



Illinois State Water Survey Division
SURFACE WATER SECTION

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**SEDIMENT CONTROL FROM
SURFACE FACILITY CONSTRUCTION**

by J. Rodger Adams and Edward Delisio

Prepared for the
Illinois Department of Energy and Natural Resources

Champaign, Illinois

December 1989



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INTRODUCTION

The design of the proposed Superconducting Super Collider (SSC) ring in northeastern Illinois specified a tunnel in the very competent dolomite rock some distance below the ground surface, but a number of access shafts and other surface construction sites would have been necessary. If Illinois had been chosen as the location for the SSC, a site-specific set of recommendations would have been prepared for each of the 32 surface structures affected by construction. With the termination of the SSC project, this general report will cover the erosion process on construction sites, review available literature and design aids, and make recommendations for construction-site erosion control in Kane County, Illinois. Erosion rates at active construction sites have been observed to be 2 to 40 times the previously existing rates, and then after construction, erosion rates have been observed to gradually return to previous levels.

Acknowledgements

Administrative guidance was provided by Richard G. Semonin, Chief, Illinois State Water Survey; and Michael L. Terstriep, Head, Surface Water Section.

Support for the project came from the Illinois Department of Energy and Natural Resources. Krishan P. Singh, Assistant Head of the Surface Water Section, was project coordinator. Ibtessam Dessouky, Water Survey Librarian, conducted the computer searches of relevant bibliographic databases and obtained selected documents. Laurie McCarthy edited and produced the report, and Becky Howard typed and formatted the camera-ready copy.

Overview

In 1984 the three Illinois scientific Surveys developed conceptual models of the erosion and sedimentation processes for the state. These models are described in a two-volume report by Bhowmik et al. (1984). Volume I contains the project summary and develops a simple overall model of how water transports suspended material in Illinois. This simple model, which is called the Level I model, identifies the various types of landscape systems in which erosion, sediment transport, and sedimentation may occur and the natural and human activities that affect these processes in particular types of environments or habitats. The Level I model is shown in figure 1.

Illinois includes upland areas of several types and riverine, palustrine (wetland), and lacustrine (lake) systems. It does not, however, have any estuarine or marine areas or systems. The classification of these landscape types, or ecosystems, generally follows the U.S. Fish and Wildlife scheme as described by Cowardin et al. (1979).

The upland system in Illinois includes six subsystems: agricultural, grassland, forest, mining, urban, and construction. The wetland system is divided into permanent and seasonal subsystems. A specific Level II model was developed for each system and subsystem. Volume II of Bhowmik et al. (1984) describes the ten Level II models (agricultural, grassland, forest, mining, urban, construction, wetland, permanent wetland, seasonal wetland, and lacustrine); identifies the interactions between the elements of each Level II model; and cross references each element to a bibliography of 795 entries. All Level II models are similar to the Construction Subsystem model shown in figure 2. The Level II Construction Subsystem model is of primary importance for this report, although construction is always considered in conjunction with one of the other systems or subsystems.

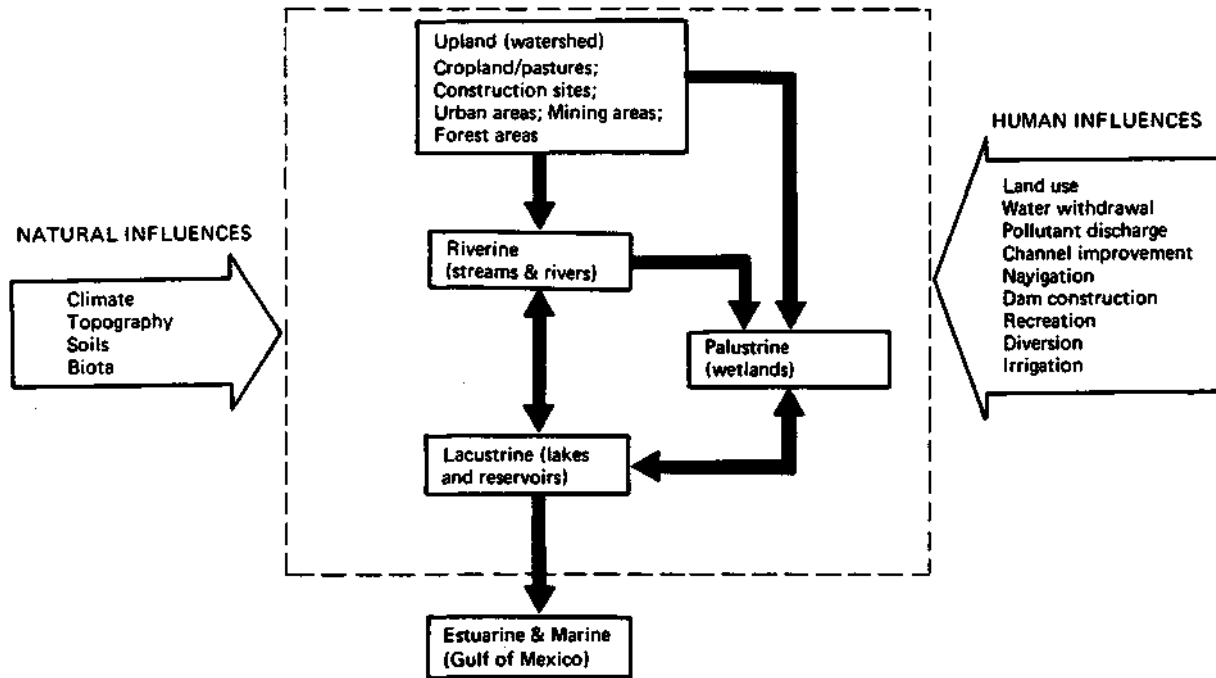


Figure 1. Level I conceptual model for the transport of sediment, biota, nutrients, and chemical pollutants by water in Illinois (from Bhowmik et al., 1984)

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 external arrows acting on the whole system representing the state of Illinois.

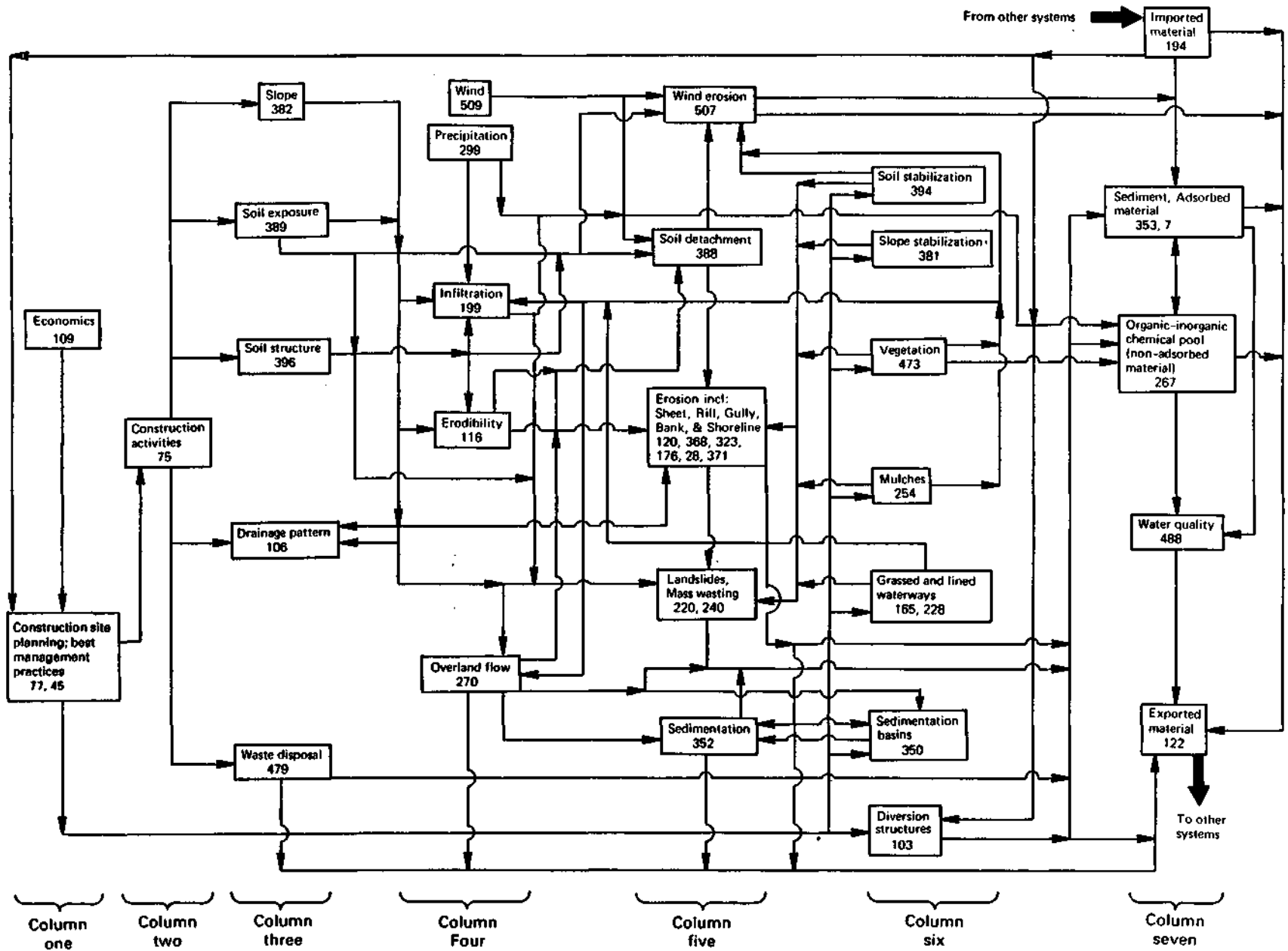


Figure 2. Level II model construction subsystem
(from Bhowmik et al., 1984)

The following discussion is adapted from Volume II of Bhowmik et al. (1984), and the reader is referred to that report for the element interactions, keywords, and related references for this model.

LEVEL II CONSTRUCTION SUBSYSTEM MODEL

This model, which is similar to most of the level II models, is laid out to be read from left to right. The first column at the left addresses the economics of development, site planning, and management. Construction-site planning and management determine the types and sequences of construction activities within the constraints of project economics.

The method and sequence of construction activities determine the need for erosion and sedimentation control measures. The second column of the model includes construction activities such as excavation, filling, piling, altering surface cover, compacting, and land grading.

The third column of the model addresses the changes that construction activities could produce on surface soils. Changes in slope, soil structure and exposure, waste disposal, and drainage patterns affect erosion directly. Waste disposal refers to the disposition of imported materials as well as wastes created on-site by activities such as excavation. Changes in these elements also affect several components in the fifth column of the model, such as erosion, soil detachment, and landslides.

The fourth column of the model includes the processes that actually move soil particles and the factors that affect the amount of soil moved and the rate of movement. The distance that eroded material moves immediately after its detachment often determines whether it is deposited elsewhere on-site or is carried off-site before being deposited.

The sixth column contains elements referring to erosion and sedimentation control. Erosion control usually involves providing cover to protect disturbed soil surfaces from being dislodged by raindrop impact or running water. Seeding, mulching, and grassed or lined waterways are common methods of erosion control. Soil and slope stabilization are effective on exposed, disturbed slopes that are especially vulnerable to erosion. Sedimentation basins retain eroded material on-site and control the locations at which deposition occurs. By diverting existing waterways, eroded material can be prevented from entering nearby waterways, and on-site flooding and bank erosion can be reduced.

The seventh and final column, on the far right side of the model, identifies the eroded material and associated materials that may leave the construction site. These include imported materials, eroded soil that has become sediment, materials adsorbed on the sediment, and dissolved constituents in the water that carries the sediment from the construction site to another system, usually a riverine system.

Depending on the location of the construction site and the type of construction activities, any of the other systems could be impacted by erosion or sedimentation caused by construction and consequently by erosion- or sediment-control measures.

LITERATURE REVIEW

The literature review was designed to search for recent publications that could not have been incorporated in the conceptual model developed by Bhowmik et al. (1984). Key word groups were developed for construction activities, erosion causes and sediment sources, and erosion- and sediment-control measures. Literature was reviewed for the period from 1982 to the present, which would reach about mid-1988 in most databases. The key word lists for each group follow.

Construction Activities

1. Excavation
2. Hauling of spoil and aggregates
3. Slope change
4. Soil exposure
5. Soil disturbance
6. Stockpiling of granular materials
7. Drainage diversion

Erosion and Sediment

1. Wind
2. Precipitation
3. Surface runoff
4. Bank erosion
5. Soil characteristics

Control Methods

1. Soil stabilization
2. Slope stabilization
3. Surface protection
4. Drainage control
5. Sediment traps and basins
6. Diversion structures
7. Import/export loss control

These lists were reviewed by the Water Survey librarian, Ibtessam Dessouky, who suggested a search strategy and two databases to be searched: the Selected Water Resources Abstracts (SWRA) and Compendex Plus. Ten key words were searched individually, and the number of items found in each database is indicated in table 1.

Table 1. Database Search Results

<i>Key word</i>	<i>Selected abstracts</i>	<i>Compendex plus</i>
Construction	15,431	82,720
Activity(ies)	16,589	47,132
Construction activity	183	243
Erosion	14,014	11,113
Sediment(s,ation)	26,561	19,098
Control	70,064	272,054
Measure(s)	35,938	377,072
Control measure(s)	1,024	1,173
Method(s)	45,720	489,954
Control method(s)	339	2,679
Construction activity + erosion + control measure	12	3
Construction activity + sediment + control measure	12	3
Erosion + sediment + control method	28	7

Several other combinations and a few more specific words were tried, but no further references were found. Abstracts for the 52 items in SWRA were obtained, and nine documents were determined to be important enough to obtain the entire article or report. Many of the references found in Compendex Plus were duplicates or not directly applicable to this project.

In addition, several items were found by manual searches and by addressing inquiries to other agencies. A brief summary of the documents reviewed makes up the remainder of this section.

General references on sedimentation engineering, such as the *ASCE Manual of Practice on Sedimentation Engineering* (Vanoni, 1975), contain introductory sections on construction, erosion, and sediment control. Conferences and symposia have produced several volumes of proceedings on a variety of erosion and sedimentation issues. Selected papers, especially from the Third Federal Inter-agency Sedimentation Conference (1976) are referenced within specific topics.

The first step in determining if control techniques are needed is to estimate the amount of soil that will be eroded from the construction site. Three papers in the 1976 Inter-agency conference addressed this issue. Holberger and Truett (1976) discussed yields and delivery ratios for eight sites. Yorke and Herb (1976) described the site conditions that affect erosion, and Herb and Yorke (1976) related erosion on construction sites to rainstorm intensity and site conditions. Glancy (1988) describes a case study of erosion and sediment transport in a developing area at Incline Village, Nevada, on the shore of Lake Tahoe. Handbooks such as Goldman et al. (1986) address this in some detail and recommend adapting the Universal Soil Loss Equation (USLE) for use on construction sites (Wischmeier and Smith, 1978).

The goal of control methods is to prevent erosion or to contain the eroded material on-site. Control methods include soil stabilization and vegetative cover, staging and minimizing disturbance, and sediment traps and filters. Goldman et al.

(1986), Vanoni (1975), Carlson (1976), Ohlander (1976), Ripken et al. (1977), Highway Research Board (1973), Thronson (1976), and the Association of Illinois Soil and Water Conservation Districts (AISWCD, 1988) describe the methods and give criteria for selection and design of control methods. Gray and Leiser (1988) have compiled a textbook on biotechnical methods of erosion prevention and control.

Perusal of any of these documents will show that most erosion-control methods are simple and moderate in cost. However, they should be considered in the planning phase (or at least during the construction sequencing phase) of project development. An early example of this policy approach is contained in the *Proceedings of the National Conference on Sediment Control* (HUD, 1970). Daniel and Klassy (1977) describe the institutional arrangements needed to implement an erosion control ordinance in Washington County, Wisconsin. Model ordinances are given by Goldman et al. (1986) and AISWCD (1988). The Highway Research Board (1973), Goldman et al. (1986), and AISWCD (1988) give detailed procedures for determining the need to control erosion and sediment and selecting control methods.

KANE COUNTY SOILS AND EROSION POTENTIAL

The soils of Kane County have been described in a soil survey by Goddard (1979). Anyone planning construction at a particular location should refer to this publication for more detailed information on soil type, since soils tend to be very heterogeneous in spatial distribution. The survey includes four map units, each containing several soils and characteristic topography, shown on a county-wide map. Following are the map unit landscapes and associated soils:

A. Nearly level to moderately steep soils that are moderately permeable in the subsoil and moderately to very permeable in the underlying material. They are located on outwash planes, kamic ridges, and eskers. This unit occupies 19 percent of the county, mostly in the northeast and far southeast areas.

Associated soils in this unit are:

1. Will-Warsaw-Canisteo
2. Fox-Casco-Dresden
3. Bowes-Dresden-Fox
4. Waupecan-Drummer

B. Nearly level to moderately steep soils that are moderately permeable. They are located on end moraines, ground moraines, and outwash plains. This unit occupies 63 percent of the county, mostly in the western two-thirds. Associated soils in this unit are:

5. Drummer-Elburn
6. Drummer-Saybrook-Catlin
7. Miami-Octagon
8. Octagon-Saybrook-Drummer
9. Dodge-Birckbeck-Camden
10. Miami-Dodge
11. Drummer-Harvard

C. Nearly level to moderately sloping soils that are moderately permeable. They are located on uplands, terraces, and flood plains. This unit occupies 4 percent of the county along the Fox River in the east. The associated soil in this unit is:

12. Dresden-Millington

D. Nearly level to moderately steep soils that are moderately slowly and slowly permeable. They are located on end moraines. This unit occupies 14 percent of the county in the uplands along the Fox River valley. Associated soils in this unit are:

13. Morley-Beecher

14. Milford-Varna-Markham

Although some general remarks are made about the erodibility of specific soil types, erosion potential is not given in the soils report for Kane County. The U.S. Department of Agriculture (1984), however, provides erosion rates, soil tolerance, and erodibility for the entire state of Illinois. The rate of soil erosion is calculated with the Universal Soil Loss Equation, as given in Wischmeier and Smith (1978). It assumes that the erosion rate is a linear function of rainfall quantity and intensity, slope length and steepness, soil erodibility, crop-management practices, and erosion-control practices. The ratio of the soil tolerance factor T (a measure of the rate of replenishment of topsoil) to the erodibility factor K indicates the susceptibility of a soil to erosion damage. Higher values of the ratio indicate resistance to erosion damage, while low values of the ratio indicate the need for erosion-control practices. Although these factors are determined for agricultural land use, the need for erosion and sediment control on construction sites is determined by modified use of the USLE with cover factors for construction activities (Goldman et al., 1986).

Although this discussion of soils primarily covers Kane County, 16 townships, including 7 in Kendall, Will, and DuPage Counties, would have been impacted by the construction of the SSC tunnel (figure 3). The various access sites are identified by letter on the figure. The 32 sites noted as E, F, J, and K comprise a total area of

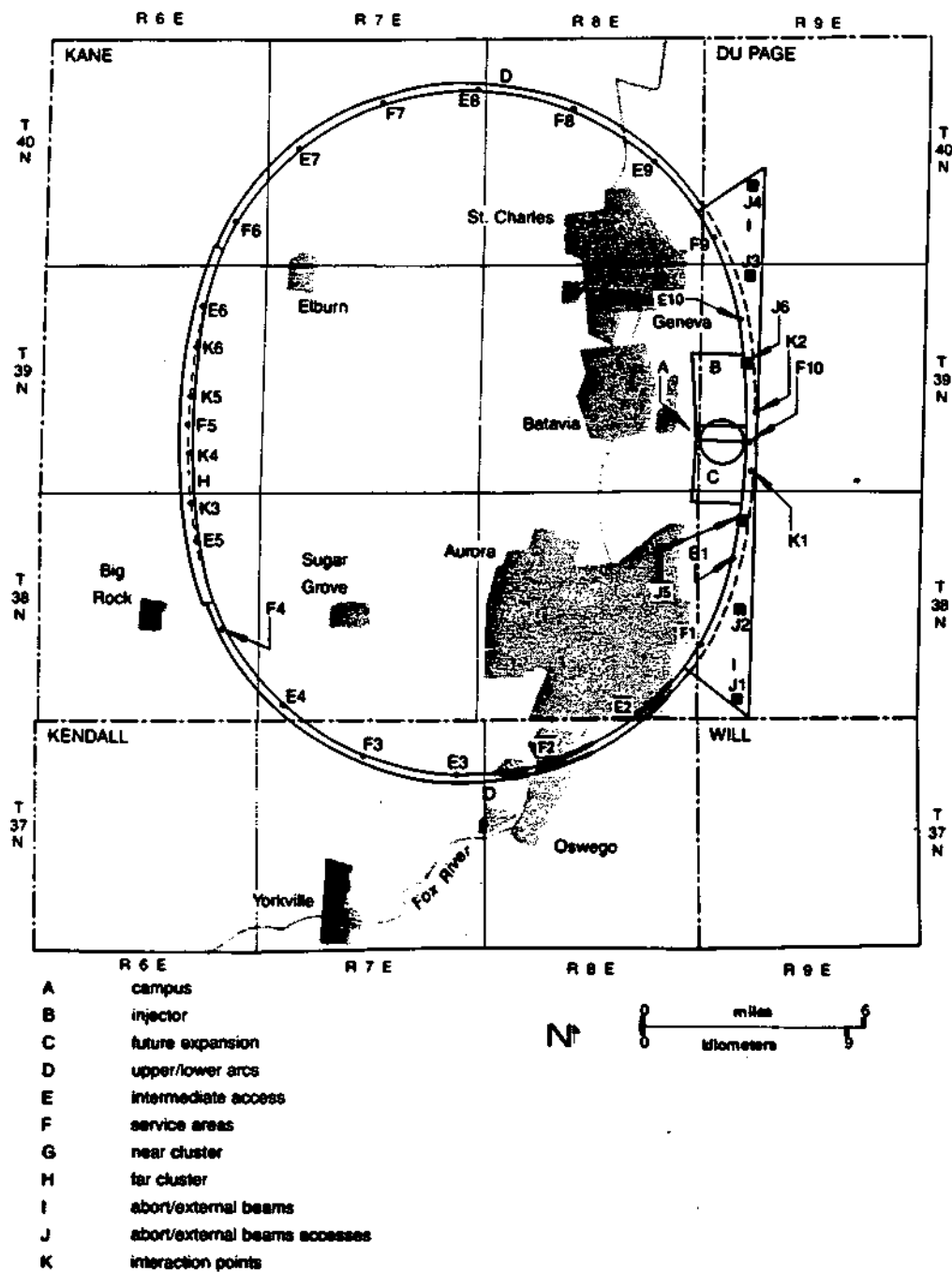


Figure 3. Sixteen-township SSC area with construction sites identified

309 acres that would have been disturbed by surface construction activities for the SSC. Some additional areas in the SSC campus and injector areas A and B would also have been subject to surface construction.

The soils in Kendall and DuPage Counties are similar in type and erodibility to those in Kane County. Almost all of Kane County has erosion rates between 5 and 10 tons per acre per year, with an average of about 5.5 tons per acre per year. Figure 4 shows areas of high, low, and average erosion potential for the SSC region and is taken from a statewide map of erosion potential (U.S. Department of Agriculture, 1984). Erosion rates are expressed in tons per acre per year, and T/K is the ratio of the allowable erosion rate to the erodibility factor. Soils with higher values of T/K are easier to protect from excessive erosion than those with low values of T/K. These parameters are factors in the USLE. A portion of the township that is occupied by the city of Aurora has an average annual erosion rate of 11 tons per acre, which is the lowest T/K ratio in the county. The rest of the county has average or high values of the T/K ratio.

Several specific conditions need to be examined on a site-by-site basis. Surface slope and length of slope before and after any site grading are important and must be determined on-site. Ditches and streams on or adjacent to a construction site may require protection from material eroded on-site. Existing vegetative cover and the use of temporary vegetative cover are basic to controlling erosion. Steeper slopes, sandy and loess soils, recently disturbed soils, and wet sites also need special consideration and are likely to require more care in order to prevent erosion and sedimentation problems.

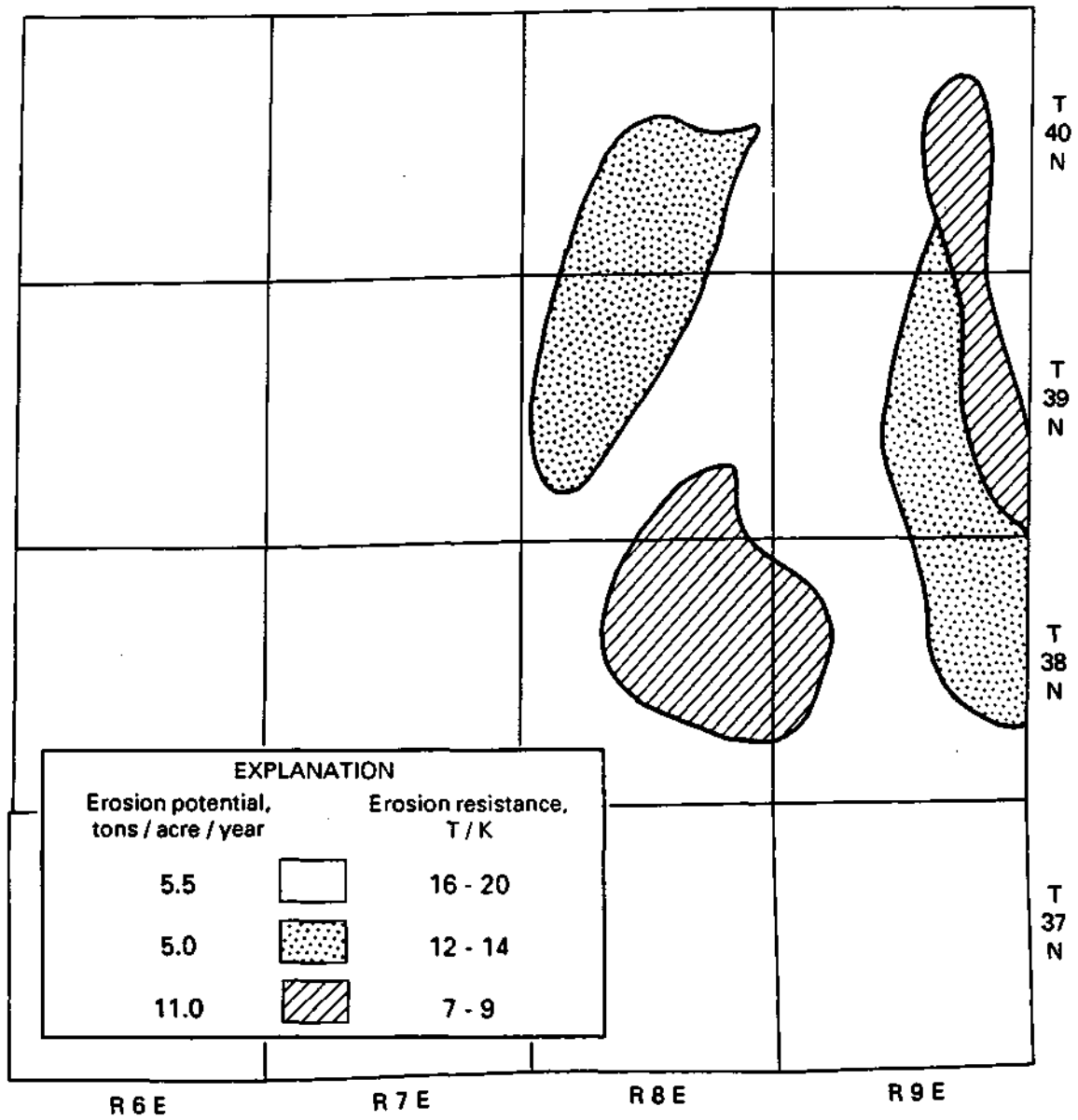


Figure 4. Erosion potential of soils in the 16-township SSC area (from USDA, 1984)

SUMMARY

The Level II Construction Subsystem from Bhowmik et al. (1984) provides a framework on which to develop an erosion-control approach for construction sites and to assess off-site impacts of sedimentation. Soil erodibility and the impacts of construction activities on the likely erosion rate must be considered at the project planning stage. Erosion and sediment control methods are described especially well in several handbooks (Goldman et al., 1986; Gray and Leiser, 1988) and in manuals (AISWCD, 1988). The AISWCD "Green Book" is specific to urban and urbanizing areas in Illinois and is recommended for use. It includes three model ordinances, and the option most appropriate to existing local ordinances governing building or subdividing may be used. Implementation requires careful integration of all applicable ordinances from the beginning of the development planning process. If erosion control is planned along with the construction schedule, no delays and only moderate additional costs will be incurred.

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