Percolation - Soil moisture:
This describes the influence of infiltration and percolation on the existing soil moisture as influenced by the intensity of rainfall, texture and structure of soil, amount and type of plant cover, and local drainage characteristics.

Related References: 6,124,176,219,331,463,471,766

M223-245 Land use - Mine management:
Present and future land use directly influence decisions on mining procedures, including decisions on the type and size of cuts, the location and maintenance of haulage roads, and the method of reclamation.

Related References: 109,110,300,356,385,394,484,566,663,718

M245-117 Mine management - Erosion control:
This describes mine management decisions on erosion control procedures such as grading, terracing steep slopes, use of mulches on spoil or cut banks, and grassed waterways or other special water diversion methods. Erosion control by revegetation is included in reclamation. Decisions to use certain erosion control procedures are influenced by the erosion problems themselves as well as by economic feasibility and government regulations.

Related References: 109,296,331,357,394,546,744

M245-310 Mine management - Reclamation (including revegetation):
This represents mine management decisions controlling reclamation procedures used in a particular site for a particular type of mining (sand and gravel, coal, lead-zinc, etc.). For maximum environmental control, reclamation should be done as early as possible.

Related References: 11,30,121,223,300,331,432,501,504,566,625, 663,760

M245-334 Mine management - Roadways:
, This represents mine management decisions on use and location of haulage roads based upon the type of material being mined, economic and local topography (including grade and drainage, proximity to stream channels, etc.). Note that there is no arrow going directly from topography to roadways because the decision to build roadways goes through mine management (M446-245-334). How the road is maintained during mining and abandoned afterwards are important aspects of roadways.

Related Reference: 296

M245-446 Mine management - Topography:
This represents mine management decisions to modify topography by strip mining and construction of roads, water diversion structures, pits, tailing piles, etc. The surface drainage system may be thrown out of equilibrium, thus affecting erosion rates.

Related References: 296,331,663

M245-479 Mine management - Waste disposal:
Mine management decisions on waste disposal methods are governed by economic considerations and government regulations relating to gob and slurry impoundment, tailing piles, backfill, dumps, etc. The chemical nature of spoil material may determine method of waste disposal. In some cases burying material may be the only way to dispose of it so the surface is suitable for the growth of plants.

Related References: 121,663

M245-484 Mine management - Water diversion:
Mine management controls the use of and methods for water diversion, taking into account local drainage patterns, topography, and hydraulic and geometric characteristics of a stream or channel. Water diversion methods such as grassed waterways or other channel works not only serve as a means for diversion of water, but are also functional as a sediment trap for locally eroded material.

Related References: none

M246-245 Mine material composition - Mine management:
Mine material composition controls procedures used to mine and to reclaim the mining area. Examples include: variations in sulfur grade of coal, physical and compositional nature of sand and gravel deposits, physical and chemical distribution of material, and mineral or element being mined.

Related References: 121,300,625,663,760

M246-401 Mine material composition - Spoil banks:
Mine material composition directly influences the quality of surface water within the mining system. It also has a long-term effect on water quality in receiving lakes and rivers. Water quality includes chemical composition, pH, sediment load, etc.

Related References: 112,502,663

M(259,132)-(386,428) Neutralizing agents, Fertilizer application - Soil composition, Surface cover:
Neutralizing agents influence soil composition by reducing toxicity and neutralizing pH. Fertilizer application influences composition through increasing nutrient levels in the soil.

Related References: 84,244,433,447,502,517

M(259,132)-401 Neutralizing agents, Fertilizer application - Spoil banks:
Neutralizing and fertilizing spoil banks enhances plant growth, reduces mobility of heavy metals, and modifies pH. This can be done by using local materials and natural leaching, or by using chemical leachates, spraying sewage sludge, etc. The overburden material put in the spoil banks can sometimes act as a natural neutralizing agent.

Related References: 447,502,664

M(259,132)-488 Neutralizing agents, Fertilizer application - Water quality:
Neutralizing mine spoils (indirectly through the choice of reclamation procedure) directly influences the quality of surface water within the mining system. It also has a long-term effect on water quality in receiving lakes and rivers. Water quality includes chemical composition, pH, sediment load, etc.

Related References: 271,433,595,601,649,651,686,728,744,773,776

M267-122 Organic-inorganic chemical pool - Exported material:
This represents the dissolved and suspended substances (which are not adsorbed to sediment) being carried to other systems. It includes substances in the water column.

Related References: 26,269,476,555

M267-435 Organic-inorganic chemical pool - Suspended sediment:
This represents the transfer of material from the water column to sediment through adsorption to suspended sediment. This is affected by several variables such as the chemical characteristics of the water column, water temperature, dissolved oxygen concentration, and composition of suspended sediment.

Related References: 89,98,113,234,322,388,457,534,550,600,690

M267-488 Organic-inorganic chemical pool - Water quality:
Composition of materials within the water column, including dissolved or suspended materials, directly influences the quality of water. Water quality includes composition of material in the water column, pH, nutrient content, trace metal concentration, toxicity, and sediment load.

Related References: 8,27,35,37,44,69,91,98,129,135,139,140,159, 174,175,178,203,209,220,223,224,230,232,234, 238,260,265,272,284,311,333,342,356,370,371, 372,373,388,409,414,420,445,472,478,483,520, 549,559,575,597,601,630,641,651,659,685,686, 690,692,713,715,720,721,722,724,731,757,767, 776,780,792

M269-245 Overburden composition - Mine management:
Overburden composition influences decisions about, and the effectiveness of, reclamation procedures (such as overburden use as the neutralizing agent for toxic tailing piles, and topsoil removal and return for reclamation). Properties of the overburden that are of interest include percent and type of pyrite, pH and potential acidity from pyritic sulfur, total and soluble plant nutrients, acid neutralizing capacity from carbonates, clay exchange and weatherable silicates, soil particle size distribution and the water holding capacity, and other physical and chemical properties likely to change in the new environment.

Related References: 625,686

M269-401 Overburden composition - Spoil banks:
Overburden material is one of the components of spoil banks along with coal (or other mineral) wastes including tailings.

Related Reference: 686

M270-120 Overland flow - Erosion:
This represents the contribution of overland flow to waterborne erosion, including sheet, rill, and gully erosion. The elements of concern are runoff rates and discharge volumes. Overland flow in conjunction with soil dislodgement influences erosion rates and ultimately the amount of material carried in suspension from a particular site.

Related References: 2,9,39,81,143,152,174,192,194,253,259,288, 404,412,421,460,472,530,543,561,564,577, 671,749,752,772

M270-267 Overland flow - Organic-inorganic chemical pool:
This interaction describes the direct transfer of dissolved materials (especially metals or pollutants) which are not attached to suspended sediment or other solids in the water column.

Related References: 26,39,69,81,174,194,472,555,577

M270-352 Overland flow - Sedimentation:
The influence of overland flow on sedimentation includes impacts on its duration and volume.

Related References: 69,81,143,153,194,259,412,421,530,564,577, 749

M270-388 Overland flow - Soil detachment:
The rate of overland flow directly influences the detachment of surface material. Clay particles in suspension act differently than sand-sized particles.

Related References: 143,174,192,194,288,412,460,543,561,577, 671,749,752

M270-389 Overland flow - Soil exposure:
Overland flow can reduce soil exposure by providing a protective layer of water through which the impact of raindrops can not be felt. This will occur only when the infiltration rate of the soil is low, depth of flow significant, and precipitation rates high relative to the amount percolating through the soil.

Related Reference: 749

M299-106 Precipitation - Drainage pattern:
Amount, intensity, and duration of precipitation influence drainage rates and patterns, including the rate and timing of water flow both as surface and subsurface drainage. This is influenced by a number of factors such as infiltration, percolation, and topography. The drainage patterns include overland and subsurface flow through tiles and pipes.

Related References: 39,63,81,143,163,280,288,438,460,735,749,752, 789,790

M299-267 Precipitation - Organic-inorganic chemical pool:
Materials carried in the atmosphere (metals, hydrocarbons, etc.) can be transported into the system through rainfall and thus contribute to the organic-inorganic chemical pool.

Related References: 8,39,81,150,331,396,459,483,559,572,591

M299-388 Precipitation - Soil detachment:
Rainfall intensity and duration, in conjunction with physical properties of the soil such as texture, cohesive strength, degree of compactness, and amount of protective cover, directly influence the dislodgement of soil particles.

Related References: 38,141,143,190,288,380,382,453,460,462,471, 474,483,485,582,748,749,752,765

M299-392 Precipitation - Soil moisture:
The duration and intensity of rainfall, in conjunction with infiltration and percolation, directly control the existing soil moisture.

Related References: 38,107,331,463,471,539,734,766

M310-117 Reclamation - Erosion control:
Reclamation needs determine the use of erosion control methods (other than revegetation) to prevent acid mine drainage, to decrease sediment load in streams and rivers, and to minimize sediment filling of ponds and lakes and disruption to biota. Common techniques include grading, terracing, and use of mulches.

Related References: 9,29,31,39,86,127,130,239,241,245,270,279, 286,331,340,497,503,568,637,664,737,770,793

M310-(259,132) Reclamation - Neutralizing agents, Fertilizer application:
Reclamation procedures for neutralizing acid soils, and returning soils to an acceptable level of fertility, will determine the types and composition of materials used for both neutralizing and fertilizing. This is not meant to indicate a direct relationship between reclamation and soil fertility because it is the neutralizers and fertilizers which determine the overall quality of soil. Overburden material is very often used as a neutralizing agent for mine tailing. Limestone or calcareous soils are used to neutralize acid mine wastes from coal or metals. The nature of the overburden determines what sort (if any) of additional neutralizing agents are needed. Plants such as legumes are often used in a revegetation mixture because of their ability to "fix" atmospheric nitrogen and thus act as a natural fertilizer (subsequently reducing costs because they provide both cover and nutrients).

Related References: 433,447,502,664,773

M310-389 Reclamation - Soil exposure:
Reclamation procedures have direct impact on soil exposure through the use of revegetation procedures on disturbed surfaces. This is similar to the influence that other erosion control methods (such as mulches) have on soil (or other surface material) exposure. They provide a cover which protects the soil from wind and rain. This specifically relates to revegetation for reclamation purposes, and subsequent reduction of exposure.

Related References: 130,503

M310-(396,397) Reclamation - Soil structure and texture:
This represents the direct influence of reclamation techniques on the texture and structure of soil or surface material. Revegetation, tillage, and surface grading are some of the ways the texture and structure are modified. Indirect modifications occur through modifying composition and exposure to wind and water.

Related References: 130,176,219,331,340,432,626,734

M310-401 Reclamation - Spoil banks:
This represents reclamation techniques (including revegetation) for neutralizing spoil banks and recontouring or backfilling banks to provide continuity with surrounding landscape. Provided that plant species are carefully chosen, they can be used to help neutralize the soil. Characteristics of plants desirable for revegetation include: 1) ability to spread, 2) resistance to diseases and insects, 3) species compatability, and 4) climatic adaptation (particularly microclimatic variation in soil).

Related References: 14,29,50,86,94,112,131,176,286,368,447,502, 503,506,637,661,663,664,737

M310-446 Reclamation - Topography:
Reclamation procedures modify local topography by recontouring, terracing, or grading of slopes. This ultimately influences slope stability, which in turn influences the potential for erosion by mass wasting.

Related References: 39,103,129,131,241,270,331,614,663,734,772

M334-389 Roadways - Soil exposure:
Road construction increases soil exposure, which may subsequently increase the amount of material eroded from a particular mining area. The use of seeding on cut and fills helps to reduce surface runoff. After construction, however, the type of road (gravel, dirt, etc.) and topographic modifications determine the amount of exposure and subsequent contribution to erosion from the disturbed land.

Related Reference: 296

M352-97 Local sedimentation - Detention basins:
Suspended sediment and adsorbed materials are transported into detention basins in the water column, but become part of the substrate through sedimentation. Sedimentation can be rapid if runoff from disturbed land is large and the suspended load is high. Detention basins act as sediment traps, preventing excess soil, sediment, and toxic minerals from entering the receiving streams and rivers.

Related References: 21,96,127,256,441,759,767

M352-106 Sedimentation - Drainage pattern:
This represents the influence that local sedimentation has on the drainage pattern. Continued sedimentation modifies flow patterns by modifying local relief (i.e., filling in gullies).

Related References: 63,69,81,88,143,153,194,259,412,421,438,530, 567,577,679,680,749,767

M352-(386,428) Sedimentation - Soil composition, Surface cover:
The deposition of material by water or wind results in changes in surface material composition. These changes feed back into texture, structure, and other factors which influence the erodibility of the soil.

Related References: 8,24,27,73,114,206,211,269,318,323,340,348, 381,396,405,426,458,465,466,467,482,483,535, 565,577,582,600,603,607,658,670,679,688,712, 718,746,748

M380-120 Slope stability - Erosion:
Slope stability influences erosion potential, specifically erosion by mass wasting. Slope stability is influenced by a number of factors including topography, soil characteristics, gradient, fracture patterns in wall rock, etc.

Related References: 95,131,160,162,294,295,316,574,662

M(386,428)-267 Soil composition, Surface cover - Organic-inorganic chemical pool:
This represents the direct influence of soil chemistry (including contaminants) on the chemistry of the water. This describes the source for material other than sediment and adsorbed material which is found in the water column.

Related References: 8,18,40,145,206,236,269,392,433,436,447,466, 517,521 ,522,554,572,577,661,743,746,794,795

M(386,428)-(396,397) Soil composition, Surface cover - Soil structure and texture:

This represents the correlation of soil composition with soil characteristics, including texture, structure, cohesiveness, and water-holding capacity. The mineralogy of the soil, especially the clay mineral composition (and concentration), influences the ability of soil to adsorb and retain water, as well as cohesiveness and overall texture.

Related References: 38,41,124,219,3^0,426,432,517,626,673

M(386,428)-390 Soil composition, Surface cover - Soil fertility:

This is the general relationship between soil composition and fertility as influenced by the chemical composition, organic matter, mineralogy, and contaminants of the soil. Soil fertility is defined here as the overall composition of the soil and its effects upon plant growth, including such properties as toxicity (the available concentrations of elements such as Al, Mg, Mn, etc.), pH, and salinity. Soil fertility responds directly to the use of fertilizers and neutralizing agents; however, it is only through the modifications in composition that this response occurs.

Related References: 20,40,50,84,94,95,206,214,392,466,517,521, 522,535,572,577,625,626,637,673,794,795

M(386,428)-(435,7) Soil composition, Surface cover - Suspended sediment, Adsorbed material:

The direct influence of soil chemistry (including contaminants) on the chemistry of suspended sediment and adsorbed material is described here.

Related Reference: 269

M388-120 Soil detachment - Erosion

The dislodgement of soil and other surface particles in conjunction with overland flow determines the rate of erosion and the volume of material carried from the land surface.

Related References: 6,7,18,38,40,45,84,136,138,140,143,171,174, 181,187,188,190,192,202,207,213,220,237,238, 239,241,251,252,256,267,271,314,315,318,323, 342,380,382,392,394,412,415,426,429,431,446, 453,460,462,471,474,483,485,511 ,529,540,543, 544,546,547,548,552,561,577,582,601 ,605,608, 609,630,637,642,645,646,662,671,678,681,682, 706,707,726,729,744,745,746,747,748,749,750, 751,752,765

M388-507 Soil detachment - Wind erosion:
The dislodgement of soil and other surface particles by wind (as affected by wind speed and duration) determines the rate of erosion by wind and the volume of material carried out of the system.

Related References: 40,323,392,394,706

M389-270 Soil exposure - Overland flow:
The amount of cover on the soil surface influences the hydraulics of overland flow through its resistance to flowing water. Where vegetation cover is thick, water flowing over the surface is impeded by the presence of plants, but where no surface cover is present water can flow more freely.

Related Reference: 749

M389-388 Soil exposure - Soil detachment:
Soil exposure directly influences soil detachment, as influenced by timing and duration of exposure to water and wind, weather patterns, and efforts to reduce erosion. Soil exposure increases the impact of raindrops or wind on surface material.

Related References: 130,529,546,582,749

M389-392 Soil exposure - Soil moisture:
This describes the influence of soil exposure (and thus evaporation) on existing soil moisture.

Related References: 130,298

M389-(396,397) Soil exposure - Soil structure and texture:
Soil exposure influences on soil structure include dessication and loss of cohesiveness, supersaturation, and loss of topsoil to sand. Prolonged exposure can lead to an impervious hard surface or very erodible soil particles. These influences on structure lead indirectly to erosion potential through modifications of the water-holding capacity and the ability of the soil to allow infiltration and percolation.

Related References: 130,298

M390-310 Soil fertility - Reclamation:
Soil fertility, toxicity, pH, trace metal concentrations, etc., influence the effectiveness of reclamation (particularly revegetation) and the choice of plant types for revegetation. Some soils are unable to sustain life and require application of certain elements such as phosphorus, calcium, and magnesium. Low pH is detrimental to many plants, due both to the acidity directly and to the change in solubility of iron, aluminum, and manganese. The condition of the soil will determine species chosen for revegetation.

Related References: 20,30,39,50,94,134,176,2^1,266,331,367,368, 369,497,503,614,622,625,626,637,663,724,734, 773,792

M392-(199,282) Soil moisture - Infiltration, Percolation:
This describes the influence of existing soil moisture on the rate of infiltration and percolation. This is related to topography, soil texture and structure, and rainfall intensity and duration.

Related References: 124,463,766

M392-(396,397) Soil moisture - Soil structure and texture:
Existing soil moisture influences the texture and structure of the soil.

Related References: 38,124,517

M(396,397)-116 Soil structure and texture - Erodibility (soil):
The texture and structure of the soil influence the potential for erosion to occur based upon particle size distribution, soil strength, cohesiveness, and infiltration properties. Factors such as soil composition, soil exposure, existing soil moisture, etc., influence the erodibility of the soil through their direct influence on structure and texture.

Related References: 38,556

M(396,397)-(199,282) Soil structure and texture - Infiltration, Percolation:
The effects of soil texture and structure on infiltration and percolation, through ped aggregation pattern, hardpan presence, root channels, etc., are described here.

Related References: 6,124,176,219,331,471

M401-(386,428) Spoil banks - Soil composition, Surface cover:
The composition of the spoil bank directly influences the composition of the soil developed on the surface. This can be a direct influence through soil development on the bank itself, or through the contamination of soil and soil water from trace or heavy metals derived from the mine waste (this occurs through the transport of these materials as dissolved in water percolating-through or adsorbed by the soil).

Related References: 50,86,94,286,447,502,503,637,661

M426-122 Subsurface flow - Exported material:
This represents the transport of material out of the system through subsurface flow. Subsurface flow can include water which has filtered into the ground water table or is diverted through tiles or pipes.

Related References: 152,421,538,731

M(435,7)-122 Suspended sediment, Adsorbed material - Exported material: This represents the suspended sediment and adsorbed material being carried to other systems in the water column.

Related References: 393,596,693,759

M(435,7)-267 Suspended sediment, Adsorbed material - Organic-inorganic chemical pool:
This represents the exchange of substances between suspended sediment, adsorbed material, and the water column. This is affected by several variables such as composition of suspended sediment, water temperature, and dissolved oxygen.

Related References: 89,98,113,234,322,388,457,534,550,600,690

M(435,7)-270 Suspended sediment, Adsorbed material - Overland flow: This describes the presence and characteristics of suspended sediment in the overland flow.

Related References: 9,26,81,143,152,194,253,404,555

M(435,7)-352 Suspended sediment, Adsorbed material - Sedimentation (local):
This represents the deposition of suspended sediment and adsorbed materials in gullies, ditches, detention basins, or other localities within the mining system.

Related References: 3,4,7,8,21,24,25,27,42,44,45,48,49,54,60,61, 62,63,65,66,67,69,73,75,76,77,78,80,81,87, 88,89,90,92,93,96,98,106,108,109,111,114, 115,117,119,126,127,128,129,130,135,136,138, 141,143,147,149,153,166,167,168,169,170,172, 173,175,180,188,193,194,198,203,204,205,206, 211,218,220,224,239,242,248,250,251,256,259, 263,269,272,276,277,281,282,283,287,302,306, 309,310,313,314,315,317,318,319,320,321,323, 327,328,332,333,334,335,338,339,340,346,347, 348,349,350,351,352,354,365,366,375,377,381, 394,396,398,399,400,401,402,405,406,409,412, 417,421,426,437,438,439,441,446,448,449,450, 451,454,457,458,465,466,467,469,479,482,483, 488,489,490,492,493,494,495,496,497,498,499, 507,512,515,524,526,529,530,532,535,537,541, 542,544,546,547,552,557,562,563,564,565,568, 570,577,582,596,600,602,603,607,614,615,618, 623,638,639,640,641,643,644,645,646,647,651, 654,658,662,667,668,670,674,678,679,680,681, 682,685,686,688,691,692,693,699,700,702,703, 704,707,709,712,718,724,727,732,733,742,746, 747,748,749,759,760,762,763,767,771,775,781, 785,787,792

M(435,7)-488 Suspended sediment, Adsorbed material - Water quality:
The composition of sediment and adsorbed material within the water column directly influences the quality of water in the system. Total water quality is described by pH, trace metal concentration, toxicity, and sediment load.

Related References: 1,6,7,8,9,12,27,44,65,69,82,98,99,101,105, 109,123,129,135,139,140,144,159,174,175,179, 181,199,203,204,206,209,213,220,223,224,239, 242,251,260,271,272,278,291,297,302,311,312, 313,315,321,332,333,342,354,356,358,359,360, 361,371,372,373,376,383,397,398,401,407,409, 412,420,421,429,442,444,445,456,468,469,472, 474,482,483,484,493,494,499,508,524,542,549, 559,560,564,568,569,575,577,587,588,589,590, 595,597,600,604,607,610,628,630,636,641,642, 651,656,658,659,667,683,685,686,690,692,693, 703,709,713,715,716,718,720,721,722,723,724, 728,739,740,741,744,746,747,748,757,763,767, 776,778,780,792,793

M446-106 Topography - Drainage pattern:
Local topography influences the characteristics of drainage such as development of surface and subsurface drainage networks as controlled by small-scale variations in slope.

Related References: 132,586,648,679,768

M446-(199,282) Topography - Infiltration, Percolation:
This represents the influence of local slope, natural or modified, on infiltration and percolation. Interacting variables include soil characteristics, plant cover, subsurface drainage potential, and existing soil moisture.

Related References: 6,162,331,453,746

M446-245 Topography - Mine management:
Topography, regional and local, influences mine management decisions on resource removal, water diversion, reclamation procedures, roadway locations, erosion control, and future land use.

Related References: 296,331,663

M446-380 Topography - Slope stability:
This represents local topographic influences on slope stability, whether hillside, streambank, or roadcut. The activities of mining which modify the local topography frequently result in the oversteepening of slopes, or fracturing of bedrock. This in turn reduces slope stability.

Related References: 95,131,160,161,162,294,295,316,574,662

M479-122 Waste disposal - Exported material:
This represents the direct removal of material from the system by hauling it or by burying it at a depth deep enough to prevent contamination of potable water.

Related References: 14,36,70,83,101,121,229,231,233,280,311,373, 506,559,596,611,622,631,632,686,692,763,793

M479-310 Waste disposal - Reclamation:
Waste disposal choices and techniques influence the reclamation procedures required.

Related References: 14,50,53,70,121,229,231,503,506,622,793

M484-97 Water diversion - Detention basins:
This represents water diversion, to control erosion and sedimentation problems and to detain chemically polluted mine waters. This method of sediment trapping is often used for the future development of wetlands or lakes.

Related References: 209,767

M488-223 Water quality - Land use:
Water quality, and thus the effectiveness of pollution control and reclamation procedures, influence whether the mined area can be used for urban and industrial development, a fish and wildlife refuge, a recreation area, or a forest or agricultural area, or whether it will be an abandoned site.

Related References: 8,14,34,35,36,70,109,139,159,222,230,238, 240,242,245,271,272,297,318,321,324,345, 354,355,356,361,383,384,385,386,389,398, 401,442,457,481,482,483,484,577,586,587, 591,622,628,630,632,670,683,703,709,718, 719,724,741,764,772,773,776,794,795

M505-122 Windborne sediment - Exported material:
This represents transport of material out of the system by wind.

Related Reference: 107

M507-(505,7) Wind erosion - Windborne sediment, Adsorbed material:
This describes the suspension of particles by wind erosion. It includes the amount and characteristics of material transported by wind.

Related Reference: 107

Table II-5. Concluded

M508-388 Wind speed, duration, and direction - Soil detachment: This describes the influence of wind speed and duration on soil detachment. In conjunction with soil erodibility, wind speed and duration determine the amount of soil detachment and erosion by wind.

Related References: none

M508-507 Wind speed, duration, and direction - Wind erosion: This describes the influence of wind speed and duration on the transport of material through wind erosion. This acts in conjunction with soil detachment by wind.

Related References: none

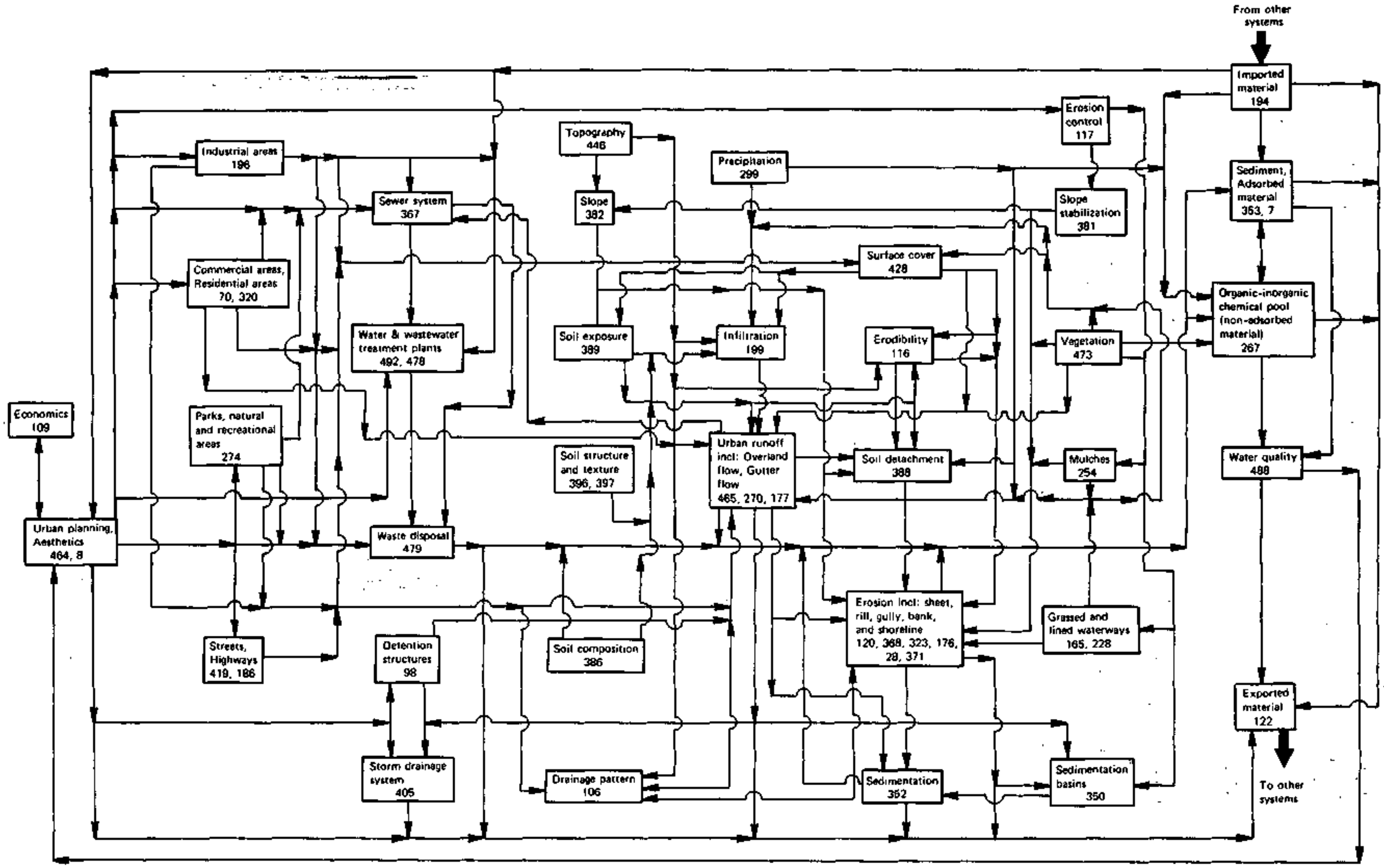


Figure II-11. Level II model for the Urban Subsystem

Urban Subsystem

Model Description and Model Interactions. Figure II-11 shows the Level II model for the Urban Subsystem.

The major components within an urban environment and the interactions between the various components are represented in the Urban Subsystem model. The model is an interactive model, in which the interactions or relationships between components are indicated by arrows, and should not be confused with a transport model, in which the actual movement of materials is diagrammed. The purpose of this brief description of the Urban Subsystem model is to provide a general overview of the model and to explain how it is constructed. Detailed descriptions of the interactions follow.

The components of the Urban Subsystem model are grouped into six major categories, from left to right. The first category consists of urban planning and economics, which influence the overall zoning and the adequacy and quality of the infrastructure such as the sewer and drainage systems, water and wastewater treatment plants, and waste disposal system. Urban planning also influences the management practices chosen for erosion and sedimentation control. Urban planning is strongly influenced by economics and vice versa. The availability of funds to build, maintain, and improve the infrastructure within an urban area is one of the most important interactions. Urban planning through zoning and through provision of adequate facilities for industrial and commercial development determines the economic well-being of an urban area.

Other factors which influence urban planning are water quality and imported materials. The availability of good quality water for domestic, municipal, and commercial use is an important consideration in urban planning. Imported materials to an urban area are of major concern when there is a river passing through a city or when a city is located on. the shoreline of a lake, sea, or ocean.

The second group of components of the Urban Subsystem model consists of the major subdivisions of an urban environment, such as industrial areas, commercial and residential areas, parks and recreational areas, and streets and highways. Their locations, size, and quality are generally influenced by urban planning. The third group essentially consists of the infrastructure for transport, storage, and treatment of water and wastewater. This group includes the sewer system, water and wastewater treatment plants, waste disposal system, storm drainage, and detention basins.

The central part of the model, which forms the fourth group, consists of the physical characteristics of an urban area such as landscape and soil, and the processes of soil erosion and sedimentation as influenced by precipitation, runoff, and surface cover. Erosion includes sheet, rill; gully, bank, and shoreline erosion. Erosion processes are influenced by a number of factors directly or indirectly. For example, precipitation affects erosion through the mechanism of soil detachment due to direct impact of raindrops and through the process of water running over exposed areas including gullies, channels, and ditches. Soil characteristics such as texture, structure, and composition, along with topography, slope, and surface cover, determine the erodibility of a soil particle, which in turn determines the amount of soil erosion. Sedimentation results from erosion.

The fifth group of parameters consists of the management practices used for controlling erosion and sedimentation. Erosion control techniques usually attempt to provide a protective surface cover from the forces of raindrops and flowing water. Such techniques include the use of vegetation, mulches, and grassed or lined waterways. Since areas with unstable slopes are major sources of erosion, slope stabilization can be a very effective erosion control technique. When there is excessive erosion in some areas, sedimentation becomes a major problem downstream. To reduce the negative impacts of sedimentation, sedimentation basins are sometimes used to reduce the amount of sediment moving downstream.

The sixth group, located on the extreme right side of the model, relates to the quantity and quality of materials moving into and out of an urban area. These include materials imported from or exported to other systems, total sediment load, adsorbed and non-adsorbed materials found in moving or pooled waters, and the quality of water as indicated by dissolved oxygen content, pH, temperature, trace metals, and other characteristics.

Table II-6 provides detailed descriptions of all the interactions for the Urban Subsystem model.

Table II-6. Descriptions of Interactions for the Urban Subsystem Model

Interaction code	Description
U(70,320)-106	Commercial areas, Residential areas - Drainage pattern: The addition of a commercial or residential area to an urban system modifies urban runoff conditions, which in. turn bring about changes in drainage pattern. Related References: none
U(70,320)-367	Commercial areas, Residential areas - Sewer system: The capacity and function of a sewer system are impacted by the quality and quantity of wastewater and sewage collected from commercial or residential areas. Related References: none
U(70,320)-428	Commercial areas, Residential areas - Surface cover: The development of commercial or residential areas changes surface cover conditions. These changes include the addition of buildings, streets, parking lots, etc. Related References: none
U(70,320)-(465,270,177)	Commercial areas, Residential areas - Urban runoff, Overland flow, Gutter flow: The addition of commercial or residential areas to an urban system modifies urban runoff conditions. These modifications include changes in surface cover, slope, etc., as well as the addition of sewer systems. Sewage, water, and wastewater coming from these areas affect the quality and quantity of urban runoff. Related References: none
U(70,320)-479	Commercial areas, Residential areas - Waste disposal: The quality and quantity of wastes produced in a commercial or residential area define the appropriate method of waste disposal. Related References: none
U98-405	Detention structures - Storm drainage system: Detention structures can be used to regulate the flow of storm water into a storm drainage system, thereby eliminating the need for large drainage systems. Related Reference: 789

U98-(465,270,177) Detention structures - Urban runoff, Overland flow, Gutter flow:
Detention structures modify the arrival time and peak flow of urban runoff from different branches of an urban drainage system.

Related Reference: 789

U106-(120,368,323,176,28,371) Drainage pattern - Sheet, rill, gully, bank, and shoreline erosion:
The drainage pattern directly affects the erosion process. For example, straightened channels will have different erosion rates than those of naturally meandering channels. (See also interactions 106-270, 270-106, 270-(120,368,323,176,28,371).)

Related References: 9,14,33,63,88,146,163,212,383,385,438,561, 767,768

. U106-(465,270,177) Drainage pattern - Urban runoff, Overland flow, Gutter flow:
Changes in drainage pattern will directly influence urban runoff. If new areas are added or old areas are removed from a drainage basin, the urban runoff is increased or decreased correspondingly.

Related References: 32,145,146,336,561,633,789

U109-(464,8) Economics - Urban planning, Aesthetics:
Economics must be taken into consideration when designing an urban system. Urban planning includes the development of flood, sedimentation, and erosion control practices, as well as the development of water, wastewater, and storm water purification systems. The design of each system depends on the comparison of the benefit/cost ratio for all options.•

Related References: 8,88,155,284,653,732

U116-020,368,323,176,28,371) Erodibility - Sheet, rill, gully, bank, and shoreline erosion:
The erodibility of a bed, bank, or shoreline directly influences the amount and type of material removed by erosion. This process is also affected by soil structure, soil texture, and flow geometry.

Related References: 2,17,38,40,51 ,56,106,107,131,165,174,180, 187,194,197,211,237,239,241,253,258,290,319, 390,406,427,430,453,460,462,472,479,556,582, 646,654,678,726,752,760,777,778

U116-388 Erodibility - Soil detachment:
Erodibility can be defined as the ease with which a soil particle can be removed. The potential for soil detachment increases with increasing erodibility. This relationship is affected by soil structure (see interaction 396-116).

Related References: 18,38,40,174,187,19^,237,239,2^1 ,453,462, 582,646,678,726,752

U117-(165,228) Erosion control - Grassed and lined waterways:
Grassed and lined waterways provide a protective surface cover and help reduce erosion. These types of waterways are used as an erosion control device for channels.

Related Reference: 561

U117-254 Erosion control - Mulches:
Mulches provide a protective surface cover which helps reduce erosion. Mulches can be made of various materials, including cinders, hay, concrete grids, or plastic.

Related References: 6,472

U117-350 Erosion control - Sedimentation basins:
The use of sedimentation basins is one method for reducing the impact of erosion. These basins collect and store sediment.

Related References: 259,546

U117-381 Erosion control - Slope stabilization:
Slope stabilization is one of the various methods of erosion control. Depending on the degree of erosion at a sloped area, slopes may be stabilized by compacting the soil, providing a protective surface cover, diverting water away from the area, or altering the slope.

Related References: 85,128,363,430

U117-473 Erosion control - Vegetation:
Vegetation provides a protective, yet pervious, surface cover which helps reduce erosion. The degree of erosion will determine which type of vegetative cover is needed: permanent or temporary, grass, trees, or bushes.

Related References: 6,7,11,14,29,31,39,50,85,86,109,130,141,207, 236,239,245,279,286,298,299,331,363,436,458, 503,554,561,628,637,664,737,778

U(120,368,323,176,28,371)-106 Sheet, rill, gully, bank, and shoreline erosion - Drainage pattern:
Soil erosion changes flow characteristics and local relief features, which in turn alter drainage patterns.

Related References: 9,14,63,88,146,163,212,383,385,43.8,538,561, 767,768

U(120,368,323,176,28,371)-122 Sheet, rill, gully, bank, and shoreline erosion - Exported material:
The quantity of sheet, rill, gully, bank, and shoreline erosion in a system determines the sediment load of exported material.

Related References: 2,3,4,5,6,7,8,9,10,17,18,21,22,25,30,31,34, 35,38,39,40,43,44,45,52,55,56,60,63,66,74, 80,81,82,88,92,93,95,97,103,106,107,109,110, 114,115,116,117,119,125,127,128,129,130,131 , 135,136,137,138,140,141,143,144,146,152,159, 162,163,174,175,177,179,180,181,187,188,189, 190,192,193,197,202,206,211,212,213,220,221, 223,224,229,236,237,238,239,241,242,243,244, 245,251,252,253,256,257,258,259,260,263,264, 267,270,271,272,274,278,279,281 ,282,283,287, 297,298,299,301,302,303,304,305,306,307,312, 313,314,315,316,317,318,319,320,321,323,329, 331,332,335,339,340,341,342,346,347,352,357, 359,360,362,367,368,377,381 ,382,383,385,390, 392,394,397,398,399,400,402,403,404,406,410, 411,412,413,415,416,418,420,421,426,429,437, 438,439,442,446,450,452,453,455,456,458,461, 462,472,473,474,475,479,480,482,483,485,488, 491,492,493,495,497,505,507,510,511,512,516, 517,520,523,525,529,530,532,537,538,539,540, 541,543,544,545,546,547,548,551,552,558,560, 561,562,564,568,569,570,574,577,579,582,583, 597,598,600,601,602,604,605,607,608,615,622, 627,628,630,631,638,641,642,644,645,646,649, 652,653,654,655,656,662,669,670,671,672,674, 678,681,682,686,688,692,693,696,699,700,703, 706,707,709,710,712,714,715,716,717,718,724, 726,727,728,729,732,734,736,741 ,742,744,745, 746,747,748,749,750,751,755,760,762,763,764, 765,767,768,771,772,773,777,778,792

U(120,368,323,176,28,371)-267 Sheet, rill, gully, bank, and shoreline erosion - Organic-inorganic chemical pool:
The extent of sheet, rill, gully, bank, and shoreline erosion determines the amount of non-adsorbed material in a system.

Related References: 4,8,18,30,35,39,44,80,81,88,89,129,135,140, 150,159,174,175,176,189,220,223,224,238, 245,260,269,286,314,315,316,318,331,342, 346,347,352,396,414,424,436,447,472,475, 483,520,544,577,597,600,601,629,630,641, 661,664,686,692,724,767,792

U(120,368,323,176,28,371)-350 Sheet, rill, gully, bank, and shoreline erosion - Sedimentation basins:
The extent of sheet, rill, gully, bank, and shoreline erosion directly influences the design of sedimentation basins. These basins are needed to reduce sediment loads in areas where erosion is extensive.

Related References: 45,175,259,546

U(120,368,323,176,28,371)-352 Sheet, rill, gully, bank, and shoreline erosion - Sedimentation:
The erosion process is controlled mainly by soil erodibility and detachment. Sedimentation rates depend not only on particle size, particle shape, and flow velocity, but also on the sediment content in overland flow. Sedimentation will be largely downstream from highly eroded places.

Related References: 3,4,7,8,21,25,44,45,60,63,66,80,81,88,89,92, 93,106,109,115,117,119,127,128,129,130,135, 136,138,141,143,149,175,180,193,205,211,220, 224,239,242,243,251,256,259,263,269,281,282, 283,287,302,306,313,314,315,317,318,319,320, 332,335,339,340,346,347,348,352,363,377,381, 394,396,398,399,400,402,406,412,421,426,437, 438,439,448,449,450,458,475,479,482,483,488, 492,493,495,497,507,512,529,530,532,537,541, 542,544,546,547,552,562,564,568,570,577,582, 600,602,607,615,638,641,644,645,646,654,662, 674,678,686,692,699,700,703,707,709,724,727, 732,746,747,748,749,760,762,763,764,767,771, 792

U(120,368,323,176,28,371)-(353,7) Sheet, rill, gully, bank, and shoreline erosion - Sediment, Adsorbed material:
The extent of sheet, rill, gully, bank, and shoreline erosion determines the amount of sediment and adsorbed material in a system.

Related References: 4,9,30,56,60,63,68,72,80,81,106,129,143,159, 175,177,181,190,205,212,216,242,245,253,254, 287,318,329,342,346,347,360,397,398,437,442, 448,488,491,507,542,543,562,570,597,600,607, 630,707,762,767

U(165,228)-(120,368,323,176,28,371) Grassed and lined waterways - Sheet, rill, gully, bank, and shoreline erosion:
Grassed and lined waterways reduce erosion by providing an erosion-resistant cover for the soil surface.

Related References: 299,383,561,717

U(165,228)-199 Grassed and lined waterways - Infiltration:
Grassed waterways increase infiltration, while lined waterways reduce infiltration.

Related References: none

U(165,228)-428 Grassed and lined waterways - Surface cover:
Grassed and lined waterways affect surface cover conditions. Grassed waterways provide a pervious surface, while lined waterways provide an impervious surface. Both provide protective covers for soil particles.

Related References: none

U(l65,228)-(465,270,177) Grassed and lined waterways - Urban runoff, Overland flow, Gutter flow:
Grassed waterways reduce urban runoff by increasing infiltration. Lined waterways, on the other hand, increase urban runoff by decreasing infiltration.

Related References: 32,561

U194-122 Imported material - Exported material:
The quality and concentration of imported material directly affect the characteristics of exported material.

Related References: none

U194-267 Imported material - Organic-inorganic chemical pool:
The quality and concentration of imported material directly affect the characteristics of non-adsorbed material.

Related References: 26,269,476,555,572,690

U194-353,7) Imported material - Sediment, Adsorbed material:
The quality and concentration of imported material directly affect the characteristics of sediment and adsorbed material.

Related References: 572,690

U194-(464,8) Imported material - Urban planning, Aesthetics:
The quality and quantity of imported material directly affect the degree of urban planning specifications. For example, it may be necessary to alter treatment procedures to accommodate a highly polluted incoming stream.

Related References: none

U194-(492,478) Imported material - Water and wastewater treatment plants:
The quality and quantity of imported material directly affect the characteristics of material entering a treatment plant. It may be necessary to adjust treatment procedures to account for changes in the water or wastewater due to these imported materials.

Related References: none

U196-106 Industrial areas - Drainage pattern:
The addition of an industrial complex to an urban area modifies urban runoff conditions, which in turn brings about changes in drainage pattern.

Related References: none

U196-367 Industrial areas - Sewer system:
Wastewater from industrial factories is sometimes collected by an urban sewer system. The quality of wastewater and sewage directly influences the quality of material flowing in a sewer system.

Related References: none

U196-428 Industrial areas - Surface cover:
The addition of buildings, parking lots, roads, storage lots, etc., to an industrial area changes the surface cover of a landscape. For example, a grassy area may be replaced by a cement parking lot.

U196-(465,270,177) Industrial areas - Urban runoff, Overland flow, Gutter flow: '
The addition of an industrial complex to an urban area modifies urban runoff conditions, including changes in surface cover, slope, and drainage pattern. Runoff and wastes coming from an industrial area affect the quality and quantity of urban runoff in an urban system.

Related References: none

U196-479 Industrial areas - Waste disposal:
The quality and quantity of wastes produced at an industrial area define the appropriate method of waste disposal.

Related References: none

U196-(492,478) Industrial areas - Water and wastewater treatment plants:
An industrial factory may treat its wastewater before discharging it into other systems. It may be necessary for a factory to alter the quality of water used in industrial operations.

Related References: none

U199-(465,270,177) Infiltration - Urban runoff, Overland flow, Gutter flow:
Infiltration and urban runoff are inversely related. High infiltration rates reduce the amount of water available for urban runoff, and vice versa.

Related References: 145,280,288

U254-(120,368,323,176,28,371) Mulches - Sheet, rill, gully, bank, and shoreline erosion:
Mulches can provide temporary or permanent surface protection against the direct impact of rainfall and against erosion by overland flow.

Related References: 6,79,190,472

U254-199 Mulches - Infiltration:
Mulches can either increase or decrease infiltration rates, depending on the type of mulch being used. A thin layer of hay will increase infiltration rates, while a thick layer of leaves will decrease these rates. Thick layers provide a protective, less permeable cover.

Related Reference: 6

U254-428 Mulches - Surface cover:
Mulches provide a protective surface cover which may be pervious or impervious, depending on the type of mulch used.

Related References: none

U254-(465,270,177) Mulches - Urban runoff, Overland flow, Gutter flow:
Mulches reduce urban runoff by increasing infiltration or by intercepting precipitation.

Related Reference: 472

U267-122 Organic-inorganic chemical pool - Exported material:
The quantity and quality of non-adsorbed material present in a system directly affect the quantity and quality of exported material.

Related References: 26,269,476,555

U267-(353,7) Organic-inorganic chemical pool - Sediment, Adsorbed material:
The relationship between non-adsorbed and adsorbed material is affected by the following parameters: sediment composition, water temperature, and dissolved oxygen concentration.

Related References: 4,27,30,59,80,81,129,159,175,194,245,318, 333,342,346,347,356,417,549,572,575,586,417, 549,572,575,586,597,600,630,634,657,667,690, 756,767,776,786,791

U267-488 Organic-inorganic chemical pool - Water quality:
The composition of non-adsorbed material directly influences water quality, which is defined by pH, nutrient content, trace metal concentration, toxicity, and sediment load.

Related References: 8,27,35,37,44,69,91,98,129,135,139,140,159, 174,175,178,203,209,220,223,224,230,232,234, 238,260,265,272,284,311,315,333,342,356,370, 371,372,373,388,409,414,420,445,472,478,483, 520,549,559,575,577,597,600,601,630,641,651, 659,667,685,686,690,692,713,715,720,721,722, 724,731,757,767,776,780,792

U274-106 Parks, natural and recreational areas - Drainage pattern:
The addition of a park or recreational area to an urban system alters drainage patterns. The changes in drainage pattern are brought about by changes in urban runoff, surface cover, infiltration, and the addition of flow structures.

Related Reference: 743

U274-367 Parks, natural and recreational areas - Sewer systems:
The quality and quantity of wastewater and sewage collected from parks or recreational areas directly affect the capacity and function of a sewer system.

Related References: none

U274-428 Parks, natural and recreational areas - Surface cover:
The development of parks and recreational areas may provide pervious surface cover conditions in urban areas. These pervious surfaces have higher infiltration rates, which lower the volume of urban runoff.

Related References: none

U274-(465,270,177) Parks, natural and recreational areas - Urban runoff, Overland flow, Gutter flow:
The addition of a park or recreational area to an urban system modifies the quality and quantity of urban runoff by changing surface cover, slope, drainage patterns, etc. Note also that these areas are sometimes used for temporary storage of flood waters.

Related References: none

U274-479 Parks, natural and recreational areas - Waste disposal:
The quality and quantity of wastes produced at parks and recreational areas define the appropriate method of waste disposal.

Related References: none

U299-199 Precipitation - Infiltration:
The intensity and duration of precipitation directly affect infiltration rates. In general, a high intensity rainfall with a long duration will produce a larger amount of water available for infiltration.

Related References: 280,288,331,453,463,471,766

U299-267 Precipitation - Organic-inorganic chemical pool:
The quality of precipitation directly influences the quality and quantity of non-adsorbed particles in a system. Precipitation transports chemicals and particulate matter from the atmosphere to the earth's surface. Chemicals are dissolved in the precipitation or are adsorbed onto particles carried by the precipitation.

Related References: 8,37,39,47,81,88,132,145,150,159,232,234, 245,286,331,389,396,433,459,483,520,559,572, 586,591,651,661,715,767

U299-388 Precipitation - Soil detachment:
The intensity of precipitation directly influences the displacement of soil particles. The greater the intensity, the stronger the impact on soil particles and the more easily soil particles are detached. Also, the longer the duration of precipitation, the more easily soil particles are detached.

Related References: 3,141,143,190,239,288,380,382,446,453,460, 462,471,474,483,485,561,582,645,646,748,749, 752,765

U299-(465,270,177) Precipitation - Urban runoff, Overland flow, Gutter flow:
The amount and intensity of precipitation determine the volume of urban runoff. Urban runoff which comes from storms is usually treated as a shock load to an urban drainage system.

Related References: 39,143,280,288,460,559,725,749,752,789

U350-352 Sedimentation basins - Sedimentation:
Sedimentation basins are used to reduce the amount of sediment transported through a system. These basins collect sediments by gravity settling. There are several types of basin designs available and each type is used to trap different kinds and sizes of sediment.

Related References: 45,54,175,259,546,679

U352-122 Sedimentation - Exported material:
Sedimentation reduces the amount of material exported from a system.

Related References: 596,693,759

U352-267 Sedimentation - Organic-inorganic chemical pool:
Sedimentation removes particulate matter from a system.

Related References: 4,8,27,44,69,77,80,81,88,89,98,129,135,166, 175,194,203,220,224,269,272,314,315,318,333, 346,347,352,396,409,417,457,465,466,475,483, 544,577,600,623,641,651,667,670,685,686,688, 691,692,724,767,792

U352-(353,7) Sedimentation - Sediment, Adsorbed material:
Sedimentation is the process by which sediment and adsorbed material are deposited in gullies, ditches, detention basins, reservoirs, or channels. Sedimentation reduces the amount of sediment and adsorbed material transported through a system.

Related References: 4,27,42,49,60,61,63,67,73,76,80,81,87,106, 108,114,129,143,147,169,170,172,173,175,194, 198,204,205,242,276,277,287,318,327,333,334, 338,346,347,350,365,366,398,401,417,437,448, 454,488,490,498,499,507,515,542,557,562,570, 596,600,607,614,640,647,667,668,693,707,733, 762,767,775,781,785,787

U(353,7)-122 Sediment, Adsorbed material - Exported material:
The amount of sediment and adsorbed material available from urban areas determines the amount of material exported to other systems.

Related References: 484,511,530

U(353t7)-267 Sediment, Adsorbed material - Organic-inorganic chemical pool:
The relationship between adsorbed and non-adsorbed material is affected by several parameters such as sediment composition, water temperature, and dissolved oxygen concentration.

Related References: 4,27,30,59,80,81,129,159,175,194,245,318, 333,342,346,347,356,417,549,572,575,586,417, 549,572,575,586,597,600,630,634,657,667,690, 756,767,776,786,791

U(353,7)-488 Sediment, Adsorbed material - Water quality:
The composition of sediment and adsorbed material within a water system directly influences the quality of water in the given system and in adjoining systems. Water quality is described by pH, trace metal concentration, toxicity, and sediment load.

Related References: 1,9,12,27,105,123,129,159,175,181,204,242, 278,291,333,342,356,358,360,397,398,401,442, 499,542,549,575,581,588,589,590,597,600,607, 630,636,667,690,693.723,767,776

U367-479 Sewer system - Waste disposal:
The quality and quantity of sewage in an urban system define the types and sizes of waste disposal sites needed.

Related References: none

U367-(492,478) Sewer system - Water and wastewater treatment plants:
The quality and quantity of material carried by a sewer system affect the design and performance of water and wastewater treatment plants.

Related References: none

U381-(120,368,323,176,28,371) Slope stabilization - Sheet, rill, gully, bank, and shoreline erosion:
Slope stabilization is one of the most effective ways of reducing erosion. Slope stabilization provides a stable grade and increases the sediment trapping capacity of a flat area.

Related References: 85,128,149,363,430

U382-106 Slope - Drainage pattern:
Changes in slope cause changes in the characteristics of overland flow, such as flow velocity and discharge. These in turn cause changes in drainage patterns.

Related References: 132,248,586,648,679,768

U382-116 Slope - Erodibility:
Soil erodibility is affected by slope. Assuming consistent soil texture, soil structure, etc., a steeper slope will increase erosion potential.

Related References: 38,165,211,430,153,462,479,528,589,777,778

U382-(120,368,323,176,28,371) Slope - Sheet, rill, gully, bank, and shoreline erosion:
Sheet, rill, gully, bank, and shoreline erosion from a land surface are strongly influenced by the slope of the surface. Generally there is more waterborne erosion from steep areas than from flat areas.

Related References: 6,18,38,45,79,85,103,120,128,129,131,141, 149,157,162,165,182,190,211,214,241,270,294, 296,316,331,341,363,380,381,430,453,462,479, 485,517,530,539,574,638,644,662,727,746,749, 755,768,772,777,778

U382-199 Slope - Infiltration:
Steep slopes reduce the rate of infiltration while increasing the volume and rate of overland flow.

Related References: 6,162,331,453,746

U382-388 Slope - Soil detachment:
Steeper slopes increase the potential for soil detachment. Higher flow velocities have more energy available for detaching and transporting soil particles.

Related References: 18,190,453,485,662,746,749

U382-(465,270,177) Slope - Urban runoff, Overland flow, Gutter flow:
Steep slopes increase the velocity of urban runoff, decrease the time of concentration, and increase the peak flow.

Related References: 149,530,749

U386-116 Soil composition - Erodibility:
The mineral and chemical composition of a soil affect the cohesive, structural, and textural features of a soil mass. These factors influence the erodibility of a soil.

Related Reference: 418

U386-199 Soil composition - Infiltration:
The mineral and chemical composition of a soil mass affect infiltration rates. Sandy soils have higher rates of infiltration than do clayey soils.

Related Reference: 219

U386-267 Soil composition - Organic-inorganic chemical pool:
The composition of a soil mass affects the quality of particulate and dissolved matter, which in turn affects the characteristics of non-adsorbed, organic, and inorganic chemicals.

Related References: 8,18,145,269,286,433,436,447,466,572,577,661

U386-(353.7) Soil composition - Sediment, Adsorbed material:
The composition of a soil mass affects the quality of eroded and dissolved matter, which in turn affects the characteristics of sediment and adsorbed material.

Related Reference: 572

U386-388 Soil composition - Soil detachment:
The mineral and chemical composition of a soil affect the cohesive, structural, and textural features of a soil mass. These factors influence the ease with which a soil particle is detached.

Related References: none

U388-(120,368,323,176,28,371) Soil detachment - Sheet, rill, gully, bank, and shoreline erosion:
The more easily a soil particle can be removed from a surface, the larger the rate of sheet, rill, gully, bank, and shoreline erosion.

Related References: 6,7,18,38,40,45,80,84,136,138,140,141,143, 171,174,181,187,188,190,192,202,207,213, 220,237,238,239,241,251,252,256,267,271, 314,315,318,323,342,380,382,392,394,412, 415,426,429,431,446,453,460,462,471 ,474, 483,485,511,529,540,543,544,546,547,548, 552,561,577,582,601,605,608,609,630,637, 642,645,646,662,671,678,681,682,706,707, 726,729,744,745,746,747,748,749,750,751, 752,765

U389-116 Soil exposure - Erodibility:
Erodibility increases with increasing soil exposure. For example, a bare surface will have a higher erosion potential than a covered surface.

Related Reference: 582

U389-199 Soil exposure - Infiltration:
The exposure of soil directly affects the amount of infiltration.

Related References: none

U389-388 Soil exposure - Soil detachment:

Soil exposure directly influences soil detachment, which is also affected by topography, weather patterns, and the duration and intensity of exposure to different mediums such as water and wind. An increase in soil exposure can result in a higher potential for soil detachment.

Related References: 130,529,546,582,749

U389-(465,270,177) Soil exposure - Urban runoff, Overland flow, Gutter flow:

Soil exposure directly affects the amount and quality of urban runoff. Under consistent environmental conditions, impervious soil surfaces, such as concrete, will have larger volumes of urban runoff and smaller sediment loads. Pervious surfaces have smaller volumes of urban runoff and larger sediment loads.

Related References: none

U(396,397)-116 Soil structure and texture - Erodibility:

The structure and texture of soil influence the potential for erosion to occur. Soil structure and texture are described by the following: particle size distribution, soil strength, cohesiveness, and infiltration properties. Factors such as soil composition, soil exposure, and existing soil moisture influence the erodibility of the soil through their direct influence on structure and texture.

Related References: 38,556

U(396,397)-199 Soil structure and texture - Infiltration:

Soil structure and texture are described by the following parameters: soil type, particle size, void ratio, particle arrangement, and moisture content. Each of these parameters can affect infiltration. Infiltration rates are higher for sandy soils than for clayey soils.

Related References: 6,124,176,219,331,471

U(396,397)-388 Soil structure and texture - Soil detachment:

Soil structure and texture directly influence soil detachment. Soil structure and texture are described by soil type, particle size and shape, void ratio, particle arrangement, and moisture content. Each of these parameters affects the cohesive property of a soil mass. Compacted soil particles are harder to detach than loose particles.

Related References: 6,38,394,426,471,706

U405-122 Storm drainage system - Exported material:

The quality and quantity of material transported through a storm drainage system directly affect the characteristics of exported material. Storm water usually contains higher concentrations of sediment and pollutants.

Related References: none

U(419,186)-106 Streets, Highways - Drainage pattern:
The construction of streets or highways which modify natural topography changes local drainage patterns.

Related References: none

U(4l9,l86)-428 Streets, Highways - Surface cover:
The construction of paved streets or highways changes the surface cover of an area from a pervious to an impervious layer. The construction of shoulders, banks, and drainage ditches also alters surface cover.

Related References: 145,363,679

U(419,186)-(465,270,177) Streets, Highways - Urban runoff, Overland flow, Gutter flow:
Streets and highways alter the drainage pattern of urban runoff. The type of surface used for roadways, shoulders, ramps, bridges, etc., alters the quantity and quality of urban runoff in a system.

Related References: 145,559

U428-116 Surface cover - Erodibility:
The addition of a surface cover reduces soil erodibility. (See interactions 116-388, 116-(120,368,323,176,28,371), 428-(120,368,323,176,28,371).)

Related References: 38,211,582

U428-(120,368,323,176,28,371) Surface cover - Sheet, rill, gully, bank, and shoreline erosion:
Surface cover decreases erosion by providing protection against the impact of rainfall, reducing soil exposure, and altering the relationship between runoff and infiltration. Erosion rates will be different for grassy, bare, or paved surfaces.

Related References: 8,38,79,211,244,341,363,381,404,458,503,582, 746

U428-199 Surface cover - Infiltration:
Surface cover changes infiltration rates. Pervious surfaces, such as mulches and vegetative covers, increase infiltration rates. Impervious surfaces, such as concrete, reduce infiltration rates.

Related References: 145,746

U428-389 Surface cover - Soil exposure:
Surface cover, which provides a protective cover, reduces soil exposure.

Related References: 8,503,582

U428-(465,270,177) Surface cover - Urban runoff, Overland flow, Gutter flow:
Pervious surfaces reduce urban runoff, while impervious surfaces increase urban runoff. Surface cover also affects the quality of urban runoff by adjusting the amount of sediment, particulate matter, and pollutants in the runoff.

Related Reference: 145

U446-106 Topography - Drainage pattern:
Channel density and land use are the major topographic factors affecting drainage pattern.

Related References: 132,586,648,679,768

U446-116 Topography - Erodibility:
Several topographic factors affect soil erodibility. These factors include relief, landscaping, land use, and slope.

Related References: none

U446-199 Topography - Infiltration:
Different aspects of topography affect infiltration. For example, flatter slopes induce higher infiltration rates. Other topographic factors affecting infiltration include relief, landscaping, and land use.

Related References: 6,331,746

U446-382 Topography - Slope;
Slope is one of the primary parameters used to describe topography.

Related References: 6,45,73,95,128,132,161,206,241,331,341,746

U446-(465,270,177) Topography - Urban runoff, Overland flow, Gutter flow:
Different aspects of topography affect urban runoff.. For example, steeper slopes induce larger volumes of urban runoff. Other topographic factors affecting urban runoff include relief, landscaping, and land use.

Related References: none

U(464,8)-(70,320) Urban planning, Aesthetics - Commercial areas, Residential areas:
Urban planning specifications include zoning laws, the layout of a transportation network, the design of sewer and storm water systems, and the design of water and wastewater treatment plants for commercial and residential areas. There specifications also call for erosion, flood, and sedimentation control practices.

Related Reference: 284

U(464,8)-98 Urban planning, Aesthetics - Detention structures:
Urban planning can be used to decide whether a detention structure is needed to reduce flood hazards, to determine the type of detention structure needed, and to design the selected system.

Related Reference: 790

U(464,8)-109 Urban planning, Aesthetics - Economics:
Urban planning specifications define the amount of money and resources needed to complete and maintain all phases of an urban project (see interaction 109-(464,8)).

Related References: 8,88,150,155,284,653,732,764

U(464,8)-117 Urban planning, Aesthetics - Erosion control:
Urban planning determines which erosion control practices need to be used in an urban system. Erosion control practices include the use of slope stabilization, vegetation, mulches, grassed and lined waterways, and sedimentation basins.

Related References: 8,43,44,88,150,764

U(464,8)-122 Urban planning, Aesthetics - Exported material:
Urban planning can be used to regulate the quality and quantity of material being exported to other systems.

Related References: none

U(464,8)-196 Urban planning, Aesthetics - Industrial areas:
Urban planning indicates possible locations for industrial plants and specifies regulations concerning such matters as industrial waste disposal, water use, pollution control, and erosion control.

Related References: 150,284

U(464,8)-274 Urban planning, Aesthetics - Parks, natural and recreational areas:
Urban planning specifications for parks and recreational areas require the use of conservation practices such as erosion, flood, and sedimentation control. For example, some parks can be used for temporary storage of flood waters.

Related References: none

U(464,8)-367 Urban planning, Aesthetics - Sewer system:
Urban planning specifications define the capacity and layout of sewer systems.

Related Reference: 790

U(464,8)-405 Urban planning, Aesthetics - Storm drainage system:
Urban planning specifications define the capacity and layout of storm drainage systems.

Related References: none

U(464,8)-(419,186) Urban planning, Aesthetics - Streets, Highways:
Urban planning specifications for streets and highways include a description of the transportation network, as well as a description of the types of road surfaces to be used. They also include designs of culverts, bridges, ditches, and shoulders needed in the network.

Related References: 142,150,152

U(464,8)-479 Urban planning, Aesthetics - Waste disposal:
Urban planning determines the location of public waste disposal systems, specifies the method of disposal and treatment or various types of wastes, and defines requirements for individual on-site treatment of commercial and industrial wastes.

Related References: none

U(464,8)-(492,478) Urban planning, Aesthetics - Water and wastewater treatment plants:
Urban planning specifications define the location, capacity, method of treatment, and acceptable concentrations of discharges from water and wastewater treatment plants.

Related References: 284,764

U(465,270,177)-98 Urban runoff, Overland flow, Gutter flow - Detention structures:
The quantity of urban runoff determines the type and location of detention structures.

Related Reference: 789

U(465,270,177)-106 Urban runoff, Overland flow, Gutter flow - Drainage pattern:
Urban runoff directly affects drainage patterns. During construction events, urbanization, or flood events, drainage patterns may be manually or naturally altered,to accommodate existing or excessive flows.

Related References: 88,145,146,789

U(465,270,177)-(120,368,323,176,28,371) Urban runoff, Overland flow, Gutter flow - Sheet, rill, gully, bank, and shoreline erosion:
Urban runoff is the main mechanism for removing and transporting soil particles from a land surface. Generally the amount of erosion is directly proportional to urban runoff.

Related References: 88,146,315,630,631,718,764

U(465,270,177)-122 Urban runoff, Overland flow, Gutter flow - Exported material:
The quality and quantity of material being exported out of a system is dependent upon the amount and velocity of urban runoff.

Related References: 88,146,149,315,559,630,683,718

U(465,270,177)-267 Urban runoff, Overland flow, Gutter flow-Organic-inorganic chemical pool:
Organic and inorganic chemicals are transported by urban runoff. These non-adsorbed materials can affect water quality and characteristics of the flow. The amount of material being transported and the distance it is transported depend on the volume and velocity of the urban runoff.

Related References: 88,145,315,559,630

U(465,270,177)-350 Urban runoff, Overland flow, Gutter flow - Sedimentation basins:
To determine the size and type of sedimentation basin needed for erosion and sedimentation control, it is necessary to know the quality and quantity of sediment carried by urban runoff.

Related Reference: 149

U(465,270,177)-352 Urban runoff, Overland flow, Gutter flow - Sedimentation:
High velocity or deeper flows are capable of transporting sediment over long distances. Larger particles will, be deposited more quickly than smaller particles; therefore, a gradation may exist. In low velocity or shallow flows, particles will settle out more quickly and at about the same place. The sediment will not be well sorted.

Related References: none

U(465,270,177)-(353,7) Urban runoff, Overland flow, Gutter flow - Sediment, Adsorbed material:
The amount of urban runoff will directly influence the amount of sediment and adsorbed material being transported from a system. The quantity of material being transported and the distance it is transported also depend on the velocity of the flow.

Related References: none

U(465,270,177)-367 Urban runoff, Overland flow, Gutter flow - Sewer system:
Urban runoff, which includes storm water and sewage, can be carried in different systems (i.e., sanitary sewer systems, storm water systems, or combined systems). The quality and quantity of urban runoff determine the capacity and performance of a sewer or combined system.

Related References: none

U(465,270,177)-388 Urban runoff, Overland flow, Gutter flow - Soil detachment:
A high flow velocity increases the possibility of soil detachment. Drag forces, which remove soil particles, are larger when the flow velocity is high.

Related References: 88,146,315,630,631,718,764

U(465,270,177)-405 Urban runoff, Overland flow, Gutter flow - Storm drainage system:
The quantity of urban runoff defines the capacity and layout of a storm drainage system.

Related Reference: 789

U473-(120,368,323,176,28,371) Vegetation - Sheet, rill, gully, bank, and shoreline erosion:
Vegetation is one of the most desirable erosion protection practices. Vegetative covers reduce the impact of rainfall on a soil surface, while vegetative roots provide reinforcement to the soil structure.

Related References: 6,7,14,29,31,39,41,45,50,52,85,86,94,109, 129,130,141,174,207,236,239,245,279,286,298, 299,304,331,341,359,363,368,403,427,436,447, 452,458,502,503,505,519,541,548,560,561,566, 582,622,628,629,630,637,663,664,669,693,710, 737,746,764,778,792

U473-199 Vegetation - Infiltration:
Vegetation retains overland flow and increases the rate of infiltration. This relationship is affected by the height of the vegetation, the root system, and the type of vegetation present.

Related References: 6,219,331,746

U473-267 Vegetation - Organic-inorganic chemical pool:
Vegetation reduces the amount of non-adsorbed material in a system by decreasing erosion rates and consuming some of the organic-inorganic chemicals..

Related References: 39,47,54,129,134,174,178,245,284,286,331, 369 ,389,436,447,586,590,623,629,630,651, 664,792

U473-428 Vegetation - Surface cover:
Vegetation provides a protective and pervious surface cover.

Related References: 341,363,458,503,554,582,746

Table II-6. Concluded

U473-(465,270,177) Vegetation - Urban runoff, Overland flow, Gutter flow: Vegetative cover is one of the most desirable methods for reducing urban runoff by increasing infiltration and intercepting precipitation.

Related References: 630,683,718,764

U479-122 Waste disposal - Exported material: Waste products can be directly diverted out of a system as exported material.

Related References: 14,36,70,83,101,121,229,231 ,233,280,311,373, 506,559,596,611,622,631,632,686,692,763,793

U479-267 Waste disposal - Organic-inorganic chemical pool: Waste disposal directly affects the quality and quantity of non-adsorbed material in a system. This relationship is also affected by the method of disposal and composition of the wastes.

Related References: 311,373,435,559,686,692

U479-(353,7) Waste disposal - Sediment, Adsorbed material: Waste disposal directly affects the quality and quantity of sediment and adsorbed material in a system. This interaction is also affected by the kind of wastes being disposed of and the method of disposal.

Related References: 101,311,373,506,559,596,686,692,763,793

U488-122 Water quality - Exported material: The quality of water in a given system directly affects the characteristics of material exported to different systems.

Related References: none

U488-(464,8) Water quality - Urban planning, Aesthetics: The quality of water entering or leaving a system directly affects urban planning decisions. Federal and local governments have defined acceptable water quality standards. It may be necessary to include plans for specific treatment procedures needed to meet these standards.

Related References: 8,44,69,284,653,764,790

U(492,478)-479 Water and wastewater treatment plants - Waste disposal: The quality and quantity of wastes in water or wastewater treatment plants define the necessary types and capacities of waste disposal sites.

Related References: none

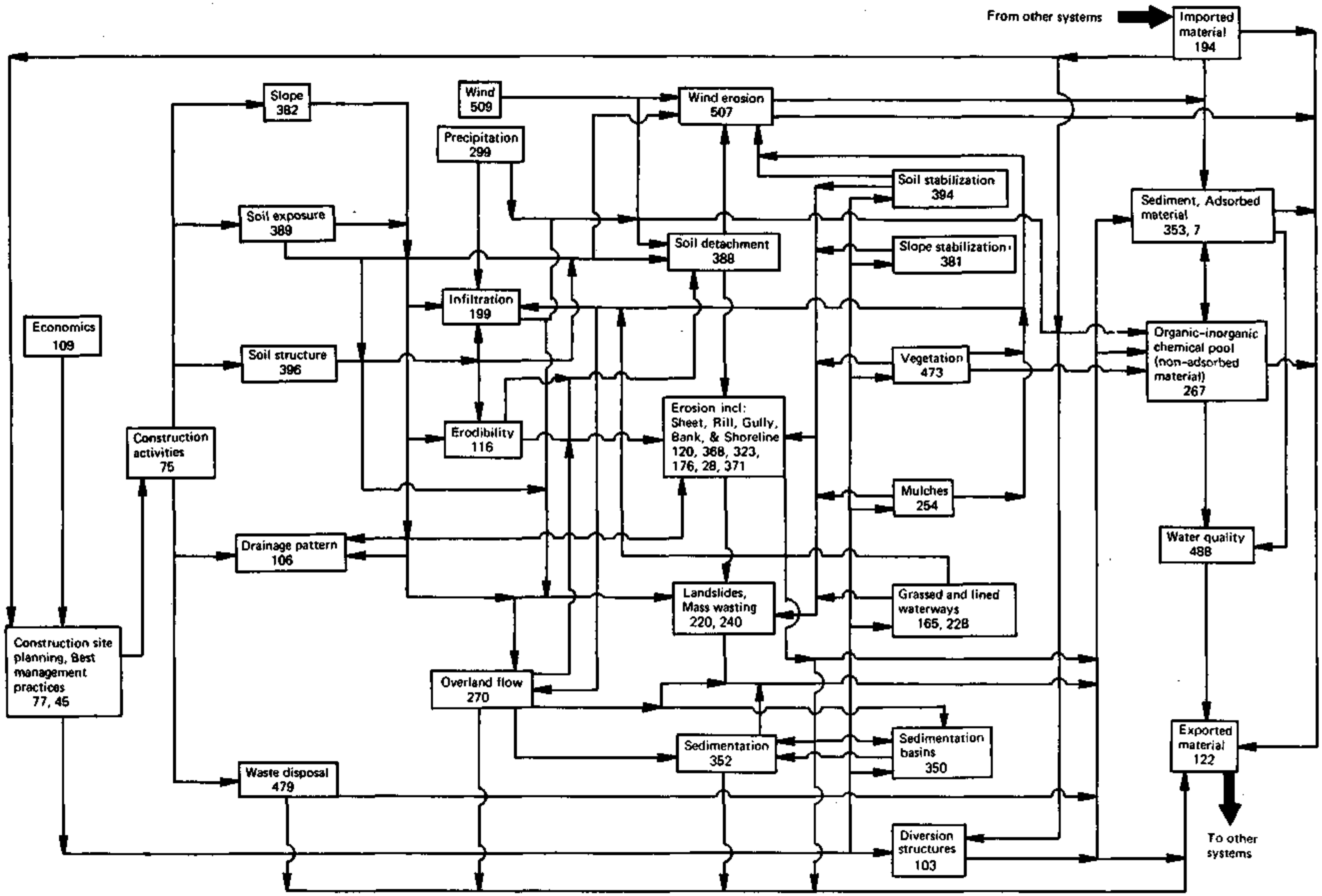


Figure II-12. Level II model for the Construction Subsystem

Construction Subsystem

Model Description and Model Interactions. Figure II-12 shows the Level II model for the Construction Subsystem.

The major components within a construction site and the interactions between the various components are represented in this model. The Construction Subsystem model is structured similarly to the Urban Subsystem model. The purpose of this brief description is to provide a general overview of the model and its structure. Detailed descriptions of the interactions follow this section.

The Construction Subsystem model was developed so it could be followed from left to right for most interactions. Its components are grouped into six major categories. The first group of parameters consists of economics and construction site planning and management. Construction site planning and management influence the types of practices chosen for erosion and sedimentation control at construction sites. They determine what construction activities need to be completed, and in what order the activities should be done. Construction site planning and management are strongly influenced by economics. The availability of funds generally determines the method of construction, the choice of construction equipment, and the choice of erosion and sedimentation control measures. Another factor which influences construction site planning and management is imported materials, which are of major concern where there is a river or stream that flows through a construction site or when a construction area is located on the shorelines of a lake, sea, or ocean.

Construction activities, including such practices as excavation, filling, piling, altering surface cover, compacting, and land grading, which alter the natural conditions at a construction site, form the second group of components for this subsystem model.

The third category consists of those components which result as a direct consequence of construction activities. Changes in slope, soil structure, soil exposure, and drainage pattern affect erosion directly or indirectly by changing soil erodibility and overland flow. Changes in these components also affect wind erosion, soil detachment, and landslides or mass wasting. Waste disposal encompasses all types of wastes imported to or created in a construction area.

The central part of the model, which forms the fourth group, represents the processes of wind erosion, landslides, and mass wasting. Erosion and sedimentation as influenced by precipitation, overland flow, wind, infiltration, and soil erodibility are also included within this group. Erosion includes sheet, rill, gully, bank, and shoreline erosion. The erosion processes are influenced by a number of factors directly or indirectly. For example, precipitation affects erosion through the mechanism of soil detachment due to direct impact of raindrops and through the process of water running over exposed areas including gullies, channels, and ditches. The erodibility of a soil particle determines the amount of soil erosion that can be expected. Sedimentation results from erosion.

The fifth group of parameters within the model is composed of the management practices used for controlling sheet, rill, gully, bank, and shoreline erosion; wind erosion; landslides and mass wasting; and sedimentation. Erosion control techniques usually attempt to provide a protective surface cover from the forces of raindrops and flowing water. Such techniques include the use of vegetation, mulches, and grassed or lined waterways. Soil stabilization reduces erosion by providing a cohesive and stable soil structure. Since areas with unstable slopes are major sources of erosion, slope stabilization can be a very effective erosion control technique. To reduce the negative impacts of sedimentation, sedimentation basins are sometimes used to reduce the amount of sediment moving through a system. Diversion structures can be used for erosion, flood, and sedimentation control by directing water away from a construction site.

The sixth group, located on the extreme right side of the model, consists of components describing the quantity and quality of materials moving into and out of a construction area. These include imported materials from other systems, materials exported to other systems, total sediment load, adsorbed and non-adsorbed materials found in moving or pooled waters, and the quality of water as indicated by dissolved oxygen, pH, temperature, trace metals, and others.

Table II-7 shows the detailed interactions for the Construction Subsystem.

Table II-7. Descriptions of Interactions for the Construction Subsystem Model

Interaction code	Description
C75-106	Construction activities - Drainage pattern: Construction activities may change the drainage pattern by changing the natural slope of the landscape, which impacts the soil erosion and sedimentation of the watershed. Related References: 88,561,679
C75-382	Construction activities - Slope: The natural slope of a landscape is temporarily or permanently altered by construction activities involving excavation, filling, and piling. Related References: 296,363,485,662,679,778
C75-389	Construction activities - Soil exposure: Construction activities generally change soil exposure by removing vegetation and topsoil at construction sites. Related References: 296,298
C75-396	Construction activities - Soil structure: Construction activities alter soil structure by compacting the soil and by removing overburden material and vegetative roots. Related Reference: 298
C75-479	Construction activities - Waste disposal: Construction activities introduce new sources of wastes at construction sites, including asphalt, cement, chemicals, and pesticides. Related References: 631,763
C(77,45)-75	Construction site planning, Best management practices - Construction activities: Construction site planning and management determine which construction activities need to be completed and in what order the activities should be done. Related References: 174,296

Table II-7. Continued

C(77,45)-103 Construction site planning, Best management practices - Diversion structures:
Construction site planning and management decisions determine the types and locations of diversion structures to be used for erosion, sedimentation, and flood control. These structures divert water away from the construction sites.

Related References: none

C(77,45)-(165,228) Construction site planning, Best management practices - Grassed and lined waterways:
Construction site planning and management determine whether a lined or grassed waterway should be used to control the volume and rate of overland flow. The type of lining affects the rate of erosion in a waterway.

Related References: none

C(77,45)-254 Construction site planning, Best management practices - Mulches:
Construction site planning and management decisions determine the type of mulch to be used. It may be necessary to use a temporary or permanent mulch to reduce erosion by stabilizing soil particles.

Related References: none

C(77,45)-350 Construction site planning, Best management practices - Sedimentation basins:
Construction site planning and management decisions determine the appropriate types and locations of sedimentation basins to be used for erosion and sedimentation control.

Related Reference: 546

C(77,45)-381 Construction site planning, Best management practices - Slope stabilization:
Construction site planning and management determine whether slope stabilization is necessary to reduce erosion, to prevent slope failures, or to control overland flow.

Related References: none

C(77,45)-394 Construction site planning, Best management practices - Soil stabilization:
Construction site planning and management determine whether soil stabilization is needed to reduce erosion and what stabilization method should be used.

Related Reference: 174

C(77,45)-473 Construction site planning, Best management practices - Vegetation:
Construction site planning and management decisions determine the type of vegetative cover to be used. This type of cover may be a permanent or temporary addition. Vegetation reduces erosion by stabilizing soil particles and reducing the impact of precipitation.

Related References: 109,174

C103-122 Diversion structures - Exported material:
Diversion structures at construction sites alter the amount of material exported from these sites. Diversion structures transport sediment and other material around the given system.

Related References: none

C103-267 Diversion structures - Organic-inorganic chemical pool:
Diversion structures transport non-adsorbed material away from construction sites, thereby reducing the amount of these materials present in a system.

Related References: none

C103-(353,7) Diversion structures - Sediment, Adsorbed material:
Diversion structures channel overland flow away from highly erodible areas and reduce peak flows. This reduces erosion rates and decreases the sediment load in a system.

Related References: none

C106-(120,368,323,176,28,371) Drainage pattern - Sheet, rill, gully, bank, and shoreline erosion:
The drainage pattern directly affects the erosion process. For example, straightened channels will have different erosion rates than those of naturally meandering channels. (See also interactions 106-270, 270-106, 270-(120,368,323,176,28,371).)

Related References: 9,14,63,88,146,163,212,383,385,438,561, 767,768

C106-270 Drainage pattern - Overland flow:
Drainage patterns directly affect overland flow. If new areas are added or old areas are removed from a drainage basin, the overland flow is increased or decreased correspondingly.

Related References: 9,32,561,633

Table II-7. Continued

C109-(77,45) Economics - Construction site planning, Best management practices:

Economics must be taken into consideration when selecting a construction site, designing the layout of a site, evaluating the need for erosion and sedimentation control practices, and determining what management practices are to be used. The particular management practice selected depends on a comparison of the benefit/cost ratio for the different options.

Related Reference: 284

C116-(120,368,323,176,28,371) Erodibility - Sheet, rill, gully, bank, and shoreline erosion:

The erodibility of a bed, bank, or shoreline directly influences the amount and type of material removed by erosion. This process is also affected by soil structure, soil texture, and flow geometry.

Related References: 2,17,38,40,51,56,106,107,131,165,174,180, 187,194,197,211,237,239,241,253,258,290,319, 390,406,427,430,453,460,462,472,479,556,582, 646,654,678,726,752,760,777,778

C116-388 Erodibility - Soil detachment:

Erodibility can be defined as the ease with which a soil particle can be removed. The potential for soil detachment increases with increasing erodibility. This relationship is affected by soil structure (see interaction 396-116).

Related References: 18,38,40,174,187,194,237,239,241,460,462, 582,646,678,726,752

C(120,368,323,176,28,371)-106 Sheet, rill, gully, bank, and shoreline erosion - Drainage pattern:

Continued erosion changes flow characteristics and local relief features, which in turn alter drainage patterns.

Related References: 9,14,63,88,146,163,212,383,438,538,561, 767,768

C(120,368,323,176,28,371)-122 Sheet, rill, gully, bank, and shoreline erosion - Exported material:

The quantity of sheet, rill, gully, bank, and shoreline erosion in a system determine the sediment load of exported material.

Related References: 2,3,4,5,6,7,8,9,10,17,18,21,22,25,30,31,34, 35,38,39,40,43,44,45,52,55,56,60,63,66,74, 80,81,82,88,92,93,95,97,103,106,107,109,110, 114,115,116,117,119,125,127,128,129,130,131, 135,136,137,138,140,141,143,144,146,152,159, 162,163,174,175,177,179,180,181,187,188,189, 190,192,193,197,202,206,211,212,213,220,221 , 223,224,229,236,237,238,239,241,242,243,244, 245,251,252,253,256,257,258,259,260,263,264,

267,270,271,272,274,278,279,281,282,283,287,
297,298,299,301,302,303,304,305,306,307,312,
313,314,315,316,317,318,319,320,321,323,329,
331,332,335,339,340,341,342,346,347,352,357,
359,360,362,367,368,377,381,382,383,385,390,
392,394,397,398,399,400,402,403,404,406,410,
411,412,413,415,416,418,420,421,426,429,437,
438,439,442,446,450,452,453,455,456,458,461,
462,472,473,474,475,479,480,482,483,485,488,
491,492,493,495,497,505,507,510,511,512,516,
517,520,523,525,529,530,532,537,538,539,540,
541,543,544,545,546,547,548,551,552,558,560,
561,562,564,568,569,570,574,577,579,582,583,
597,598,600,601,602,604,605,607,608,615,622,
627,628,630,631,638,641,642,644,645,646,649,
652,653,654,655,656,662,669,670,671,672,674,
678,681,682,686,688,692,693,696,699,700,703,
706,707,709,710,712,714,715,716,717,718,724,
726,727,728,729,732,734,736,741,742,744,745,
746,747,748,749,750,751,755,760,762,763,764,
765,767,768,771,772,773,777,778,792

C(120,368,323,176,28,371)-(220,240) Sheet, rill, gully, bank, and shoreline erosion - Landslides, Mass wasting:

Increasing erosion rates increase the possibility of occurrence of landslides or mass wasting. The erosion process decreases slope stability, which is the main factor affecting landslides or mass wasting.

Related References: 253,294,337,552,622

C(120,368,323,176,28,371)-267 Sheet, rill, gully, bank, and shoreline erosion - Organic-inorganic chemical pool:

The extent of sheet, rill, gully, bank, and shoreline erosion determines the amount of non-adsorbed materials in a system.

Related References: 4,8,18,30,35,39,44,80,81,88,89,129,135,140,
150,159,174,175,176,189,220,223,224,238,245,
260,269,286,314,315,316,318,331,342,346,347,
352,396,414,424,436,447,472,475,483,520,544,
577,597,600,601,629,630,641,661,664,686,692,
724,767,792

C(120,368,323,176,28,371)-350 Sheet, rill, gully, bank, and shoreline erosion - Sedimentation basins:

The extent of sheet, rill, gully, bank, and shoreline erosion directly influences the design of sedimentation basins. These basins are needed to reduce sediment loads in areas where erosion is extensive.

Related References: 45,175,259,546

C(120,368,323,176,28,371)-352 Sheet, rill, gully, bank, and shoreline erosion - Sedimentation:

The erosion process is controlled mainly by soil erodibility and detachment. Sedimentation rates depend not only on particle size, particle shape, and flow velocity, but also on the sediment content in overland and stream flow. Sedimentation will be large downstream from highly erodible places.

Related References: 3,4,7,8,21,25,44,45,60,63,66,80,81,88,89,92, 93,106,109,115,117,119,127,128,129,130,135, 136,138,141,143,149,175,180,193,205,211,220, 224,239,242,243,251,256,259,263,269,281 ,282, 283,287,302,306,313,314,315,317,318,319,320, 332,335,339,340,346,347,348,352,363,377,381, 394,396,398,399,400,402,406,412,421,426,437, 438,439,448,449,450,458,475,479,482,483,488, 492,493,495,497,507,512,529,530,532,537,541, 542,544,546,547,552,562,564,568,570,577,582, 600,602,607,615,638,641,644,645,646,654,662, 674,678,686,692,699,700,703,707,709,724,727, 732,746,747,748,749,760,762,763,764,767,771, 792

C(120,368,323,176,28,371)-(353,7) Sheet, rill, gully, bank, and shoreline erosion - Sediment, Adsorbed material:

The extent of sheet, rill, gully, bank, and shoreline erosion determines the amount of sediment and adsorbed material in a system.

Related References: 4,9,30,56,60,63,68,72,80,81,106,129,143,159, 175,177,181,190,205,212,216,242,245,253,254, 287,318,329,342,346,347,360,397,398,437,442, 448,488,491,507,542,543,562,570,597,600,607, 630,707,762,767

C(165,228)-(120,368,323,176,28,371) Grassed and.lined waterways - Sheet, rill, gully, bank, and shoreline erosion:

Grassed and lined waterways reduce erosion by providing an erosion-resistant cover for the soil surface.

Related References: 299,383,561,717

C(165,228)-199 Grassed and lined waterways - Infiltration:

Grassed waterways increase infiltration, while lined waterways reduce infiltration.

Related References: none

C(165,228)-(220,240) Grassed and lined waterways - Landslides, Mass wasting:
Grassed and lined waterways can decrease the occurrence of landslides or mass wasting by providing a protective cover for the land and stabilizing the channel.

Related References: none

C(l65,228)-270 Grassed and lined waterways - Overland flow:
Grassed waterways reduce overland flow by increasing infiltration. Lined waterways, on the other hand, increase overland flow by decreasing infiltration.

Related References: 32,561

C194-(77,45) Imported material - Construction site planning, Best management practices:
Imported materials are of major concern when there is a river passing through a construction site or when a construction area is located on the shoreline of a lake, sea, or ocean.

Related References: none

C194-103 Imported material - Diversion structures:
If a significant amount of material is imported from other areas, diversion structures may be needed to route the material around a construction site. This process may be necessary to reduce the sediment load and chemical concentration in a given system.

Related References: none

C194-122 Imported material - Exported material:
The quality, concentration, and volume of imported material directly affect the characteristics of exported material.

Related References: none

C194-267 Imported material - Organic-inorganic chemical pool:
The quality and concentration of imported material directly affect the characteristics of non-adsorbed material.

Related References: 26,269,476,555,572,690

C194-(353»7) Imported material - Sediment, Adsorbed material:
The quality and concentration of imported material directly affect the characteristics of sediment and adsorbed material.

Related References: 572,690

Table II-7. Continued

C199-(220,240) Infiltration - Landslides, Mass wasting:
Infiltration affects the occurrence of landslides and mass wasting by altering the moisture content of the soil mass. Moisture content affects the cohesive strength, weight, and particle arrangement of the soil, which in turn affect the erodibility and stability of the soil mass.

Related References: none

C199-270 Infiltration - Overland flow:
Infiltration and overland flow are inversely related. High infiltration rates reduce the amount of water available for overland flow, and vice versa.

Related References: 280,288

C(220,240)-267 Landslides, Mass wasting - Organic-inorganic chemical pool:
Landslides and mass wasting can be the sources for non-adsorbed and adsorbed material.

Related References: none

C(220,240)-(353,7) Landslides, Mass wasting - Sediment, Adsorbed material:
Landslides and mass wasting can be a major source of sediment and adsorbed material.

Related Reference: 253

C254-(120,368,323,176,28,371) Mulches - Sheet, rill, gully, bank, and shoreline erosion:
Mulches can provide temporary or permanent surface protection against the direct impact of rainfall and against erosion by overland flow.

Related References: 6,79,190,472

C254-199 Mulches - Infiltration:
Mulches can either increase or decrease infiltration rates, depending on the type of mulch being used. A thin layer of hay will increase infiltration rates, while a thick layer of leaves will decrease the rates. Thick layers provide a protective, less permeable cover.

Related Reference: 6

C254-(220,240) Mulches - Landslides, Mass wasting:
Mulches prevent gully formation, reduce flow velocities, provide a protective surface cover, and stabilize slopes. All of these factors help reduce the occurrence of landslides and mass wasting.

Related References: none

C254-270 Mulches - Overland flow:
Mulches reduce overland flow by increasing infiltration or by intercepting precipitation.

Related Reference: 472

C254-507 Mulches - Wind erosion:
Mulches provide a protective surface cover which reduces the possibility of soil detachment. This provides protection against wind erosion.

Related References: none

C267-122 Organic-inorganic chemical pool - Exported material:
The quantity and quality of non-adsorbed material present in a system directly affect the quantity and quality of exported material.

Related References: 26,269,476,555

C267-(353,7) Organic-inorganic chemical pool - Sediment, Adsorbed material:
The relationship between non-adsorbed and adsorbed material is affected by sediment composition, water temperature, and dissolved oxygen concentration.

Related References: 4,27,30,59,80,81,129,159,175,194,245,318, 333,342,346,347,356,417,549,572,575,586,417, 549,572,575,586,597,600,630,634,657,667,690, 756,767,776,786,791

C267-488 Organic-inorganic chemical pool - Water quality:
The composition of non-adsorbed material directly influences water quality, which is defined by pH, nutrient content, trace metal concentration, toxicity, and sediment load.

Related References: 8,27,35,37,44,69,91,98,129,135,139,140,159, 174,175,178,203,209,220,223,224,230,232,234, 238,260,265,272,284,311,315,333,342,356,370, 371,372,373,388,409,414,420,445,472,478,483, 520,549,559,575,577,597,600,601,630,641,651, 659,667,685,686,690,692,713,715,720,721,722, 724,731,757,767,776,780,792

C270-106 Overland flow - Drainage pattern:
Overland flow directly affects drainage patterns. During construction events, urbanization, or flood events, drainage patterns may be manually or naturally altered to accommodate the flow.

Related References: 9,32,561,633

C270-(120,368,323,176,28,371) Overland flow - Sheet, rill, gully, bank, and shoreline erosion:

Overland flow is the main mechanism for removing and transporting soil particles from a land surface. Generally the amount of erosion is directly proportional to overland flow. The impact of overland flow on shore erosion is not always significant.

Related References: 2,9,39,81,113,152,174,192,194,253,259,288, 404,412,421,460,472,530,543,561,564,577,671, 749,752,772

C270-122 Overland flow - Exported material:

The quality and quantity of material being exported out of a system may be a function of the quantity and velocity of overland flow.

Related References: 26,152,555

C270-267 Overland flow - Organic-inorganic chemical, pool:

Organic and inorganic chemicals are transported by overland flow. These non-adsorbed materials can affect water quality. The amount of material being transported and the distance it is transported depend on the volume and velocity of the flow.

Related References: 26,39,69,81,174,194,472,555,577

C270-350 Overland flow - Sedimentation basins:

In order to determine the size and type of sedimentation basin needed for erosion and sedimentation control, it is necessary to know the quality and quantity of sediment carried by overland flow.

Related Reference: 259

C270-352 Overland flow - Sedimentation:

High velocity or deeper overland flows are capable of transporting sediment over long distances. Larger particles will be deposited more quickly than smaller particles; therefore, a gradation may exist. In low velocity or shallow flows, particles will settle out more quickly and at about the same place, and the sediment will not be well sorted.

Related References: 69,81,143,153,194,259,412,421,530,564, 577,749

C270-(353,7) Overland flow - Sediment, Adsorbed material:

The amount of overland flow will directly influence the amount of sediment and adsorbed material being transported through a system. The quantity of material being transported and the distance it is transported also depend on the velocity of the flow.

Related References: 9,81,143,194,253,543

C270-388 Overland flow - Soil detachment:
High velocity in overland flow increases the possibility of soil detachment. Drag forces, which remove soil particles, are larger when the flow velocity is high.

Related References: 174,194,288,460,561,577,671,7^9,752

C299-199 Precipitation - Infiltration:
The intensity and duration of precipitation directly affect infiltration rates. In general, a high intensity rainfall with a long duration will produce a larger amount of water available for infiltration.

Related References: 280,288,331,453,471 ,766

C299-267 Precipitation - Organic-inorganic chemical pool:
The quality of precipitation directly influences the quality and quantity of non-adsorbed particles in a system. Precipitation transports chemicals and particulate matter from the atmosphere to the earth's surface. Chemicals are dissolved in the precipitation or are adsorbed onto particles carried by the precipitation.

Related References: 8,39,81,150,331,396,459,483,559,572,591

C299-270 Precipitation - Overland flow:
The amount and intensity of precipitation directly affect the amount of overland flow. In general, a high intensity rainfall with a long duration will produce a larger amount of water available for overland flow.

Related References: 39,81,143,280,288,460,749,752

C299-388 Precipitation - Soil detachment:
The intensity of precipitation directly influences the displacement of soil particles. The higher the intensity, the stronger the impact on soil particles, and the more easily soil particles are detached. Also, the longer the duration of precipitation, the more easily soil particles are detached.

Related References: 38,141,143,190,239,288,380,382,446,453,460, 462,471,474,483,485,561,582,645,646,748,749, 752,765

C350-352 Sedimentation basins - Sedimentation:
Sedimentation basins are used to reduce the amount of sediment transported through a system. These basins collect sediments by gravity settling. There are several types of basin designs available and each type is used to trap different kinds and sizes of sediment.

Related References: 45,54,175,259,546,679

C352-122 Sedimentation - Exported material:
Sedimentation reduces the amount of material exported by a system.

Related References: 596,693,759

C352-267 Sedimentation - Organic-inorganic chemical pool:
Sedimentation removes particulate matter from a system.

Related References: 4,8,27,44,69,77,80,81,88,89,98,129,135,166, 175,194,203,220,224,269,272,314,315,318,333, 346,347,352,396,409,417,457,465,466,475,483, 544,577,600,623,641,651,667,670,685,686,688, 691,692,724,767,792

C352-(353,7) Sedimentation - Sediment, Adsorbed material:
Sedimentation is the process by which sediment and adsorbed material is deposited in gullies, ditches, detention basins, reservoirs, or channels. Sedimentation reduces the amount of sediment and adsorbed material transported through a system.

Related References: 4,27,42,49,60,61,63,67,73,76,80,81,87,106, 108,114,129,143,147,169,170,172,173,175,194, 198,204,205,242,276,277,287,318,327,333,334, 338,346,347,350,365,366,398,401,417,437,448, 454,488,490,498,499,507,515,542,557,562,570, 596,600,607,614,640,647,667,668,693,707,733, 762,767,775,781,785,787

C(353,7)-122 Sediment, Adsorbed material - Exported material:
The amount of sediment and adsorbed material available from construction sites affects the amount of exported material.

Related Reference: 596

C(353,7)-267 Sediment, Adsorbed material - Organic-inorganic chemical pool:
The relationship between adsorbed and non-adsorbed material is affected by several parameters such as sediment composition, . water temperature, and dissolved oxygen concentration.

Related References: 4,27,30,59,80,81,129,159,175,194,245,318, 333,342,346,347,356,417,549,572,575,586,417, 549,572,575,586,597,600,630,634,657,667,690, 756,767,776,786,791

C(353,7)-488 Sediment, Adsorbed material - Water quality:
The composition of sediment and adsorbed material within a water system directly influences the quality of water in the given system and in adjoining systems. Water quality is described by pH, trace metal concentration, toxicity, and sediment load.

Related References: 1 ,9,12,27,105,123,129,159,175,181 ,204,242, 278,291,333,342,356,358,360,397,398,401,442, 499,542,549,575,581,588,589,590,597,600,607, 630,636,667,690,693,723,767,776

C381-(120,368,323,176,28,371) Slope stabilization - Sheet, rill, gully bank, and shoreline erosion:
Slope stabilization is one of the most effective ways of reducing erosion. Slope stabilization provides a stable grade and decreases the impact of precipitation, overland flow, and flow velocity.

Related References: 85,128,149,363,430

C381-(220,240) Slope stabilization - Landslides, Mass wasting:
Slope stabilization reduces the occurrence of landslides and mass wasting. Slope stabilization attempts to adjust the soil failure angle, to reduce overland flow velocities, to account for stresses caused by groundwater flow, to determine the correct angle of repose, and to reduce the gravitational tendency of slope failure.

Related References: none

C382-106 Slope - Drainage pattern:
Changes in slope cause changes in the characteristics of overland flow, such as flow velocity and discharge. These in turn cause changes in drainage patterns.

Related References: 132,586,648,679,768

C382-116 Slope - Erodibility:
Soil erodibility is affected by slope. Assuming consistent soil texture, soil structure, etc., a steeper slope will increase erosion potential.

Related References: 38,165,211,430,453,462,479,528,589,777,778

C382-(120,368,323,176,28,371) Slope - Sheet, rill, gully, bank, and shoreline erosion:

Sheet, rill, gully, bank, and shoreline erosion from a land surface are strongly influenced by the slope of the surface. Generally there is more waterborne erosion from steep areas than from flat areas.

Related References: 6,18,38,45,79,85,103,120,128,129,131,141, 149,157,162,165,182,190,211,214,241,270,294, 296,316,331,341,363,380,381,430,453,462,479, 485,517,530,539,574,638,644,662,727,746,749, 755,768,772,777,778

C382-199 Slope - Infiltration:

Steep slopes reduce the rate of infiltration while increasing the volume and rate of overland flow.

Related References: 6,162,331,453,746

C382-(220,240) Slope - Landslides, Mass wasting:

The slope of a landscape will have a strong influence on the occurrence of landslides or mass wasting, which tend to occur more often on steep slopes than on flat slopes. Flatter slopes decrease flow velocities and reduce gravitational tendencies for slope failure.

Related References: 95,160,294,295

C382-270 Slope - Overland flow:

Steep slopes increase the velocity of overland flow, decrease the time of concentration, and increase the peak flow.

Related References: 530,749,772

C382-388 Slope - Soil detachment:

Steeper slopes increase the potential for soil detachment. Higher flow velocities have more energy available for detaching and transporting soil particles. Note also that the gravitational resistance of a particle is decreased on steeper slopes.

Related References: 18,190,453,485,662,746,749

C388-(120,368,323,176,28,371) Soil detachment - Sheet, rill, gully, bank and shoreline erosion:
Soil detachment is a direct function of sheet, rill, gully, bank, and shoreline erosion.

Related References: 6,7,18,38,40,45,80,84,136,138,140,141,143, 171,174,181,187,188,190,192,202,207,213,220, 237,238,239,241,251,252,256,267,271,314,315, 318,323,342,380,382,392,394,412,415,426,429, 431,446,453,460,462,471,474,483,485,511,529, 540,543,544,546,547,548,552,561,577,582,601, 605,608,609,630,637,642,645,646,662,671,678, 681,682,706,707,726,729,744,745,746,747,748, 749,750,751,752,765

C388-507 Soil detachment - Wind erosion:
The direction and speed of wind can alter the rate of soil detachment. This erosion process is also affected by such factors as topography, soil structure, and erodibility of soil particles.

Related References: 40,323,392,394,706

C389-116 Soil exposure - Erodibility:
Increasing soil exposure increases the erodibility of the soil. For example, a bare erodible surface will have a higher erosion potential than a covered surface.

Related Reference: 582

C389-199 Soil exposure - Infiltration:
The exposure of soil directly affects the amount of infiltration.

Related References: none

C389-(220,240) Soil exposure - Landslides, Mass wasting:
Soil exposure has a strong influence on the occurrence of landslides and mass wasting. Soil exposure affects the erodibility and stability of a soil mass (see interactions 389-116, 389-388).

Related References: none

C389-270 Soil exposure - Overland flow:
Soil exposure directly affects the amount and quality of overland flow. Under consistent environmental conditions, impervious soil surfaces, such as concrete, will have larger volumes of overland flow and smaller sediment loads. Pervious surfaces have smaller volumes of overland flow and larger sediment loads.

Related Reference: 749

C389-388 Soil exposure - Soil detachment:
Soil exposure directly influences soil detachment. Soil detachment is affected by topography, weather patterns, and the duration and intensity of exposure to different mediums such as water and wind.. An increase in soil exposure can result in a higher potential for soil detachment.

Related References: 130,529,546,582,749

C389-507 Soil exposure - Wind erosion:
Wind erosion takes place only when soil particles are exposed to wind energy. If there is enough cover to protect soil particles from the wind, there will be no wind erosion.

Related Reference: 8

C394-(120,368,323,176,28,371) Soil stabilization - Sheet, rill, gully, bank, and shoreline erosion:
Soil stabilization reduces erosion potential by creating a comprehensive and stable soil structure. Stabilized particles are not easily detached by erosion processes.

Related References: 6,94,150,174,436,746

C394-(220,240) Soil stabilization - Landslides, Mass wasting:
Soil stabilization reduces the occurrence of landslides and mass wasting. These erosion processes can be controlled by such soil stabilization techniques as chemicals, compaction, surface cover, and slope stabilization.

Related References: none

C394-507 Soil stabilization - Wind erosion:
Soil stabilization provides protection against wind erosion by creating a cohesive and stable soil structure. Soil particles that have been stabilized are not easily detached by the wind. Soil stabilization can involve use of chemicals, compaction, surface cover, or slope stabilization.

Related References: none

C396-116 Soil structure - Erodibility:

The structure of a soil influences the potential for erosion to occur. Soil structure is described by particle size distribution, soil strength, cohesiveness, and infiltration properties. Factors such as soil composition, soil exposure, and existing soil moisture influence the erodibility of the soil through their direct influence on structure.

Related References: none

C396-199 Soil structure - Infiltration:

Soil structure is described by soil type, particle size, void ratio, particle arrangement, and moisture content. Each of these parameters can affect infiltration. Infiltration rates are higher for sandy soils than for clayey soils.

Related References: 219,331,471

C396-(220,240) Soil structure - Landslides, Mass wasting:

The structure of soil has a strong influence on the occurrence of landslides or mass wasting. Soil structure affects the erodibility and stability of a soil mass (see interaction 396-116).

Related References: none

C396-388 Soil structure - Soil detachment:

Soil structure, which is described by soil type, particle size and shape, void ratio, particle arrangement, and moisture content, directly influences soil detachment. Each of these parameters affects the cohesive property of a soil mass. Compacted soil particles are harder to detach than loose particles.

Related References: 394,471

C396-507 Soil structure - Wind erosion:

The structure of a soil mass is defined by the following parameters: particle size, shape, and arrangement; mineral content; moisture content; and void ratio. These parameters affect the erodibility of a soil, which in turn affects the potential for wind erosion to occur.

Related Reference: 394

C473-(120,368,323,176,28,371) Vegetation - Sheet, rill, gully, bank, and shoreline erosion:

Vegetation is one of the most desirable erosion protection practices. Vegetative covers reduce the impact of rainfall on a soil surface, while vegetative roots provide reinforcement to the soil structure.

Related References: 6,7,14,29,31 ,39,41,45,50,52,85,86,94,109, 129,130,141,174,207,236,239,245,279,286,298, 299,304,331,341,359,363,368,403,427,436,447, 452,458,502,503,505,519,541,548,560,561 ,566, 582,622,628,629,630,637,663,664,669,693,710, 737,746,764,778,792

C473-199 Vegetation - Infiltration:

Vegetation retains overland flow and increases the rate of infiltration. This relationship is affected by the height of the vegetation, the root system, and the type of vegetation present.

Related References: 6,124,176,219,331,746

C473-(220,240) Vegetation - Landslides, Mass wasting:

Vegetation provides reinforcement to a soil mass through its root system, prevents gully formation, reduces flow velocities, and . provides a protective surface cover. All of these factors tend to reduce the occurrence of landslides and mass wasting.

Related Reference: 622

C473-267 Vegetation - Organic-inorganic chemical pool:

Vegetation reduces the amount of non-adsorbed material in a system by decreasing erosion rates and consuming some of the organic-inorganic chemicals.

Related References: 39,47,54,129,134,174,178,245,284,286,331, 369,389,428,436,447,586,590,623,629,630,651, 664,792

C473-270 Vegetation - Overland flow:

Vegetation reduces overland flow by increasing infiltration and intercepting precipitation.

Related References: 39,174,561

C473-507 Vegetation - Wind erosion:

Vegetative leaves and stems provide a protective cover, while the root system stabilizes soil particles against wind erosion.

Related Reference: 427

C479-122 Waste disposal - Exported material:
Waste products can be directly diverted out of a system as exported material.

Related References: 14,36,70,83,101 ,121,229,231 ,233,280,311,373, 506,559,596,611,622,631,632,686,692,763,793

CJ79-267 Waste disposal - Organic-inorganic chemical pool:
Waste disposal directly affects the quality and quantity of non-adsorbed material in a system. This relationship is also affected by the method of disposal and composition of the wastes.

Related References: 311,373,435,559,686,692

C479-(353,7) Waste disposal - Sediment, Adsorbed material:
Waste disposal directly affects the quality and quantity of sediment and adsorbed material in a system. This interaction is also affected by the kind of wastes being disposed of and the method of disposal.

Related Reference: 596

C188-122 Water quality - Exported material:
The quality of water in a given system directly affects the characteristics of material exported to different systems.

Related References: none

C507-122 Wind erosion - Exported material:
The extent of wind erosion within a system will influence the amount of material available for export to other systems.

Related References: none

C507-(353,7) Wind erosion - Sediment, Adsorbed material:
Wind erodes and transports soil particles from exposed areas to water bodies. This increases the amount of sediment and adsorbed material in the water.

' Related References: 242,562

C509-388 Wind - Soil detachment:
Wind affects the process of soil detachment. The mechanisms of wind erosion and soil detachment are discussed with regard to interactions 388-507 and 509-507.

Related Reference: 394

Table II-7. Concluded

C509-507 Wind - Wind erosion:
The intensity, duration, and fetch of wind acting on a ground surface determine the degree of wind erosion.

Related References: 3,8,40,103,107,242,317,377,394,427,497,562,705,732

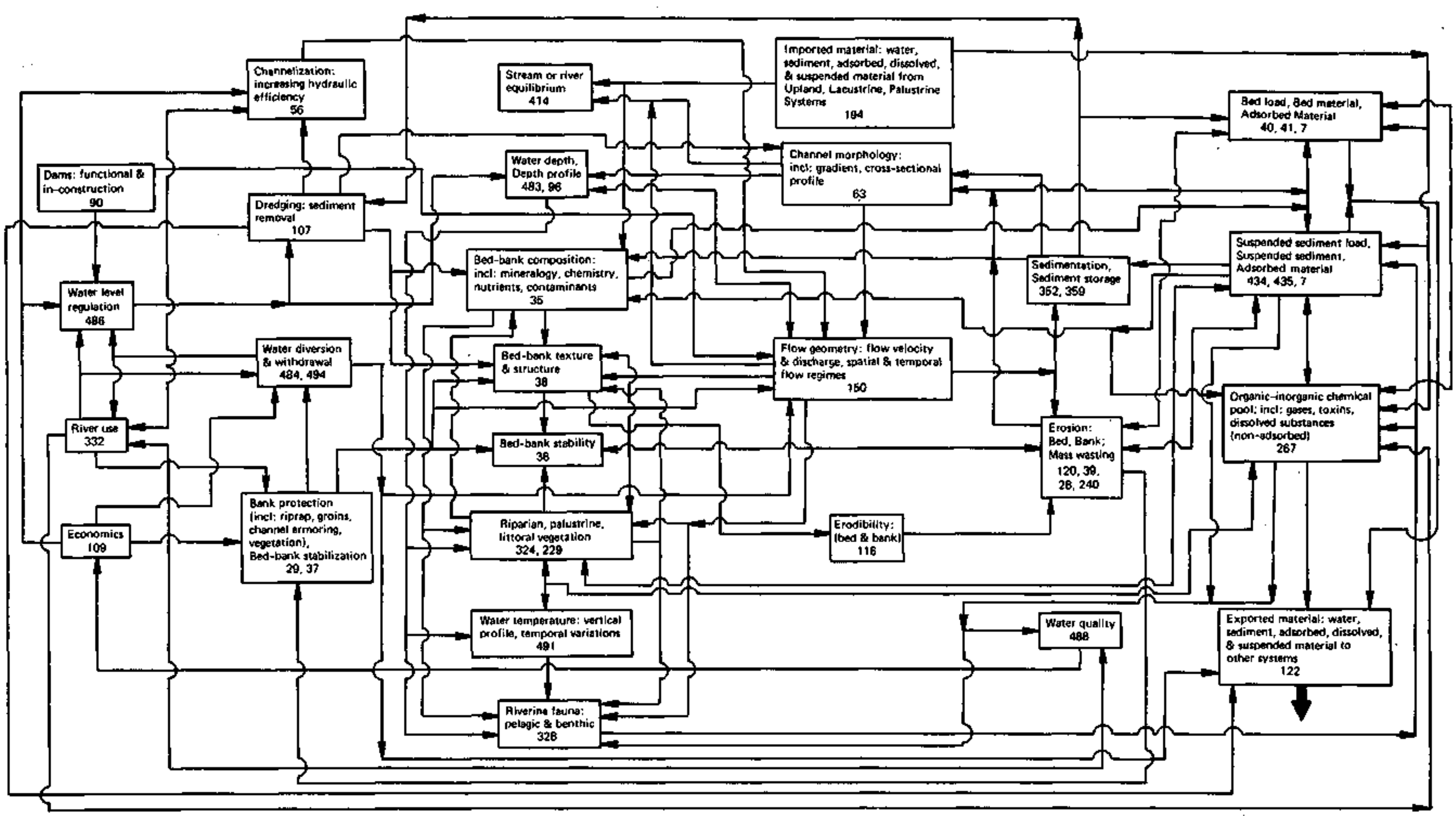


Figure II-13. Level II model for the Streams and Rivers (Riverine) System

Streams and Rivera (Riverine) System

Model Description and Model Interactions. Figure II-13 shows the Level II model for the Riverine System, which should be applicable to any fluvial system including side channels.

This model encompasses a system which is primarily responsible for the transport and movement of eroded sediments significantly downstream from the source areas. Moreover, transport and movement of sediment become visible within this system.

The model can be subdivided into four major categories from left to right: hydraulic and hydrologic controls including modifiers, physical characteristics of the system, factors controlling the movement of water and sediment, and quantity and composition of the materials imported into or exported out of the system.

Most streams and rivers in Illinois are not significantly controlled except for man-made dams and locks and dams on the three major rivers. Most of the rivers are in a state of dynamic equilibrium where erosion and sedimentation processes are constantly taking place. The dynamic equilibrium is generally altered when an excessive amount of sediment or water is delivered to the system or when man-made changes such as dams or straightening of meanders take place.

An example of first-order interactions within this system is as follows: erosion, including bed and bank erosion and mass wasting (Box R120,39,28, 210) is impacted by flow geometry (Box R150) and erodibility of bed and bank (Box R116), whereas erosion impacts bank protection and bed-bank stabilization (Box R29,37), channel morphology (Box R63), and bed-bank composition (Box R35). Two-way interactions exist between bed and bank erosion, mass wasting (Box R120,39,28,240) and the parameters bed-bank stability (Box R36);

suspended sediment load, suspended sediment', and adsorbed material (Box R434,435,7); and bed load, bed material, and adsorbed material (Box R40, 41,7). Second-and third-order interactions can be deduced by following , arrows from any one of these boxes.

Table II-8 provides the detailed descriptions of all the interactions for the Streams and Rivers System.

Table II-8. Descriptions of Interactions for the Streams and Rivers (Riverine) System Model

Interaction code	Description
R(29,37)-36	Bank protection, Bed-bank stabilization - Bed-bank stability: Bed-bank protection through the use of channel armoring (including riprap and pilings) and vegetation establishment directly influences the stability of bed or bank, and thus the amount of material derived from an instream sediment source. Related References: 66,85,403,413,430
R(29,37)-38	Bank protection, Bed-bank stabilization - Bed-bank texture and structure: Through the use of protective covers, such as vegetation for stabilization, bank protection influences the physical characteristics of the bank. Related References: 66,545
R(29,37)-150	Bank protection, Bed-bank stabilization - Flow geometry: Bank protection influences on flow velocity include diversion of currents through use of groins or pilings. Modifications on flow patterns to protect banks ultimately influence stream or river equilibrium by reducing in-stream sediment sources. Related References: 6,205,424,541,674
R35-38	Bed-bank composition - Bed-bank texture and structure: The composition of material on the bed, and along the bank, is correlated with the physical characteristics of the bed or bank. This correlation includes texture, particle size, distribution, cohesiveness, etc. Related References: 158,217,254,269,361,579,732
R35-(40,41,7)	Bed-bank composition - Bed load, Bed material, Adsorbed material: Bed and bank composition may influence the composition of materials carried as bed load and the quantity of adsorbed materials. Related Reference: 217

R35-267 Bed-bank composition - Organic-inorganic chemical pool:
The influence of bed or bank material composition on the composition of materials in the water column (other than suspended sediment and adsorbed material) involves dissolution or disaggregation of minerals, elements, or pollutants.

Related References: 8,26,27,30,98,102.113,115,139,145,230,260, 265,268,269,318,322,352,364,370,371,372,373, 396,420,435,166,476,483,555,559,572,576,597, 600,629,630,650,657,659,670,688,691,715,720, 721,722,757

R35-(324,229) Bed-bank composition - Riparian, palustrine, littoral vegetation:
Bed-bank composition influences vegetation through nutrient content, favorability to plant growth, gas and pore water composition, toxin content, etc.

Related Reference: 629

R35-(434,435,7) Bed-bank composition - Suspended sediment load, Suspended sediment, Adsorbed material:
Bed or bank material composition influences the composition of suspended sediment and adsorbed material. Composition includes such variables as mineralogy, nutrients, and other contaminants.

Related Reference: 254

R36-(120,39,38,240) Bed-bank stability - Bed and bank erosion, Mass wasting:
The stability of the bed or bank, especially oversteepened banks, influences the rate of erosion by mass wasting or bank failure. This is primarily influenced by current undercutting the toe of the bank. .

Related References: 55,57,66,85,214,247,257,258,403,413,430,483, 671,696

R38-36 Bed-bank texture and structure - Bed-bank stability:
The physical characteristics of the bed or bank material (particle size distribution, cohesive strength) directly influence stability. This is especially important for oversteepened river banks.

Related References: none

R38-116 Bed-bank texture and structure - Erodibility:
The physical characteristics of bed or bank, including grain size distribution, fluidity, and cohesiveness, directly influence the potential for erosion to occur. All variables which influence the texture and structure of substrate, therefore, indirectly influence its erodibility.

Related References: none

R38-(324,229) Bed-bank texture and structure - Riparian, palustrine, littoral vegetation:
Bed and bank characteristics influence the growth of vegetation through favorability to root growth, degree of aeration, substrate cohesiveness, texture, etc.

Related Reference: 693

R38-328 Bed-bank texture and structure - Riverine fauna:
Substrate characteristics influence the feeding and dwelling habits of riverine fauna and limit the occurrence of some species from areas where food availability is scarce or the substrate is too hard or soft.

Related Reference: 89

R(40,41 ,7)-(120,39,28,240) Bed load, Bed material, Adsorbed material - Bed and bank erosion, Mass wasting:
The quantity and physical characteristics of material carried along the river bed result from the erosion of bed, bank, or the landscape.

Related References: 26,125,152,208,217,269,317,377,393,437,476,
487,494,535,555,571,579,614,716,747

R(40,41,7)-122 Bed load, Bed material, Adsorbed material - Exported material:
Sediment and adsorbed material being carried out of the system by the bed load contribute significantly toward the quantity and quality of exported material.

Related References: 208,217,393,437,535,614

R(40,41,7)-267 Bed load, Bed material, Adsorbed material - Organic-inorganic chemical pool:
An exchange of substances occurs between bed load material and material (other than sediment and adsorbed material) within the water column. This is influenced by water temperature, flow velocity, composition of the water and of bottom sediments, particle size, amount of bottom disturbance, etc. From the standpoint of biota, the exchange of dissolved gases is especially important.

Related References: none

R56-150 Channelization - Flow geometry:
Channelization procedures influence flow geometry by increasing the hydraulic efficiency of the channel. This is often done by straightening (shortening channel length) or dredging (deepening). Channelization procedures, by whatever method, set off a series of changes including increased flow velocity, increased sediment load, increased gradient, and a loss of potential aquatic habitat.

Related References: 63,198,247,285,443,623,696

R56-332 Channelization - River use:
Channel improvement in turn influences how the river is used (i.e., for navigational purposes).

Related References: 198,584

R63-150 Channel morphology - Flow geometry:
Channel morphology, hydraulic geometry, and gradient influence the flow patterns within the river or stream.

Related References: 56,57,59,61,62,169,193,195,285,332,335,351, 398,405,406,437,443,525,527,618,619,648,674, 698,771,775,784,788

R63-414 Channel morphology - Stream or river equilibrium:
This describes the effect that modifications of the channel morphology and stream gradient have upon the equilibrium state of a stream or river. Such modifications as dredging, channel straightening, and damming are included here.

Related References: 62,587

R63-483 Channel morphology - Water depth:
This describes the relationship of channel morphology to water depths. Modifications of channel morphology by dredging indirectly influence water depths.

Related References: 56,58,195,351,525,618,648,775,784

R90-150 Dams - Flow geometry:
Dams, both functional and in-construction, modify flow patterns by blocking the natural flow of the river, causing sediment accumulation both near the dam and upstream, where the river is not directly influenced by the pool. Because these sediment accumulations cause a change in the gradient, which produces a corresponding change in flow velocity, dredging may be required to maintain the channel.

Related References: 1,148,169,258,277,424,619,623,696

R90-486 Dams - Water level regulation:
Dams are used as a means for controlling water levels. Both functional dams and dams used for diverting water from construction sites (coffer dams) alter flow patterns and can result in severe sedimentation and bed scour problems.

Related References: 277,421,619,679,696,762

R107-35 Dredging - Bed-bank composition:
The removal of material by dredging, in order to maintain a required water depth, may modify the composition of the river bed.

Related References: 113,266,596,629,658

R107-38 Dredging - Bed-bank texture and structure:
The disruption of the substrate by dredging equipment results in a modification of substrate characteristics. This can destroy certain habitats and decrease stability of bed or bank.

Related References: none

R107-56 Dredging - Channelization:
Dredging is the commonly used method for removal of sediment for channelization purposes. Dredging increases channel depth, which in turn increases hydraulic efficiency and modifies flow patterns.

Related References: 69,149,198,623,696

R107-63 Dredging - Channel morphology:
Dredging of the river bottom modifies the depth profile and thus the river morphology.

Related References: 193,266,696

R107-122 Dredging - Exported material:
Dredging directly removes material from the river.

Related References: 44,69,113,149,193,198,242,266,344,721,424,
438,456,475,497,499,523,549,550,569,596,598,
623,629,658,696

R109-(29,37) Economics - Bank protection, Bed-bank stabilization:
Cost/benefit ratios are important in the determination of bank protection methods.

Related References: 7,11,14,29,50,51,94,130,207,219,286,299,307,
359,430,436,468,497,505,566,567,625,637,663,
694,737

R109-56 Economics - Channelization:
Economics influences the type of channelization to be used.

Related References: none

R109-(484,494) Economics - Water diversion and withdrawal:
Cost/benefit ratios are important in water diversion and withdrawal projects.

Related References: 209,580

R109-486 Economics - Water level regulation:
Economic considerations have a direct influence on the costs of maintaining a desired water level for navigational, recreational, or industrial use.

Related References: none

R116-(120,39,28,240) Erodibility - Bed and bank erosion, Mass wasting:
The erodibility of bed or bank, as influenced by structure and texture, along with flow geometry, directly influences the amount and type of material removed by erosion.

Related References: 2,17,38,40,51,56,106,107,131,165,174,180, 187,194,197,211,237,239,241 ,253,258,290,319, 390,406,427,430,453,460,462,472,479,556,582, 646,654,678,726,752,760,777,778

R(120,39,28,240)-(29,37) Bed and bank erosion, Mass wasting - Bank protection, Bed-bank stabilization:
The rate and location of erosion directly influence the need for bank protection. Erosion rates, in conjunction with cost/benefit ratios, influence the bank protection measures taken.

Related References: 6,7,14,15,17,29,39,41,45,50,51,52,66,79,85, 86,94,110,129,130,141,174,190,205,207,236, 239,245,256,279,286,298,299,304,307,331,341, 350,359,363,368,403,413,418,424,427,430,436, 440,447,452,458,472,497,502,503,505,519,541, 545,548,560,561,566,582,622,628,629,637,663, 664,674,693,694,710,737,746,792

R(120,39,28,240)-35 Bed and bank erosion, Mass wasting - Bed-bank composition:
Removal of material from the bed or bank by erosion modifies the composition of the material.

Related References: 8,26,30,38,56,58,67,68,72,102,110,118,119, 125,140,148,152,154,158,181,217,248,254,260, 266,269,278,317,318,323,332,336,352,361,364, 377,392,396,411,420,426,450,451 ,474,476,482,

483,484,487,494,517,525,538,542,555,562,571,
579,597,600,607,620,621,629,630,642,649,650,
656,658,669,670,684,688,691,712,714,715,716,
717,718,732,747,748,781,785

R(120,39,28,240)-36 Bed and bank erosion, Mass wasting - Bed-bank stability:
Undercutting by the erosive action of water (especially at the eroded banks) produces a more unstable slope, thus reducing the stability of the bank.

Related References: 55,57,66,85,214,247,257,258,403,413,430,483,
671,696

R(120,39,28,240)-(40,41,7) Bed and bank erosion, Mass wasting - Bed load, Bed material, Adsorbed material:
Erosion significantly contributes to the bed load and the adsorbed material.

Related References: 26,125,152,208,217,269,317,377,393,437,476,
487,494,535,555,571,579,614,716,747

R(120,39,28,240)-63 Bed and bank erosion, Mass wasting - Channel morphology:
The removal of material from the channel by bank erosion or bed scour results in modifications of the channel morphology, which can be either large- or small-scale changes.

Related References: 56,57,58,61,169,193,208,248,253,266,332,335,
359,361,365,375,398,406,437,479,484

R(120,39,28,240)-(434,435,7) Bed and bank erosion, Mass wasting - Suspended sediment load, Suspended sediment, Adsorbed material:
Eroded materials contribute significantly to the quantity and type of materials present in the suspended load.

Related References: 9,30,60,80,81,125,143,152,159,175,177,181,
212,245,253,287,317,346,347,360,377,398,442,
462,488,525,540,562,579,597,600,607,630,693,
707,716,747,767

R150-38 Flow geometry - Bed-bank texture and structure:
Flow regimes and hydraulic geometry influence substrate characteristics through sorting, sedimentary structure, and grain size distribution within the river or stream.

Related References: 217,328,448

R150-(120,39,28,240) Flow geometry - Bed and bank erosion, Mass wasting:
Flow geometry, including velocity profiles, influences erosion rates (bed or bank). This includes temporal variations in flow patterns.

Related References: 2,3,4,6,56,57,60,61,63,67,68,72,80,81,106, 108,116,119,129,148,169,170,172,173,193,198, 205,206,212,217,247,254,258,263,276,277,278, 296,314,327,328,329,332,335,336,338,339,347, 350,357,393,397,398,406,417,424,437,438,446, 448,449,475,488,525,537,541 ,561 ,570,597,613, 614,615,621,647,650,660,668,674,693,696,732, 733,745,746,771,775,781,785,787

R150-(324,229) Flow geometry - Riparian, palustrine, littoral vegetation:
Flow patterns directly influence the distribution of flora through the tolerance of the flora for certain physical conditions.

Related References: 590,693

R150-328 Flow geometry - Riverine fauna:
Flow patterns directly influence the distribution of fauna through the tolerance of the fauna for certain physical conditions such as high or low flow velocity. Current patterns also influence chemical distribution, suspended sediment, and suitable surfaces for feeding, reproduction, etc.

Related References: 67,68,72,101,344,470,696

R150-352 Flow geometry - Sedimentation:
Flow geometry, including velocity profiles and turbulence, influences sedimentation rates. This includes temporal variations in flow patterns.

Related References: 3,4,49,60,61,62,63,65,67,80,81,87,106,108, 119,129,169,170,172,173,193,198,205,206,218, 263,276,277,314,327,328,332,335,338,339,347, 348,350,351,366,398,405,406,417,437,438,446, 448,449,454,465,466,488,489,490,498,499,515, 526,537,541 ,557,570,614,615,618,623,640,643, 647,668,674,693,732,733,746,771,775,781 ,785, 787

R150-414 Flow geometry - Stream or river equilibrium:
Spatial and temporal changes in flow patterns (due to modifications on water depth, bank protection, channel straightening, etc.) directly influence the river or stream equilibrium. Modifications on the system result in a disruption of a stream's natural state.

Related References: 62,446

R150-483 Flow geometry - Water depth:
Flow geometry directly influences water depth.

Related References: 56,68,103,117,195,258,314,338,344,351,389, 390,409,434,448,449,470,525,614,618,621,648, 733,766,775,784,782

R194-35 Imported material - Bed-bank composition:
Material brought into the system from the uplands, lakes, or wetlands can influence the composition of material on the bed or bank.

Related References: 26,125,152,269,317,377,476,487,494,555,571, 572,579,716,747

R194-(40,41,7) Imported material - Bed load, Bed material, Adsorbed material:
Imported material may contribute toward the bed load or the adsorbed material.

Related References: 26,125,152,269,317,377,476,487,494,555,571, 572,579,716,747

R194-267 Imported material - Organic-inorganic chemical pool:
This concerns the direct influx of chemical species (not adsorbed to sediment) into the river system. This transport occurs through overland flow, from lakes or wetlands, or by direct dumping.

Related References: 26,269,476,555,572,690

R194-414 Imported material - Stream or river equilibrium:
The rate and quantity of water, sediment, and adsorbed material from other systems which are carried into the system directly influence the balance of the river or stream. A rapid or long-term influx of sediment (i.e., soil loss from agricultural land) changes the equilibrium balance of sediment in lakes and rivers, producing a sequence of downstream changes in stream geometry. These in turn influence erosion or aggradation rates, water quality, bed stability, etc.

Related References: none

R194-(434,345,7) Imported material - Suspended sediment load, Suspended sediment, Adsorbed material:
The direct influx of suspended sediment and adsorbed material into the system impacts the suspended sediment. The input source is one of the major controls on the composition of suspended sediment and adsorbed material in the river or stream.

Related References: 26,125,152,269,317,377,476,487,494,555,571, 572,579,690,716,747

Table II-8. Continued

R267-35 Organic-inorganic chemical pool - Bed-bank composition:
The chemical species within the river or stream influence the chemical composition of bed or bank materials.

Related References: 8,26,27,30,98,102,113,115,139,145,230,260, 265,268,269.318,322,352,364,370,371,372,373, 396,420,435,466,476,483,555,559,572,576,597, 600,629,630,650,657,659,670,688,691,715,720, 721,722,757

R267-(40,41,7) Organic-inorganic chemical pool - Bed load, Bed material, Adsorbed material:
This represents the exchanges of substances between the chemical pool and bed load material. This is influenced by water temperature, flow velocity, characteristics of bottom sediment, composition of bed and suspended material, particle sizes, etc.

Related References: 4,26,129,269,333,342,417,476,549,555,786

R267-122 Organic-inorganic chemical pool - Exported material:
Dissolved and suspended substances (which are not adsorbed to sediment) that are being carried to other systems in the water column are the exported materials.

Related References: 26,269,476,555

R267-(324,229) Organic-inorganic chemical pool - Riparian, palustrine, littoral vegetation:
This represents the exchange of chemical species between riverine vegetation and the water column. Most important is the exchange of gases due to photosynthesis and decay. Rooted plants take up nutrients or toxins primarily through bottom sediment, but free-floating or attached unicellular and multicellular plants adsorb all materials from the water column.

Related Reference: 629

R267-328 Organic-inorganic chemical pool - Riverine fauna:
This represents the exchange of chemical species between riverine fauna and the water column, including the intake of nutrients, gases, and toxins during feeding and respiration. The major influences on the presence and distribution of fauna include pH, dissolved oxygen concentration, toxicity, and nutrient availability.

Related References: 89,98,113,234,322,388,457,534,550,600,690

R267-(434,435,7) Organic-inorganic chemical pool - Suspended sediment load, Suspended sediment, Adsorbed material:
This represents the exchange of substances between suspended sediment and adsorbed material and the chemical pool. This is influenced by water temperature, flow velocity, composition of suspended materials, particle size, etc.

Related References: 4,8,26,27,30,44,47,59,69,77,80,81,88,89,98, 100,102,129,135,139,140,159,166,174,175,176, 189,194,200,203,209,220,223,224,245,260,268, 269,272,311,314,315,316,318,322,331,333,342, 346,347,352,356,364,371,372,373,396,409,417, 420,445,457,465,466,472,475,476,483,544,549, 550,555,559,572,575,576,577,586,591,597,600, 623,629,630,634,641,651,655,657,659,667,670, 685,686,688,690,691,692,713,715,720,721,722, 724,756,757,767,776,780,786,791 ,792

R267-488 Organic-inorganic chemical pool - Water quality:
The chemical composition and concentrations of particular components directly influence the quality of the water, including temperature, pH, dissolved oxygen concentration, flora and fauna, etc.

Related References: 8,27,35,37,44,69,91,98,129,135,139,140,159, 174,175,178,203,209,220,223,224,230,232,234, 238,260,265,272,284,311,333,342,356,370,371, 372,373,388,409,414,420,445,472,478,483,520, 549,559,575,597,601,630,641,651,659,685,686, 690,692,713,715,720,721,722,724,731,757,767, 776,780,792

R267-491 Organic-inorganic chemical pool - Water temperature:
This represents the influence of chemical species in the water column on the temperature of the water. Trace metals or other impurities change the specific heat of water.

Related References: 100,371,372,373,409,576,720,721,722,757

R(324,229)-35 Riparian, palustrine, littoral vegetation - Bed-bank composition:
The type and distribution of vegetation have a minimal influence on the composition of bed or shoreline substrate.

Related Reference: 629

R(324,229)-36 Riparian, palustrine, littoral vegetation - Bed-bank stability:
Riparian and littoral vegetation help to stabilize both littoral zones and banks of a river or stream by binding unconsolidated material and by dissipating flow velocity. Riparian vegetation is an important mechanism for limiting erosion from the banks.

Related Reference: 629

Table II-8. Continued

R(324,229)-38 Riparian, palustrine, littoral vegetation - Bed-bank texture and structure:

The type and distribution of riparian and littoral vegetation have minimal influence on substrate characteristics. Vegetation influences include stabilization of bank or near bank sediments, filtering of sediment, aeration, and sediment trapping. These characteristics, in turn, influence habitat structure, lacustrine biota, bed and bank stability, etc.

Related References: none

R(324,229)-267 Riparian, palustrine, littoral vegetation - Organic-inorganic chemical pool:

Riparian and littoral vegetation exchange chemical species within the water column. Especially important is the exchange of gases due to photosynthesis and decay.

Related Reference: 269

R(324,229)-328 Riparian, palustrine, littoral vegetation - Riverine fauna:

Riparian and littoral vegetation influence riverine fauna by providing a refuge from predators, food, and protection from strong currents. Established vegetation also provides a surface for reproduction including egg deposition.

Related References: none

R(324,229)-491 Riparian, palustrine, littoral vegetation - Water temperature:

Riparian and littoral vegetation influence local water temperature primarily through shading by floating or emergent plants. On a localized scale, this influences biota through moderation of temperature.

Related References: 359,693

R328-35 Riverine fauna - Bed-bank composition:

Riverine fauna influence bed and bank composition through the deposition of organic wastes and filtering of sediment.

Related References: 58,68,72,98

R328-38 Riverine fauna - Bed-bank texture and structure:

Riverine fauna modify substrate characteristics through feeding, crawling, dwelling, etc. This may cause sediment resuspension, increased aeration, textural variations, etc.

Related Reference: 89

Table II-8. Continued

R328-267 Riverine fauna - Organic-inorganic chemical pool:
This represents the exchange of chemical species between fauna and the water column. It includes the intake of gases, toxins, and nutrients during feeding and respiration.

Related References: 89,98,234,600,690

R328-(434,435,7) Riverine fauna - Suspended sediment load, Suspended sediment, Adsorbed material:
Riverine fauna may influence suspended sediment through the processing of sediment, particulate organic matter, and adsorbed material; through filter-feeding or ingestion; and through other functions. The disruption of the substrate by bioturbation or crawling directly increases suspended sediment.

Related References: 600,690

R332-(29,37) River use - Bank protection, Bed-bank stabilization:
River use influences the need for and type of bank protection. Protection of near-shore homes or roads from undercutting is done by channel armoring (using riprap or other techniques) to stabilize a particular stretch of river bank. Vegetative cover also serves to minimize bank failure. Groins or other obstructions to flow serve to direct local currents away from the bank.

Related References: 66,519,674

R332-56 River use - Channelization:
River use influences the need for improving the channel (by dredging) for purposes of maintaining a navigation channel, keeping harbors open for recreational boats, etc.

Related References: 198,584

R332-267 River use - Organic-inorganic chemical pool:
Human activities influence the composition of water and thus its quality. Discharge of industrial, municipal, private, or other waste has an adverse effect on the composition of water and its use for recreational, fishing, or drinking purposes.

Related References: 324,417,692

R332-(484,494) River use - Water diversion and withdrawal:
This represents the influence of river use on diversion or withdrawal of river water.

Related References: none

R332-486 River use - Water level regulation:
The designated use for a particular river, especially if it serves as a navigation channel, will influence decisions on the monitoring of water levels. In Illinois this is done through the use of gate-controlled dams. Maintenance of a "deep" channel allows for navigation. Water level changes influence fish and wildlife, and recreation.

Related References: none

R352-35 Sedimentation - Bed-bank composition:
Material deposited within the system can change the composition of the bed and bank materials.

Related References: 8,24,27,63,67,98,119,248,269,310,317,318,
323,332,348,351,352,377,396,405,406,426,450,
451,465,466,467,482,483,494,542,562,565,596,
600,607,640,658,670,688,691,712,718,732,747,
748,781,785

R352-(40,41,7) Sedimentation -Bed load, Bed material, Adsorbed material:
Material deposited within the river becomes part of bed load when transported along the river bed (not in suspension). It is through sedimentation that suspended sediment becomes part of the bed load.

Related References: 269,317,377,437,494,535,614,747

R352-63 Sedimentation - Channel morphology:
Material deposited within the system results in a modification of the stream or river morphology. This refers to changes which occur on any scale from point bar deposition to sediment filling from dams. This is an indirect influence on water depth through aggradation.

Related References: 61,62,169,193,248,332,335,351,365,375,398,
405,406,437,457,479,562,615,618,674,702,
771,775

R352-107 Sedimentation - Dredging:
The rate and distribution of deposited material directly influences the need for and frequency of dredging. This is also dependent upon the designated river use, economic feasibility, etc.

Related References: 44,69,149,193,198,242,421,438,497,499,596,
623,658

R(434,435,7)-(120,39,28,240) Suspended sediment load, Suspended sediment, Adsorbed material - Bed and bank erosion, Mass wasting:
This describes the influence of suspended sediment upon erosion. Especially important is the role of particle size on the erosive action of water.

Related References: 9,26,30,60,61,63,76,80,81,125,143,147,148, 152,159,169,170,172,175,177,181,194,198,205, 212,217,242,245,253,254,269,277,287,317,326, 327,333,342,346,347,360,365,377,393,398,417, 434,437,442,448,462,476,487,488,494,525,540, 542,555,562,571,579,597,600,607,613,630,660, 668,693,707,716,733,747,762,767,775,781,785, 787

R(434,435,7)-122 Suspended sediment load, Suspended sediment, Adsorbed material - Exported material:
This represents the transport of suspended sediment and adsorbed material out of the system. This includes the suspended load and the rate of transport.

Related References: 26,125,152,269,317,377,393,476,487,494,555, 571,579,596,693,716,747

R(434,435,7)-267 Suspended sediment load, Suspended sediment, Adsorbed material - Organic-inorganic chemical pool:
This represents the exchange of substances between suspended sediment and adsorbed material, and other chemical species within the water column. This is influenced by several variables such as composition of suspended material in the water, water temperature, flow velocity, particle size, etc.

Related References: 4,8,26,27,30,44,47,59,69,77,80,81,88,89,98, 100,102,129,135,139,140,159,166,174,175,176, 189,194,200,203,209,220,223,224,245,260,268, 269,272,311,314,315,316,318,322,331,333,342, 346,347,352,356,364,371,372,373,396,409,417, 420,445,457,465,466,472,475,476,483,544,549, 550,555,559,572,575,576,577,586,591,597,600, 623,629,630,634,641,651,655,657,659,667,670, 685,686,688,690,691,692,713,715,720,721,722, 724,756,757,767,776,780,786,791,792

R(434,435,7)-(324,229) Suspended sediment load, Suspended sediment, Adsorbed material - Riparian, palustrine, littoral vegetation:
The effects of suspended sediment on lacustrine flora include a reduction of light penetration, a smothering of leaf surfaces and inhibition of gas exchange, and in some cases burial of benthic plants.

Related References: none

R(434,435,7)-328 Suspended sediment load, Suspended sediment, Adsorbed material - Riverine fauna:
Suspended sediment and adsorbed material directly influence fauna. Fauna respond to the chemical composition and concentration of material in the water column. Excessive amounts of suspended sediment and adsorbed material in the water column can physically disrupt the feeding of biota through a clogging of pores by sediment. Suspended sediment also reduces light availability.

Related References: 487,600,690

R(434,435,7)-352 Suspended sediment load, Suspended sediment, Adsorbed material - Sedimentation:
Suspended sediment and adsorbed material redeposited through siltation become part of bed or bank material. The rate of deposition is controlled by flow patterns, trap efficiency, concentration of suspended sediment, and the particle size distribution of material in suspension.

Related References: 3.4,7,8,21,24,25,27,42,44,45,48,49,54,60,61, 62,63,65,66,67,69,73,75,76,77,78,80,81,87, 88,89,90,92,93,96,98,106,108,109,111,114, 115,117,119,126,127,128,129,130,135,136,138, 141,143,147,149,153,166,167,168,1 69,170,172, 173,175,180,188,193,194,198,203,204,205,206, 211,218,220,224,239,242,248,250,251 ,256,259, 263,269,272,276,277,281,282,283,287,302,306, 309,310,313,314,315,317,318,319,320,321,323, 327,328,332,333,334,335,338,339,340,346,347, 348,349,350,351,352,354,365,366,375,377,381, 394,396,398,399,400,401,402,405,406,409,412, 417,421,426,437,438,439,441,446,448,449,450, 451,454,457,458,465,466,467,469,479,482,483, 488,489,490,492,493,494,495,496,497,498,499, 507,512,515,524,526,529,530,532,535,537,541, 542,544,546,547,552,557,562,563,564,565,568, 570,577,582,596,600,602,603,607,614,615,618, 623,638,639,640,641 ,643,644,645,646,647,651, 654,658,662,667,668,670,674,678,679,680,681, 682,685,686,688,691 ,692,693,699,700,702,703, 704,707,709,712,718,724,727,732,733,742,746, 747,748,749,759,760,762,763,767,771 ,775,781, 785,787,792

R(434,435,7)-488 Suspended sediment load, Suspended sediment, Adsorbed material - Water quality:
The composition and concentration of waterborne sediment and adsorbed material, including trace metals, nutrients, and organic matter, directly influence the water quality.

Related References: 1 ,6,7,8,9,12,27,44,65,69,82,98,99,101,105, 109,123,129,135,139,140,144,159,174,175,179, 181,199,203,204,206,209,213,220,223,224,239, 242,251,260,271,272,278,291,297,302,311 ,312, 313,315,321,332,333,342,354,356,358,359,360, 361,371,372,373,376,383,397,398,401,407,409, 412,420,421,429,442,444,445,456,468,469,472, 474,482,483,484,493,494,499,508,524,542,549, 559,560,564,568,569,575,577,587,588,589,590, 595,597,600,604,607,610,628,630,636,641 ,642, 651 ,656,658,659,667,683,685,686,690,692,693, 703,709,713,715,716,718,720,721,722,723,724, 728,739,740,741,744,746,747,748,757,763,767, 776,778,780,792,793

R483-150 Water depth - Flow geometry:
Water depth influences flow patterns, discharge, and hydraulic geometry directly through controls on velocity profiles both vertical and horizontal. Increases in water depth result in increased hydraulic conveyance.

Related References: 56,68,103,117,195,258,314,338,344,351,389, 390,409,434,448,449,470,525,614,618,621 ,648, 733,766,775,782,784

R483-(324,229) Water depth - Riparian, palustrine, littoral vegetation:
Water depth determines the diversity and distribution of plant species through the response of vegetation, light availability, vertical temperature variations, and dissolved oxygen concentration. Water depth is commonly used as an indicator of habitat suitability for some species.

Related References: none

R483-328 Water depth - Riverine fauna:
Water depth influences riverine fauna through its influence on light availability, water temperature, distribution of vegetation, and other variables.

Related References: 58,68,344,470

R483-491 Water depth - Water temperature:
Water depth is related to water temperature (particularly temperature profiles) through attenuation of light. Fauna and vegetation must be adapted to temperature and light availability, as well as water quality and substrate characteristics.

Related References: 409,448,470,564

Table II-8. Continued

R(484,494)-122 Water diversion and withdrawal - Exported material: Water withdrawal or diversion (for irrigation or for private, municipal, industrial, or other use).removes water from the system which may include suspended or dissolved materials.

Related References: none

R(484, 494) —150 Water diversion and withdrawal - Flow geometry: Diversion of flow, for withdrawal or other purpose, directly influences flow geometry within the river.

Related References: none

R(484,494)-332 Water diversion and withdrawal - River use: Water diversion or withdrawal is one of the uses of a river. This is especially true in the case of channel diversion in order to maintain a navigable channel.

Related References: none

R(484,494)-486 Water diversion and withdrawal - Water level regulation: Water withdrawal or diversion (for irrigation or for industrial or municipal use) influences decisions on water level regulation.

Related Reference: 178

R486-107 Water level regulation - Dredging: In an effort to maintain a specified water depth for navigation, recreation, or water withdrawal use, water level regulation requires the use of dredging to remove bottom sediment. Sediment accumulation rates, along with water depth requirements for navigation or recreation, influence the need for and frequency of dredging.

Related References: 113,149,424,569,696

R486-483 Water level regulation - Water depth: Water level regulation has a direct influence on water depth. The water level must be regulated closely where commercial navigation depends upon a certain channel depth throughout the year.

Related References: 48,413,564,762

R486-(484, 494) Water level regulation - Water diversion and withdrawal: Water levels are sometimes regulated to meet the demand for water diversion and withdrawal.

Related Reference: 178

Table II-8. Concluded

R488-109 Water quality - Economics:
Water quality (as characterized by the composition of suspended sediment and adsorbed material, and other chemical species in the water column) influences economics in the sense of costs for pollution control and water treatment, as well as damage to water treatment facilities, recreation, and aquatic habitats.

Related References: 7,8,14,34,35,37,40,70,121,144,199,209,229, 231,233,246,251,260,271,272,284,313,315,321, 359,361,370,383,420,456,468,480,482,483,484, 493,494,505,524,567,595,601,604,607,610,632, 641,652,653,667,692,709,713,739,740,741,763, 764,772,776

R488-332 Water quality - River use:
Water quality influences river use for recreational, commercial fishing, or water supply purposes. Water quality, however, is determined by the chemical composition of the water and material carried in the water column.

Related References: 1,65,332,692

R491-267 Water temperature - Organic-inorganic chemical pool:
Water temperature affects the states and conversions of chemical species in the water column. From the perspective of biota, water temperature plays a critical role in the dissolution of gases and their availability.

Related References: 100,265,269,371,372,373,409,549,575,576,720, 721,722,757

R491-(324,229) Water temperature - Riparian, palustrine, littoral vegetation:
Water temperature (including vertical profile and temporal variations) influences the type of vegetation present. It affects plant metabolism, growth, and survival, either directly or indirectly (the latter by influencing fauna associated with the plants).

Related References: 359,693

R491-328 Water temperature - Riverine fauna:
Water temperature (including vertical profile and temporal variations) influences the spatial and seasonal distribution of fauna. Water temperature is a critical regulator of habitat suitability, affecting flood availability, light availability, and respiration and metabolic rates.

Related References: none

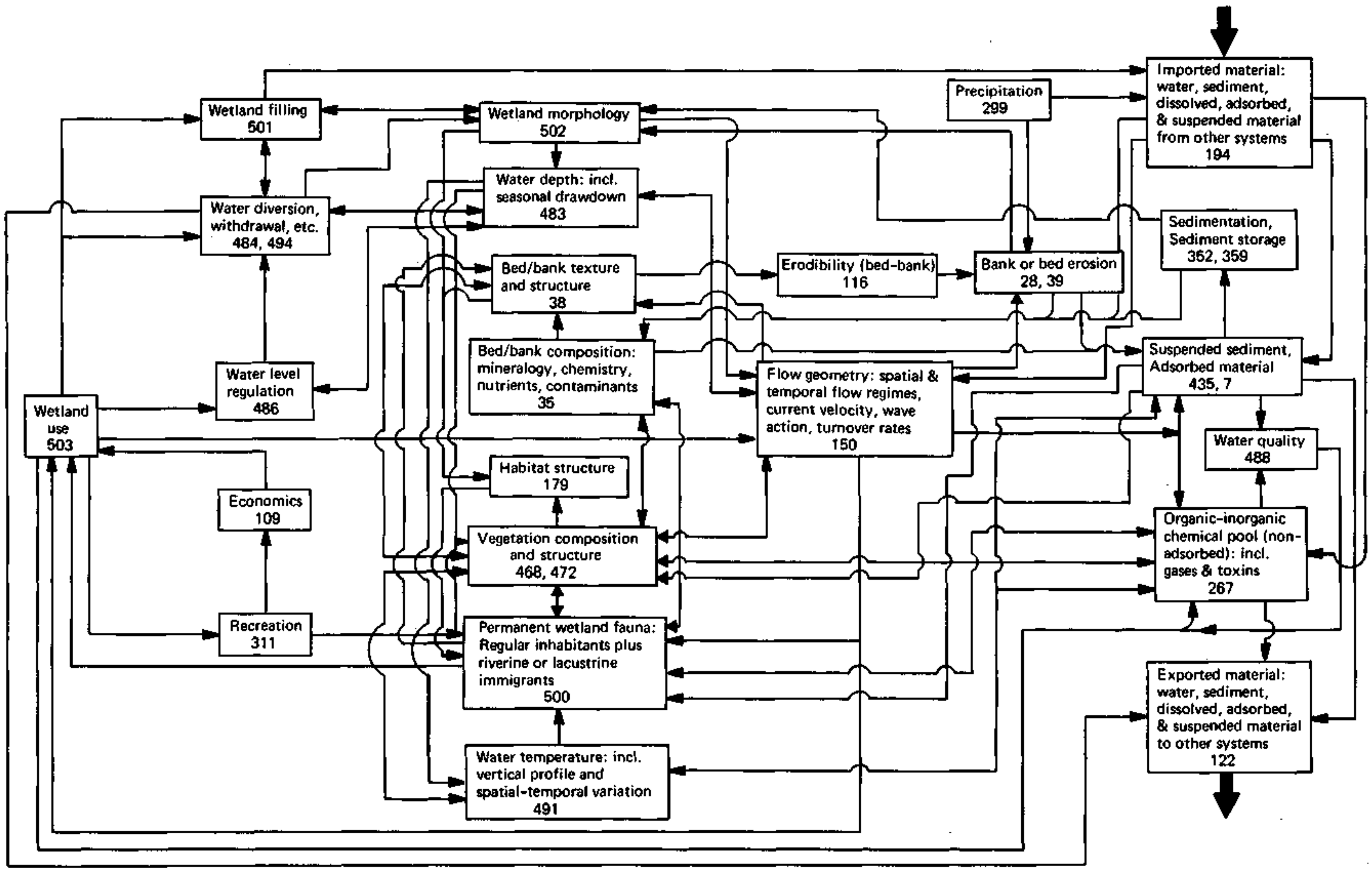


Figure II-14. Level II model for the Permanent Wetland Subsystem

Wetland System (Palustrine System)

It has already been mentioned that the Wetland System has been subdivided into the Permanent Wetland Subsystem and the Seasonal Wetland Subsystem. Descriptions of the Level II models, and detailed interaction lists for these two subsystems, follow.

Permanent Wetland Subsystem

Model Description and Model Interactions. Figure II—14 shows the Level II model for the Permanent Wetland Subsystem. The Permanent Wetland Subsystem includes all continuously inundated water bodies with emergent vegetation (herbaceous or woody) that exist either independently (e.g., bogs or marshes with no open water) or as fringes bordering streams or lakes. The distinction between permanent and seasonal wetlands is made on the basis of seasonal periodicity in exposure/inundation. A permanent wetland is theoretically never exposed, whereas seasonal wetlands are typically exposed for a major fraction of the year. The latter includes river floodplains, fringes of lakes subject to significant seasonal changes in water depth, and even upland depressions that remain inundated for periods long enough to cause marked changes in vegetation composition and structure toward a wetland aspect. The seasonal wetlands may also be termed "intermittent wetlands."

Permanent (and seasonal) wetlands play significant roles in the hydrological cycle and in the exchanges of organic/inorganic matter between the true upland and riverine or lacustrine systems. The influences of permanent wetlands on the life histories, trophic relationships, and population dynamics of terrestrial and aquatic animals can be profound. They typically support a plant/animal community distinct from the surrounding aquatic and upland systems while providing food, refuge and/or breeding sites for migrants from these other systems. In addition, bog wetlands are remnant signatures of former glacial retreat that possess both unique biogeochemistry and rare associations of plants and animals.

The various services that the permanent wetlands perform, in addition to the ecological roles, are filtering sediments, raising water quality, and supporting a variety of useful pursuits. Their roles in buffering aquatic systems from aggradation and water quality deterioration due to upland erosion are paramount among these services.

As was the case for the six Upland Subsystem models, the right halves of the Permanent and Seasonal Wetland Subsystem models are identical, illustrating the fact that detachment, transport, and deposition are the same in the two subsystems. Portions of the wetland models are identical to the Streams and Rivers System model. In addition, there are strong parallels between these models and the Upland System and Streams and Rivers System models. Some of the relationships between the Permanent Wetland Subsystem model and the other models are as follows:

1) Soil composition (386), soil structure and texture (396, 397), and soil erodibility (116) have been replaced by their analogues bed-bank composition (P35), bed-bank texture and structure (P38), and bed erodibility (P116). This analogy does not imply that a wetland substrate or river bed is no different than an agricultural field. However, from the perspective of mechanisms of soil detachment and transport, and soil variables leading to these processes, the analogy is useful.
2) Flow geometry (P150) replaces drainage pattern (106) and especially overland flow (270).
3) Erosion of the wetland bed (P39) is a combination of bed erodibility (P116) and flow geometry (P150) and flow variables.

4) The following components are identical in function in all models in which they appear: imported material (194), exported material (122), suspended sediment and adsorbed material (435, 7), and non-adsorbed organic-inorganic chemical pool (267).

There is a greater emphasis in the wetland models than in the upland models on variables that affect plants and animals. These include here substrate characteristics (P35 and P38), physical water characteristics (P483, P491, P150, and P267), and chemical water characteristics (P435, P488, P267). Habitat structure (P179) is a concept easy to understand but difficult to explain. Animals respond to several physical cues in their environment as a composite indicator of habitat suitability apart from other variables such as water temperature and chemistry. These physical cues are collectively termed habitat structure. They include, in wetland models, wetland morphology (P502), water depth (P483), bed-bank texture and structure (P38), and vegetation structure and composition (P472, 468).

The wetland biota both stabilize and destabilize the substrate in addition to selectively filtering suspended sediments. These roles are not trivial, and several arrows account for these interactions. In general, sedimentation and stabilization are enhanced by rooted vegetation or benthic algal mats; erosion and resuspension are accelerated by animals, especially bottom-dwellers and burrowers.

Permanent wetlands are subject to fewer destructive uses than other subsystems as long as they remain wetlands. However, there is a strong tendency to either drain (P484, 494) or fill (P501) wetlands, based on the economic cost/benefit ratio (P109). Filling may cause severe sedimentation problems in the short term, disrupting water quality and the biota. In the long run, the beneficial effects of wetlands in ameliorating erosional and sedimentation impacts are foregone if the wetland is eliminated by whatever means.

Table II-9 gives detailed descriptions of all the interactions for the Permanent Wetland Subsystem model.

Table II-9. Descriptions of Interactions for the Permanent Wetland Subsystem Model

Interaction code	Description
P(28,39)-35	Bank or bed erosion - Bed-bank composition: Removal of sediment particles and adsorbed materials may change the physical and chemical characteristics of the bed or bank and thus affect all other components that interact with bed-bank composition. Related Reference: 525
P(28,39)-(435,7)	Bank or bed erosion - Suspended sediment, Adsorbed material: Bed erosion may lead to an increase in suspended sediment concentrations. The variables that affect detachment and transport (such as flow velocity) likewise affect the composition of sediment put in suspension. Related Reference: 525
P(28,39)-502	Bank or bed erosion - Wetland morphology: The removal of sediments through bed or bank erosion changes the morphology of the wetland on either small or large scales, depending on erosion rates. Subsequent flow geometry and all associated components may be affected. Related References: none
P35-38	Bed-bank composition - Bed-bank texture and structure: The composition of the bed and bank affects their texture and structure through mineralogy, particle size, and chemical constitution, both organic and inorganic. Related References: 158,217,25^,269,361,579,732
P35-267	Bed-bank composition - Organic-inorganic chemical pool (non-adsorbed): This and the reverse interaction represent the exchanges of substances between the bed or bank and the water column, as affected by flow velocity, water temperature, characteristics of the bottom sediments, disturbance of the bottom, etc. Of critical interest from the standpoint of the biota are the exchanges of dissolved gases, especially oxygen. Related References: 8,26,27,30,98,102,113,115,139,145,230,260, 265,268,269,318,322,352,364,370,371,372,373, 396,420,435,466,476,483,555,559,572,576,597, 600,629,630,650,657,659,670,688,691 ,715,720, 721,722,757

Table II-9. Continued

P35-(435,7) Bed-bank composition - Suspended sediment, Adsorbed material:
The characteristics of suspended sediments will reflect their nature before detachment and transport. Thus all aspects, physical and chemical, of the bed and bank sediments influence suspended sediment composition.

Related Reference: 254

P35-(468,472) Bed-bank composition - Vegetation composition and structure:
Bottom sediments affect wetland plants through favorability to root growth, gas content, toxin content, nutrient concentrations, etc.

Related References: none

P35-500 Bed-bank composition - Wetland fauna:
Characteristics of the bottom sediments (other than their input as physical factors into habitat structure) affect wetland fauna, especially bottom dwellers. Examples of these characteristics are dissolved gases, organic matter content, and toxins.

Related References: none

P38-116 Bed-bank texture and structure - Erodibility:
The texture and structure of the bed or bank will in large part determine their erodibility in response to the detaching power of moving water, and will alter erosion rates.

Related References: none

P38-179 Bed-bank texture and structure - Habitat structure:
The physical characteristics of the bed and bank are an important component of the habitat requirements of a large portion of the aquatic biota. Here the emphasis is on habitat structure, particularly texture, consolidation, and stability of the bed and bank sediments.

Related References: none

P38-(468,472) Bed-bank texture and structure - Vegetation composition and structure:
The texture and structure of the bed or bank affect wetland plants through favorability to root growth and anchoring properties.

Related References: none

P109-503 Economics - Wetland use:
The costs and benefits of any proposed use of a permanent wetland will partially determine the decision to proceed with that use. This interaction will operate through all levels of wetland alteration, from uses that do not disturb the natural functioning of the wetland in any major way to full-scale conversion of the system.

Related References: none

P116-(28,39) Erodibility (bank or bed) - Bank or bed erosion:
Physical and chemical characteristics of the bed (or bank) will determine its erodibility. In conjunction with moving water, especially the velocity of flow, bed or bank erosion may result.

Related References: 2,17,38,40,51,56,106,T07,131,165,174,180, 187,194,197,211,237,239,241,253,258,290,319, 390,406,427,430,453,460,462,472,479,556,582, 646,654,678,726,752,760,777,778

P150-38 Flow geometry - Bed-bank texture and structure:
Moving water alters the texture and structure of the bed by sorting particles and causing small-scale changes in the bed surface (ripples, dunes, etc.) which in turn affect erodibility.

Related References: 66,217,254,328,434,448

P150-39 Flow geometry - Bed erosion:
In conjunction with erodibility, all flow variables will affect bed erosion rates.

Related References: 66,103,263,257,258,525,541,561,570,674, 696,746

P150-267 Flow geometry - Organic-inorganic chemical pool (non-adsorbed):
The flow geometry of the wetland will regulate the composition and fates of the non-adsorbed chemicals in the water column. Flow rates will also influence the reactivities of chemical species through the effect of flow velocity on dissolved oxygen concentration, water temperature, etc.

Related References: 4,59,80,81,129,230,314,347,373,389,409,417, 424,435,465,466,475,559,597,623,650,757,791

Table II-9. Continued

P150-(352,359) Flow geometry - Sedimentation, Sediment storage:
Flow geometry plays an important role in determining the local sedimentation. Sedimentation in turn may alter wetland morphology on various scales.

Related References: 3,4,49,60,61,62,63,65,66,67,80,81,87,93,106,108,117,119,129,169,170,172,173,193,198,205,206,218,263,276,277,282,314,327,328,332,335,338,339,347,348,350,351,366,398,405,406,409,417,437,446,448,449,454,465,466,488,489,490,497,498,499,515,526,537,541,557,570,614,615,618,623,640,643,647,668,674,693,732,733,746,771,775,781,785,787

P150-(435,7) Flow geometry - Suspended sediment, Adsorbed material:
In.the same manner that flow geometry affects non-adsorbed chemical pools, suspended sediments and their adsorbed constituents are also influenced (see P150-267). In addition, flow geometry, especially velocity and turbulence, will determine whether or. not the sediments remain in suspension. Because of their influence on the extent of bed erosion, flow velocities also affect the composition of materials removed from the bed and placed in suspension (e.g., particle size).

Related References: 2,3,4,6,13,49,56,59,60,61,62,63,65,66,67,68,72,80,81,87,93,101,106,108,117,119,129,148,169,170,172,173,193,197,198,205,206,212,216,217,218,254,263,276,277,278,282,285,291,301,305,314,327,328,329,332,335,336,338,339,344,347,348,350,351,366,373,393,397,398,405,406,409,417,434,437,438,443,446,448,449,454,465,466,470,475,488,489,490,491,497,498,499,506,509,515,516,525,526,527,537,541 ,557,559,570,590,597,613,614,615,618,619,621 ,623,640,643,647,660,668,674,675,693,723,732,733,736,745,746,757,771,775,781,782,784,785,787,788,791

P150-(468,472) Flow geometry - Vegetation composition and structure:
Wetland flow geometry affects plants through selection of species most suited to flow velocities and spatial and temporal patterns of flow (especially seasonal drawdown or flooding).

Related References: 243,350

P150-483 Flow geometry - Water depth:
In conjunction with wetland morphology, spatial and temporal flow geometry will determine variations in water depth across the wetland.

Related References: 56,68,103,17,195,258,314,338,344,351,389,390,409,434,448,449,470,525,614,618,621 ,648,733,766,775,782,784

P150-500 Flow geometry - Wetland fauna:
Flow regime affects wetland fauna primarily through flow geometry and indirectly through wetland turnover rates, accumulations of toxins, regulation of dissolved gases (especially oxygen), etc.

Related References: none

P150-503 Flow geometry - Wetland use:
Certain uses of wetlands will require consideration of the flow geometry. Examples would be construction along the wetland perimeter, use of the wetland for water supplies or side channel reservoirs, etc.

Related References: none

P179-500 Habitat structure - Wetland fauna:
Habitat structure is a major component of the suitability of a given wetland site for a particular species or category of species (wading birds, for instance). Site suitability is dependent on the use of that site by the animals, for feeding, reproduction, refugium, etc.

Related References: none

P194-35 Imported material - Bed-bank composition:
For any materials imported into the wetland and directly added to the bed or bank (as opposed to remaining in suspension for a time and then settling out), this interaction refers to the physical or chemical alteration of the bed-bank by the imported material. This may be an important consideration during wetland filling.

Related References: 26,125,152,269,317,377,476,487,494,555,571, 572,579,716,747

P194-150 Imported material - Flow geometry:
The imported material component includes all waters, sediments, etc., entering the wetland and thus directly regulates flow geometry in the wetland. For the wetland models, precipitation is not displayed as a separate component; thus it is included under imported material.

Related References: none

P194-267 Imported material - Organic-inorganic chemical pool (non-adsorbed):
This interaction represents imported direct additions to the non-adsorbed chemical pools in the wetland. This will occur through waters entering the wetland (streams, ditches), sheet flow from the perimeter of the wetland, or precipitation.

Related References: 26,269,476,555,572,690

P194-(435,7) Imported material - Suspended sediment, Adsorbed material:
This interaction, like that between imported material and non-adsorbed organic-inorganic chemical pools (PI94-267), represents the direct addition of suspended sediment and adsorbed material to the wetland from external sources. Except for very small sediments that may enter via precipitation, the major sources for such inputs will be water entering the wetland or intentional wetland filling.

Related References: 26,125,152,269,317,377,476,487,494,555,571, 579,690,716,747

P267-35 Organic-inorganic chemical pool (non-adsorbed) - Bed-bank composition:
This interaction represents the alteration of bed or bank composition by the activity of chemicals in the non-adsorbed pools in the water column. This represents direct effects, like the transfer of oxygen or non-adsorbed heavy metals to the bed; indirect effects would involve adsorption to suspended sediment and sedimentation.

Related References: 8,26,27,30,98,102,113,115,139,145,230,260, 265,268,269,318,322,352,364,370,371,372,373, 396,420,435,466,476,483,555,559,572,576,597, 600,629,630,650,657,659,670,688,691,715,720, 721,722,757

P267-122 Organic-inorganic chemical pool (non-adsorbed) - Exported material:
This represents the contribution of non-adsorbed chemicals to total materials exported from the wetland.

Related References: 26,269,476,555

P267-(435,7) Organic-inorganic chemical pool (non-adsorbed) - Suspended sediment, Adsorbed material:
This represents the effect of non-adsorbed chemicals on suspended sediment and adsorbed material composition.

Related References: 4,8,26,27,30,44,47,59,69,77,80,81,88,89,98, 100,102,129,135,139,140,159,166,174,175,176, 189,194,200,203,209,220,223,224,245,260,268, 269,272,311,314,315,316,318,322,331,333,342, 346,347,352,356,364,371,372,373,396,409,417, 420,445,457,465,466,472,475,476,483,544,549, 550,555,559,572,575,576,577,586,591,597,600, 623,629,630,634,641,651,655,657,659,667,670, 685,686,688,690,691,692,713,715,720,721,722, 724,756,757,767,776,780,786,791,792

P267-(468,472) Organic-inorganic chemical pool' (non-adsorbed) - Vegetation composition and structure:
The effects of non-adsorbed chemicals on wetland plants involve dissolved and suspended (but non-adsorbed) gases, nutrients, and toxins.

Related Reference: 436

P267-488 Organic-inorganic chemical pool (non-adsorbed) - Water quality:
Non-adsorbed chemicals may add or detract from water quality, depending on the chemical species and their concentration.

Related References: 8,27,35,37,44,69,91,98,129,135,139,140,159, 174,175,178,203,209,220,223,224,230,232,234, 238,260,265,272,284,311,333,342,356,370,371, 372,373,388,409,414,420,445,472,478,483,520, 549,559,575,597,601,630,641,651,659,685,686, 690,692,713,715,720,721,722,724,731,757,767, 776,780,792

P267-491 Organic-inorganic chemical pool (non-adsorbed) - Water temperature:
Non-adsorbed chemicals (especially heavy metals) in significant quantities may raise the specific heat of the volume of water that contains them.

Related References: 100,265,269,371,372,373,409,549,575,576,720, 721,722,757

P267-500 Organic-inorganic chemical pool (non-adsorbea) - Wetland fauna:
The effects of non-adsorbed chemicals on wetland fauna involve dissolved or suspended gases, toxins, and nutrients, and may occur during any of several activities on the part of the animals (feeding, respiration, etc.) during various segments of their life cycles.

Related Reference: 47

P299-39 Precipitation - Bed erosion:
Raindrop size, velocity, and rainfall rates will influence the detachment of soil particles from exposed wetland beds or banks, contributing directly to erosion rates.

Related References: none

P299-194 Precipitation - Imported material:
Precipitation is one component of all materials imported into the wetland, consisting of water, dissolved chemicals, and small particles with adsorbed substances. One of the major effects of precipitation as an imported material would be on the pH of the wetland waters.

Related Reference: 572

P311-109 Recreation - Economics:
Recreational use of wetlands will influence cost-benefit considerations for this particular use and any other proposed use of the wetland ecosystem. Chief among recreational uses would be fishing, hunting, and birdwatching.

Related References: 37,83,250,321,592,652,653,697,700,776

P311-500 Recreation - Wetland fauna:
Forms of recreation involving wetland animals are basically fishing and hunting, which directly affect wildlife populations. The effects are more pronounced if these activities are not well regulated.

Related References: none

P(352,359)-35 Sedimentation, Sediment storage - Bed-bank composition:
Sedimentation may alter the characteristics of the bed or bank if the deposited materials differ physically or chemically from the substrate they are covering.

Related References: 8,24,27.63,67,98,199,248,269,310,317,31.8, 323,332,348,351,352,377,396,405,406,426,450, 451,465,466,467,482,483,494,542,562,565,596, 600,607,640,658,670,688,691,712,718,732,747, 748,781,785

P(352,359)-502 Sedimentation, Sediment storage - Wetland morphology:
Wetland morphology may be altered by natural or accelerated accumulation of sediments on either small or large scales. Because sedimentation influences flow geometry via changes in wetland morphology, deposition may cause continually fluctuating patterns of erosion and sedimentation in the wetland.

Related References: none

P(435,7)-122 Suspended sediment, Adsorbed material - Exported material:
This interaction represents the contribution of suspended sediments and their adsorbed materials to total quantities of material exported from the wetland.

Related References: 393,596,693,759

P(435,7)-267 Suspended sediment, Adsorbed material - Organic-inorganic chemical pool (non-adsorbed):

This interaction represents the effects of suspended sediment on the non-adsorbed chemical pools. This is either the release of adsorbed chemicals, or the influence of bound materials on free chemical species.

Related References: 4,8,26,27,30,44,47,59,69,77,80,81,88,89,98, 100,102,129,135,139,140,159,166,174,175,176, 189,194,200,203,209,220,223,224,245,260,268, 269,272,311,314,315,316,318,322,331,333,342, 346,347,352,356,364,371,372,373,396,409,417, 420,445,457,465,466,472,475,476,483,544,549, 550,555,559,572,575,576,577,586,591,597,600, 623,629,630,634,641,651,655,657,659,667,670, 685,686,688,690,691,692,713,715,720,721,722, 724,756,757,767,776,780,786,791,792

P(435,7)-(352,359) Suspended sediment, Adsorbed material - Sedimentation, Sediment storage:

In conjunction with other flow parameters, suspended sediment may lead to sedimentation.

Related References: 3,4,7,8,21,24,25,27,42,44,45,48,49,54,60,61, 62,63,65,66,67,69,73,75,76,77,78,80,81,87, 88,89,90,92,93,96,98,106,108,109,111,114, 115,117,119,126,127,128,129,130,135,136,138, 141,143,147,149,153,166,167,168,169,170,172, 173,175,180,188,193,194,198,203,204,205,206, 211 ,218,220,224,239,242,248,250,251,256,259, 263,269,272,276,277,281,282,283,287,302,306, 309,310,313,314,315,317,318,319,320,321 ,323, 327,328,332,333,334,335,338,339,340,346,347, 348,349,350,351,352,354,365,366,375,377,381, 394,396,398,399,400,401,402,405,406,409,412, 417,421,426,437,438,439,441,446,448,449,450, 451,454,457,458,465,466,467,469,479,482,483, 488,489,490,492,493,494,495,496,497,498,499, 507,512,515,524,526,529,530,532,535,537,541, 542,544,546,547,552,557,562,563,564,565,568, 570,577,582,596,600,602,603,607,614,615,618, 623,638,639,640,641,643,644,645,646,647,651, 654,658,662,667,668,670,674,678,679,680,681, 682,685,686,688,691,692,693,699,700,702,703, 704,707,709,712,718,724,727,732,733,742,746, 747,748,749,759,760,762,763,767,771,775,781 , 785,787,792

P(435,7)-(468,472) Suspended sediment, Adsorbed material - Vegetation composition and structure:
The effects of suspended sediments on wetland plants are numerous, including a reduction of light intensity and hence photosynthetic rate, smothering of leaf surfaces and inhibition of gas exchange, and in extreme cases, burial of benthic plants or lower portions of floating and emergent plants.

Related References: 7,45,239,298,299,331,350,358,403,411,468, 586,589,778

P(435,7)-488 Suspended sediment, Adsorbed material - Water quality:
Suspended sediments and their adsorbed materials usually detract from water quality, with the effect depending on the concentration of such substances and their composition.

Related References: 1,6,7,8,9,12,27,44,65,69,82,98,99,101,105, 109,123,129,135,139,140,144,159,174,175,179, 181,199,203,204,206,209,213,220,223,224,239, 242,251,260,271,272,278,291,297,302,311,312, 313,315,321,332,333,342,354,356,358,359,360, 361,371,372,373,376,383,397,398,401,407,409, 412,420,421,429,442,444,445,456,468,469,472, 474,482,483,484,493,494,499,508,524,542,549, 559,560,564,568,569,575,577,587,588,589,590, 595,597,600,604,607,610,628,630,636,641,642, 651,656,658,659,667,683,685,686,690,692,693, 703,709,713,715,716,718,720,721,722,723,724, 728,739,740,741,744,746,747,748,757,763,767, 776,778,780,792,793

P(435,7)-491 Suspended sediment, Adsorbed material - Water temperature:
One of the primary effects of suspended sediments is the increase in water temperature due to enhanced absorption of solar radiation.

Related References: 12,49,100,101,123,153,206,269,278,285,341, 349,359,360,371,372,373,409,448,470,549,557, 564,575,576,584,660,693,720,721,722,757,775, 782,784

P(435,7)-500 Suspended sediment, Adsorbed material - Wetland fauna:
The effects of suspended sediment on wetland fauna are numerous, occurring during all life history stages and including clogging of gills and filter-feeding apparatuses, smothering of eggs and young, reduced visibility, reduced oxygen concentrations, etc. For some classes of organisms, and to varying extents, increased suspended sediment concentrations may represent increased food sources (e.g., for detrital processers that glean bacteria and other microorganisms from small organic and inorganic particles).

Related References: 47,468

Table II-9. Continued

P(468,472)-35 Vegetation composition and structure - Bed-bank composition:
Wetland plants affect bed composition directly through exchange of water, nutrients, and other substances by roots. In addition, any dead plant parts that are deposited directly on or in the bed without extended residence in suspended form (in which case the plants would be affecting bed-bank composition through a four-way interaction, P468,472-435-352-35) represent an alteration of the bed composition.

Related References: none

P(468,472)-38 Vegetation composition and structure - Bed-bank texture and structure:
The' direct effects of wetland plants on bed-bank texture and structure (again, separate from indirect effects that are displayed through either suspended sediment or non-adsorbed chemical pool components) are primarily due to root activities such as anchoring.

Related References: none

P(468,472)-150 Vegetation composition and structure - Flow geometry:
Wetland plants affect flow patterns primarily through reducing flow velocities (and promoting sedimentation) and rerouting flow. This effect is greatest for rooted macrophytes and depends on plant architecture.

Related Reference: 243

P(468,472)-179 Vegetation composition and structure - Habitat structure:
Wetland plants, particularly the rooted forms, provide a key element of habitat structure, often as refugia, ambush sites, or reproductive sites.

Related References: none

P(468,472)-267 Vegetation composition and structure - Organic-inorganic chemical pool (non-adsorbed):
This interaction represents the contribution of wetland plants to the non-adsorbed chemical pool in the water column. Most important here are gases, due to the photosynthesis/respiration CO_2-O_2 turnover. Rooted plants adsorb nutrients or toxins primarily through the bottom sediments, but free-floating or attached plants may absorb all their materials through the water column and are thus greatly affected by the non-adsorbed pools.

Related Reference: 436

P(468,472)-(435,7) Vegetation composition and structure - Suspended sediment, Adsorbed material:
Wetland plants, especially rooted macrophytes, increase roughness arid decrease flow velocity, thus encouraging sedimentation. For this reason, wetlands can be important filters of sediment-laden waters, and often accrete because of this activity (in addition to the accumulation of dead organic matter). The structure of the vegetation is important here.

Related References: none

P(468,472)-491 Vegetation composition and structure - Water temperature:
Wetland plant structure, as determined by composition, plays a large role in the regulation of water temperature, principally through shading.

Related References: none

P(468,472)-500 Vegetation composition and structure - Wetland fauna:
Wetland plants provide food sources either directly, for herbivores, or indirectly, as surfaces for periphyton development (which grazers exploit), or through decomposition pathways. They may also provide reproductive surfaces (mating sites, egg deposition, etc.), may lower water temperature, may increase dissolved oxygen concentrations (particularly important in stagnant waters), etc.

Related Reference: 468

P483-150 Water depth - Flow geometry:
Water depth is a function of flow geometry.

Related References: 56,68,103,117,195,258,314,338,344,351,389, 390,409,434,448,449,470,525,614,618,621,648, 733,766,775,782,784

P483-(468,472) Water depth - Vegetation composition and structure:
Water depth determines in part the plant species that will be able to establish, survive, and grow in a given area of the wetland, and by affecting species composition it likewise affects vegetation structure.

Related References: hone

P483-(484,494) Water depth '- Water diversion or withdrawal:
Spatial and temporal patterns in water depth, as modified by flow geometry and wetland morphology, will influence decisions on the tapping of wetland waters.

Related References: none

Table II-9. Continued

P483-486 Water depth - Water level regulation:
Spatial and temporal patterns of water depth, as modified by flow geometry and wetland morphology, will influence decisions on the regulation of water levels in the wetland, often in conjunction with water withdrawal.

Related References: 48,413,564,762

P483-491 Water depth - Water temperature:
Water depth is related to water temperature (and particularly temperature profiles) through the attenuation of light. Cooler bottom waters significantly affect wetland vegetation and fauna.

Related References: 409,448,470,564

P483-500 Water depth - Wetland fauna:
Water depth (particularly spatial and temporal fluctuations in depth) directly affects wetland fauna. Depth also influences fauna indirectly through water temperature and other factors.

Related References: none

P(484-494)-122 Water diversion or withdrawal - Exported material:
The contribution of water withdrawal to total quantities of materials exported from the wetland is represented here.

Related References: none

P(484,494)-150 Water diversion or withdrawal - Flow geometry:
The removal or rerouting of wetland waters will influence spatial and temporal flow geometry.

Related References: none

P(484,494)-483 Water diversion or withdrawal - Water depth:
The removal or rerouting of wetland waters will influence spatial and temporal patterns of water depth in the same manner that they influence flow geometry.

Related References: none

P(484,494)-502 Water diversion or withdrawal - Wetland morphology:
If water diversion or withdrawal involves physical alteration of wetland configuration (through ditching, channelization of existing natural channels, etc.), wetland morphology is affected.

Related References: none

P486-483 Water level regulation - Water depth:
Intentional regulation of wetland water levels for reasons other than water diversion or withdrawal will also affect spatial-temporal patterns of water depth.

Related References: 48,413,564,762

p486-(484,494) Water level regulation - Water diversion or withdrawal:
This interaction represents the interplay between two avenues whereby wetland waters are intentionally altered, though for different reasons. In wetlands in which both sets of forces are operable, decisions to regulate water levels for reasons other than withdrawal or diversion will be influenced by the latter two objectives, and vice versa.

Related Reference: 178

P488-503 Water quality - Wetland use:
Water quality may affect several forms of wetland use, from recreation to water withdrawal.

Related References: none '

P491-267 Water temperature - Organic-inorganic chemical pool (non-adsorbed):
Water temperature affects the states and conversions of non-adsorbed chemical species in the water column. From the perspective of the biota, water temperature plays a critical role in the dissolution of gases and their maximum possible concentrations.

Related References: 100,265,269,371,373,409,549,575,576,720,721,722,757

P491-(435,7) Water temperature - Suspended sediment, Adsorbed material:
The effects of water temperature on suspended sediments are similar to those of water temperature on non-adsorbed chemicals--primarily regulators of chemical activity.

Related References: 12,49,100,101,123,153,206,269,278,285,341,349,359,360,371,372,373,409,448,470,549,557,564,575,576,584,660,693,720,721,722,757,775,782,784

P491-(468-472) Water temperature - Vegetation composition and structure:
Water temperature affects wetland plant metabolism, growth, and survival, either directly or indirectly (the latter by influencing chemical pools, adsorbed or non-adsorbed, and fauna, especially pathogens).

Related References: none

P491-500 Water temperature - Wetland fauna:
Water temperature is a critical regulator of habitat suitability for wetland fauna, affecting respiration rates, pathogen susceptibility, plant food sources, etc.

Related References: none

P500-35 Wetland fauna - Bed-bank composition:
This interaction represents the direct influence of fauna on the composition of the bed or bank (i.e., not involving significant residence in suspension in the water column). Examples would be the activities of bottom-dwellers (exchange with sediments), or direct deposition or incorporation of materials on or into the sediments by non-benthic animals.

Related References: none

P500-38 Wetland fauna - Bed-bank texture and structure:
Wetland animals affect the texture and structure of bed or bank sediments through bioturbation (burrowing, nest construction, defense, feeding, etc.) which may cause sediment resuspension and increased aeration, in addition to loosening of bed materials.

Related References: none

P500-267 Wetland fauna - Organic-inorganic chemical pool (non-adsorbed):
This interaction represents the alterations of the non-adsorbed chemical pools by wetland fauna, including the intake of gases, nutrients, and toxins during feeding and respiration; excretion of gases and other wastes; and decay following death.

Related Reference: 47

P500-(435,7) Wetland fauna - Suspended sediment, Adsorbed material:
The effects of wetland animals on suspended sediments are primarily due to resuspension by bioturbation (P500-38) and the intentional or inadvertent processing of sediment, particulate organic matter, and adsorbed materials through filter-feeding or ingestion and other functions such as respiration.

Related References: 47,468

P500-(468,472) Wetland fauna - Vegetation composition and structure:
Wetland fauna affect plants through feeding (herbivory or grazing), burrowing (and root disruption), waste excretion (directly onto the plants), pathogen transfer, pollination, etc.

Related Reference: 468

P500-503 Wetland fauna - Wetland use:
Wetland animals affect wetland uses in many ways, most often by increasing their value as fish and wildlife habitats (often breeding sites) and hence for outdoor recreation.

Related References: none

P501-194 Wetland filling - Imported material:
Materials used to fill all or part of a wetland may significantly contribute to total amounts of material imported into the wetland.

Related References: none

P501-(484,494) Wetland filling - Water diversion or withdrawal:
Filling of portions of a wetland may represent an integral part of overall plans to divert wetland flows. If such is not the case, independent filling decisions may influence other decisions involving diversion or withdrawal.

Related References: none

P501-502 Wetland filling - Wetland morphology:
Filling portions of a wetland alters wetland morphology.

Related References: none

P502-150 Wetland morphology - Flow geometry:
Wetland morphology influences flow geometry by determining general features of the flow geometry, and may also influence spatial patterns of velocity, turnover rates, etc.

Related References: none

P502-179 Wetland morphology - Habitat structure:
The morphology of the wetland will determine, in large part, the potential diversity in habitat structure across the wetland. Other variables related to this effect are flow geometry, water depth, and vegetation structure.

Related References: none

P502-483 Wetland morphology - Water depth:
In conjunction with flow geometry, riverine or lacustrine wetland morphology will determine the spatial and temporal patterns of water depth in the wetland.

Related References: none

P502-501 Wetland morphology - Wetland filling:
The current morphology of the wetland will influence decisions regarding wetland filling: feasibility, which portions to fill, etc.

Related References: none

P503-150 Wetland use - Flow geometry:
Wetland use may alter flow geometry.

Related References: none

Table II-9. Concluded

P503-267 Wetland use - Organic-inorganic chemical pool (non-adsorbed): Certain uses of wetlands contribute to non-adsorbed chemical pools. Examples are sewage outfalls, boat petroleum wastes, etc.

Related References: none

P503-311 Wetland use - Recreation: This interaction represents outdoor recreation as one form of wetland use. In addition, all other wetland uses not included in the model as separate components may affect recreation in the wetland.

Related References: none

P503-(484,494) Wetland use - Water diversion or withdrawal: All wetland uses not included here as separate components may affect decisions regarding water diversion or withdrawal.

Related References: none

P503-486 Wetland use - Water level regulation: All wetland uses not included here as separate components may affect decisions regarding water level regulation.

Related References: none

P503-501 Wetland use - Wetland filling: All wetland uses not included here as separate components may affect decisions regarding wetland filling.

Related References: none

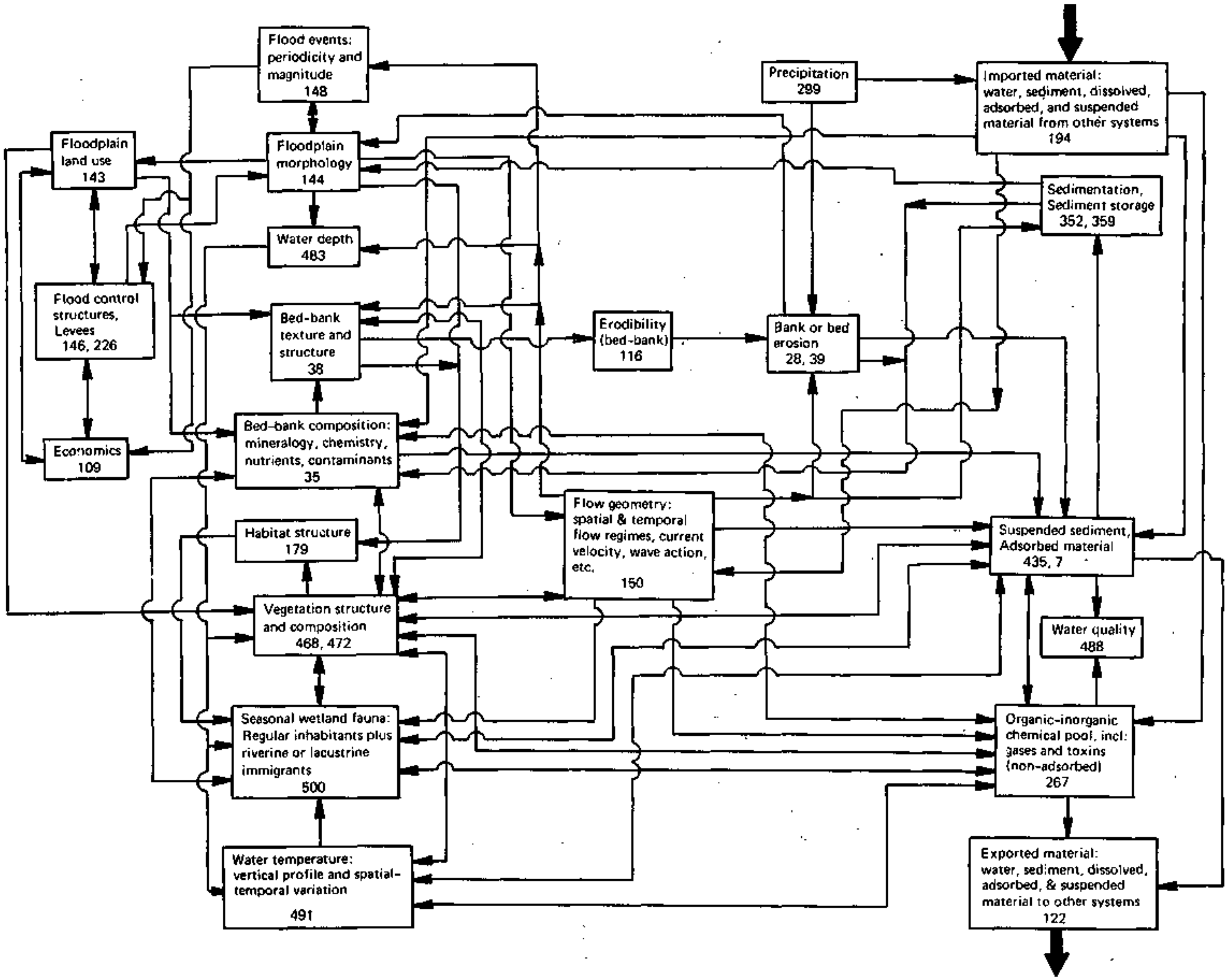


Figure II-15. Level II model for the Seasonal Wetland Subsystem

Seasonal Wetland Subsystem

Model Description and Model Interactions. Figure II-15 shows the Level II model for the Seasonal Wetland Subsystem. The Seasonal Wetland Subsystem contains all areas that are seasonally inundated and have emergent vegetation (herbaceous or woody). These are either 1) river floodplains, 2) lacustrine fringes, or 3) upland depressions that are inundated long enough to alter vegetation composition and structure toward a wetland aspect. In Illinois, river and stream floodplains are the predominant seasonal wetland. Applying this general description in a rigorous manner may lead to ambiguity. For example, a depression in a corn field that has been inundated by standing water for two weeks is not a seasonal wetland since the vegetation of this upland depression has not been altered by flooding toward a true wetland composition and structure.

There is a sense in which an inundated river floodplain may be considered as an extension of the river channel. However, the morphology, substrate, biota, and particularly the responses of these three factors to flood events make it useful to distinguish between this subsystem and the Riverine System.

Though components and interactions depicted in the Permanent and Seasonal Wetland Subsystem models are quite similar, particularly in the right two-thirds of the diagrams, the dynamics of these two subsystems are strikingly different. This is true for two principal reasons:

1) The movement of water over the seasonal wetland substrate is an intermittent, somewhat, unpredictable event, usually occurring during spring flooding. The substrate and the vegetation, though affected and to a degree altered by flood forces, are often not true wetland substrates and vegetation. The net result is the probability of

much greater erosional disturbance by any given flood event, particularly in areas that are infrequently flooded with low predictability.

2) The seasonal inundation allows uses of the floodplain in other parts of the year that may generate soil conditions conducive to massive erosion and sedimentation during flood stages. This is particularly true for intensive agriculture in annually flooded bottomlands, since fields are often plowed in the fall and left exposed during spring thaw and heavy rainfall.

These differences are illustrated by the inclusion of flood events, periodicity and magnitude (S148); floodplain land use (S143); and levees and other flood control structures (S146) in the model. The buffering role of vegetation in reducing flood water velocities, encouraging sedimentation, and anchoring the substrate is substantially more important in seasonal wetlands versus permanent wetlands. This includes both natural floodplain vegetation and even agricultural vegetation since plant cover due to pasture, hayfield, or row crops may be just as effective in reducing erosion. Of course this effectiveness may result in serious sedimentation and crop loss.

The relationships between floodplain land use (S143) and economics (S109) are more complex than in permanent wetlands due to the variable risks associated with the interacting magnitudes of investment and potential flood damage. In Illinois the conflict will often be played out on the farm, where the benefits of nutrient subsidy provided by floods that result in higher crop yields are periodically offset by reduced yields or serious crop losses due to major flood damage.

The detailed interactions for this model are described in Table II-10.

Table II-10. Descriptions of Interactions for the Seasonal Wetland Subsystem Model

Interaction code	Description
S(28,39)-35	Bank or bed erosion - Bed-bank composition: (same as P(28,39)-35) Related References: 525
S(28,39)-144	Bank or bed erosion - Floodplain morphology: The removal of sediments through bed or bank erosion changes the morphology of the floodplain on either small or large scales, depending on erosion rates. Subsequent flow geometry and all associated components may be affected. Related References: none
S(28,39)-(435,7)	Bank or bed erosion - Suspended sediment, Adsorbed material: (same as P(28,39)-(435,7)) Related References: 143,159,242,525
S35-38	Bed-bank composition - Bed-bank texture and structure: (same as P35-38) Related References: 158,217,254,269,361,579,732
S35-267	Bed-bank composition - Organic-inorganic chemical pool (non-adsorbed): (same as P35-267) Related References: 8,26,27,30,98,102,113,115,139,145,230,260, 265,268,269,318,322,352,364,370,371,372,373, 396,420,435,466,476,483,555,559,572,576,597, 600,629,630,650,657,659,670,688,691,715,720, 721,722,757
S35-(435,7)	Bed-bank composition - Suspended sediment, Adsorbed material: (same as P35-(435,7)) Related Reference: 254
S35-(468,472)	Bed-bank composition - Vegetation composition and structure: (same as P35-(468,472)) Related References: none

Table II-10. Continued

S35-500 Bed-bank composition - Wetland fauna:
(same as P35-500)

Related References: none

S38-116 Bed-bank texture and structure - Erodibility:
(same as P38-116)

Related References: none

S38-179 Bed-bank texture and structure - Habitat structure:
(same as P38-179)

Related References: none

S38-(468,472) Bed-bank texture and structure - Vegetation composition and structure:
(same as P38-(468,472))

Related References: none

S109-(146,226) Economics - Flood control structures, Levees:
Projected costs and benefits of levees or other flood control structures, as weighed against probabilities of flood damage of varying magnitudes, will influence decisions on their construction.

Related References: none

S109-143 Economics - Floodplain land use:
Cost-benefit considerations influence nearly all forms of floodplain land use They may become the central focus around which discussions or controversies about proposed floodplain uses revolve, in either the private sector *or* public works projects.

Related Reference: 321

S1l6-(28,39) Erodibility - Bank or bed erosion:
(same as P116-(28,39))

Related References: 2,17,38,10,51,56,106,107,131,165,174,180, . 187,194,197,211,237,239,241,253,258,290,319, 390,406,427,430,453,460,462,472,479,556,582, 646,654,678,726,752,760,777,778

S143-35 Floodplain land use - Bed-bank composition:
The composition of the bed or bank may be altered by certain land uses, such as agriculture (fertilization and pesticides). This interaction thus represents the direct addition or removal of materials to or from the floodplain substrate by a particular land use.

Related References: none

Table II-10. Continued

S143-38 Floodplain land use - Bed-bank texture and structure: Similar to their effects on bed-bank composition, floodplain land uses may significantly alter bed-bank texture and structure. Again, bottomland agriculture is a prime example, particularly row crops.

Related References: none

S143-109 Floodplain land use - Economics: Many forms of land use in the floodplain will involve economics; specific land uses will carry individual sets of economic implications.

Related Reference: 321

S143-144 Floodplain land use - Floodplain morphology: Floodplain morphology may be altered by specific land uses on either small or large scales.

Related References: none

S143-(146,226) Floodplain land use - Flood control structures, Levees: Many floodplain land uses will require, or at least benefit from, the construction of flood control systems. This interaction represents the benefits that existing land uses may experience from such systems, and thus differs from S(146,226)-143, which deals with the potential for new, previously absent land uses made possible by flood control.

Related References: none

S143-(468,472) Floodplain land use - Vegetation composition and structure: This interaction refers to the wide range in states of plant cover that result from different land uses in floodplains. Of particular importance are row-crop agriculture and forests in bottomlands; the former may contribute enormous sediment loads through floodplain scour during flood events, while the latter are generally recognized as purifiers of sediment laden waters. The role of forested wetlands in the management and preservation of fish and wildlife resources has recently become a national issue.

Related References: none

S144-143 Floodplain morphology - Floodplain land use: Existing floodplain morphology will affect whichever variety of potential land uses are feasible (on the basis of morphology alone, as opposed to the effect of morphology on flood events and then on proposed land uses).

Related References: none

S144-148 Floodplain morphology - Flood events:
Floodplain morphology directly impacts flood stages and indirectly and minimally impacts flood events.

Related References: none

S144-150 Floodplain morphology - Flow geometry:
Floodplain morphology and flow geometry are directly interrelated.

Related References: none

S144-179 Floodplain morphology - Habitat structure:
(same as P502-179)

Related References: none

S144-483 Floodplain morphology - Water depth:
(same as P502-483)

Related References: none

S(146,226)-109 Flood control structures, Levees -Economics:
In contrast to S109-(146,226), which deals with the effects of economics on proposed flood control structures, this interaction signifies the effects of existing structures on subsequent cost-benefit concerns.

Related References: none

S(146,226)-143 Flood control structures, Levees - Floodplain land use:
The presence or absence of flood control structures, and the current flood periodicity and magnitude, will determine the feasibility of a given land use in the floodplain, apart from any economic considerations (which are under S109-143).

Related References: none

S(146,226)-144 Flood control structures, Levees - Floodplain morphology:
Flood control structures represent an alteration of floodplain morphology for the purpose of controlling flood flow geometry. Such structures have additional indirect effects on floodplain morphology through their influence on flow geometry and thus erosion/sedimentation patterns. This is an example of a fifth-order interaction: S(l46,226)-l44-150-(28,39)(or 352)-l44.

Related References: none

S148-109 Flood events - Economics:
The spatial and temporal patterns of flood occurrence (especially periodicity and magnitude) will influence cost-benefit considerations regarding activities in the wetland.

Related References: 250,308,466,603,652,653,709,740

Table II-10. Continued

S148-144 Flood events - Floodplain morphology:
This interaction emphasizes the alteration of floodplain morphology by flood waters. The same interaction could be traced through flow geometry, erosion or sedimentation, and then morphology (S150-(28,39)(or 352)-l44).

Related References: none

S148-(146,226) Flood events - Flood control structures, Levees:
Two distinct effects are shown here. The first is the direct effect of flood waters on flood control structures. The second effect is more general and refers to the influence of spatial and temporal patterns of flood occurrence (especially periodicity and magnitude) on decisions to build levees or other structures.

Related Reference: 702

S150-(28,39) Flow geometry - Bank or bed erosion:
Bank or bed erosion requires the detachment and transport of sediment. Flow variables that influence both of these processes are included here.

Related References: 66,103,257,258,263,525,541,561,570,674,
696,746

S150-38 Flow geometry - Bed-bank texture and structure:
(same as P150-38)

Related References: 66,217,254,328,434,448

S150-148 Flow geometry - Flood events:
Flood events are represented in this model as the convergence of floodplain morphology, flow geometry, and rainfall-runoff relationships.

Related References: 64,68,148,258,263,308,437,438,466,581,
618,790

S150-267 Flow geometry - Organic-inorganic chemical pool (non-adsorbed):
(same as P150-267)

Related References: 4,59,80,81,129,230,314,347,373,389,409,417,
424,435,465,466,475,559,597,623,650,757,791

S150-(352,359) Flow geometry - Sedimentation, Sediment storage:
(same as P150-(352,359))

Related References: 3,4,49,60,61,62,63,65,66,67,80,81,87,93,106,
108,117,119,129,169,170,172,173,193,198,205,
206,218,263,276,277,282,314,327,328,332,335,
338,339,347,348,350,351,366,398,405,406,409,
417,437,446,448,449,454,465,466,488,489,490,
497,498,499,515,526,537,541,557,570,614,615,
618,623,640,643,647,668,674,693,732,733,746,
771,775,781,785,787

S150-(435,7) • Flow geometry - Suspended sediment, Adsorbed material:
(same as P150-(435,7))

Related References: 2,3,4,6,13,49,56,59,60,61,62,63,65,66,67,68,
72,80,81,87,93,101,106,108,117,119,129,148,
169,170,172,173,193,197,198,205,206,212,216,
217,218,254,263,276,277,278,282,285,291,301,
305,314,327,328,329,332,335,336,338,339,344,
347,348,350,351,366,373,393,397,398,405,406,
409,417,434,437,438,443,446,448,449,454,465,
466,470,475,488,489,490,491,497,498,499,506,
509,515,516,525,526,527,537,541,557,559,570,
590,597,613,614,615,618,619,621,623,640,643,
647,660,668,674,675,693,723,732,733,736,745,
746,757,771,775,781,782,784,785,787,788,791

S150-(468,472) Flow geometry - Vegetation composition and structure:
(same as P150-(468,472))

Related References: 243,350

S150-483 Flow geometry - Water depth:
(same as P150-483)

Related References: 56,68,103,117,195,258,314,338,344,351,389,
390,409,434,448,449,470,525,614,618,621,648,
733,766,775,782,784

S150-500 Flow geometry - Wetland fauna:
(same as P150-500)

Related References: none

S179-500 Habitat structure - Wetland fauna:
(same as P179-500)

Related References: none

S194-35 Imported material - Bed-bank composition:
This interaction refers to the physical or chemical alteration of bed or bank composition by the direct addition of imported materials (as opposed to material that is added to waters, remains in suspension for awhile, and then settles out). Because of the greater variety of land uses that are routinely employed in seasonal wetlands, a correspondingly larger variety of imported materials may influence bed or bank composition.

Related References: 26,125,152,269,317,377,476,487,494,555,571, . 572,579,716,747

S194-150 Imported material - Flow geometry:
(same as P194-150)

Related References: none

S194-267 Imported material - Organic-inorganic chemical pool (non-adsorbed):
(same as P194-267)

Related References: 26,269,476,555,572,690

S194-(435,7) Imported material - Suspended sediment, Adsorbed material:
(same as P194-(435,7))

Related References: 26,125,152,269,317,377,476,487,494,555,571, 579,690,716,747

S267-35 Organic-inorganic chemical pool (non-adsorbed) - Bed-bank composition:
(same as P267-35)

Related References: 8,26,27,30,98,102,113,115,139,145,230,260, 265,268,269,318,322,352,364,370,371,372,373, 396,420,435,466,476,483,555,559,572,576,597, 600,629,630,650,657,659,670,688,691,715,720, 721,722,757

S267-122 Organic-inorganic chemical pool (non-adsorbed) - Exported material:
(same as P267-122)

Related References: 26,269,476,555

S267-(435,7) Organic-inorganic chemical pool (non-adsorbed) - Suspended sediment, Adsorbed material:
(same as P267-(435,7))

Related References: 4,8,26,27,30,44,47,59,69,77,80,81,88,89,98, 100,102,129,135,139,140,159,166,174,175,176, 189,194,200,203,209,220,223,224,245,260,268, 269,272,311,314,315,316,318,322,331,333,342, 346,347,352,356,364,371,372,373,396,409,417, 420,445,457,465,466,472,475,476,483,544,549, 550,555,559,572,575,576,577,586,591,597,600, 623,629,630,634,641,651,655,657,659,667,670, 685,686,688,690,691,692,713,715,720,721,722, 724,756,757,767,776,780,786,791,792

S267-(468,472) Organic-inorganic chemical pool (non-adsorbed) - Vegetation composition and structure:
(same as P267-(468,472))

Related Reference: 436

S267-488 Organic-inorganic chemical pool (non-adsorbed) - Water quality:
(same as P267-488)

Related References: 8,27,35,37,44,69,91,98,129,135,139,140,159, 174,175,178,203,209,220,223,224,230,232,234, 238,260,265,272,284,311,333,342,356,370,371, 372,373,388,409,414,420,445,472,478,483,520, 549,559,575,597,601,630,641,651,659,685,686, 690,692,713,715,720,721,722,724,731,757,767, 776,780,792

S267-491 Organic-inorganic chemical pool (non-adsorbed) - Water temperature:
(same as P267-491)

Related References: 100,265,269,371,372,373,409,549,575,576,720, 721,722,757

S267-500 Organic-inorganic chemical pool (non-adsorbed) - Wetland fauna:
(same as P267-500)

Related Reference: 47

S299-(28,39) Precipitation - Bank or bed erosion:
Precipitation variables related to raindrop size, velocity, and rainfall rates will influence the detachment of soil particles from exposed banks or floodplain substrates and will contribute directly to erosion rates.

Related Reference: 143

Table II-10. Continued

S299-194 Precipitation - Imported material:
Precipitation is one component of all materials imported into the wetland, consisting of water, dissolved chemicals, and small particles with adsorbed substances. One of the major effects of precipitation as an imported material would be on the pH of wetland waters.

Related Reference: 572

S(352,359)-35 Sedimentation, Sediment storage - Bed-bank composition:
(same as P(352,359)-35)

Related References: 8,24,27,63,67,98,119,248,269,310,317,318, 323,332,348,351,352,377,396,405,406,426,i»50, 451,465,466,467,482,483,494,542,562,565,596, 600,607,640,658,670,688,691,712,718,732,747, 748,781,785

S(352,359)-144 Sedimentation, Sediment storage - Floodplain morphology:
(same as P(352,359)-502)

Related References: none

S(435,7)-122 Suspended sediment, Adsorbed material - Exported material:
(same as P(435,7)-122)

Related References: 393,596,693,759

S(435,7)-267 Suspended sediment, Adsorbed material - Organic-inorganic chemical pool (non-adsorbed):
(same as P(435,7)-267)

Related References: 4,8,26,27,30,44,47,59,69,77,80,81,88,89,98, 100,102,129,135,139,140,159,166,174,175,176, 189,194,200,203,209,220,223,224,245,260,268, 269,272,311,314,315,316,318,322,331,333,342, 346,347,352,356,364,371,372,373,396,409,417, 420,445,457,465,466,472,475,476,483,544,549, 550,555,559,572,575,576,577,586,591,597,600, 623,629,630,634,641,651,655,657,659,667,670, 685,686,688,690,691,692,713,715,720,721,722, 724,756,757,767,776,780,786,791,792

Table II-10. Continued

S(435,7)-(352,359) Suspended sediment, Adsorbed material - Sedimentation, Sediment storage:
(same as P(435,7)-(352,359))

Related References: 3,4,7,8,21 ,24,25.,27,42,44,45,48,49,54,60,61 , 62,63,65,66,67,69,73,75,76,77,78,80,81,87, 88,89,90,92,93,96,98,106,108,109,111,114, 115,117,119,126,127,128,129,130,135,136,138, 141,143,147,149,153,166,167,168,169,170,172, 173,175,180,188,193,194,198,203,204,205,206, 211 ,218,220,224,239,242,248,250,251,256,259, 263,269,272,276,277,281,282,283,287,302,306, 309,310,313,314,315,317,318,319,320,321,323, 327,328,332,333,334,335,338,339,340,346,347, 348,349,350,351,352,354,365,366,375,377,381 , 394,396,398,399,400,401,402,405,406,409,412, 417,421,426,437,438,439,441,446,448,449,450, 451,454,457,458,465,466,467,469,479,482,483, 488,489,490,492,493,494,495,496,497,498,499, 507,512,515,524,526,529,530,532,535,537,541, 542,544,546,547,552,557,562,563,564,565,568, 570,577,582,596,600,602,603,607,614,615,618, 623,638,639,640,641,643,644,645,646,647,651 , 654,658,662,667,668,670,674,678,679,680,681, 682,685,686,688,691,692,693,699,700,702,703, 704,707,709,712,718,724,727,732,733,742,746, 747,748,749,759,760,762,763,767,771,775,781, 785,787,792

S(435,7)-(468,472) Suspended sediment, Adsorbed material - Vegetation composition and structure:
(same as P(435,7)-(468,472))

Related References: 7,45,239,298,299,331,350,358,403,441,468, •586,589,778

S(435,7)-488 Suspended sediment, Adsorbed material - Water quality:
(same as P(435,7)-488)

Related References: 1,6,7,8,9,12,27,44,65,69,82,98,99,101,105, .109,123,129,135,139,140,144,159,174,175,179, 181,199,203,204,206,209,213,220,223,224,239, 242,251,260,271,272,278,291,297,302,311,312, 313,315,321,332,333,342,354,356,358,359,360, 361,371,372,373,376,383,397,398,401 ,407,409, 412,420,421,429,442,444,445,456,468,469,472, 474,482,483,484,493,494,499,508,524,542,549, 559,560,564,568,569,575,577,587,588,589,590, 595,597,600,604,607,610,628,630,636,641,642, 651 ,656,658,659,667,683,685,686,690,692,693, 703,709,713,715,716,718,720,721,722,723,724, 728,739,740,741,744,746,747,748,757,763,767, 776,778,780,792,793

S(435,7)-491 Suspended sediment, Adsorbed material - Water temperature:
(same as P(435,7)-491)

Related References: 12,49,100,101,123,153,206,269,278,285,341, 349,359,360,371,372,373,409,448,470,549,557, 564,575,576,584,660,693,720,721,722,757,775, 782,784

S(435,7)-500 Suspended sediment, Adsorbed material - Wetland fauna:
(same as P(435,7)-500)

Related References: 47,468

S(468,472)-35 Vegetation composition and structure - Bed-bank composition:
(same as P(468,472)-35)

Related References: none

S(468,472)-38 Vegetation composition and structure - Bed-bank texture and structure:
(same as P(468,472)-38)

Related References: none

S(468,472)-143 Vegetation composition and structure - Floodplain land use:
The existing vegetation of the river bank (or lakeshore) may influence proposed use of the floodplain (or lake fringe). This is particularly true for agricultural uses of bottomlands, where existing riparian forests may strongly affect field configurations. From the standpoint of resource conservation and outdoor recreation, the composition and structure of the vegetation may heavily influence wetland fauna and thus determine the suitability of a given floodplain wetland for a wildlife refuge, state park or natural area, etc.

Related References: none

S(468,472)-150 Vegetation composition and structure - Flow geometry:
(same as P(468,472)-150)

Related Reference: 243

S(468,472)-179 Vegetation composition and structure - Habitat structure:
(same as P(468,472)-179)

Related References: none

S(468,472)-267 Vegetation composition and structure - Organic-inorganic chemical pool (non-adsorbed):
(same as P(468,472)-267)

Related Reference: 436

S(468,472)-(435,7) Vegetation composition and structure - Suspended sediment, Adsorbed material:

Wetland plants, whether they are true, wetland species or simply inundated riparian or upland species, affect suspended sediments through increased roughness and reduced velocity. For this reason, seasonal wetlands can be important filters of sediment-laden waters. However, this function is commonly offset by land uses in the floodplain that increase soil exposure and erodibility and result in increased erosion and suspended sediment concentrations. This is a critical point of difference between permanent and seasonal wetlands.

Related References: none

S(468,472)—491 Vegetation composition and structure - Water temperature:
(same as P(468,472)-491)

Related References: none

S(468,472)-500 Vegetation composition and structure - Wetland fauna:
(same as P(468,472)-500)

Related Reference: 468

S483-150 Water depth - Flow geometry:
(same as P483-150)

Related References: 56,68,103,117,195,258,314,338,344,351,389, 390,409,434,448,449,470,525,614,618,621,648, 733,766,775,782,784

S483-(468,472) Water depth - Vegetation composition and structure:
(same as P483-(468,472))

Related References: none

S483-491 Water depth - Water temperature:
(same as P483-491)

Related References: 409,448,470,564

S483-500 Water depth - Wetland fauna:
(same as P483-500)

Related References: none

S491-267 Water temperature - Organic-inorganic chemical pool (non-adsorbed):
(same as P491-267)

Related References: 100,265,269,371,372,373,409,549,575,576,720, 721,722,757

Table II-10. Concluded

S491-(435,7) Water temperature - Suspended sediment, Adsorbed material:
(same as P491-(435,7))

Related References: 12,19,100,101,123,153.206,269,278,285,341, 319,359,360,371,372,373,409,448,470,549,557, 564,575,576,584,660,693,720,721,722,757,775, 782,784

S491-(468,472) Water temperature - Vegetation composition and structure:
(same as P491-(468,472))

Related References: none

S491-500 Water temperature - Wetland fauna:
(same as P491-500)

Related References: none

S500-35 Wetland fauna - Bed-bank composition:
(same as P500-35)

Related References: none

S500-38 Wetland fauna - Bed-bank texture and structure:
(same as P500-38)

Related References: none

S500-267 Wetland fauna - Organic-inorganic chemical pool (non-adsorbed):
(same as P500-267)

Related Reference: 47

S500-(435,7) Wetland fauna - Suspended sediment, Adsorbed material:
(same as P500-(435,7))

Related References: 47,468

S500-(468,472) Wetland fauna - Vegetation composition and structure:
(same as P500-(468,472))

Related Reference: 468

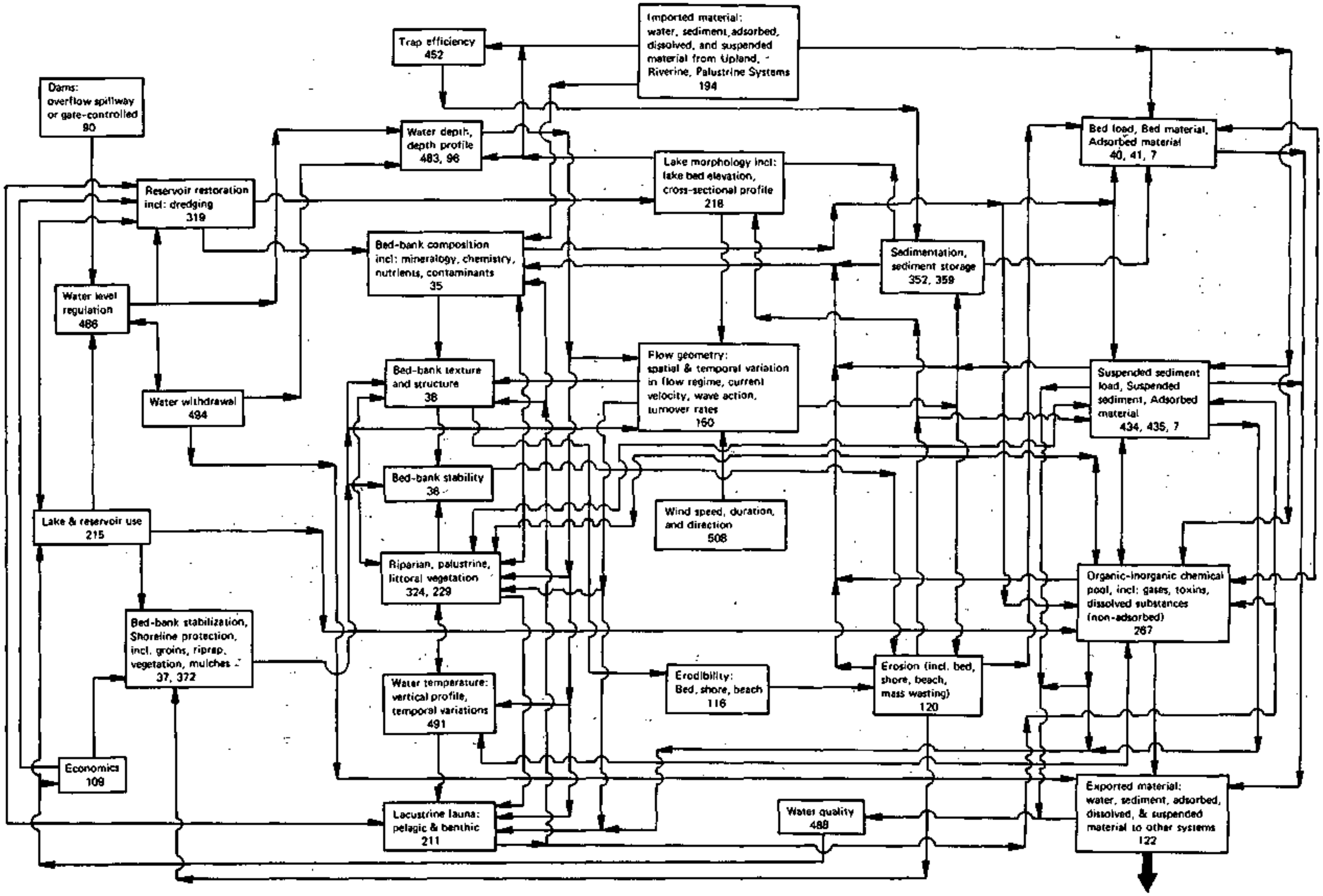


Figure II-16. Level II model for the Lakes and Reservoirs (Lacustrine) System

Lakes and Reservoirs (Lacustrine) System

Model Description and Model Interactions. Figure II-16 shows the Level II model for this system. The Level II model of the Lacustrine System shows the influence that lake or reservoir management and modifications of the system have on the sediment budget of the lake or reservoir. Although lakes in Illinois vary in size, water depth, origin (man-made or natural), and the nature of environmental concerns (beach and shoreline erosion on Lake Michigan vs. siltation in a particular lake or reservoir), efforts have been made to ensure application of the model to all types, including backwater lakes, farm ponds, man-made or natural lakes, oxbow lakes, and reservoirs.

The model can be broken down into four major categories from left to right: 1) water management and lake or reservoir use, as well as methods and types of alterations to the shoreline, water, or substrate; 2) physical characteristics of the lake or reservoir (including substrate composition and texture, water depth, and biota); 3) factors controlling water or sediment movement (erosion and sedimentation) within the system such as flow geometry and lake morphology, wind speed, and erodibility of shoreline or bed material; and 4) the quantity and composition of material involved in sedimentation and erosion within (and transported out of) the lake environment.

Lake or reservoir management and control are not clearly defined due to the wide range of uses and activities which can modify the natural or balanced state of the lake environment. In areas where shoreline erosion is causing extensive real estate loss, shoreline protection (as influenced by economics and lake or reservoir use) is the primary management influence on the system. In another area, a reservoir may be rapidly filling in with sediment, and water level regulation and watershed protection may be the primary management influence and may result in decisions to dredge or modify water withdrawal. These modifications on the lake system disrupt the physical characteristics of the lake or reservoir, such as bed or shore stability, water depth, bed or bank composition, and habitat structure. As illustrated in the model, there are many possible scenarios which describe the effect of human activities (both within the lake system and outside the system) on the sediment-budget and water quality of the lake or reservoir. One such example is as follows: the use of riprap for shoreline protection modifies the textural and structural characteristics of the shoreline. Addition of larger rock fragments to a shore, through their influence on bed and shore textural characteristics, improves stability and modifies the erodibility of the particular shoreline.. Erodibility, in conjunction with parameters such as wind speed, duration and direction, water depth, lake morphology, and any diversion structures along the shoreline, determines erosion and sedimentation of material along that shoreline.

Table II-11 gives the detailed interactions for the Lakes and Reservoirs System model.

This concludes the descriptions and interaction lists for all the Level II models. A listing of the keywords and their associated numbers is given right after Table II-11. A discussion of the keywords, which also form the Level II model components for all the models, is given in the introduction to this volume.

Table II-11. Descriptions of Interactions for the Lakes and Reservoirs (Lacustrine) System Model

Interaction code	Description
L35-38	Bed-bank composition - Bed-bank texture and structure: The composition of material along the shore and on the bed is correlated with the physical characteristics of the shore or bed. This correlation includes texture, particle size distribution, cohesiveness, etc. Related References: 217,269
L35-(40,41,7)	Bed-bank composition - Bed load, Bed material, Adsorbed material: This represents the influence of bed or shoreline material composition on the composition of materials carried along the lake bed. Related Reference: 217
L35-267	Bed-bank composition - Organic-inorganic chemical pool: This represents the influence of shoreline or bed material composition on the composition of materials in the water column (other than suspended sediment and adsorbed material). This involves dissolution or disaggregation of minerals, elements, or pollutants. Related References: 8,26,27,30,98,102,113,115,139,145,230,260, 265,268,269,318,322,352,361,370,371,372,373, 396,420,435,466,476,483,555,559,572,576,597, 600,629,630,650,657,659,670,688,691,715,720, 721,722,757
L35-(324,229)	Bed-bank composition - Riparian, palustrine, littoral vegetation: Bed and shore composition influence vegetation through nutrient content, favorability to plant growth, gas content, toxin content, etc. Related References: none
L35-(434,435,7)	Bed-bank composition - Suspended sediment load, Suspended sediment, Adsorbed material: This describes the influence of shoreline or bed material composition on the composition of suspended sediment and adsorbed material. Composition includes such variables as particle sizes, mineralogy, nutrients, or other contaminants. Related Reference: 254

L36-120 Bed-bank stability - Erosion:
The stability of bed or shore, especially oversteepened banks or bluffs, controls erosion.

Related References: 55,57,66,85,21 4, 247,257,258,403,413,430,483, 671,696

L(37,372)-36 Bed-bank stabilization, Shoreline protection - Bed-bank stability:
Shoreline protection by use of groins, riprap, seawalls, mulching, nourishment, etc., directly influences shore stability (including stability of all banks, beaches, bluffs, etc.). Shoreline protection measures vary depending on economic considerations, materials available, and nature of erosion problems. A protective measure in one area may cause increased erosion in another adjoining area.

Related References: none

L(37,372)-38 Bed-bank stabilization, Shoreline protection - Bed-bank characteristics:
Shoreline protection influences the physical characteristics of the bed or shore through the use of protective covers, nourishment with coarser sands on beaches, vegetation for stabilization of banks or substrates, etc.

Related References: 283,545

L(37,372)-150 Bed-bank stabilization, Shoreline protection - Flow geometry:
Shoreline protection influences on flow geometry include deflection of water (currents) through use of groins, or pilings. Riprap, mulches, vegetation, or other bank protection measures influence flow patterns only by breaking up the impact of waves or strong currents on the shore.

Related References: 52,117,197,301,304,305,337,390,516

L38-36 Bed-bank texture and structure -Bed-bank stability:
The physical characteristics of the bed or shoreline material (particle size distribution, cohesive strength) directly influence stability. This is especially important to shorelines characterized by steep banks or bluffs. This in conjunction with the influence of flow patterns determines stability.

Related References: none

L38-116 Bed-bank texture and structure - Erodibility:
The physical characteristics of the bed or shore, including grain size distribution, fluidity, and cohesiveness, directly influence the potential for erosion to occur. All the variables which influence texture and structure, therefore, indirectly influence the potential for erosion to occur.

Related References: none

L38-211 Bed-bank texture and structure - Lacustrine fauna:
Substrate characteristics influence the feeding and dwelling habits of lacustrine biota and limit the occurrence of some species from areas where food availability is scarce or the substrate is too hard or soft.

Related References: none

L38-(324,229) Bed-bank texture and structure - Riparian, palustrine, littoral vegetation:
Bed and shoreline material characteristics influence the growth of vegetation through favorability to root growth, degree of aeration, substrate cohesiveness, texture, etc.

Related Reference: 693

L(40,41 ,7)-120 Bed load, Bed material, Adsorbed material - Erosion:
This describes the influence of bed material characteristics on bed erosion and scour.

Related References: 26,125,152,208,217,269,317,377,393,437,476, 487,494,535,555,571,579,614,716,747

L(40,41,7)-122 Bed load, Bed material, Adsorbed material - Exported material:
This represents the carrying of sediment and adsorbed material out of the system by saltation or rolling along the lake bed.

Related References: 208,217,393,437,535,614

L(40,41,7)-267 Bed load, Bed material, Adsorbed material - Organic-inorganic chemical pool:
This represents the exchange of substances between bed load material and material (other than sediment and adsorbed material) within the water column. This is influenced by water temperature, flow velocity, characteristics of the bottom sediment, disturbance of the bottom, etc. From the standpoint of biota, the exchange of dissolved gases is especially important.

Related References: none

L90-150 Dams - Flow geometry:
This describes the relationship between dams and the flow of water within the reservoir.

Related References: 1,148,169,258,277,424,619,623,696

L90-486 Dams - Water level regulation:
Dams are used as a means for controlling water level. Dams, whether fixed spillway or gate controlled, will alter flow patterns (especially when the lake's formation resulted from the construction of a dam on a particular river).

Related References: 277,421,619,679,696,762

L109-(37,372) Economics - Bed-bank stabilization, Shoreline protection:
Cost/benefit ratios determine the methods of protection or restoration of beaches, bluffs, or banks. This is especially important where valuable real estate is being lost to erosion.

Related References: 51,307,512,694

L109-319 Economics - Reservoir restoration:
Cost / benefit ratios determine the methods of restoration (if any) as influenced by water use requirements, trapping efficiency, sediment load from upland sources, biological need, etc.

Related References: 51,456,475,497,523,550

L116-120 Erodibility - Erosion:
The erodibility of bed, bank, or beach, as influenced by structure and texture, along with flow geometry, directly influences the amount and type of material removed by erosion.

Related References: 2,17,38,40,51,56,106,107,131,165,174,180, 187,194,197,211,237,239,241,253,258,290,319, 390,406,427,430,453,460,462,472,479,556,582, 646,654,678,726,752,760,777,778

L120-35 Erosion - Bed-bank composition:
Removal of material from the bed or shore by erosion modifies composition of the material.

Related References: 8,26,30,38,56,58,67,68,72,102,110,118,119, 125,140,148,152,154,158,181,217,248,254,260, 266,269,278,317,318,323,332,336,352,361,364, 377,392,396,411,420,426,450,451,474,476,482, 483,484,487,494,517,525,538,542,555,562,571, 579,597,600,607,620,621,629,630,642,649,650, 656,658,669,670,684,688,691,712,714,715,716, 717,718,732,747,748,781,785

L120-36 Erosion - Bed-bank stability:
Undercutting by the erosive action of water may produce a more unstable slope, thus reducing stability.

Related References: 55,57,66,85,214,247,257,258,403,413,430,483, 671,696

Table II-11. Continued

L120-(37,372) Erosion - Bed-bank stabilization, Shoreline protection:
The rate and location of erosion directly influence the need for shoreline protection. Erosion rates, in conjunction with cost/benefit ratios, influence the shoreline protection measure taken.

Related References: 16,51,52,117,163,197,283,301,304,305,307,
337,390,512,516,545,694,792

L120-(40,41 ,7) Erosion - Bed load, Bed material, Adsorbed material:
This describes the transport of material along the lake bed through the erosive action of water.

Related References: 26,125,152,208,217,269,317,377,393,437,476,
487,494,535,555,571 ,579,614,716,747

L120-218 Erosion - Lake morphology:
The process of erosion and thus the removal of material from a lacustrine bed or shoreline results in a modification of lake morphology. This can be a large- or small-scale influence.

Related References: 282,283,303,304,306,390,421,450,645

L120-(434,435,7) Erosion - Suspended sediment load, Suspended sediment, Adsorbed material:
This represents the suspension of material through the erosive action of water, and dislodgement of material from bed or shoreline.

Related References: 9,30,60,80,81,125,143,152,159,175,177,181,
212,245,253,287,317,346,347,360,377,398,442,
462,488,525,540,562,579,597,600,607,630,693,
707,716,747,767

L150-38 Flow geometry - Bed-bank texture and structure:
Flow regimes and hydraulic geometry influence the textural characteristics of bed or bank through sorting, sedimentary structures, and grain size distribution.

Related References: 217,328,488

L150-120 Flow geometry - Erosion:
Flow geometry, including velocity profiles and wave action, influences erosion rates. This is influenced by the erodibility of bed or shoreline material, the relative position of the lake bed or shore with regard to current or wave action, and the wind speed and duration (with regard to wave action).

Related References: 2,3,4,6,56,57,60,61,63,67,68,72,80,81,106, 108,116,119,129,148,169,170,172,173,193,198, 205,206,212,217,247,254,258,263,276,277,278, 296,314,327,328,329,332,335,336,338,339,347, 350,357,393,397,398,406,417,424,437,438,446, 448,449,475,488,525,537,541,561,570,597,613, 614,615,621,647,650,660,668,674,693,696,732, 733,745,746,771,775,781,785,787

L150-211 Flow geometry - Lacustrine fauna:
Flow geometry and velocity profiles influence the distribution of certain fauna through tolerance for certain physical conditions such as current strength or wave intensity. Flow patterns also influence chemical distribution, suspended sediment, and suitable surfaces for feeding, reproduction, etc.

Related Reference: 757

L150-(324,229) Flow geometry - Riparian, palustrine, littoral vegetation:
Flow geometry and velocity profiles influence the distribution of certain flora through tolerance for certain physical conditions such as wave action or energy content of the flow.

Related References: 590,693

L150-352 Flow geometry - Sedimentation:
Flow geometry, including velocity profiles and wave action, influences sedimentation rates. This is especially important with regard to wave action, and the temporal variations which occur.

Related References: 3,4,49,60,61,62,63,65,67,80,81,87,106,108, 119,129,169,170,172,173,193,198,205,206,218, 263,276,277,314,327,328,332,335,338,339,347, 348,350,351,366,398,405,406,417,437,438,446, 448,449,454,465,466,488,489,490,498,499,515, 526,537,541,557,570,614,615,618,623,640,643, 647,668,674,693,732,733,746,771,775,781,785, 787

L194-35 Imported material - Bed-bank composition:
Material brought into the system from the uplands, rivers, or wetlands may influence the composition of material on the shore-line and lake bed.

Related References: 26,125,152,269,317,377,476,487,494,555,571, 572,579,716,747

L194-(40,41 ,7) Imported material - Bed load, Bed material, Adsorbed material:
This describes the transport of material from outside of the system by bed load or saltation transport.

Related References: 26,125,152,269,317,377,476,487,494,555,571, 579,716,747

L194-267 Imported material - Organic-inorganic chemical pool:
This represents the direct influx of chemical species (not adsorbed to sediment) into the lacustrine environment from outside sources. This transport occurs through rivers or overland flow, or through direct dumping.

Related References: 26,269,476,555,572,690

L194-(434,435,7) Imported material - Suspended sediment load, Suspended sediment, Adsorbed material:
This represents the direct influx of water and suspended material into the lacustrine environment from outside sources. The input source is one of the controls on the chemical composition and quantity of suspended sediment in the water.

Related References: 26,125,152,269,317,377,476,487,494,555,571, 579,690,716,747

L194-452 Imported material - Trap efficiency:
The imported materials, flow, and lake morphology (natural or designed) determine the trapping efficiency of the lake.

Related References: 93,254,256,275,276,310,316,449,450,475,564, 565,643,658,679,758

L211-35 Lacustrine fauna - Bed-bank composition:
Lacustrine fauna influence the composition of substrate through deposition of organic wastes and filtering of sediment.

Related Reference: 757

L211-38 Lacustrine fauna - Bed-bank texture and structure:
Lacustrine fauna modify substrate characteristics through feeding, crawling, swelling, etc. This may cause sediment resuspension, increased aeration, deposition of organic wastes, etc. Activities such as bioturbation loosen bottom sediment and increase the potential for erosion to occur.

Related References: none

Table II-11. Continued

L211-267 Lacustrine fauna - Organic-inorganic chemical pool:
This represents the exchange of chemical species between fauna and the water column. This includes the intake of gases, toxins, and nutrients during feeding and respiration.

Related References: 369,549,550,575,600,757

L211-319 Lacustrine fauna - Reservoir restoration:
Lacustrine fauna may influence the decision to restore a reservoir. The distribution and diversity of fauna, in conjunction with economics and the designated use for the particular lake or reservoir, influence the need for, and type of, restoration.

Related References: 549,550

L211-(434,435,7) Lacustrine fauna - Suspended sediment load, Suspended sediment, Adsorbed material:
Lacustrine fauna influence suspended sediment through the processing of sediment, particulate organic matter, and adsorbed material; through filter-feeding or ingestion; and through other functions such as respiration. Lacustrine fauna also increase suspended sediment and adsorbed material concentration through suspension of material (through crawling or bioturbation).

Related References: 575,600

L215-(37,372) Lake and reservoir use - Bed-bank stabilization, Shoreline protection:
Lake and reservoir use influences the need for beach or shore protection. In areas where the lake is primarily a recreational area, this becomes an important factor in deciding upon appropriate protection measures.

Related References: none

L215-267 Lake and reservoir use - Organic-inorganic chemical pool:
Human activities influence the composition of the water and thus its quality. Discharge of industrial, municipal, or agricultural waste has an adverse effect on the quality of water and its use for recreational, fishing, or drinking purposes.

Related References: none

L215-319 Lake and reservoir use - Reservoir restoration:
Preservation of a particular lake or reservoir for continued use requires periodic restoration. Restoration includes dredging to increase lake capacity.

Related References: none

L215-486 Lake and reservoir use - Water level regulation:
The designated use for a particular lake or reservoir as a water supply source, wildlife refuge, recreational area, etc., will influence decisions on design, storage capacity, and maintenance of water levels; and decisions on lifting or closing flood gates, dredging, etc.

Related References: none

L218-150 Lake morphology - Flow geometry:
The morphology of the lake or reservoir influences the spatial distribution of velocity structure, and overall flow geometry. Morphological controls on water-holding capacity, in conjunction with amount of and rate of imported water, determine the turnover rate within a lake or reservoir.

Related References: 282,304,351,390,419

L218-452 Lake morphology - Trap efficiency:
Lake morphology, whether natural or man-made, influences the rate and efficiency of sediment trapping.

Related References: 449,450,643

L218-483 Lake morphology - Water depth:
This describes the relationship of lake morphology to water depth, especially in regard to modifications of the morphology by dredging. The lake morphology or reservoir design directly influences water-holding capacity and depth profiles.

Related References: 306,351,390,449,450,614

L267-35 Organic-inorganic chemical pool - Bed-bank composition:
The influence of chemical species within the water column on the composition of the shoreline or bed materials is represented here.

Related References: 8,26,27,30,98,102,113,115,139,145,230,260, 265,268,269,318,322,352,364,370,371,372,373, 396,420,435,466,476,483,555,559,572,576,597, 600,629,630,650,657,659,670,688,691,715,720, 721,722,757

L267-(40,41,7) Organic-inorganic chemical pool - Bed load, Bed material, Adsorbed material:
This represents the exchange of substances between the chemical pool and bed load material. This is influenced by water temperature, flow velocity, characteristics of the bottom sediment, composition of bed and suspended material, particle size, etc.

Related References: 4,26,129,269,333,342,417,476,549,555,786

Table II-11. Continued

L267-122 Organic-inorganic chemical pool - Exported material: This represents the dissolved and suspended substances (which are not adsorbed to sediment) being carried to other systems in the water column. This includes the total content of the substances in the water column.

Related References: 26,269,476,555

L267-211 Organic-inorganic chemical pool - Lacustrine fauna: This represents the exchange of chemical species between lacustrine fauna and the water column, including the intake of nutrients, gases, and toxins during feeding and respiration. The major influences on the presence and distribution of fauna include pH, dissolved oxygen concentration, toxicity, and nutrient availability.

Related References: 369,549,550,575,600,757

L267-(324,229) Organic-inorganic chemical pool - Riparian, palustrine, . littoral vegetation: This represents the exchange of chemical species between lacustrine flora and the water column. Most important is the exchange of gases (due to photosynthesis and decay). Rooted plants take up nutrients or toxins primarily through bottom sediments, but free-floating or attached unicellular and multicellular plants adsorb all materials from the water column.

Related Reference: 629

L267-(434,435,7) Organic-inorganic chemical pool - Suspended sediment load, Suspended sediment, Adsorbed material: This represents the exchange of substances between suspended sediment and adsorbed material, and the chemical pool. This is influenced by water temperature, flow velocity, composition of suspended materials, particle size, etc. From the standpoint of biota, the exchange of dissolved gases is especially important.

Related References: 4,8,26,27,30,44,47,59,69,77,80,81 ,88,89,98, 100,102,129,135,139,140,159,166,174,175,176, 189,194,200,203,209,220,223,224,245,260,268, 269,272,311,314,315,316,318,322,331,333,342, 346,347,352,356,364,371,372,373,396,409,417, 420,445,457,465,466,472,475,476,483,544,549, 550,555,559,572,575,576,577,586,591,597,600, 623,629,630,634,641,651,655,657,659,667,670, 685,686,688,690,691,692,713,715,720,721,722, 724,756,757,767,776,780,786,791 ,792

Table II-11. Continued

L267-488 Organic-inorganic chemical pool - Water quality:
The chemical composition, concentrations of particular components, etc., directly influence the quality of the water in the same way they influence temperature, pH, dissolved oxygen concentration, flora and fauna, etc.

Related References: 8,27,35,37,44,69,91,98,129,135,139,140,159, 174,175,178,203,209,220,223,224,230,232,234, 238,260,265,272,284,311,333,342,356,370,371, 372,373,388,409,414,420,445,472,478,483,520, 549,559,575,597,601,630,641,651,659,685,686, 690,692,713,715,720,721,722,724,731,757,767, 776,780,792

L267-491 Organic-inorganic chemical pool - Water temperature:
This represents the influence of chemical species in the water column on water temperature. Trace metals or other impurities change the specific heat of water.

Related References: 100,371,372,373,409,576,720,721,722,757

L319-35 Reservoir restoration - Bed-bank composition:
The removal of material by dredging for restoration purposes modifies the composition of the lake bed.

Related References: 113,266,596,629

L319-211 Reservoir restoration - Lacustrine fauna:
Through efforts to improve the quality of the water, reservoir restoration influences lacustrine fauna, modifying the substrate and increasing water depth.

Related References: 189,549

L319-215 Reservoir restoration - Lake and reservoir use:
Reservoir restoration allows for continued use of the lake or reservoir as a recreational area, wildlife refuge, water supply source, or flood control facility.

Related References: 456,549,658

L319-218 Reservoir restoration - Lake morphology:
Reservoir restoration by dredging modifies the morphology of the lake.

Related References: none

L(324,229)-35 Riparian, palustrine, littoral vegetation - Bed-bank composition:
The type and distribution of vegetation may influence the composition of bed or shoreline substrate through filtering sediment, increasing nutrient content or substrate, and organic decay.

Related Reference: 629

L(324,229)-36 Riparian, palustrine, littoral vegetation - Bed-bank stability:
Vegetation acts as a natural stabilizing agent for bed or bank, through the binding of unconsolidated sediments and the dissipation of velocity or wave action.

Related Reference: 629

L(324,229)-38 Riparian, palustrine, littoral vegetation - Bed-bank texture and structure:
Vegetation influences on bed and shore characteristics include stabilization of shoreline and near-shore sediments, filtering of sediment, and sediment trapping. These characteristics in turn influence habitat structure, lacustrine biota, bed and shoreline stability, temperature, etc.

Related References: none

L(324,229)-211 Riparian, palustrine, littoral vegetation - Lacustrine fauna:
Littoral and riparian vegetation influences lacustrine fauna by providing a refuge from predators, food, and protection from strong currents or waves. Established vegetation also provides a surface for reproduction including egg deposition.

Related References: none

L(324,229)-267 Riparian, palustrine, littoral vegetation - Organic-inorganic chemical pool:
Littoral and riparian vegetation exchange chemical species within the water column. Especially important is the exchange of gases due to photosynthesis and decay.

Related Reference: 629

L(324,229)-491 Riparian, palustrine, littoral vegetation - Water temperature:
Littoral and riparian plants influence water temperature primarily through shading by floating and emergent plants. On a localized scale, this influences biota through moderation of temperature.

Related References: 359,693

L352-35 Sedimentation - Bed-bank composition:
Materials deposited within the system make up part of the bed sediment and sometimes affect the bank material composition.

Related References: 8,24,27,63,67,98,119,248,269,310,317,318, 323,332,348,351,352,377,396,405,406,426,450, 451,465,466,467,482,483,494,542,562,565,596, 600,607,640,658,670,688,691,712,718,732,747, 748,781,785

L352-(40,41,7) Sedimentation - Bed load, Bed material, Adsorbed material:
Material deposited within the system becomes bed load when transported along the lake bottom (not in suspension). Bed load is not significant in lakes.

Related References: 269,317,377,437,494,535,614,747

L352-218 Sedimentation - Lake morphology:
Material deposited within the system results in a modification of lake morphology. This can be a large- or small-scale influence.

Related References: 75,77,282,283,306,351,421,449,450,451,614, 643,645

L352-319 Sedimentation - Reservoir restoration:
The rate and location of sedimentation within a lake or reservoir influence the need for reservoir restoration. The need for reservoir restoration is indirectly controlled by the trapping efficiency, the design of the lake or reservoir if man-made, and the amount of material being brought into the system from other sources.

Related References: 44,69,149,193,198,242,421,438,497,499,524, 596,623,658

L(434,435,7)-120 Suspended sediment load, Suspended sediment, Adsorbed material - Erosion:
This describes the influence that suspended sediment has upon erosion.

Related References: 9,26,30,60,61 ,63,76,80,81 ,125,143,147,148, 152,159,169,170,172,175,177,181,194,198,205, 212,217,242,245,253,254,269,277,287,317,326, 327,333,342,346,347,360,365,377,393,398,417, 434,437,442,448,462,476,487,488,494,525,540, 542,555,562,571,579,597,600,607,613,630,660, 668,693,707,716,733,747,762,767,775,781,785, 787

L(434,435,7)-122 Suspended sediment load, Suspended sediment, Adsorbed material - Exported material:
This represents the transport of suspended sediment and adsorbed material out of the system.

Related References: 26,125,152,269,317,377,393,476,487,494,555, 571,579,596,693,716,747

Table II-11. Continued

L(434,435,7)-211 Suspended sediment load, Suspended sediment, Adsorbed material - Lacustrine fauna:
Suspended sediment and adsorbed material directly influence fauna. Fauna respond to the chemical composition and concentration of material in the water column. Excessive amounts of suspended sediment and adsorbed material in the water column can physically disrupt the feeding of certain biota through clogging of pores by sediment. Suspended sediment also reduces light availability, as well as water temperature.

Related References: 575,600

L(434,435,7)-267 Suspended sediment load, Suspended sediment, Adsorbed material - Organic-inorganic chemical pool:
This represents the exchange of substances between suspended sediment and adsorbed material, and other chemical species within the water column. This is influenced by several variables such as composition of suspended material in the water, water temperature, flow velocity, particle size, etc.

Related References: 4,8,26,27,30,14,47,59,69,77,80,81,88,89,98, 100,102,129,135,139,140,159,166,174,175,176, 189,194,200,203,209,220,223,224,245,260,268, 269,272,311,314,315,316,318,322,331,333,342, 346,347,352,356,364,371,372,373,396,409,417, 420,445,457,465,466,472,475,476,483,544,549, 550,555,559,572,575,576,577,586,591,597,600, 623,629,630,634,641,651,655,657,659,667,670, 685,686,688,690,691,692,713,715,720,721,722, 724,756,757,767,776,780,786,791,792

L(434,435,7)-(324,229) Suspended sediment load, Suspended sediment, Adsorbed material - Riparian, palustrine, littoral vegetation:
The effects of suspended sediment on lacustrine flora include a reduction of light penetration (and thus photosynthesis), a smothering of leaf surfaces and inhibition of gas exchange, and in some cases burial of benthic plants.

Related References: none

L(434,435,7)-352 Suspended sediment load, Suspended sediment, Adsorbed material - Sedimentation:

Suspended sediment and adsorbed material deposited through siltation become part of bed or bank materials. The rate of deposition is controlled by flow, trap efficiency, concentration of suspended sediment, and the particle size distribution of material in suspension.

Related References: 3,4,7,8,21 ,24,25,27,42,44,45,48,49,54,60,61, 62,63,65,66,67,69,73,75,76,77,78,80,81,87, 88,89,90,92,93,96,98,106,108,109,111,114, 115,117,119,126,127,128,129,130,135,136,138, 141,143,147,149,153,166,167,168,169,170,172, 173,175,180,188,193,194,198,203,204,205,206, 211,218,220,224,239,242,248,250,251 ,256,259, 263,269,272,276,277,281,282,283,287,302,306, 309,310,313,314,315,317,318,319,320,321,323, 327,328,332,333,334,335,338,339,340,346,347, 348,349,350,351,352,354,365,366,375,377,381, 394,396,398,399,400,401,402,405,406,409,412, 417,421,426,437,438,439,441,446,448,449,450, 451,454,457,458,465,466,467,469,479,482,483, 488,489,490,492,493,494,495,496,497,498,499, 507,512,515,524,526,529,530,532,535,537,541, 542,544,546,547,552,557,562,563,564,565,568, 570,577,582,596,600,602,603,607,614,615,618, 623,638,639,640,641,643,644,645,646,647,651, 654,658,662,667,668,670,674,678,679,680,681, 682,685,686,688,691,692,693,699,700,702,703, 704,707,709,712,718,724,727,732,733,742,746, 747,748,749,759,760,762,763,767,771,775,781 , 785,787,792

L(434,435,7)-488 Suspended sediment load, Suspended sediment, Adsorbed material - Water quality:

The composition and concentration of waterborne sediment and adsorbed material (including trace metals, nutrients, organic matter) directly influence water quality.

Related References: 1,6,7,8,9,12,27,44,65,69,82,98,99,101,105, 109,123,129,135,139,140,144,159,174,175,179, 181,199,203,204,206,209,213,220,223,224,239, 242,251,260,271,272,278,291,297,302,311 ,312, 313,315,321,332,333,342,354,356,358,359,360, 361,371,372,373,376,383,397,398,401,407,409, 412,420,421,4.29,442,444,445,456,468,469,472, 474,482,483,484,493,494,499,508,524,542,549, 559,560,564,568,569,575,577,587,588,589,590, 595,597,600,604,607,610,628,630,636,641,642, 651,656,658,659,667,683,685,686,690,692,693, 703,709,713,715,716,718,720,721,722,723,724, 728,739,740,741,744,746,747,748,757,763,767, 776,778,780,792,793

L452-352 Trap efficiency - Sedimentation:
Trap efficiency, along with the sediment load from the watershed of a particular lake or reservoir, influences the rate of sedimentation. Lakes and reservoirs provide storage sites for incoming sediment, which may be stored there from years to centuries.

Related References: 93,256,276,310,449,450,564,565,643,658,679

L483-150 Water depth - Flow geometry:
Water depth influences flow patterns and hydraulic geometry.

Related References: 56,68,103,117,195,258,314,338,344,351,389, 390,409,434,448,449,470,525,614,618,621,648, 733,766,775,782,784

L483-211 Water depth - Lacustrine fauna:
Water depth influences lacustrine fauna through its influence on light availability, water temperature, and distribution of vegetation.

Related Reference: 709

L483-(324,229) Water depth - Riparian, palustrine, littoral vegetation:
Water depth determines the plant species that will be able to survive in a given part of the lake. By affecting the distribution of species, it likewise affects structure. The influence of water depth on vegetation may be direct, or indirect through water temperature, light intensity, dissolved oxygen availability, etc.

Related References: none

L483-491 Water depth - Water temperature:
Water depth is related to water temperature (particularly temperature profiles) through attenuation of light. Fauna and vegetation must be adapted to temperature and light availability, as well as water composition and substrate characteristics.

Related References: 409,448,470,564

L486-319 Water level regulation - Reservoir restoration:
Water level regulation, in conjunction with the rate of sedimentation and lake or reservoir use, determines the need for restoration.

Related References: 113,149,424,569,696

L486-483 Water level regulation - Water depth:
Water level regulation has a direct influence on water depth. In smaller lakes and reservoirs this is done only through fixed spillway elevation.

Related References: 48,413,564,762

Table II-11. Continued

L486-494 Water level regulation - Water withdrawal:
Water demands for water supply, private use, and industrial use all vary with season. Water level within a particular lake or reservoir must be regulated to meet the demands.

Related Reference: 178

L488-109 Water quality - Economics:
Water quality (as characterized by the composition and concentration of suspended and adsorbed material, and other chemical species) influences economics in the sense of costs for pollution control and water treatment. This in turn influences decisions on reservoir restoration.

Related References: 7,8,14,34,35,37,40,70,121,144,199,209,229, 231,233,246,251,260,271,272,284,313,315,321, 359,361,370,383,420,456,468,480,482,483,484, 493,494,505,524,567,595,601,604,607,610,632, 641,652,653,667,692,709,713,739,740,741,763, 764,772,776

L488-215 Water quality - Lake and reservoir use:
Water quality, as influenced by the composition of suspended sediment and adsorbed material, and other chemical species in the water column, influences the present and future use of a particular lake or reservoir (for recreation, fishing, or water supply).

Related References: 209,456,549,569,658,709,746

L491-211 Water temperature - Lacustrine fauna:
Water temperature (including vertical profile and spatial and temporal variations) influences fauna in their distribution in time and space. Water temperature is a critical regulator of habitat suitability for lacustrine fauna, affecting light availability, flood sources, respiration rates, pathogen susceptibility, etc.

Related Reference: 757

L491-267 Water temperature - Organic-inorganic chemical pool:
Water temperature affects the states and conversions of chemical species in the water column. From the perspective of biota, water temperature plays a critical role in the dissolution of gases and their availability.

Related References: 100,265,269,371,372,373,409,549,575,576,720, 721,722,757

Table II-11. Concluded

L491-(324,229) Water temperature - Riparian, palustrine, littoral vegetation:

Water temperature (including vertical profile and spatial and temporal variations) influences the type of vegetation present. It affects lacustrine plant metabolism, growth, and survival, either directly or indirectly (the latter by influencing fauna associated with the plants, including pathogens).

Related References: 359,693

L494-122 Water withdrawal - Exported material:

Water withdrawal for water supply, industrial, or other use will remove some materials from the lake environment.

Related Reference: 178

L494-483 Water withdrawal - Water depth:

Water withdrawal rates can influence the water depth where the lake or reservoir is used for public or private water supply.

Related References: none

L494-486 Water withdrawal - Water level regulation:

Water withdrawal requirements (for industrial or drinking purposes) influence decisions on water level regulation. Public and private use, as well as availability of water, will vary from season to season as controlled by weather patterns. The demand for water influences procedures followed for maintenance of required levels.

Related Reference: 178

L508-150 Wind speed, duration, and direction - Flow geometry:

Wind speed and duration are especially important in lakes due to the influence on the waves. The impact that waves have on shoreline is largely dependent upon the wind speed and duration, bank composition, and bank slope.

Related References: none

KEYWORDS

1 Abandoned mines
2 Accelerated erosion
3 Acid mine drainage
4 Acid mine soil
5 Acid streams
6 Acreage
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A total of 795 bibliographical references have been assembled for the present project. Each citation was reviewed and the associated keywords identified. All the keywords are included with each citation. The citations are arranged in alphabetical order and numbered consecutively. This section gives all the citations, their identifying numbers, and the associated keywords.

A considerable amount of time and effort were spent in assembling this extensive list of references. A description of the methods used, which illustrates how to arrive at such a product, is included below because of its potential usefulness for other such efforts.

Methods for Generating Bibliographic Information

The main purpose of this description is to inform the reader of the procedures involved in the undertaking of such a task. As stated previously, one of the major goals of the project was to assemble as complete a bibliography as possible on the broad subject of erosion and sedimentation as it applies to the state of Illinois.

Initially, several national data bases, the University of Illinois, and Illinois State Libraries were searched for relevant literature. In addition, researchers known to be involved in the study of erosion and sedimentation in Illinois were asked to contribute to the bibliography. The references were then located and read. Keywords identifying the contents of a particular report or article were noted for all relevant references. References which are either too general to be useful, or not relevant to erosion and sedimentation problems in Illinois, were not included in the compiled bibliography.

In order to compile a bibliography of this scale, the aid of the computer is a necessity. In particular, we used a computer program, "Biblio," designed specifically for the storage and retrieval of citations. Biblio was purchased by the Illinois State Water Survey from the Harvard School of Public Health. It is written in C language and runs under the Bell System Unix on the VAX 11/780 operated by the computing services of the University of Illinois.

Biblio is an interactive system in which the user is given prompts to supply certain information (reference number, type of reference, author(s), title, source, pages, date, keywords, contributor's initials, and other optional information such as an abstract) and in turn can give commands to retrieve that information. After references are entered into the data base, the user can then retrieve any set of these citations based on specific combinations of this information (in our case, we were able to sort our bibliographic data base by model interactions—through keyword field--and provide a list of references dealing with specific model interactions), or print the entire field. The fields of information within each reference can also be arranged to conform to any standard journal format, or the user can create new formats. We chose to create our own format. Finally, output specifications such as single or double spacing, line width, and page length can also be chosen before printing. It is especially important to mention here that the final output is heavily dependent upon the operating system, and support staff is needed in formatting the text.

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