

GEOLOGIC CONSTRAINTS ON LAND USE
IN NORTHEASTERN MORRIS COUNTY,
KANSAS

By

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Abstract

Northeastern Morris County, Kansas is located in the headwaters region of the Neosho River in the Flint Hills physiographic province. Located within the area are the towns of Council Grove, Wilsey, White City and Parkerville and two man-made lakes, Council Grove Reservoir and Council Grove City Lake. Council Grove City Lake is the water supply for Council Grove and has a densely populated lake shore with many second homes whereas Council Grove Reservoir, a U.S. Army Corps of Engineers project, is sparsely developed with camping and recreational facilities. Most of the land area is in crop or rangeland. The region is underlain by essentially flat-lying Permian limestones, cherty limestones, and shales. The bedrock is covered by variable thickness of soil, alluvial, and colluvial materials consisting of chert gravels, silt and clay.

In northeastern Morris County three basic types of environmental settings occur: 1) the uplands, which include ridgetopes, side slopes, and floodplains of the area; 2) streams; and 3) man-made lakes. Each setting includes both living and non-living components interacting in a distinctive ecosystem. In order to describe the functioning of ecosystems, both the static and dynamic aspects must be known. Composite resource areas are small land areas with similar environmental properties such as bedrock type soils, biota, topographic expression, and geomorphic processes. These units represent the static aspect of the ecosystem and can be used to show favorable and unfavorable locations for specific activities of man by pointing out

the natural capabilities of each site. The ecologic systems diagram is a useful symbolic representation of the dynamic aspects of ecosystems and describes the impact of human activities on the ecosystem. In northeastern Morris County, three ecosystems have been identified: the upland, stream, and reservoir ecosystem.

The ecologic systems diagrams and the characteristics of the composite resource areas show that certain land uses are suitable for portions of the region and changes in land use could have significant impact on water quality in the two large reservoirs in northeastern Morris County. None of the soils is suitable for septic tanks. Many sites were found to be suitable for both trench- and area-type landfills. Sewage lagoons were also evaluated and many of the composite resource areas are suitable for this type of land use. Site suitability for residential and light industrial development was also evaluated. Composite resource areas found to have several limitations for this land use have some degree of flood hazard or high shrink-swell potential soils. In most cases, investigation of sites should be conducted to determine the limitations of specific localities. Converting unsuitable lands now under cropland agriculture back into grassland would produce many human use values, such as recreation and increased flood control. Residential development around lake shore areas will also promote an increase in the amount of sediment and nutrients carried into the lake by overland flow. This impact will be both short and long term. The influx of nutrients could be especially significant if conventional septic systems are installed.

ACKNOWLEDGEMENTS

Many people contributed to the success of this work and I would like to acknowledge their efforts. First, special thanks are extended to the members of my committee who worked diligently to review and shape this work. I would also like to express my deeply felt appreciation to Dr. Charles Woodruff of the Texas Bureau of Economic Geology, Austin, Texas, who provided insight into natural systems and the Activity Assessment Routine. Lastly, I would like to thank my wife, who bore much of the brunt of the typing from rough handwritten manuscript, and my typist, Joan McCabe Moore, who produced the final copy. The research for this work was funded by the Nuclear Regulatory Commission under research contract numbers: AT (49-24)-0286 and NRC-04-77-017.

P. A. M.

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Lawrence, Kansas

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CHAPTER I

INTRODUCTION

Urbanization and suburban development of previously rural land in northeastern Kansas is steadily increasing. Lujan (1975) has predicted that the population of the northeastern part of the state will increase by about 44 percent between 1970 and 2000. His study indicated that the greatest population density in the state will continue to be in the area bounded by Kansas City, Manhattan, and Emporia. This increase in population will result in increased demand for land and water resources both within and outside of the major growth area.

The natural resource base of northeastern Kansas is finite. Problems may result from human demands on the drainage-basin systems because not all lands and waters are equally suited for all uses and projects in the public and private sectors have often been undertaken without knowledge of the constraints imposed by local land and water conditions. Thus, it is important for planners and the general public to understand the diversity and complexity of natural systems.

Purpose

This report presents a geologic inventory of that portion of northeastern Morris County comprising most of the

Neosho River basin northwest of Council Grove, Kansas, in order to delineate the geologic factors that will impose constraints on further development of the region by man. The inventory procedure consists of "mapping the distribution of the basic elements of natural environments, their associated processes, and modern and/or ancient facies" (Fisher, et al., 1972). The results of the inventory are here used to derive site-suitability maps for specific land uses. Furthermore, data obtained during the inventory are used to develop ecologic systems diagrams (Odum, 1971, 1972). These diagrams illustrate relationships between biotic and abiotic (non-biotic) systems and are useful tools for evaluating the impact of man on all aspects of the environment.

Northeastern Morris County was chosen for this study because it is located near the major growth area of the state and because the relatively recent creation of two man-made lakes in the drainage basin is likely to induce many new stresses on the natural environment. It is important to understand the geological constraints on land use in the region before extensive development occurs so that degradation of natural systems can be minimized. The inventory will provide state and regional planners with a detailed data base of the natural resources of the region. In addition, the results of this inventory and an Activity Assessment Routine can be used to determine the environmental impact of human activities on the drainage basin. This infor-

mation will be especially useful to planning agencies such as the Flint Hills Regional Planning Commission, and will also provide additional data for the Automated Resource Evaluation System (ARES) which is being planned by the Kansas Geological Survey.

CHAPTER II

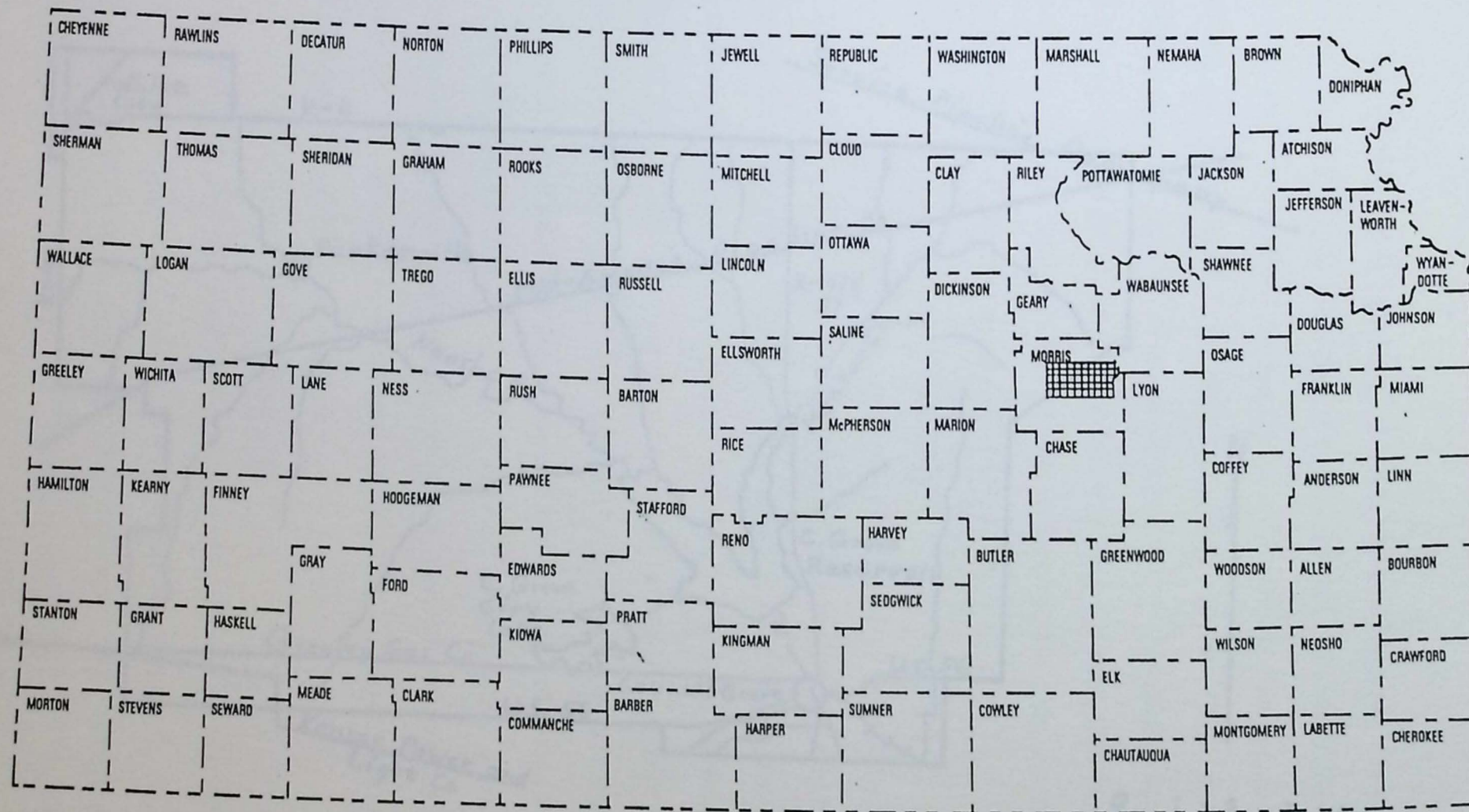
PHYSICAL SETTING

Location and Physical Geography

The study area is located in northeastern Morris County, Kansas, and is included in the Flint Hills physiographic province (Shoewe, 1949) (see Figure 1). The contrasting resistance to erosion among the several bedrock formations, and variations in soils and vegetation, produce considerable diversity in the region. The characteristic types of terrain in the area are: (1) dissected bluestem upland prairie underlain by thick, massive limestones that are mantled by unconsolidated deposits; (2) steep, wooded, stair-step valley sides adjacent to downcutting streams; and (3) valley bottoms underlain by alluvial sediments and covered by flood-plain forest, savanna, or fresh-water marsh vegetation. The average elevation of the land surface in this part of the county is about 1300 feet (400 meters). The highest elevations are in the southwest where the maximum elevation is 1525 feet (469 meters). The lowest elevation is along the Neosho River south of Council Grove and is 1200 feet (369 meters).

The principal stream that drains the northeastern portion of Morris County is the Neosho River (see Figure 2).

Figure 1. Location of the Study Area



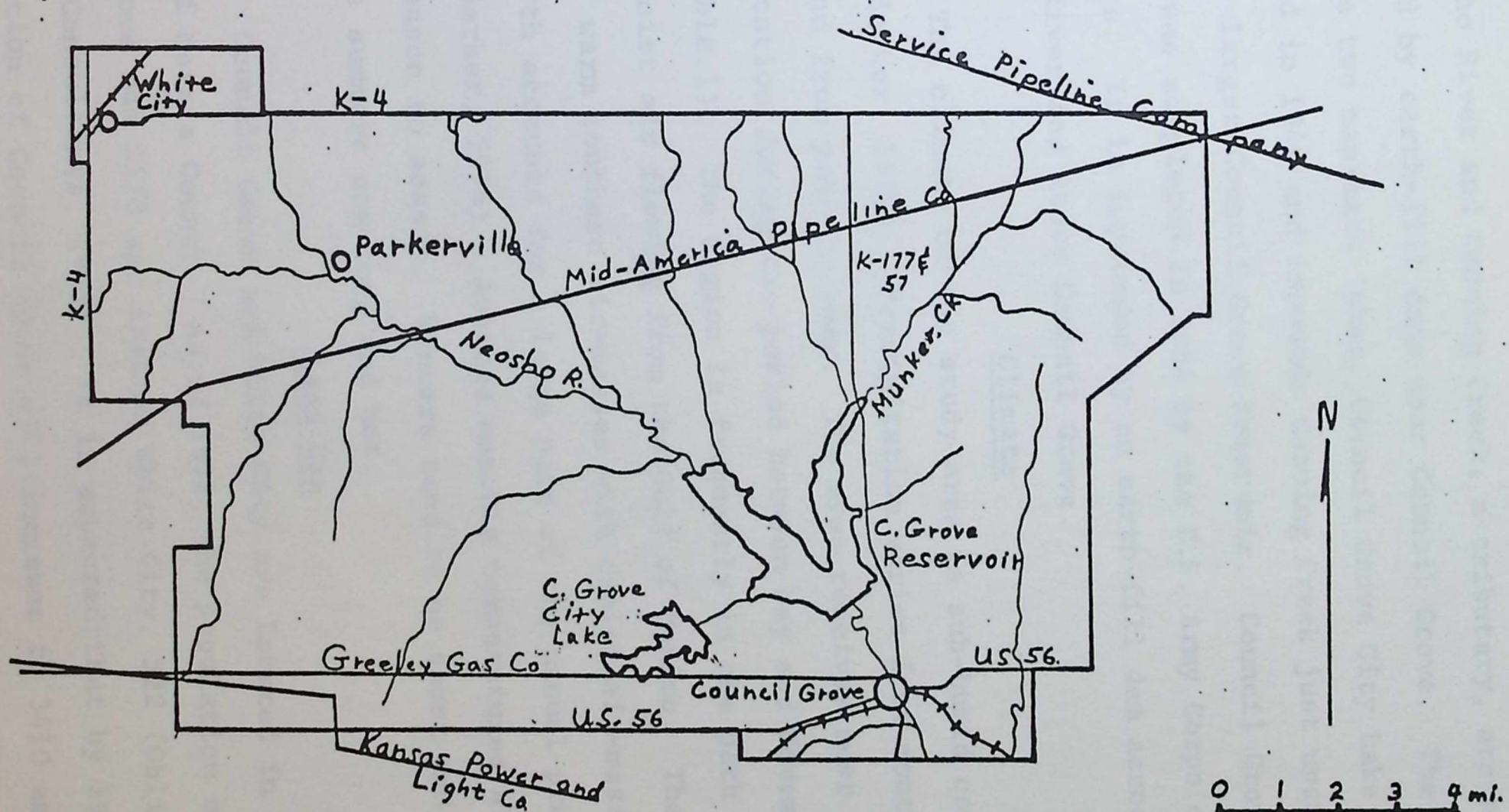
0 50 100

Scale in miles

0 50 100

Scale in kilometers

Figure 2. Surface Water Drainage, Transportation, and Transmission Lines, Northeastern Morris County, Kansas (From Oblinger-Smith Consultants, 1973).



The Neosho River and Canning Creek, a tributary, are each impounded by earth-fill dams near Council Grove. The smaller to the two man-made lakes, Council Grove City Lake, was completed in 1940 and impounds Canning Creek just upstream from the larger Council Grove Reservoir. Council Grove Reservoir was completed in 1964 by the U.S. Army Corps of Engineers. It is impounded by an earth-fill dam across the Neosho River and above Council Grove.

Climate

The climate of the study area is sub-humid continental (Barker, 1974). Precipitation varies from month to month and from year to year. The area receives most of its precipitation during the period between May and November (see Table 1). The region is frequently in the path of warm, moist air flowing from the Gulf of Mexico. The collision of warm southern air-masses with cooler air-masses from the north accounts for a large part of the annual precipitation (Barker, 1974). Average monthly temperatures also vary from season to season. Winters tend to be short and cold, whereas summers are long and hot.

Land Use

Council Grove and White City are located in this part of Morris County. As of 1972, the population of Council Grove was 2570 and that of White City, 522 (Oblinger-Smith Consultants, 1973). It is expected that by 1990 the population of Council Grove will increase to 3410 and the

Table 1. Average Climatic Data for Council Grove, Kansas, over a 15-year Period*

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Temperature												
°F	26.2	30.6	40.8	54.5	63.9	72.0	77.8	75.7	66.4	56.3	42.9	32.4
°C	-3.2	-0.8	4.9	12.5	17.7	22.2	25.4	24.3	19.1	13.5	6.1	0.2
Precipitation												
inches	.6	.6	1.0	3.61	4.02	5.67	3.67	2.37	4.06	2.93	1.50	1.35
centimeters	1.52	1.52	2.54	9.17	10.21	14.40	9.32	6.02	10.31	7.44	3.81	3.43
Average Annual Temperature: 53.6°F (12.0°C)												
Average Annual Precipitation: 31.45 inches (79.88 centimeters)												

*(Barker, 1974).

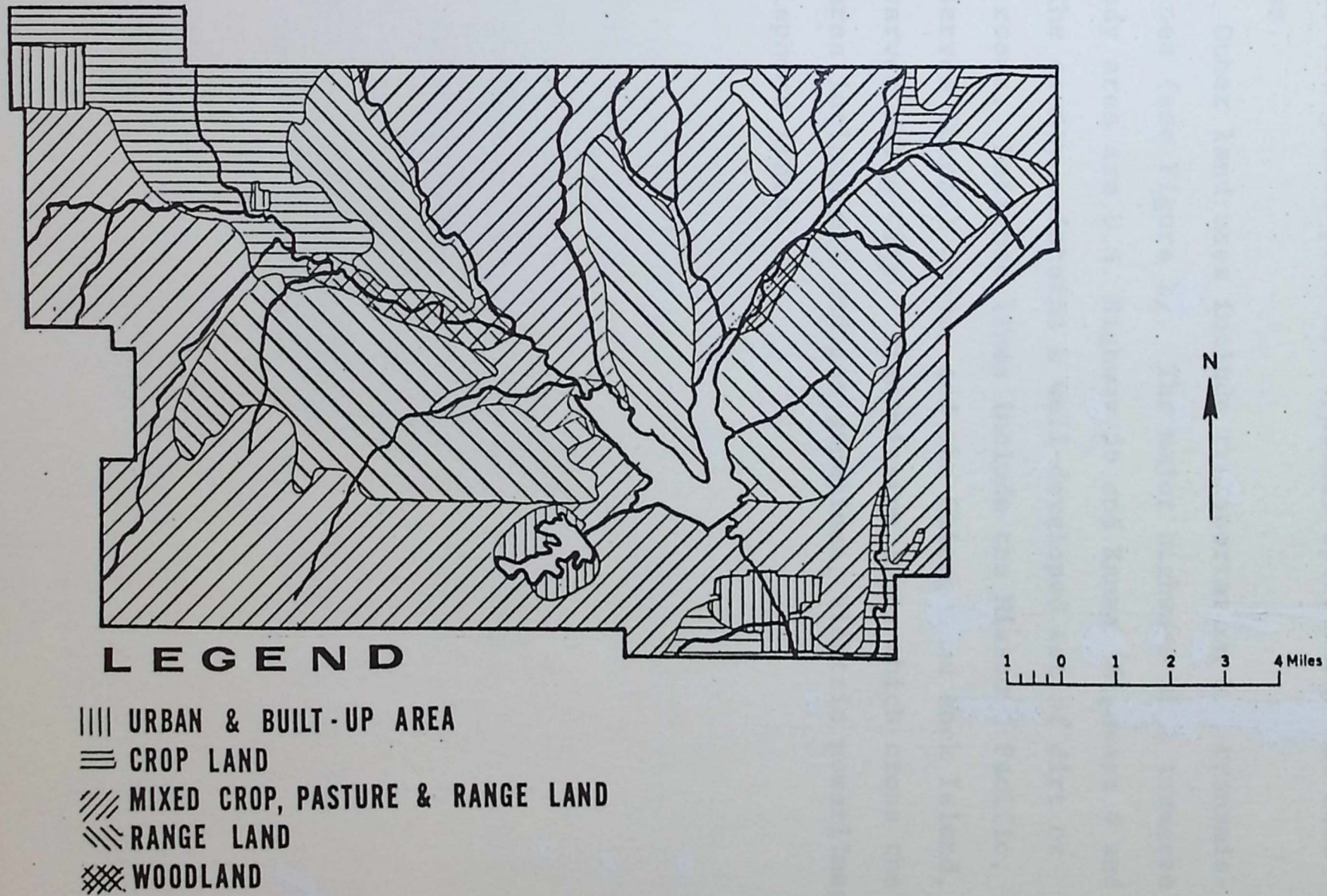
population of White City will remain stable (Ibid.). There is extensive second-home and residential development around Council Grove City Lake. It is expected that some development will take place along the shore of Council Grove Reservoir in the future (Ibid.).

Both Council Grove City Lake and Council Grove Reservoir have recreational areas on their respective lake shores. These include marinas and picnic and camping areas. More intensive land uses in the lake shore area of Council Grove Reservoir are not permitted at this time. Much of the lake shore is owned by the Federal Government or the State of Kansas.

In the remaining portion of the study area the dominant land uses are for cropland, rangeland, and pasture (see Figure 3). Crops are grown where the soil is suitable for plowing. However, in many areas of the county the soil is too thin to plow or is highly susceptible to wind erosion. Areas used for crop growth include alluvial valleys and uplands, especially near stream divides where the soil is thicker. Typical crops include wheat, sorghum, alfalfa, corn, and soybeans. Those areas not suitable for crops are set aside for range and pasture land.

Other industries which make use of the land include oil and construction-materials companies. Oil is currently being withdrawn from a small field near Wilsey in the southwest part of the study area. Currently, all of the rock

Figure 3. Generalized Land Use Map.



quarries and gravel pits are operated sporadically as need requires.

Other land uses include transportation and transmission lines (see Figure 2). The major highways that traverse the study area are U.S. Highway 56 and Kansas Highways 4 and 177. The county maintains a well-developed set of dirt or gravel roads. Railroad lines include the Missouri Pacific, which serves Council Grove, and the Chicago and Rock Island, which serves White City. Transmission lines which cross the study area include oil and gas pipelines, electric powerlines and telephone lines.

CHAPTER III

A METHOD OF CHARACTERIZING NORTHEASTERN MORRIS COUNTY, KANSAS

In northeastern Morris County three basic types of environmental settings occur: (1) the uplands, which include ridgetops, side slopes, and floodplains of the area; (2) streams; and (3) man-made lakes. Each setting includes both living or biotic and non-living or abiotic components interacting in a distinctive ecosystem. In order to describe the functioning of ecosystems, both the static and dynamic aspects must be known. In this thesis "composite resource areas" will be used to describe the static components of the ecosystems. The dynamic aspects will be elucidated with "ecologic systems diagrams."

"Composite resource areas" are small land areas with similar environmental properties such as bedrock type, soils, biota, topographic expression, and geomorphic processes. This unit was originally defined for use in delineating environments along the Texas Coastal Zone (Armstrong, 1976) and is similar to the "resource capability unit" of Brown, et al. (1976).

Composite Resource Areas

Because the land in each composite resource area has properties that are suitable for certain uses, and limita-

tions that argue against its use in other ways, "composite resource areas" show favorable and unfavorable locations for specific activities by pointing out the natural capabilities of each site. Areas suitable for specific land uses can be delineated by comparing the requirements for that land use with the descriptions of the "composite resource areas."

In the study area, "composite resource areas" have been delineated by using soil series and soil-complex boundaries. This method of subdivision was used because of the close correlation between soil types and the physical processes and properties of materials in the basin. Certain soil types are associated with certain combinations of parent materials, topographic characteristics, and geomorphic processes. Each resource area has been described by using a range of degree of slope, soil thickness, parent material type, active geomorphic processes, and biota (see Table 2). The distribution of composite resource areas is shown on the set of quadrangle maps of the study area (see Plate B).

Ecologic Systems Diagrams

The term ecosystem is used to describe the total environment, including both the living and non-living portions. All terrestrial ecosystems are made up of a number of components including plants and animals, nutrients, soils, bed-rock and water. In the organic world, energy acquisition and use are basic. As a result, physiological and morphological adaptations, day-to-day functioning, and evolution-

Table 2. Composite Resource Areas of Northeastern Morris County, Kansas. Data used to construct this table come from Barker (1974) (a) or field observations (b).

Composite Resource Area	Degree of Slope (a) (percent-age slope)	Soil Series (a)	Depth to Bedrock (a)	Soil Parent Materials (a)	Active Processes and Geologic Features (b)	Biota (a)	Physical Setting (b)
A	0-5	Irwin Dwight	5-7 feet (1.6-2.1 meters) but may be less	Clayey residuum over limestone or cherty limestone	Soil formation. Wind and water erosion of long, moderately inclined, unvegetated slopes producing blowing soil and rills and gullies are common. Some aquifer recharge through sink-holes. High seasonal or perched water tables are possible.	Blue-stem Prairie	on undissected upland areas and near drainage divides
B	1-8	Labette-Dwight Florence	0-4 feet (0-1.3 meters)	Limestone or cherty limestone	Weathering and erosion of limestone and cherty limestone. Springs common where bedrock crops out on side slopes. Infiltration of water through the soil to bedrock aquifers.	Blue-stem Prairies, wooded along upland drainages	on dissected uplands

Table 2 (Continued)

Composite Resource Area	Degree of Slope (a) (percentage slope)	Soil Series (a)	Depth to Bedrock (a)	Soil Parent Materials (a)	Active Processes and Geologic Features (b)	Biota (a)	Physical Setting (b)
C	3-15	Tully	variable	Shale or clayey residuum over shale	Severe water erosion on steep slopes producing extensive rill and gully networks. "Cat steps" also common on steep slopes. Springs and seeps common where thin limestones crop out on the sides of hills.	Blue-stem Prairie	on steep to moderately steep slopes below limestone outcrops
D	highly variable	Alluvial land and Reading	variable	Alluvium	Frequent flooding and erosion of stream valleys during periods of high rainfall. Deposition of sediments from upstream sources and locally from up-slope.	Blue-stem	on upland drainages adjacent to intermittent streams

Table 2 (Continued)

Composite Resource Area	Degree of Slope (a) (percentage slope)	Soil Series (a)	Depth to Bedrock (a)	Soil Parent Materials (a)	Active Processes and Geologic Features (b)	Biota (a)	Physical Setting (b)
E	5-10	Clime-Sogn complex	0-2 feet (0-.6 meters)	Interbedded limestone and shale	Severe water erosion because of steep slopes. Springs common where limestone crops out at the surface. Weathering and erosion of limestones and shales.	Blue-stem Prairie; occasionally wooded	on steep slopes
F	0-2	Lady-smith Smolan	5 feet (1.6 meters)	alluvium	Soil formation. Deposition of eroded materials from upslope. Water may pond in low areas after heavy rains because of slow infiltration. High seasonal water tables are possible.	Blue-stem Prairie	on older terraces of major streams

Table 2 (Continued)

Composite Resource Area	Degree of Slope (a) (percentage slope)	Soil Series (a)	Depth to Bedrock (a)	Soil Parent Materials (a)	Active Processes and Geologic Features (b)	Biota (a)	Physical Setting (b)
G	0-3	Mason and Reading	5 feet (1.6 meters)	alluvium	Occasional flooding and deposition of sediment by nearby streams. Infiltration of water from streams and precipitation to recharge alluvial groundwater systems.	Flood-plain, forest and savannah	on high terraces just above bottom lands
H	variable	Ivan- Kennebec	5 feet (1.6 meters)	alluvium	Frequent flooding and deposition of sediment by nearby streams. Infiltration of water from streams and precipitation to recharge alluvial groundwater systems.	Flood-plain, forest and savannah	on low terraces adjacent to streams

Table 2 (Continued)

Composite Resource Area	Degree of Slope (a) (percent-age slope)	Soil Series (a)	Depth to Bedrock (a)	Soil Parent Materials (a)	Active Processes and Geologic Features (b)	Biota (a)	Physical Setting (b)
I	3-15	Reading, Tully, Lady-smith, Smolan; rarely Irwin and Dwight	4 feet (1.3 meters)	colluvium-alluvium	Water erosion severe on steep slopes. Rill and gully systems extensively developed. High seasonal water table possible.	Blue-stem Prairie	on pediment-like surfaces
J	0-2	Lady-smith	5 feet (1.6 meters)	loess	Soil formation. Wind erosion likely on un-vegetated slopes. High seasonal water table possible.	Blue-stem Prairie	on ridgetops near stream divides
K	variable	Florence Labette	4 feet (1.3 meters)	cherty gravels	Aquifer recharge is possible if the gravels are on limestone bedrock.	Blue-stem Prairie	on uplands or side slopes

Table 2 (Continued)

Composite Resource Area	Degree of Slope (a) (percentage slope)	Soil Series (a)	Depth to Bedrock (a)	Soil Parent Materials (a)	Active Processes and Geologic Features (b)	Biota (a)	Physical Setting (b)
L	variable	Chase	5 feet (1.6 meters)	alluvium	Deposition of sediment by flooding and ponding of water in depressions after heavy rains. Frequently flooded.	Flood-plain, forest and savannah	on old stream meanders and backwater areas
M	variable	variable	5 feet (1.6 meters)	alluvium	Periodically flooded by lake level manipulation	fresh water marsh	on artificially flooded areas
N	variable	variable	5 feet (1.6 meters)	alluvium	Artificially flood-protected areas of intensive human development	none	in urban areas

ary strategy are closely linked to the energy sources of the natural system. All of the components of the system are linked through transfers of energy between different biotic components, as in feeding relationships, and between abiotic and biotic components, as in providing nutrients to plants. Some of the components of the natural system exert control over other parts of the system as through a direct energy relationship or through indirect means using a small amount of energy.

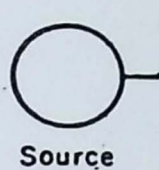
Ecologic systems are complex because large numbers of linkages and control mechanisms are possible in a given environment. Simple narrative descriptions of such ecologic systems are often difficult and, at the other end, quantitative models, though excellent descriptors and predictors of the functioning of ecosystems, are too abstract to allow visualization of system operation.

Odum (1971, 1972) suggested that an energy-circuit language common in electrical engineering could be used to represent complex natural and man-made systems schematically. This energy-circuit language is not a perfect representation of the natural system that is being described but does symbolize the essential functions. The resultant schematic diagram is a generalized description of a given system and is a tool for identification of components in the system. In addition, the diagram can serve as a basis for the synthesis of new information. These diagrams do not re-

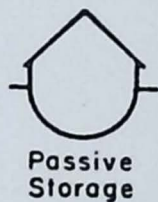
place mathematical models, but serve as a visual framework to organize information in their absence. The following is not a treatise on the schematic diagramming of systems and the reader is encouraged to look at Odum (1972) for further description of the theory behind this method of schematic representation and for applications outside the scope of this discussion.

Figure 4 is a list of the symbols used in ecologic systems diagrams. The circle represents input into a system (Figure 4,a). The input can be in any form of matter or energy such as precipitation, nutrients, or management activity. The tank-shaped symbol (Figure 4,b) represents a temporary storage within the system. In dynamic systems, the rate of storage can be calculated as the difference between the rates of input and output. Figure 4,e shows a work-gate which acts as a regulator of energy flow through the system. The regulated flow is J_1 and the regulating flow into the work-gate is J_2 and is generally much less than J_1 . All energy converters within a system are described by the hexagon symbol (Figure 4,f). Green plants and any system component that has a production function are symbolized by the bullet (Figure 4,d). Figure 5 is copied from Odum (1971) and shows how the ecosystem of a house can be diagrammed.

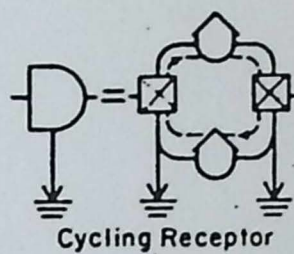
Figure 4. Symbols of the Energy Circuit Language
(From Odum, 1971).



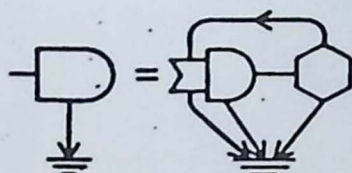
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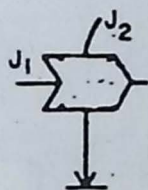
Passive Storage



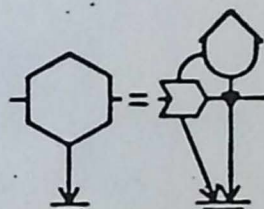
Cycling Receptor



Green Plant

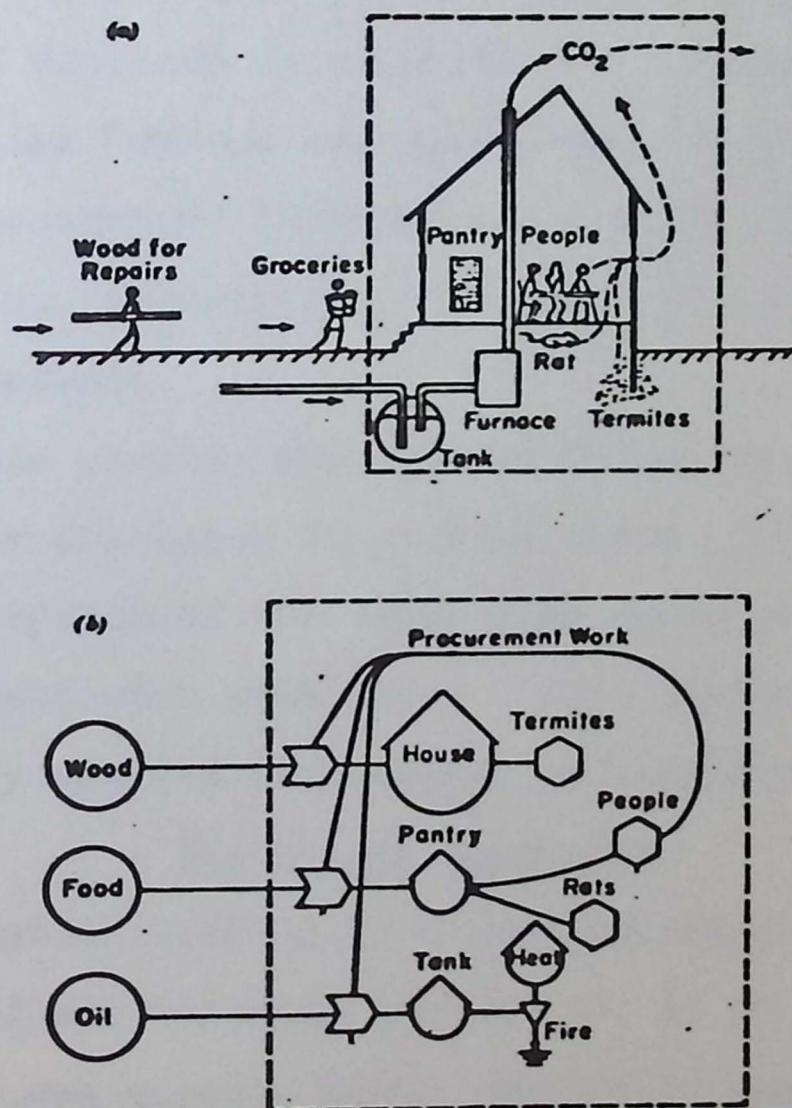


Work Gate



Self Maintenance

Figure 5. Diagram of a House Ecosystem. Power circuit diagram for a human habitation showing three outside energy sources, work by people, and steady-state maintenance of population and the structures of furnace and house. (a) Schematic diagram; (b) energy diagram (From Odum, 1971).



CHAPTER IV

THE ECOLOGIC SYSTEMS OF NORTHEASTERN MORRIS COUNTY

In northeastern Morris County there are three ecosystems: the uplands, streams, and man-made lakes. This threefold division could be subdivided into more ecosystems with further study, but, for the purposes of this discussion, the threefold division is satisfactory. Throughout this report the terms "upland ecosystem" and "uplands" are used. The "upland ecosystem" includes the uplands, side-slopes, and floodplains, whereas the "uplands" is used as a subdivision of the terrain.

In this chapter the essential features of each ecosystem will be discussed in general terms. This will include a description of the major components and how the components interact with each other. This discussion will be facilitated by the use of ecologic systems diagrams.

The Upland Ecosystem

The upland setting is a very important part of the open system of all drainage basins. It is an environment of weathering and erosion which eventually causes sediment and nutrients to move to downstream environments. The geologic processes that shape the overall drainage basin are numerous and include soil formation, mass wasting, runoff,

solution of limestones, and aeolian erosion and deposition.

The upland system also receives input from outside the basin. Most of the precipitation received by the basin falls on the upland surface. Also, this part of the basin receives airborne dust and sunlight.

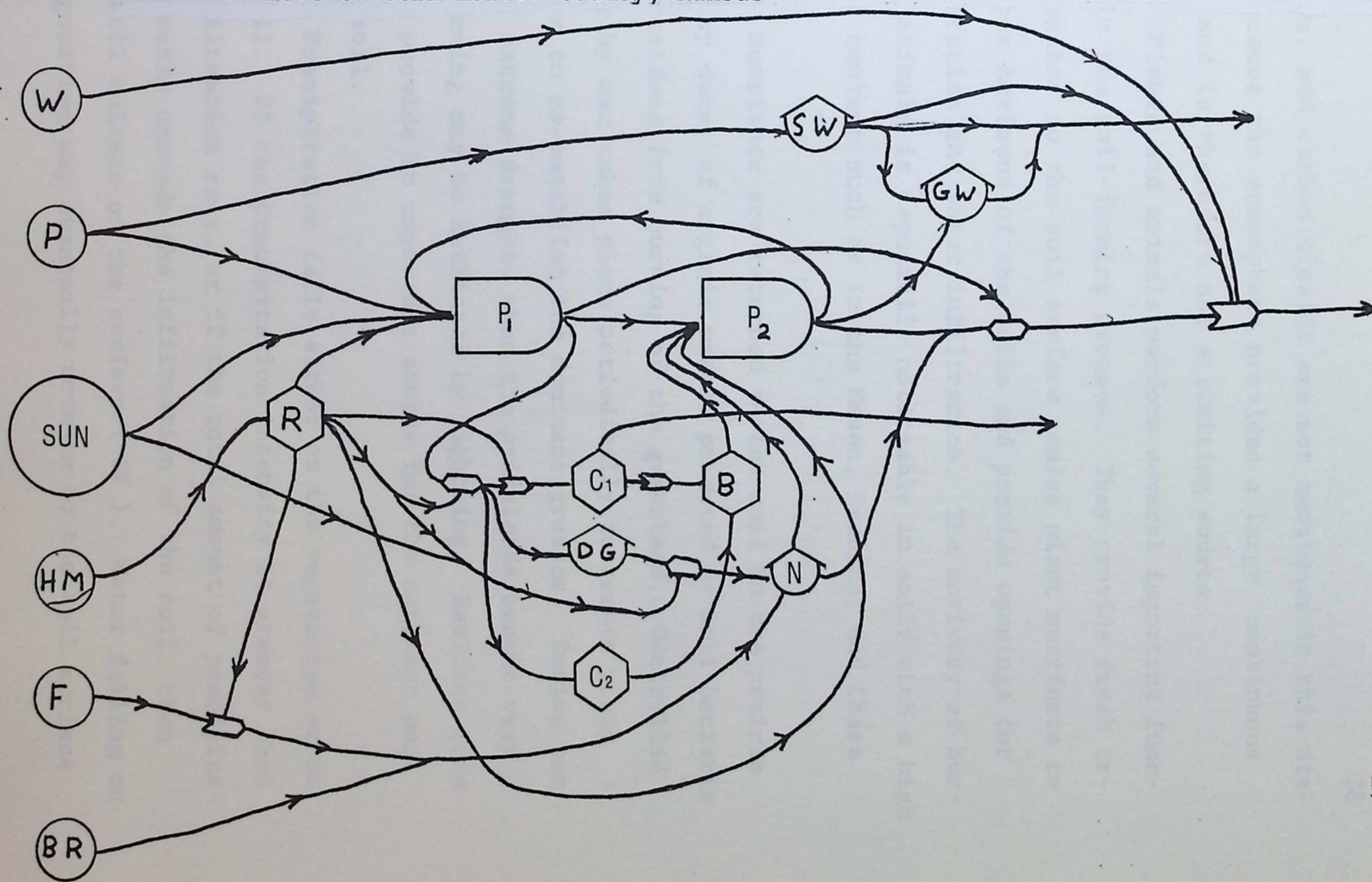
While much is known about prairie ecosystems and management of these very important environments, very little has been written specifically about the ecosystems of the Flint Hills, of which Morris County is a part. Barker (1974) described the soil series of Morris County and discussed soils and biota in relation to range management. The U.S. Army Corps of Engineers (1970) conducted an inventory of local biota as part of the Draft Environmental Impact Statement for the Cedar Creek Dam Project in Chase County. These studies have provided valuable information, but have not discussed ecosystem relationships.

The basis of organization of all ecosystems is the food web. Plants are primary producers, creating from soil and water carbohydrates, proteins, and lipids, which they then store. Herbivores ingest plant material and use the stored end products of photosynthesis as an energy source. In turn, carnivores rely on herbivores for energy to maintain life support. Plant and animal wastes are returned to the soil by decay processes. Decay is accomplished by either soil bacteria or bacteria in animal wastes. The end result of the decay process is the replenishment of the nutrient

supply and humus in the soil.

Figure 6 is a simplified ecologic systems diagram of the upland ecosystem illustrating the relationships between the important components and processes in the Bluestem Prairie. The large bullet-shaped symbols represent major subdivisions within the prairie. These are the vegetation and soil subsystems and are modules of organic production. Vegetation above the soil surface receives energy from the sun and the soil receives input from nutrients produced by decay and burn-off of the grass and by weathering of bedrock. The tank-shaped symbol represents storage of materials, in this case dried grass and plants that supply nutrients to the soil. The hexagonal shapes represent herbivores, carnivores, and man; C_1 being domestic herbivores feeding directly on plant material, and C_2 being untamed herbivores and carnivores. The carnivores play a minor role in this ecosystem and are, therefore, grouped with untamed herbivores. The hexagonal symbol labelled B represents bacteria which use the wastes of man and animals to produce nutrients for the soil. The arrows represent the direction of energy flow. It should be noted that arrows leading to the bacteria tank from the "C" hexagons represent not only decay of excreted material but also of carcasses of dead animals. In addition, it should be noted that the number of subscripted "C"-hexagon symbols could be increased if more complexity were desired. Input into the system, such as the gases oxygen,

Figure 6. An Ecologic Systems Diagram of the Major Features of the Upland Ecosystem in Northeastern Morris County, Kansas



nitrogen, and carbon dioxide are not mentioned in this diagram because the atmosphere provides a large, continuous supply and is therefore not a limiting source.

Plants and animals perform several important functions in the soil-forming process. They provide fresh organic matter to the soil surface, raise plant nutrients to the upper horizons of the soils and provide openings for soil aeration and water infiltration. The activity of burrowing animals is especially noticeable in soils with a high organic content such as in the Mason, Reading, and Chase series.

Nutrients are returned to the soil in the prairie either by decay of organic matter promoted by soil bacteria or by residues from burning of the grassland. Controlled burning by man takes place periodically to remove young trees or to re-establish the dominant grasses. During periods of extreme drought, when the grasslands become very dry, burning may be initiated by lightning. Residues from burning provide an important source for the nutrient pool of the soil.

Precipitation falls either on the vegetation or on bare soil. If the precipitation intensity is greater than the infiltration rate, or if the total amount of precipitation greatly exceeds the infiltration of the soil, then water will collect on the surface (SW). Water falling on the vegetation may eventually move on to the soil surface

and infiltrate or evaporate. Water infiltrating into the soil may be retained in the soil or continue downward to become a part of the groundwater system (GW). Water may leave the upland system in three ways; through evapotranspiration, through the drainage network, or through the groundwater system.

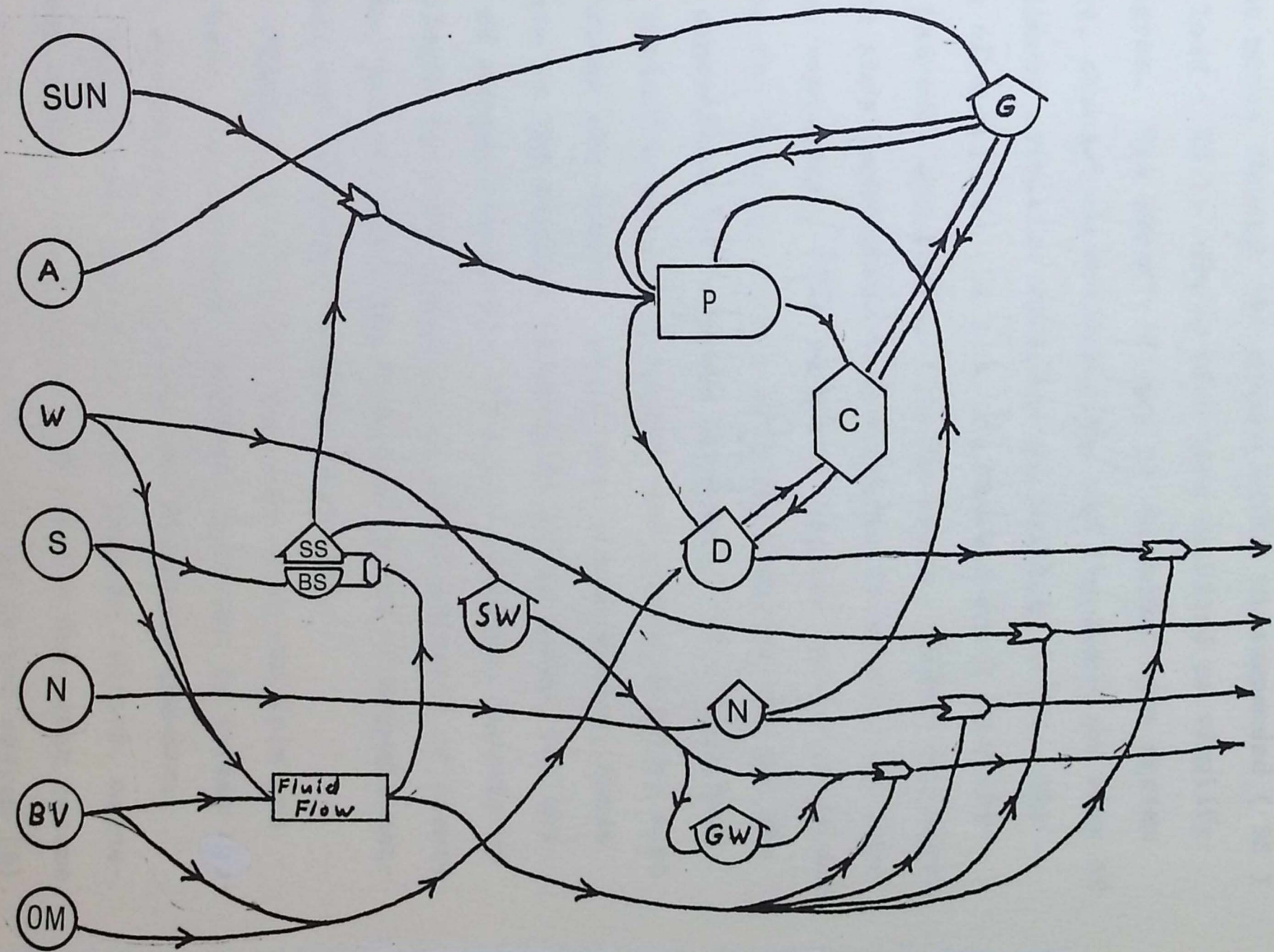
Stream Ecosystem

Figure 7 illustrates the relationship between the biotic and abiotic components of the stream ecosystem. No attempt was made during the course of study to identify and inventory any of the stream biota that might be present in this part of the Flint Hills. The diagram and discussion point out only generalized relationships that have been described by Hynes (1970) for most stream environments. It is assumed that these relationships are also present in the streams draining the Flint Hills region.

Stream communities are patchy and discontinuous because of the influences of current and fluxes of sediment and nutrients. In addition, these environments are also influenced by the stream-bank or riparian environment. Vegetation along the bank of the stream contributes organic matter (OM), influences the temperature regime and the amount of light in the stream (1), and modifies the hydraulic regime of the stream (2).

Materials put into the stream ecosystem include water, sediment, nutrients, organic matter, and dissolved

Figure 7. An Ecologic Systems Diagram of the Major Components of Stream Ecosystems in Northeastern Morris County, Kansas



gases. In general, the rate of input is dependent upon the volume of water moving into and through each stream reach. Sediment moves through the system either as suspended (SS) or bed load (BS). These have been combined to simplify the diagram. The amount of each is dependent upon stream velocity, channel characteristics, and the shape and size of the sediment particles (Gregory and Walling, 1973). The amounts of nutrients (N) in the water depends upon the soils, bedrock, and land use in the basin. Additional nutrients are also contributed from atmospheric sources and from riparian vegetation. The amount of organic matter is dependent upon the level of biotic activity upstream (2) and the amount contributed by riparian vegetation (3). Dissolved gases, including oxygen, nitrogen, and carbon dioxide, also move through the system. Under most circumstances, these gases are at 100 percent saturation in the water, but the amount of oxygen and carbon dioxide in solution depends on the geologic terrain, respiration, photosynthesis of plants upstream, and the biochemical oxygen demand of organic matter decay and inorganic chemical oxidation.

Plants use nutrients from the water and from the stream bed. The nutrient ions most important to stream ecosystems are potassium, nitrate, and phosphate (Sanders, 1972). Other, less important, ions include calcium, magnesium, and sulfur. When plants and animals die, they become a part of the detritus temporarily stored in the system (6).

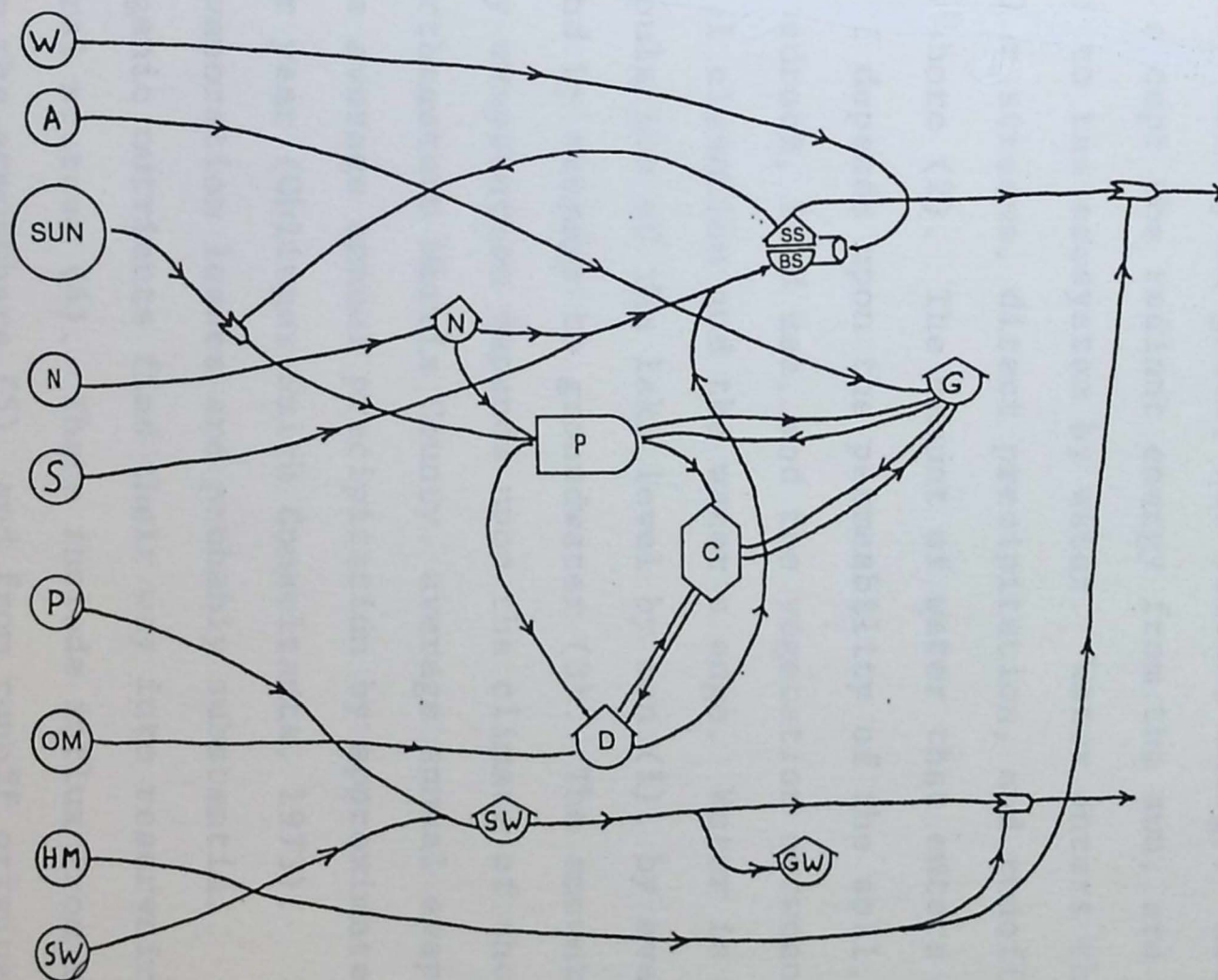
Other components of the detritus include non-degraded plant litter from riparian sources and degraded colloidal organic matter from upstream sources (2). Non-degraded materials are eaten by detritivores. Organic materials are also oxidized by bacteria, which deplete the oxygen supply during the decay process. Other components of the stream ecosystem use the plankton as a food source. These in turn are a source of food for first and second order carnivores which include fish.

In addition to nutrients, dissolved gases, and food, many other factors influence the distribution and abundance of organisms in the stream environment, especially in the life cycle of most organisms. These factors include temperature, availability of light, current velocity, substratum, alkalinity, water hardness, and fluctuations of discharge. Each of these factors may be affected by events taking place upstream or in the riparian environment.

The Reservoir Ecosystem

Figure 8 illustrates the relationships that are important in the man-made lake ecosystem. During the course of investigation, no attempt was made either to inventory the biota or to study their relationships in Council Grove Reservoir or Council Grove City Lake. This systems diagram points out only generalized relationships that have been described by Hynes (1965). The assumption is made that the ecosystems described by this author are similar to those in

Figure 8. An Ecologic Systems Diagram of the Major Components of the Reservoir Ecosystems in Northeastern Morris County, Kansas



the study area.

The principal flows of materials and energy into the man-made lake ecosystem include water, sediment, nutrients, organic matter, dissolved gases, and radiant energy. All of these flows, except the radiant energy from the sun, are transported into the ecosystem by water. Water enters the lake from inlet streams, direct precipitation, and runoff from the lakeshore (2). The amount of water that enters the lake by runoff depends upon the permeability of the soil, the type of bedrock, land use, and the vegetation between the flood-pool elevation and the water's edge. Water is lost by manipulation of the lake level by man (1), by evaporation (2), and by seepage to groundwater (3). The amount of water lost by evaporation depends upon the climate of the area. In northeastern Morris County, average annual evaporation exceeds average annual precipitation by approximately 20 inches per year (Oblinger-Smith Consultants, 1973). Therefore, evaporation losses are probably substantial.

Inorganic nutrients find their way into reservoirs through several sources (4). These include influx from the streams, from the atmosphere (5), and from runoff originating from the lakeshore area. These nutrients include ions dissolved in water, ions absorbed onto clay-sized particles, and organic matter. Nutrients remain in the water column, become incorporated in the bottom sediments, or are used by the biota for life support (8). Nutrients leave the ecosys-

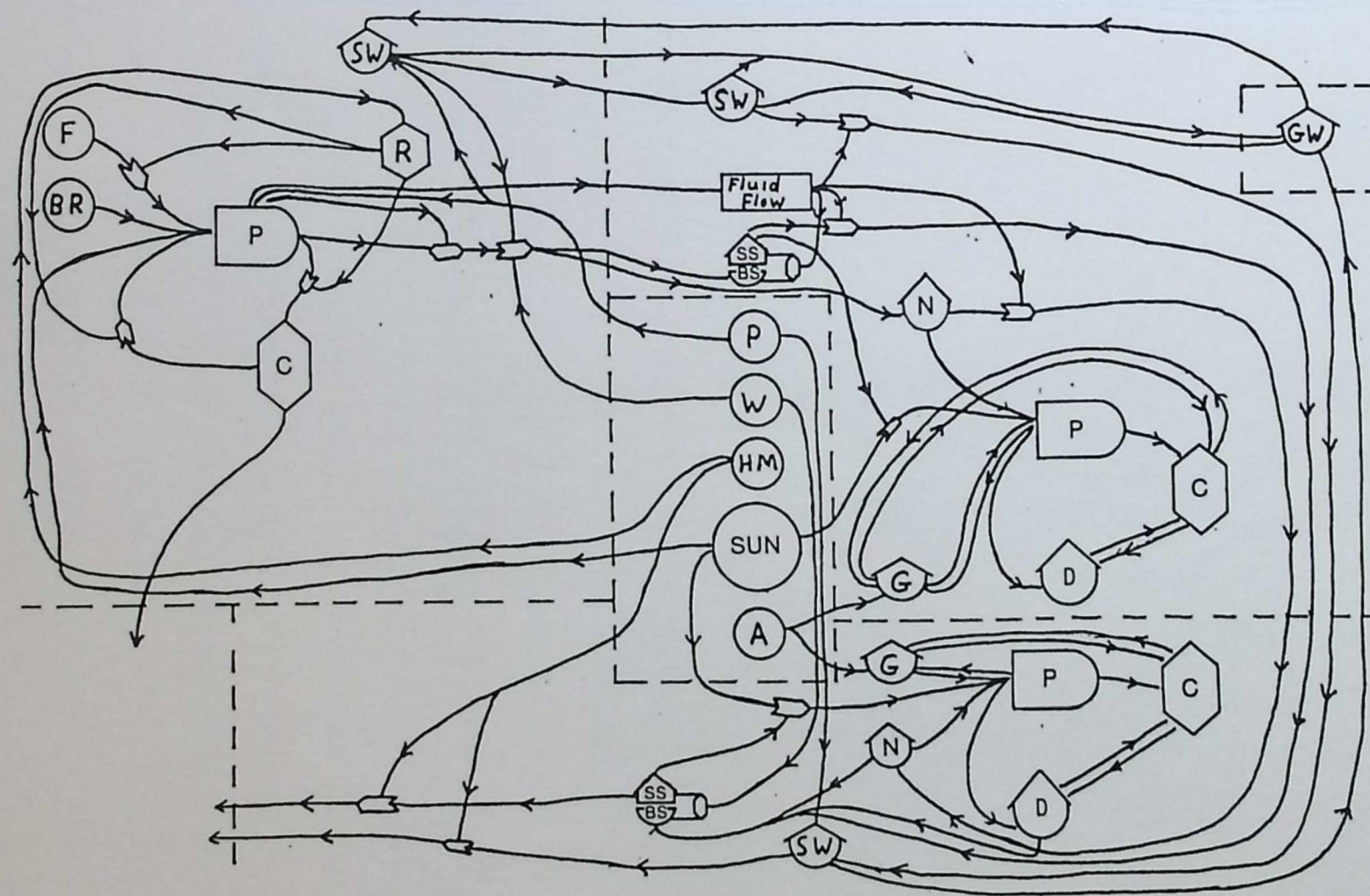
tem through the spillways of the dam and through the groundwater system.

Organic matter is supplied to the reservoir by the impounded river and the lakeshore area (9). The form of the organic matter supplied is either as plant and animal remains or degraded in colloidal form. Once in the lake, the organic matter either remains in the water column or settles to the bottom. In either case, it can be consumed by detritivores, degraded by bacteria, or incorporated in the bottom sediments (10). Organic matter is produced from the ecosystem as suspended sediment in the water column (11).

Lake level regulation of man-made lakes clearly distinguishes them from natural lakes and has profound ecologic effects on reservoir ecosystems. Lake level regulation alters the volume of the lake and hence the amount of available nutrients in the ecosystem. The zone around the lakeshore between high and low water is also greatly affected. Conditions may be too variable for many terrestrial and aquatic plants to colonize the zone and little or no vegetation may grow in the zone. Soil erosion due to runoff and wave action may pose a threat to parts of the shore habitat. Also, few microhabitats will be provided if the shallows of the reservoir slope too steeply. Microhabitats may be destroyed by excess runoff and silt from these vegetationless areas along the shore.

Figure 9 is a combined ecologic systems diagram for

Figure 9. A Combined Ecologic Systems Diagram of the Major Ecosystems of Northeastern Morris County, Kansas



all of northeastern Morris County. Some simplification has been used in order to produce the diagram. This illustration shows the interrelationships between major components in all of the ecosystems of the study area.

CHAPTER V

BEDROCK AND SURFICIAL DEPOSITS

The properties of the geologic materials exposed in the study area are important parameters in determining land-use suitability. First of all, the properties of the earth materials often determine the difficulty that will be encountered in site preparation. The economics of excavating shale are different from those of limestone because of the need for more heavy-duty excavating equipment or special procedures such as drilling and blasting when limestone is involved. Therefore, it is important to know the positions of all limestones and shales in the stratigraphic section. Secondly, the conditions of unconsolidated materials above the bedrock could indicate other special problems that might be encountered. For example, soils (in the engineering sense) with high shrink-swell potential often cause foundation failures. The origin of the deposit may indicate special hazards such as flooding. Third, a knowledge of the properties of the bedrock and surficial deposits is important because they may be sources of natural resources. Limestone and gravel are used in construction and they are the primary mineral resources of the region.

A general discussion is conducted here of the bedrock and surficial deposits. Discussion of the properties

of these materials as they relate to site suitability is included in the Land Use Constraints Based on Composite Resource Areas Section.

Many studies of the bedrock and surficial deposits have been conducted both in the study area and in adjacent areas. These include a geology and construction materials survey of Morris County (Mudge, et al., 1958); the geology and water resources of Chase County (Moore, et al., 1951); and a map of the Precambrian bedrock surface of Kansas (Cole, 1976).

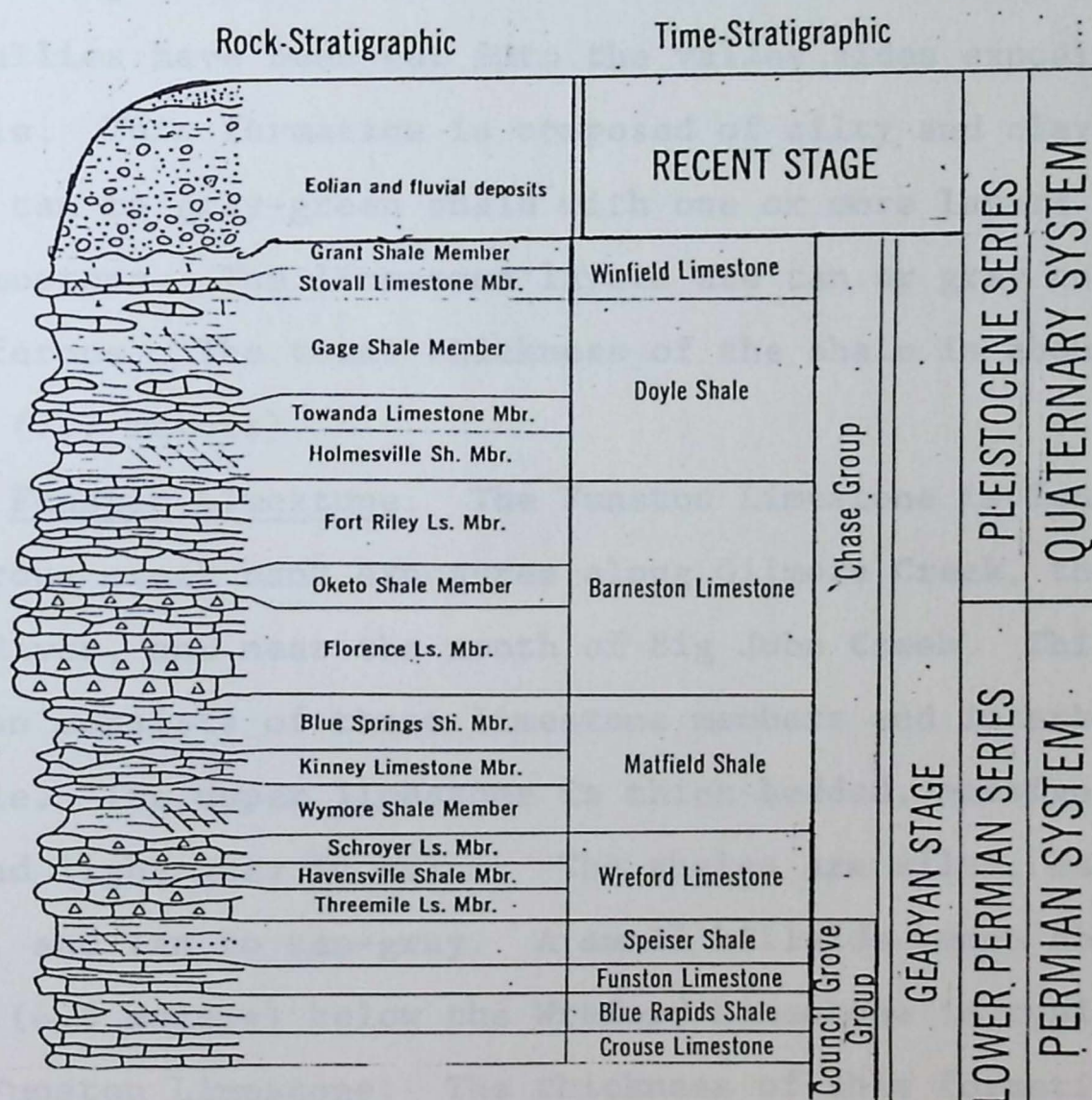
The bedrock and surficial deposits that crop out in the study area range in age from Lower Permian to Recent (see Figure 10). The rock units are well-exposed along valley sides, but are poorly exposed where they are covered by soil and unconsolidated Quaternary deposits in both the upland areas and the floodplains. The surficial deposits consist of loess, and alluvial and colluvial materials. Bedrock units consist of layers of limestone, cherty limestone, and shale. The distribution of the bedrock units and surficial deposits is shown on Plate A.

Permian System

Council Grove Group

Crouse Limestone. The Crouse Limestone is best exposed along valley sides near the confluence of Big John Creek and the Neosho River and in some of the bedrock-floored gullies that empty into Gilmore Creek above Council

Figure 10. Columnar Section of the Bedrock and Surficial Deposits of Northeastern Morris County, Kansas (Zeller, 1968)



Grove Reservoir. It consists of a thick layer of gray unfossiliferous, platy limestone which weathers into numerous light-gray plates. The total exposed thickness is about five feet (1.5 meters).

Blue Rapids Shale. The Blue Rapids Shale is best exposed along the south bank of Elm Creek near Council Grove where gullies have been cut into the valley sides exposing the shale. This formation is composed of silty and clayey beds of tan to gray-green shale with one or more layers of thin limestone. The limestone layers are tan or gray and fossiliferous. The total thickness of the shale is about 25 feet (7.7 meters).

Funston Limestone. The Funston Limestone is found in numerous creek bank exposures along Gilmore Creek, the Neosho River, and near the mouth of Big John Creek. This formation consists of three limestone members and interbedded shale. The upper limestone is thick-bedded, massive, soft, and light gray in color. The shales are silty, calcareous, and tan to tan-gray. A small hillside bench about 15 feet (4.6 meters) below the Wreford Limestone is typical of the Funston Limestone. The thickness of this formation is about ten feet (3.1 meters).

Speiser Shale. The Speiser Shale is best exposed along Gilmore Creek near its confluence with the Neosho River and near Council Grove along the west side of the Neosho River valley. The Speiser Shale is composed of beds of

varicolored shale with tan-gray and gray-green zones in the upper part and maroon shales common toward the base. The beds of shale are silty to clayey and calcareous. Total thickness of the shale is about 16 feet (4.9 meters).

Chase Group

Wreford Limestone. The Wreford Limestone is the basal formation of the Chase Group. Prominent hillside benches are formed of this formation throughout the study area but especially around Council Grove. The Wreford Limestone consists of three members which are, in ascending order: the Three Mile limestone member, the Havensville shale, and the Schroyer limestone member. The limestone members consist of thick, massive, hard cherty limestones. Chert occurs either as distinct bands or as nodules. Many zones in the limestones have abundant solution cavities. The Havensville shale member consists of silty and calcareous, tan-gray shale with a single layer of hard, massive limestone near the middle. The total thickness of this formation is variable but averages around 35 feet (10.8 meters).

Matfield Shale. The Matfield Shale is poorly exposed in the study area because it is usually covered by colluvial-alluvial or colluvial deposits. It forms prominent slopes beneath the Florence limestone member of the Barneston Limestone. The Matfield Shale consists of three members which are, in ascending order: the Wymore shale, the Kinney limestone, and the Blue Springs shale members.

The two shale members consist of varicolored, calcareous shales with thin discontinuous layers of limestone. Colors range from gray to tan, green, and purple. The Kinney limestone member is a thin, hard, dense, light tan to gray, limestone layer that varies in thickness from one to four feet (.3 to 1.2 meters). Where it is not covered by colluvial deposits, it produces a slight bench in the topography below the Florence limestone. The Matfield Shale is about 65 feet thick (20 meters).

Barneston Limestone. The Barneston Limestone consists of three members: the Florence limestone, the Oketo shale, and the Fort Riley limestone members. The limestones are described separately because each limestone has properties that sets each apart from the other.

Florence limestone member. Outcrops of the Florence limestone member are abundant throughout the study area. It produces a very distinctive bench in the landscape and caps many of the dissected ridges in the southeastern third of the study area. Good exposures can be found along the Neosho River in the Parkerville area and along Munker Creek north of Council Grove Reservoir.

This member consists of thick beds of limestone and cherty limestone separated by thin shales. The proportion of shale is higher in the lower portion of the member than in the upper. The limestone and cherty limestone are dense and hard. The color of the limestone is light tan on fresh

surfaces but weathers gray. Total thickness of the member is about 25 feet (7.7 meters), but may be as high as 30 feet (9.2 meters) in places.

Oketo shale member. The Oketo shale member consists of beds of tan, calcareous, silty shale with a single discontinuous layer of silty limestone near the top of the member. Total thickness is about six feet (1.9 meters).

Fort Riley limestone member. Outcrops of the Fort Riley limestone member are conspicuous in the western and northern portions of the study area. Commonly, one or more resistant layers of the Fort Riley limestone crops out at the surface as a line of weathered limestone boulders roughly following the contour of the land surface above the Florence limestone member. This member consists of layers of medium-hard to soft, tan, porous, massive limestones separated by partings and thin layers of silty, calcareous shale. The upper limestone layers weather easily and are often covered by a substantial thickness of soil. The limestones are jointed and often have abundant solution channels and sinkholes. Total thickness is about 35 feet (10.1 meters).

Doyle Shale. The Doyle Shale crops out in the western and northwestern portions of the study area above the Barneston Limestone. This formation consists of three members which are, in ascending order: the Holmesville shale, the Towanda limestone, and the Gage shale members.

Holmesville shale member. The Holmesville shale member consists of a gray to green, blocky, silty shale which contains a single, one foot (.3 meters) thick layer of hard, dense limestone near the top of the member. The limestone weathers easily into porous blocks. Total thickness of the member is about 16 feet (4.9 meters).

Towanda limestone member. The Towanda limestone member consists of interbedded layers of thick, massive, hard, dense, gray limestone and thin layers and partings of shale. Individual layers of limestone are generally up to about one foot (.3 meters) in thickness. Shales are calcareous, silty, and usually not more than six inches (.1 meters) thick. Outcrops of this member are usually highly fractured and ungraded cuts into this member slump easily. This member produces a slight bench in the landscape where it is not covered by colluvium. Total thickness is about ten feet (3.1 meters).

Gage shale member. The Gage shale member is poorly exposed in the northwestern and extreme southwestern portions of the study area. It consists of beds of tan to tan-gray, clayey shales and gray to gray-green, silty shales. A thin bed of tan limestone is present near the top of the member. The total thickness of this member is about 40 feet (12.3 meters).

Winfield Limestone. Outcrops of the Winfield Limestone are only poorly exposed in the northwestern part of

the study area around White City and in the extreme southwestern part of the area. The Winfield Limestone is composed of three members, two of which crop out in the study area. These are the Stovall limestone and the Grant shale members.

Stovall limestone member. The Stovall limestone member consists of a single layer of massive, hard, gray, cherty limestone. Its total thickness is about one foot (.3 meters).

Grant shale member. The Grant shale member consists of tan, silty, calcareous shale with many calcite-, quartz-, and chalcedony-filled geodes. The total thickness of this unit exposed in the study area is about eight feet (2.5 meters).

Quaternary Unconsolidated Deposits

The Quaternary unconsolidated deposits in the study area consist of several categories of materials. These have been put into four groups; loess, alluvial deposits, colluvium, and modern soil.

Loess deposits can be found on flat upland surfaces near the head-waters area of some of the major streams in the study area. The loess is gray to tan and composed of silt- and clay-sized particles.

Alluvial deposits in the study area consist of mixtures of chert gravel, clay, and silt commonly found along all of the streams in the area. Included in this category

are terrace deposits. These have the same lithologic composition as the modern alluvium. Some gravel deposits of questionable origin have also been assigned to this category as a matter of convenience. These mixtures of brown chert gravel, light gray to white chert gravel, and red silt-clay have been found on upland surfaces away from modern stream courses.

The colluvial materials consist of slopewash deposits of silt, clay, and gravel produced from the weathering of limestones and cherty limestones commonly found below the benches produced by the weathering of resistant limestones on shale slopes.

CHAPTER VI

SOILS

Soil is defined in this section as a weathered, bacterially active surficial material that supports vegetative growth (Woodruff, 1974), whereas to an engineer, soil is any unconsolidated material above bedrock (Terzaghi and Peck, 1967). The distinction between these two definitions of soil will be made throughout this report where ambiguities might exist.

The properties of soils often determine their suitability for engineering and agricultural land-uses. These properties include texture, permeability, shrink-swell potential, available water capacity, and depth to bedrock (see Table 3). Texture is given using the average USDA texture and Unified Soil Classification System for the whole profile.

Soil properties are important for a variety of reasons. Texture and shrink-swell potential determine the shear strength of the soil, a characteristic important for earthwork and foundations. Permeability is an important parameter of the soil for engineering purposes because many earthen structures require no seepage. Depth to limestone bedrock is an important parameter because the costs of excavation increase significantly if the excavation involves limestone (Woodruff, 1974).

Table 3. Selected Physical Properties and Soils Classifications of the Soil Series in Northeastern Morris County, Kansas (modified from Barker, 1974)

Soil Series	Depth (cm)	USDA	Unified	Permeability	Available Water Capacity	Shrink-Swell
Alluvial and Reading	 too variable					
Chase	152	silty clay	CH-CL	.2-.63	.17-.19	high
Clime Sogn	15	silty clay	CL-CH	.20-2.00	.17-.19	moderate
Dwight	107-152	silty clay	CH	.06	.17-.19	high
Florence	15-152	cherty silty clay	ML, GM, CG, CL, or CH	.2-.63	.04-.08	low
Irwin	107-183	silty clay	CH	.06	.17-.19	high
Ivan-Kennebec	152	silt loam	CL-ML	.63-2.00	.17-.19	moderate
Labette	46-107	silty clay	ML-CL	.2-.63	.17-.19	moderate
Ladysmith	152	silty clay	CH	.06	.17-.19	high
Mason	152	silty clay loam	M-CL	.2-.63	.17-.19	moderate

Table 3. (Continued)

Soil Series	Depth (cm)	USDA	Unified	Permeability	Available Water Capacity	Shrink-Swell
Reading	152	silty clay loam	CH-CL	.2-.63	.17-.19	high
Smolan	61-152	silty clay loam	CL-CH	.06-.20	.17-.19	high
Tully	0-152 °	silty clay	CH	.06-.20	.17-.19	high

The terminology used in this section is that of Barker (1974). "Soil series" is the basic unit of soil classification and consists of soils which are essentially alike in all major profile characteristics, although the texture of the A-horizon may vary somewhat. "Soil associations" are groups of soil series that are commonly found together in a characteristic pattern in the landscape. In a particular landscape, not all of the basic units need occur. Also, many soil series that occur in one association may also be found in other associations. The association is commonly named for the characteristic series found in that association.

The soil series in the study area are grouped together into three associations (Barker, 1974): the Labette-Florence; the Irwin-Ladysmith; and the Mason-Tully-Reading associations. The first two are located in upland and side-slope areas, whereas the third association is found in the floodplains of major streams and most of their tributaries (Figure 11).

The Labette-Florence association consists of moderately deep, gently sloping soils that have a clayey subsoil and deep, sloping to moderately steep, cherty soils that have a cherty, clay subsoil. Figure 12 is a block diagram showing the position in the landscape of each of the soil series in the association. The Labette series soils make up 26 percent; the Florence series, 21 percent; the Tully series, 16 percent; and the Dwight series, 15 percent of the

Figure 11. Distribution of the Major Soil Associations, Northeastern Morris County, Kansas (from Barker, 1974)

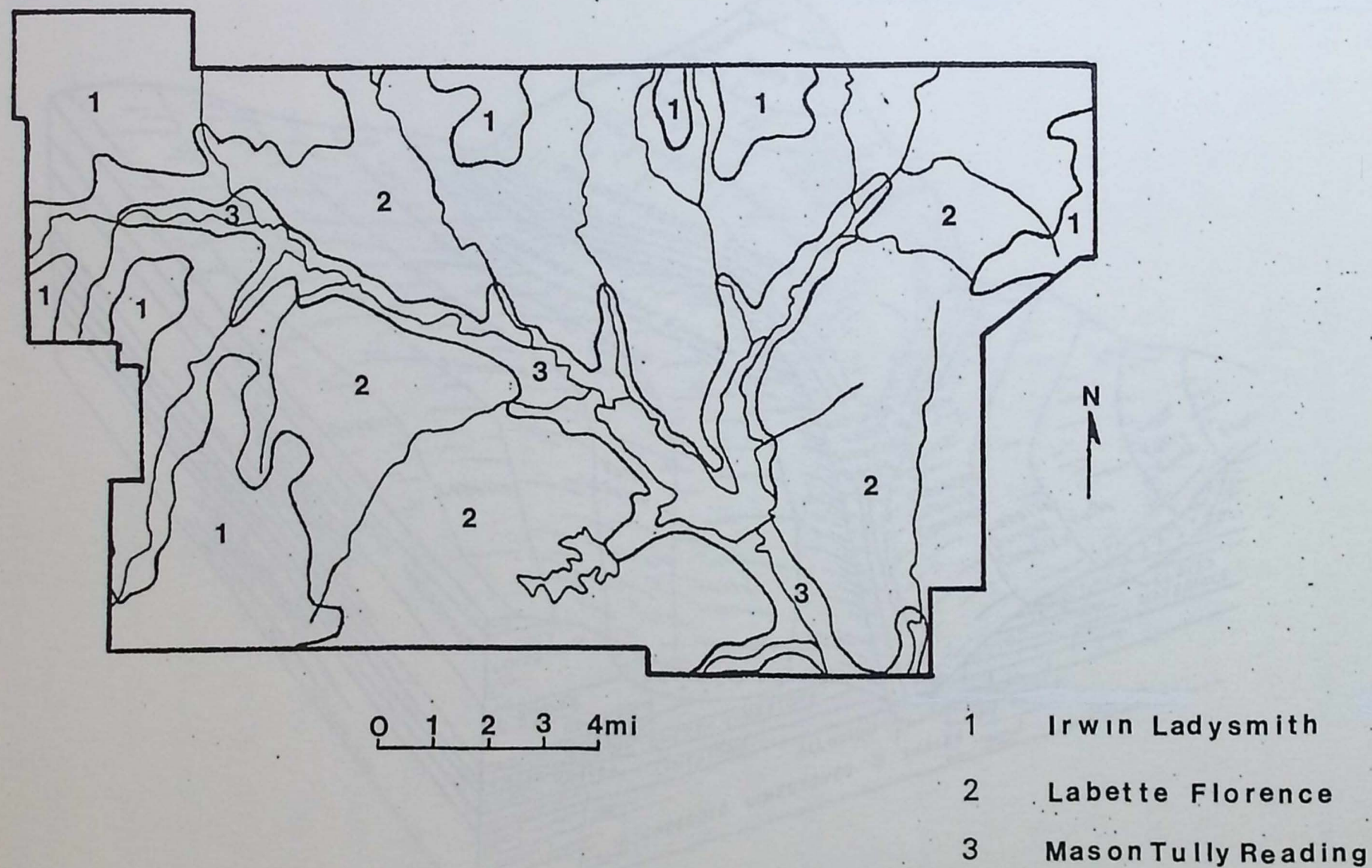
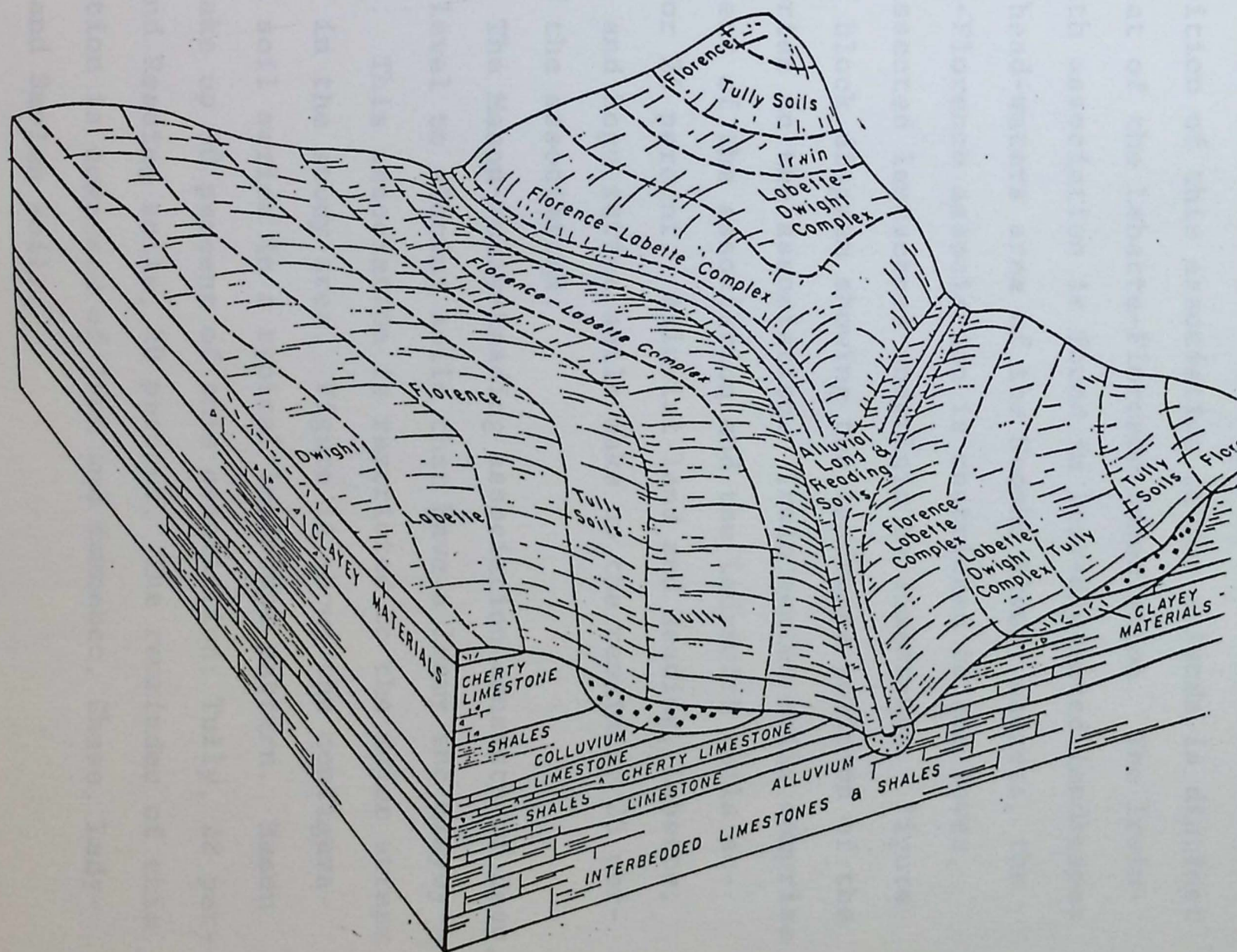


Figure 12. Block Diagram of the Labette-Florence Association (from Barker, 1974)



association. The remainder consists of Irwin, Clime, Sogn, and Reading series soils.

The Irwin-Ladysmith association is composed of deep, nearly level to sloping soils that have a clayey subsoil. The position of this association in the uplands is distinct from that of the Labette-Florence association. The Irwin-Ladysmith association is found in less-dissected landscapes in the head-waters area of the Neosho River; whereas, the Labette-Florence association is restricted to the lower, more dissected landscapes underlain by limestones. Figure 13 is a block diagram showing the landscape position of the soil series in the association. Irwin series soils comprise 51 percent of the association and the Ladysmith soils account for 26 percent. Alluvial land and Reading, Labette, Dwight, and Sogn series soils make up the remaining 23 percent of the association.

The Mason-Tully-Reading association consists of deep, nearly level to sloping soils that have a loamy and clayey subsoil. This association is restricted to the major stream valleys in the study area. Figure 14 shows the configuration of soil series in a typical landscape pattern. Mason soils make up 30 percent of this association; Tully, 28 percent; and Reading soils, 20 percent. The remainder of this association is composed of Ivan and Kennebec, Chase, Ladysmith, and Smolan soils.

Each association is used for different types of land

Figure 13. Block Diagram of the Mason-Tully-Reading Association (from Barker, 1974)

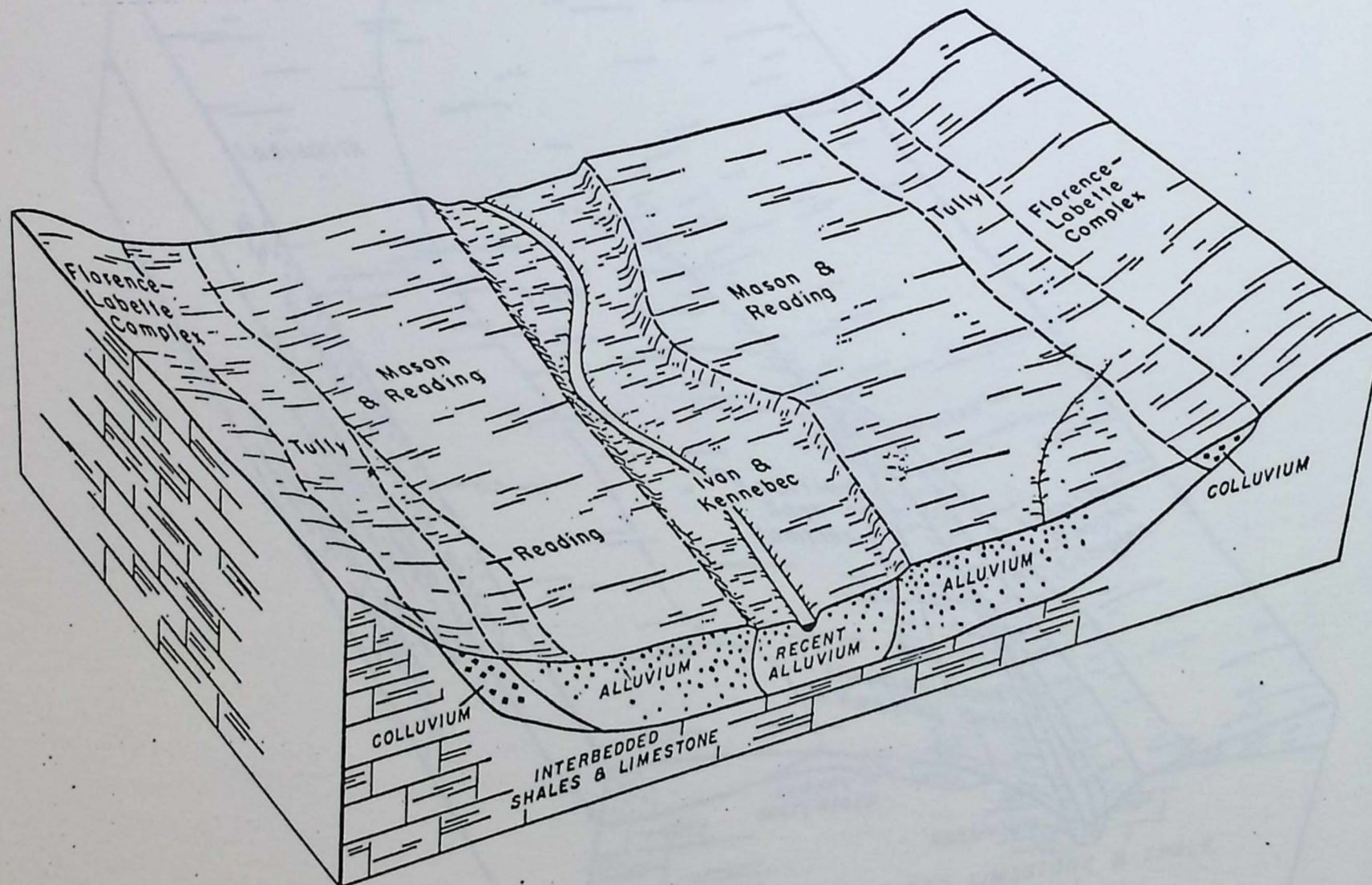
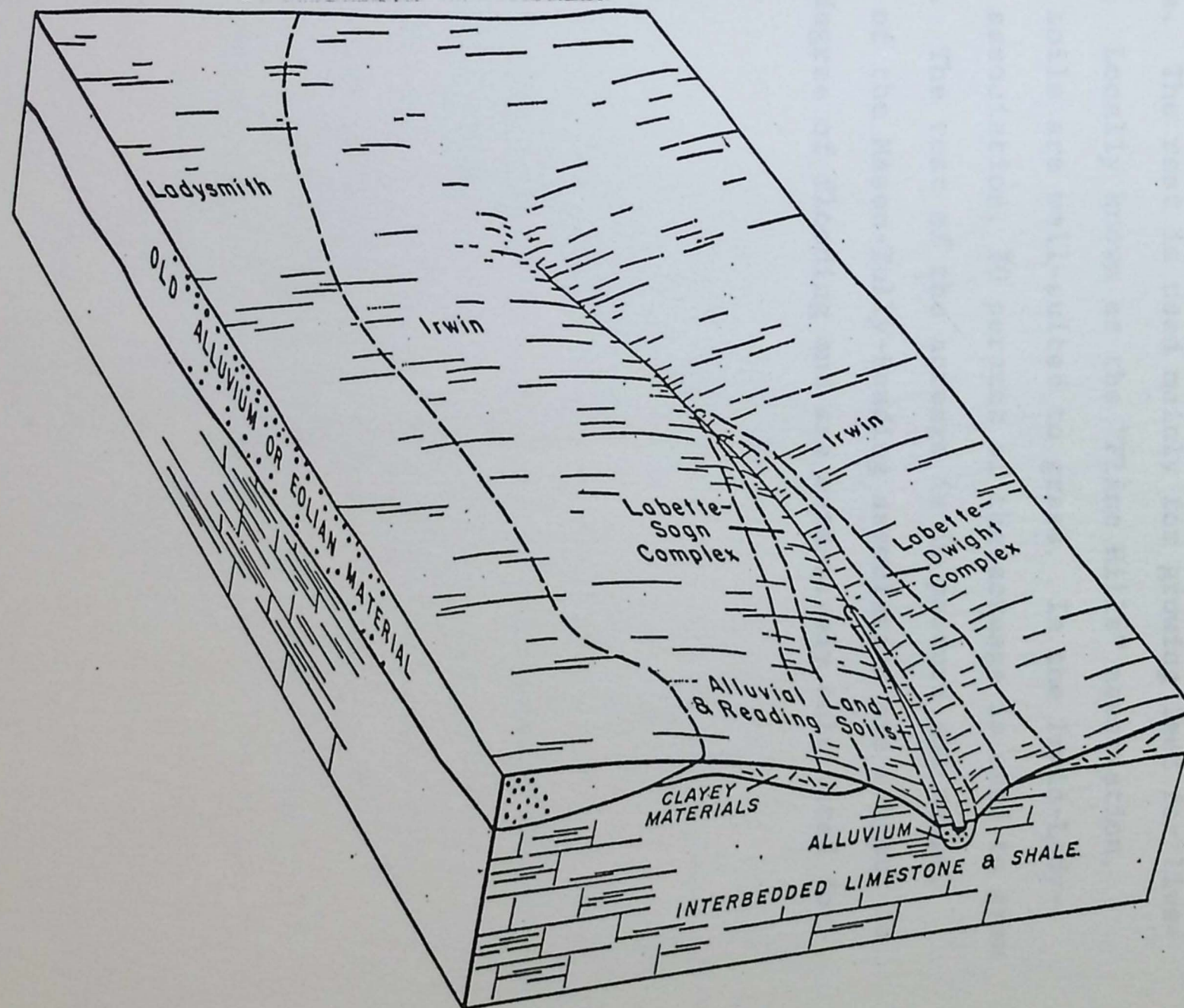


Figure 14. Block Diagram of the Irwin-Ladysmith Association (from Barker, 1974)



use in the study area. Ninety percent of the Labette-Florence acreage is used as native range for raising beef cattle. The rest is used mainly for growing feed for livestock. Locally known as the "Flint Hills" association, these soils are well-suited to grass. In the Irwin-Lady-smith association, 70 percent of the acreage is used to grow crops. The rest of the acreage is in pasture and range. Soils of the Mason-Tully-Reading association are subject to some degree of flooding and are extensively cultivated for crops.

CHAPTER VII

HYDROGEOLOGY

Groundwater supplies come from fractured limestones or from the alluvium of the major stream valleys. The amount of groundwater contained in the limestones is small and well yields of less than ten gallons per minute (.6 liters per second) are common. During periods of drought these yields are considerably diminished as the aquifers de-water and many wells go dry. Groundwater is more plentiful and more easily obtained from alluvium of the major stream valleys.

Many features of hydrogeologic significance are common throughout the study area and most of these are associated with groundwater recharge and discharge to surface water bodies. Sinkholes and enlarged joints produced by dissolution of limestones by surface waters are prominent pathways of groundwater recharge in the southwestern and north-central portions of the area. These landforms are very common in the Fort Riley member of the Barneston Limestone and are generally less than 25 feet (eight meters) in diameter and less than eight feet (2.5 meters) deep. Some of these have a well-developed internal drainage system leading to a point of entry into the rock.

Springs are also very common throughout the region,

especially near the base of some limestones such as the Florence Limestone member of the Barneston Limestone. Most of these are wet weather springs and receive recharge only from the immediate area. The perennial springs flow usually at less than five gallons per minute (.3 liters per second) but may flow at higher rates during wet years. Springs and seeps sustain baseflow in the streams between precipitation events and during periods of drought. The groundwater system is recharged by precipitation in areas of thin or absent soil cover and by streams where recharge is through the alluvium or bedrock depending upon the permeability of stream-bed materials.

The principal aquifers in northeastern Morris County are the Florence limestone member of the Barneston Limestone and the Schroyer and Three Mile limestone members of the Wreford Formation. Some private wells in the southeastern part of the area tap supplies further down in the stratigraphic section, but the units from which these wells obtain water have not been identified. The occurrence of groundwater in these limestones is related to the amount of secondary permeability and storage produced by fracturing and dissolution of limestone, the amount of recharge received and the local geologic structure. The base of the Florence member and the lower portions of the limestones of the Wreford Formation produce moderate amounts of hard water that has a high iron content.

Plate C is a structure contour map of the base of the Barneston Limestone. This map shows the areal variation of the elevation above sea level of the base of this unit. This information will be useful to anyone interested in drilling a well for water in the northwest portion of the study area. The approximate depth to the base of the Barneston Limestone is computed by subtracting the surface elevation shown on the appropriate seven and one-half minute topographic map sheet from the elevation on the structure contour map.

CHAPTER VIII

LAND-USE CONSTRAINTS BASED ON COMPOSITE RESOURCE AREAS

Not all sites in northeastern Morris County, Kansas, are equally suitable for all land uses. Each site differs in its physical characteristics and physical processes that have shaped the landscape. As a result, planners and decision-makers need to be made aware of the diversity of the natural environment if they are to develop realistic land-use plans for the region.

In this chapter, the geologic constraints on certain types of land use will be discussed. The main criteria used to evaluate each land use are the characteristics of the composite resource areas. The areal distribution of site suitability is indicated on Plate B, which shows the distribution of composite resource areas. The following land uses are here considered: cropland agricultural, residential and light industrial development, septic systems, sewage lagoons, and sanitary landfills. Much of the discussion of soil constraints on waste disposal comes from Olson (1974).

Cropland Agriculture

This subsection briefly describes the suitability of each composite resource area for cropland agriculture. The discussion has been adapted from Barker (1974) and for more

details the reader is referred to this source.

Almost all of the soils of the composite resource areas in northeastern Morris County have at least moderate geological constraints imposed upon them when used for cropland agriculture, except the Mason and Reading soil complex, composite resource area G (see Table 2). These are deep, nearly level, well-drained loamy soils located on stream terraces.

The soils in the remaining composite resource areas require at least the adoption of some moderate conservation practices. Reading and Smolan series soils (composite resource areas F and I) are subject to moderate erosion if they are cultivated and not protected. Ivan-Kennebec and Chase soils (composite resource areas K and M) are susceptible to flooding and have moderate limitations because of excess water. Dense clay subsoils limit the use of some of the Irwin and Ladysmith series soils (composite resource areas A, F, I, and J) for cropland agriculture.

Because of their susceptibility to water erosion, many of the soil series have severe limitations, when used for cropland agriculture, and will require careful management. These include certain soils in the Irwin, Ladysmith, Tully, Dwight, and Smolan series (composite resource areas A, B, C, D, F, I, and J).

Some of the soils in the area have severe limitations for other reasons, such as susceptibility to wind ero-

sion or depth to bedrock. If not protected by vegetation, Irwin and Ladysmith series soils (composite resource areas A and J) are susceptible to wind erosion, especially on long cultivated slopes near ridgetops. Clime-Sogn, Florence, Tully, and Labette series soils (composite resource areas C, E, B, K, and L) are generally too thin and cherty to be cultivated. On steep slopes these soils are susceptible to water erosion.

Residential Housing and Light Industrial Development

Site suitability for residential and light industrial development have been grouped together because of similar foundation requirements. In most cases, the size of building required for light industry is not significantly larger than twice the size of most private dwellings, and the shear-strength requirements for soils below the foundations of buildings that house most light industries are not that much different from those of single family dwellings.

Site suitability for residential and light industrial development is determined by a wide variety of geologic factors. These are indicated in Tables 4, 5, and 6. Table 4 presents site suitability for foundations and Table 5 for road location. Table 6 provides estimates of rippability of all bedrock formations in the study area. Site suitability should be extended to include suitability for septic systems if sewer lines will not be constructed.

Table 4. Geologic Constraints on Foundations for Residential Construction Based on Composite Resource Areas (modified from Barker, 1974)

Composite Resource Area	Flood Hazard	Low Soil Thickness	Degree of Slope	High Shrink-swell	Poor Drainage	Erosion Potential	Low Sheer Strength Soils	Limestone Sinkholes
A	SL	SL	SL	M	SL	M	M	M
B	SL	S	SL	M	SL	SL	SL	SL
C	SL	M	M S	M	SL	S	SL	SL
D	S	SL	SL	SL	SL	S	SL	SL
E	SL	S	S	SL	SL	S	SL	SL
F	SL	SL	SL	M	SL	SL	SL	SL
G	M	SL	SL	SL	SL	SL	SL	SL
H	S	SL	SL	SL	SL	SL	SL	SL
I	SL	SL	M S	S	SL	M	SL	SL
J	SL	SL	SL	M	SL	SL	SL	SL
K	SL	SL	variable	M	SL	SL	SL	SL
L	SL	M	M S	M	SL	S	SL	SL
M	S	SL	variable	S	SL	SL	M	SL
N	S	SL	SL	SL	SL	SL	SL	SL
O	M	SL	variable	variable	variable	variable	variable	N/A

SL (slight)--composite resource area properties favorable for rated land use

M (moderate)--some composite resource area properties are unfavorable for the rated land use but can be overcome or modified by special planning or design

S (severe)--composite resource area properties so unfavorable and so difficult to correct or overcome as to require special considerations, designs, or intensive maintenance

Table 5. Geologic Constraints on Road-building Based on Composite Resource Areas
(modified from Barker, 1974)

Composite Resource Area	Sinkholes	Excessive Chert Fragments in Soils	Depth to Hard Bed- rock (low)	High Plasticity Soils	High Shrink-swell Potential Soils	Slope	Flooding
A	M	SL	SL	S	S	SL-M	M
B	SL	M	M	M	S	SL-M	SL
C	SL	M	variable	S	S	M-S	SL
D	SL	SL	variable	variable	variable	SL	S
E	SL	SL	S	SL	SL	M-S	SL
F	SL	SL	SL	S	S	SL	SL
G	SL	SL	SL	SL	M	SL	M
H	SL	SL	SL	SL	M	SL-S	S
I	SL	SL	SL	S	S	M-S	SL
J	SL	SL	SL	S	S	S	SL
K	SL	S	M-S	SL	M	SL-S	SL
L	SL	S	SL	SL	SL	M-S	SL
M	SL	SL	SL	S	S	SL-S	S
N	SL	SL	SL	M	S	SL	S
O	SL	SL	SL	M	S	SL	SL

SL (slight)--composite resource area properties favorable for the rated land use

M (moderate)--some composite resource area properties are unfavorable for the rated land use but can be overcome or modified by special planning or design

S (severe)--composite resource area properties so unfavorable and so difficult to correct or overcome as to require special considerations, designs, or intensive maintenance

Table 6. Estimates of Rippability of the Bedrock Units,
Northeastern Morris County, Kansas

Formation	Member	Rippability		
		Rippable	Marginal	Non-Rippable
Winfield	Grant	x		
	Stovall	x		
Doyle	Gage	x		
	Towanda		x	x
	Holmesville	x		
Barneston	Fort Riley		x	x
	Oketo	x		
	Florence			x
Matfield Shale	Blue Springs	x		
	Kinney			x
	Wymore	x		
Wreford	Schroyer			x
	Havensville	x		
	Three Mile			x
Speiser		x		
Funston		x	x	x
Blue Rapids		x		
Crouse			x	

Site suitability for foundations depends chiefly upon the shear strength and shrink-swell potential of the soil in each composite resource area (Barker, 1974). Shear strength determines the ability of the soil to support a foundation under normal loading conditions. Shrink-swell potential is important because shrinkage cracks weaken the

soil and expansion and contraction of soils during wetting and drying may crack the foundation. Other hazards include flooding, collapse of limestone sinkholes, poor soil drainage, high erosion potential, steep slopes, and slope instability. The presence of any of these hazards could seriously affect the shear-strength properties of the soil.

Another geologic constraint which bears on site suitability for foundations is the ease with which a site may be excavated and graded. Rippability is one measure that can be applied to earth materials that indicates the degree of difficulty that hand tools and light excavation equipment would encounter during the excavation of earth materials. One method of determining rippability relies on correlating seismic velocity with rippability (Wylie, 1969). This procedure could not be followed because seismic velocities are not available for the earth materials that crop out in the study area. Therefore, estimates of rippability have been made from field observations (see Table 6). These estimates can be applied only to specific bedrock units and not to complete composite resource areas since different limestones may underlie different localities.

Site suitability for road location is evaluated on the basis of the ease of construction and maintenance of the road (Barker, 1974). The important geologic constraints are shrink-swell potential, shear strength, and drainage characteristics of the soil, and depth to bedrock, degree of flood

hazard, ease of excavation and grading, degree of slope, susceptibility to erosion, and potential for sinkhole collapse.

Septic Systems

The criteria used to evaluate the suitability of sites for septic systems include permeability of the soil, depth to water table, degree of flood hazard, slope, depth to bedrock, the proportion of clasts in the soil and the presence of surface outcrops of limestone (Olson, 1974). These characteristics of the site are important because in a tile septic system the effluent must be able to move down the pipes and into the soil. The speed of movement must be slow enough that some of the pollutants will decay or become sorbed by soil particles, but fast enough to prevent back-up. The more permeable the soil, the faster the effluents can move to bedrock. The greater the soil thickness and depth to water table, the greater is the probability that the effluent has had sufficient time to decay and not contaminate groundwater. In karst topography, fractures and solution channels may be conduits for the rapid movement of contaminants entering groundwater systems. Groundwater supplies are easily polluted from seepage fields over fractured bedrock. The degree of flood hazard is also important because flood waters may carry away undiluted sewage. The degree of slope is important because on slopes greater than eight percent, the efficiency of tile septic systems drops

off (Olson, 1974).

Based upon the criteria discussed above, none of the composite resource areas are suitable for tile septic systems. Most of the composite resource areas have soils that are too impermeable, too shallow, or are susceptible to flooding. In addition, some of the composite resource areas have soils with high seasonal or perched water tables. In some cases the proximity to fractured bedrock or sinkholes is enough to make a site unsuitable.

Sewage Lagoons

The criteria used to evaluate a site for sewage lagoon suitability include depth to permanent or seasonal high water table, permeability of the soil, depth to bedrock, degree of slope, degree of flood hazard, and the texture of the soil that is used in constructing the floor and berm of the lagoon (Olson, 1974). All of these features are important in confining the effluent and protecting surface and groundwater. Permeability and depth to the water table are important considerations in protecting groundwater supplies. Flood waters can easily carry away the effluent by breaching the berm. The properties of the soils used in constructing the berm must be such that the soils can be easily worked, possess sufficient shear strength to retain the liquid in the lagoon and resist shrinkage and cracking (low shrink-swell potential). The degree of slope must be low enough to allow smoothing of the bottom of the lagoon

and to diminish runoff. Depth to bedrock is important because the depth of the lagoon must be at least two feet and no more than five feet (Olson, 1974). This criterion is especially critical where local water supplies come from groundwater. Lagoons should not be sited in the vicinity of sinkholes because of the potential for collapse of the lagoon bottom. Sinkholes are found in composite resource area A in the southwest and north central parts of the study area.

In northeastern Morris County, most of the composite resource areas are suitable for sewage lagoons, although some have increased limitations as the degree of slope increases (composite resource areas C, G, and I) (see Table 7). Susceptibility to flooding and depth to bedrock contribute the most serious limitations. Soils in composite resource areas A and B can not be used for constructing the berm because they have extremely high shrink-swell potential. Soils in composite resource areas K and L should not be used because there is an excess of coarse chert fragments that reduces the ability of machines to compact the soil. In addition, depth to bedrock is shallow and may not provide adequate soil for construction of the lagoon.

Sanitary Landfills

Solid waste can be disposed of either in trench or areal sanitary landfills. Trench-type landfills are used where there is a sufficient thickness of unconsolidated

Table 7. Geologic Constraints on Sewage Lagoons Based on Composite Resource Areas
(modified from Barker, 1974, and Olson, 1974)

Composite Resource Area	Depth to Seasonal or Permanent Water Table	Permeability	Depth to Bedrock	Slope	Flooding	Workability Based on Unified Soil Group
A	SL	SL	M	SL	SL	SL
B	SL	SL	S	M	SL	SL
C	SL	SL	M	S	SL	SL
D	SL	SL	SL	M	S	SL
E	SL	SL	S	S	SL	M
F	M	SL	SL	SL	SL	SL
G	SL	SL	SL	SL	S	SL
H	SL	SL	SL	SL	S	SL
I	M	SL	SL	M	SL	SL
J	M	SL	SL	SL	SL	SL
K	SL	M	SL	SL	SL	S
L	SL	M	S	S	SL	M
M	SL	SL	SL	SL	S	SL
N	S	SL	SL	SL	S	SL
O	SL	SL	SL	SL	SL	SL

SL (slight)--composite resource area properties favorable for the rated land use

M (moderate)--some composite resource area properties are unfavorable for the rated land use but can be overcome or modified by special planning or design

S (severe)--composite resource area properties so unfavorable and so difficult to correct or overcome as to require special considerations, designs, or intensive maintenance.

material to allow trench excavation. Moisture content of soils is a primary consideration in determining site suitability for this disposal method. Soils (in the engineering sense) with low permeability are most desirable because of their ability to retard the movement of contaminants away from the site. Groundwater contamination can be further minimized by compacting the bottom and sides of the trench. Slope is a serious consideration because runoff from upslope can carry away contaminants and erode cover materials. In addition, the bottom of the trench should be level so that it does not act as a seepage plane. In general trench-type sanitary landfills should not be operated where the soil has high permeability, shallow zones of saturation, significant flood hazard, high proportion of coarse fragments, shallow depth to bedrock, or soils with characteristics that allow poor workability and trafficability (Olson, 1974) (see Table 8).

Area-type sanitary landfills are used where the depth to bedrock is not sufficient for trench-type landfills. Refuse is placed on the surface of the soil in successive layers alternating with layers of soil for cover materials that is generally imported from other areas. Olson (1977) and Lutton (1978) have discussed the criteria for determining the suitability of area landfills. Depth to the seasonal high water table is important because this distance determines the margin of safety from contamination of the

Table 8. Geologic Constraints on Trench-type Sanitary Landfills Based on Composite Resource Areas (modified from Barker, 1974, and Olson, 1974)

Composite Resource Area	Depth to Seasonal or Permanent Water Table	Soil Drainage	Flood Hazard	Permeability	Slope	Depth to Bedrock	Trafficability and Workability Based on Soil Texture
A	M	SL	SL	SL	SL	M	S
B	SL	SL	SL	SL	SL	S	S
C	SL	SL	SL	SL	SL	S	S
D	SL	SL	S	variable	SL	S	variable
E	SL	SL	SL	SL	M	S	S
F	M	SL	SL	SL	SL	SL	S
G	SL	SL	M	SL	SL	SL	M
H	SL	SL	S	SL	SL	SL	SL
I	M	SL	SL	SL	SL	SL	S-M
J	M	SL	SL	SL	SL	SL	S
K	SL	SL	SL	SL	SL	S	S
L	SL	SL	SL	SL	SL	S	S
M	SL	SL	S	SL	SL	SL	S
N	SL	SL	S	SL	SL	SL	S
O	SL	SL	SL	SL	SL	SL	S

SL (slight)--composite resource area properties favorable for the rated land use.

M (moderate)--some composite resource area properties are unfavorable for the rated land use but can be overcome or modified by special planning or design.

S (severe)--composite resource area properties so unfavorable and so difficult to correct or overcome as to require special considerations, designs, or intensive maintenance.

groundwater supply. Flood hazards are an especially important consideration because of the ease with which floodwaters can erode garbage. Moderate to slow permeability soils are desirable because the permeability of the soil will determine the speed of downward migration of leachate to the water table. However, the consistence of the cover material should be friable so that the soil can be easily worked and will allow some degradation of the garbage. On steep slopes erosion may be a problem. Also, the original land surface could act as a seepage face and allow movement of groundwater through the garbage. As a result, gentle slopes to flat terrain are most preferable.

Most of the composite resource areas in the study are suitable for area-type landfills (see Table 9). Limitations on site suitability are locally possible because of flood hazard (composite resource areas D, G, H, M, and N) or excessive slopes (composite resource areas C, I, and L). However, the greatest limitations on the use of the area-type landfill will result from the need for imported cover material. This is because of the high costs of transportation and additional land and labor costs needed to maintain the waste disposal operation.

Table 9. Geologic Constraints on Area-type Sanitary Landfills Based on Composite Resource Areas (modified from Barker, 1974, and Olson, 1974)

Composite Resource Area	Depth to Seasonal or Permanent Water Table	Soil Drainage	Flooding	Permeability	Slope
A	M	SL	SL	SL	SL
B	SL	SL	SL	SL	SL
C	SL	SL	SL	SL	SL-S
D	SL	SL	SL	SL	SL-S
E	SL	SL	SL	SL	SL-S
F	M	SL	SL	SL	SL
G	SL	SL	M	SL	SL
H	SL	SL	S	SL	SL-S
I	SL	SL	SL	SL	SL-M
J	M	SL	SL	SL	SL
K	SL	SL	SL	SL	SL
L	SL	SL	SL	SL	SL-S
M	SL	SL	S	SL	SL
N	S	SL	S	SL	SL
O	SL	SL	SL	SL	SL

SL (slight)--composite resource area properties favorable for the rated land use.

M (moderate)--some composite resource area properties are unfavorable for the rated land use but can be overcome or modified by special planning or design.

S (severe)--composite resource area properties are so unfavorable and so difficult to correct or overcome as to require special considerations, designs, or intensive maintenance.

CHAPTER IX

ACTIVITY ASSESSMENT OF FLINT HILLS ECOSYSTEMS IN NORTHEASTERN MORRIS COUNTY, KANSAS

The Activity Assessment Routine was developed by the Texas Coastal Management Program to predict the impact of human activities on the ecosystems of the Texas coastal zone (Armstrong, 1976). This method has many advantages. First of all, the method provides a structure in which information about ecosystems can be stored and organized. One of the features of the Activity Assessment Routine is that it is easy to determine areas in the impact evaluation where information is lacking. Second, because the method relies on ecologic systems diagrams of composite resource areas, both the static and dynamic aspects of environmental impact are considered. Third, with this method it is possible to trace environmental impacts that are spatially and temporally removed from the site. This is made possible through the ecologic systems diagram. Fourth, environmental impacts are derived in terms of human use as well as the functioning of the ecologic system. In this way both the social and economic as well as the environmental trade-offs become clearer and more informed decisions can be made by decision-makers. The Activity Assessment Routine presented here has been modified for the ecologic systems of northeastern Morris County

from Armstrong (1976). The method of impact prediction and step-by-step procedure are indicated in Table 10.

Socioeconomic Sectors and Activities

The human environment can be described by a series of economic sectors (Armstrong, 1976). These sectors generate human uses of the natural environment and as a result produce alterations in the natural systems. Socioeconomic sectors are entities that are used as indicators of economic growth. Sectors are valuable indicators of past and projected economic development. In the northeastern part of Morris County, the socioeconomic sectors belong to four categories (see Table A, Appendix). The categories shown illustrate the dependence of human activities on water and illustrate which sectors of the economy in the region could potentially alter the current land-use pattern.

Uses of the natural resources of the drainage basin are generated by the economic sectors (Armstrong, 1976). Human uses or activities are described by specific actions which use natural resources of the region. In the study area, human activities can be divided into two categories: those activities which could significantly alter water quality or physical processes within the drainage basin and those activities which rely on water quality (see Table B, Appendix). These categories were chosen for two reasons. First, many uses of the drainage basin require an acceptable level of water quality. Second, almost all human activities

Table 10. An Activity Assessment Routine for Northeastern Morris County, Kansas

Sector Development

Identification of socioeconomic generators of human activities.

Human Activities

Activities that directly impinge upon the land surface and may affect the environment.

Composite Resource Areas

The ecosystems constituting Northeastern Morris County as defined by environmental characteristics.

Primary Environmental Alterations

The principal natural processes and forms which may describe detailed changes in environmental attributes.

Environmental Attributes

Components of the natural ecosystem, including biota, energy and material storages or inputs, and regulating factors.

Parameters

Sustaining factors and products of natural areas, capable of measuring alteration of environmental attributes.

Consequences

Changes in human life support, economic bases, or quality of life values brought about by environmental alterations.

affect basin processes to some degree. Those activities which affect basin processes the most are likely to create a substantial impact on water quality.

Resource Areas

The land surface is a mosaic of smaller areas, each with its own biotic and abiotic characteristics. Composite resource areas are subdivisions of the natural environment based on processes and materials. These units are defined by soils, geomorphic process, bedrock, slope, and biota.

The Ecologic Systems Diagram

The degree of impact caused by human activity in the ecologic system is expressed qualitatively by the ecologic systems diagram (Armstrong, 1976). Environmental impact is signified by the alteration of flows of materials and energy. The components of the ecologic systems diagram are either inputs, storages, or transformers (system attributes) which help describe the types, locations, and transfers of materials and energy within each composite resource area.

Primary Environmental Alterations

All human activities have the potential for altering and modifying ecologic systems and these alterations and modifications result in altered flows of materials and energy. By identifying the likely primary environmental alterations resulting from a particular activity and using the ecologic systems diagram, human activities can be analyzed for their impact on the environment and a chain or network

of impacts and effects predicted.

Attribute Alterations

Attribute alterations result from human activities in two ways (see Table C, Appendix). Energy and material pathways may be short-circuited, as when a part of the basin is paved over with concrete or an energy and material pathway may become overloaded as when the grass cover is removed from easily erodable soils. For example, the input of soil into the drainage network may tremendously increase the quantity of suspended load and dissolved solids. As a result, the sediment input into stream and reservoir ecosystems is increased, perhaps so greatly that the affected systems cannot recover. Secondary and indirect effects can be found by tracing through the system diagrams as was done in the example above.

One of the advantages of using this method of impact assessment is that it is possible to indicate both the extent and duration of impact. The extent of impact is measured by the number of system attributes affected by the activity. The duration of impact and a range of qualitative probabilities (probable/possible) can be estimated if sufficient information about the ecosystems is known.

Parameters

Parameters are the factors which characterize each ecosystem (see Tables D, E, and F, Appendix) and for the most part they are measurable properties. These properties

can be used to determine significant impacts when they are related to the attributes of each composite resource area. A significant impact is one which alters environmental parameters beyond a threshold value, thus altering the functioning of the resource area and causing the resource area to cease functioning as the resource area was originally defined.

Baseline studies are completed by monitoring the parameters before impact. For parameters to adequately represent the sustaining characteristics of a resource area, it is essential that the list contain as much quantitative information as possible including temporal influences and the range of variation of each parameter. If a sound parameter baseline is established for each resource area, this information is used to describe the resource area and with follow-up studies can be used to verify predicted impacts.

Consequences

The potential consequences originating from alteration of the natural environment fall into two categories: environmental and economic/human use (see Table G, Appendix). Environmental consequences result from advantageous or detrimental changes in the environment caused by the alteration of natural processes, products, or amenities. Economic or human use consequences are an expression of values in terms of the part they play in sustaining human activity. Activities include both economic and non-economic uses of the

environment.

CHAPTER X

POSSIBLE ENVIRONMENTAL IMPACTS OF LAND-USE CHANGES

All of man's activities affect the environment by altering the flows of materials and energy through the ecosystem. The Activity Assessment Routine is a useful management tool for predicting the effects of these activities. The Activity Assessment Routine can also be used to show natural resource trade-offs resulting from particular land-use decisions.

Studies of future development in the Flint Hills region by Oblinger-Smith Consultants (1973) have shown that there will be some increases in the amount of land used for residential housing in the future. In addition, development of the natural resources of the region will be important because of increasing population density in northeastern Kansas (Lujan, 1975) and the needs of the people already living in the Flint Hills area (Flint Hills Regional Planning Commission, 1974). The natural resources of this region that are likely to feel the most impact from this development are water, wildlife, crop and rangeland agriculture, and mineral resources.

In this chapter, the impacts of increasing residential development around reservoirs and conversion of crop-

land to urban and rangeland uses will be evaluated by using the assessment method discussed in the previous chapter. These human activities have been chosen for discussion because future trends in regional development indicate that these land changes are likely to occur.

Conversion of Unsuitable Cropland to Rangeland

One of the most severe problems confronting the agricultural development of the Flint Hills region is soil loss by wind and water from marginally suitable cropland (Flint Hills Regional Planning Commission, 1974). Over 13000 acres (5200 hectares) of cropland in Morris County should be under permanent vegetative cover (Ibid.) The main effects of this soil loss are a decrease in the natural productivity of the land, loss of soil and nutrients from the land, and large inputs of soil and nutrients to streams and eventually into the Council Grove Reservoir and Council Grove City Lake.

The impact of converting this unsuitable or marginally suitable cropland back into grassland is tabulated in Tables 11, 12, and 13 for each ecosystem in northeastern Morris County. The most significant impact is a decrease in the amount of sediment and nutrients lost from the land and finally deposited in the reservoirs. The resulting human use consequences are (1) the natural productivity and scenic value of the converted lands are allowed to recover, (2) the

Table 11. Activity Assessment Routine Analysis of Possible Impacts Associated with Conversion of Unsuitable Cropland to Rangeland

Sector	Activity	Resource Area	Environmental Alterations			
Agriculture	crop agriculture	A, B, C, J	Alteration of habitat			
			Alteration of runoff, infiltration, evapotranspiration			
			Alteration of sediment storage and transport			
			Alteration of inorganic nutrient cycle			
Attribute Alterations						
Ecosystem	Transformer	Input	Storage	Increase	Decrease	Comment
Upland	producers			x		stability increase with time
	consumers			x		
			soil moisture		x	

Table 11 (Continued)

Attribute Alterations						
Ecosystem	Transformer	Input	Storage	Increase	Decrease	Comment
			sediment		x	less natural soil nutrients lost
			nutrients		x	fertilizer use discontinued
Consequences						
Parameters		Ecologic Values		Human Use Values		
Diversity indices annual biomass		(+) organic productivity		(-) available cropland (+) enhanced recreation (+) cattle raising		
Stream hydrographs average runoff		(+) flood buffer		(+) flood protection		
Rills and gullies		(+) natural productivity of the land				
Yearly amounts of fertilizer applied NO ₃ in groundwater		(-) nitrates in groundwater				

Table 12. Activity Assessment Routine Analysis of Possible Impacts Associated with Conversion of Unsuitable Cropland to Rangeland

Sector	Activity	Resource Area	Environmental Alterations			
Agriculture	crop agriculture	A, B, C, J	Alteration of channel geometry			
			Alteration of drainage network			
			Alteration of sediment storage and transport			
			Alteration of surface water quality			
			Alteration of consumer trophic levels			
			Alteration of nutrient cycles			
			Alteration of producer trophic cycles			
Attribute Alterations						
Ecosystem	Transformer	Input	Storage	Increase	Decrease	Comment
Streams						stream rejuvenation due to decreasing sediment loads

Table 12 (Continued)

Attribute Alterations						
Ecosystem	Transformer	Input	Storage	Increase	Decrease	Comment
					x	inactive rills and gullies by decreasing the amount of runoff
		sediment			x	more efficient stream channels
	producers			x		check for toxics
	consumers			x		
	consumers			x		due to less turbid waters
			nutrients		x	from cropland agriculture
	producers			x		due to less turbid waters

Table 12 (Continued)

Parameters	Consequences	
	Ecologic Values	Human Use Values
Flood frequency	(+) flood water buffer	(+) flood protection
Increases in grass-stabilized rills and gullies	(+) erosion control	(+) productive range
Channel features characteristics of the sediment	(+) habitat diversity	
Turbidity; total dissolved solids	(+) organic productivity	(+) recreation
Diversity indices	(+) organic productivity	
Nitrates; phosphates	(-) organic productivity	
Diversity indices	(+) organic productivity	

Table 13. Activity Assessment Routine Analysis of Possible Impacts Associated with Conversion of Unsuitable Cropland to Rangeland

Sector	Activity	Resource Area	Environmental Alterations			
Agriculture	crop agriculture	A, B, C, J	Alteration of producer trophic levels			
			Alteration of consumer trophic levels			
			Alteration of inorganic nutrient cycles			
			Alteration of sediment storage and transport			
			Alteration of surface water quality			
			Alteration of habitat			
Attribute Alterations						
Ecosystem	Transformer	Input	Storage	Increase	Decrease	Comment
Reservoir	producer			x		because of decreased turbidity

Table 13 (Continued)

Attribute Alterations						
Ecosystem	Transformer	Input	Storage	Increase	Decrease	Comment
	consumer			x		because of decreased turbidity
		nutrients			x	less fertilizer and soil nutrients lost
		sediment			x	from streams
	consumers			x		check for herbicides and pesticides
	consumers			x		benefits to shallow breeding areas

Table 13 (Continued)

Parameters	Consequences	
	Ecologic Values	Human Use Values
Diversity indices biomass calculations	(+) inorganic productivity	
Diversity indices biomass calculations		(+) recreation
Nitrates; phosphates	(+) nutrient moderation capacity (-) organic production	
Bedload suspended solids and total dissolved solids in streams	(+) flood buffer	(+) flood protection
Turbidity, TDS	(+) organic productivity	(+) water supply
Diversity indices	(+) organic productivity	

design life of the reservoirs will not be shortened, thereby increasing the ability of the reservoirs to sustain flood flows, and (3) the tendency to eutrophication because of excess nutrients might be lessened, thereby making the reservoir more desirable for recreation.

Conversion of Rangeland to Residential Uses

Residential development around Council Grove City Lake has already occurred and future development is likely around Council Grove Reservoir away from the immediate lakeshore area. Most of the land that might be converted to residential uses is now rangeland. Table 14 is the Activity Assessment Routine analysis of the impact of increasing residential development on the reservoirs and on the upland areas nearby. This assessment assumes (1) use of conventional septic systems for domestic waste disposal and (2) paved roadways in the development area.

The impact of converting rangeland into suburban development will be felt at the development site and on the man-made lakes. Little, if any, impact is expected on streams because most of this development will occur on slopes adjacent to the lakeshore area.

The main effect of suburban development will be an increase in the amount of storm runoff and an increase in the nutrient and sediment loads accepted by the reservoirs. Storm runoff will increase because of increases in the per-

Table 14. Activity Assessment Routine Analysis of Possible Major Impacts Associated with Conversion of Agricultural Lands to Residential Uses Around Council Grove City Lake and Council Grove Reservoir

Sector	Activity	Resource Area	Environmental Alterations			
Urban	Construction and Habitation	A, B, C, L	Alteration of inorganic nutrient cycle			
			Alteration of sediment transport process			
			Introduction of toxicants			
			Alteration of runoff, infiltration, and evapotranspiration			
			Loss of habitat			
Attribute Alterations						
Ecosystem	Transformer	Input	Storage	Increase	Decrease	Comment
Reservoir			nutrients	x		faulty septic tanks
Reservoir		sediment		x		

Table 14 (Continued)

Attribute Alterations						
Ecosystem	Transformer	Input	Storage	Increase	Decrease	Comment
Upland			soil		x	from runoff
Reservoir	consumers			x		from roadways and pesticide and herbicide use
Upland			water		x	from houses
Upland	consumers				x	loss of rangeland
Reservoir	consumers				x	from siltation of shallow areas

Consequences		
Parameters	Ecologic Values	Human Use Values
Nitrates; phosphates	(+) organic productivity	(-) recreation
Turbidity of lake water TDS	(-) sediment storage	(-) flood control buffer

Table 14 (Continued)

Parameters	Consequences	
	Ecologic Values	Human Use Values
Rills and gullies amount of soil loss	(-) erosion buffer (-) soil productivity	(-) scenic values (+) housing
Heavy metals, pesticides, herbicides	(-) food chain diversity	(-) recreation
Increased permeable surface area Rills and gullies	(-) flood buffer (-) erosion control	(+) in housing
Land use changes		(-) cattle raising
Decreased diversity of consumers	(-) organic productivity	(-) recreation

centage of impermeable surface at the development site and because of a loss of flood buffer capacity due to a decrease in the amount of vegetation and an increase in compacted soils around construction sites. The nutrient levels should increase because of (1) the use of conventional septic systems in unsuitable soils, (2) fertilizer use in gardens and on lawns, and (3) erosion of soil by excess runoff. Sediment input into the reservoir will be higher in the short term during construction than in the long term.

CHAPTER XI

CONCLUSIONS

Geologic constraints on land use in northeastern Morris County are related to the characteristics of composite resource areas. The distribution of composite resource areas is shown on Plate B. Each resource area is defined by geologic materials, biota, and geomorphic processes that help shape the land surface at each locality. This view of the natural environment of the area points out the natural capabilities of the region as well as the diverse nature of its natural resources.

Site suitability of certain types of land has been determined by using the characteristics of the composite resource areas. None of the soils is suitable for septic tanks. Many sites were found to be suitable for both trench- and area-type landfills. Sewage lagoons were also evaluated and many of the composite resource areas are suitable for this type of land use. Site suitability for residential and light industrial development was also evaluated. Composite resource areas found to have several limitations for this land use have some degree of flood hazard or high shrink-swell potential soils. In most cases, investigation of sites should be conducted to determine the limitations of specific localities.

Erosion by wind and water is one geomorphic process portrayed on the ecologic systems diagrams that is very important to the quality of the natural systems of northeastern Morris County. Erosion by wind and water is particularly a problem on unprotected slopes. Barren slopes promote rapid erosion of soil and nutrients by overland flow and movement into streams and man-made lakes. The increased sediment load carried by streams and deposited in lakes alters aquatic food chains, destroys microhabitats, shortens the design life of reservoirs, and promotes eutrophication. Converting unsuitable lands now under cropland agriculture back into grassland would produce many human-use values, such as recreation and increased flood control. Residential development around lakeshore areas will also promote an increase in the amount of sediment and nutrients carried into the lake by overland flow. This impact will be more important in the short term than in the long term. The influx of nutrients could be especially significant if conventional septic systems are installed.

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APPENDIX

SUPPORTING TABLES FOR THE ACTIVITY ASSESSMENT ROUTINE AND PLATES

Table A. Socioeconomic Sectors

*Sectors Dependent Upon Surface Water

Agriculture

farming

livestock production

Recreation/Tourism

boating

fishing

wildlife management and hunting

passive recreation

Manufacturing

Construction

earth dams

*Sectors Dependent Upon Groundwater

Agriculture

farming

livestock production

manufacturing

*Sectors Locationally Attracted Non-dependent

Silvaculture

Mining--mineral production and distribution

limestone quarries--surface mining

gravel pits--surface mining

petroleum--subsurface

pipelines

processing facilities

Transportation--Highways, Railroads

Residential Construction

*Sectors Potentially Could Alter Current Land Use

Agriculture

livestock grazing

farming

Residential Construction

Non-manufacturing--services and trades

Construction--large earth dams

Transportation

Table B. Activities Which Could Significantly Alter Water Quality or Basin Processes

*Flood Control Structures

channelizations

levees

earth dams

*Surface Mining

overburden removal

stripping

*Subsurface Mining

oil storage tank leakages

*Waste Disposal

liquid waste--municipal, industrial, septic tank

solid waste--municipal, industrial

spoil piles

brine pits

*Construction

vegetation removal

excavation

paving and grading

bridge construction

highway construction

filling

pipeline placement

spoil disposal

*Application of Conservation Measures

- crop rotation
- contour farming
- range management practices
- windbreaks

*Agricultural Practices

- plowing and cultivation
- fertilizer and pesticide application
- irrigation
- groundwater withdrawal
- grazing

*Mine Reclamation

*Recreation

- boating

Activities Requiring Surface and Groundwater of High Water Quality

*Recreation

- swimming-bathing
- boating
- fishing/hunting

*Irrigation and Stock Watering Operations

- water wells
- construction of small earth dams

*Municipal Water Supply

- construction of water treatment facilities
- dam construction and intake

groundwater wells

domestic waterlines

*Industrial Water Supply

dam construction and intake

groundwater wells

Table C. Types of Environmental Alterations Associated with
Man's Activities in Drainage Basins

Modification of channel geometry

Modification of drainage network

Alteration of surface water quality and quantity

Alteration of sediment storages and water transport

Alteration of organic and inorganic nutrient cycle

Introduction of toxicants

Alteration of landforms

Alteration of trophic levels: primary producers
consumers

Alteration of habitat

Alteration of runoff, infiltration, evaporation.

Alteration of groundwater quality and quantity

Alteration of soil properties

Table D. Ecological Parameters Capable of Measuring Environmental Alterations in Surface Water Bodies

Water

*Physical Properties

Salinity

pH

Color

Taste-tainting

Odor

Turbidity

Particulate Matter

Flotable

Settleable

Interminably suspended

Temperature

Alkalinity

Sediment

bed load

suspended sediment load

TDS

*Chemical Properties

BOD

COD

DO

*Biota

Producers

Phytoplankton

Attached Algae

Higher plants

Consumers

Fish

Zooplankton

Invertebrates

*Hydraulic Geometry

Changes in channel dimensions

Changes in channel meander wavelength

*Sedimentation

Agradation/degradation

*Flood Occurrences

*Nutrients

Nitrates

Nitrites

Phosphorus

Silicates

*TOC

CO₂

HCO₂

CO₃

H₂CO₃

*Ionic Balance

*Micronutrients

Vitamin B₁₂ (and others)

Trace elements

*Toxic Materials

Pesticides

Herbicides

Heavy metals

Ammonia

Cyanides

Sulfides

Fluorides

Detergents

Surfactants

Tar, Gas, and Coke Wastes

*Petroleum Products

*Radionuclides

*Pathogens

Table E. Ecologic Parameters Capable of Measuring Environmental Alterations in Groundwater

*Physical Properties

pH

Temperature

Specific conductivity

turbidity

taste

odor

Particulate matter

flotable

settleable

interminably suspended

Alkalinity

carbonate

bicarbonate

Color

Total dissolved solids

*Chemical Properties

Chloride

Sulfate

Fluoride

Nitrate

Sodium

Table F. Ecologic Parameters Capable of Measuring Environmental Alterations in Upland Areas

Soils

*Physical Properties

pH

Soil structure

Permeability

Liquid limit

Plasticity index

Shear strength

Clay composition and amount/organic matter amount

Texture

Wilting point

Field capacity

Porosity

Depth to water table

Degree of horizontation

*Chemical Properties

CEC

Nutrients

Micronutrients

Toxic substances

heavy metals

pesticides

herbicides

oil and tar

miscellaneous organic compounds

ammonia

radionuclides

*Soil Biota

*Vegetation

Plant communities

Seral stage

Diversity

Productivity

*Erosion

Soil loss

Gullies and rills

Magnesium

Calcium

Iron

Potassium

Strontium

*Biologic Properties

Pathogens

*Miscellaneous

Pesticides

Herbicides

Heavy metals

Ammonia

Detergents

Surfactants

Radionuclides

Other organic compounds

Table G. Types of Consequences Resulting from Environmental Alteration

Environmental Consequences

- Loss or gain of water quality
- Loss or gain of erosion control capacity
- Loss or gain of pollution assimilation and processing capacity
- Loss or gain of nutrient moderation capacity
- Loss or gain of sediment storage capacity
- Loss or gain of flood water buffer
- Loss or gain of organic productivity

Economic/Human-Use Consequences

- Impaired or enhanced water quality
- Impaired or enhanced waste disposal
- Impaired or enhanced recreation
- Impaired or enhanced land development
- Impaired or enhanced agriculture
- Impaired or enhanced agriculture
- Impaired or enhanced waste treatment
- Impaired or enhanced oil and mineral extraction