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METHODOLOGY FOR THE ESTIMATION AND EVALUATION OF NONPOINT POLLUTION LOADING FROM WATERSHEDS IN OKLAHOMA

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METHODOLOGY FOR THE ESTIMATION AND EVALUATION
OF NONPOINT POLLUTION LOADING FROM WATERSHEDS IN OKLAHOMA

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ABSTRACT

The objective of this study was to develop a model which would allow the user, for planning purposes, to locate and evaluate potential nonpoint source pollution (NPSP) problem areas in the state of Oklahoma. This would allow a ranking to be made on which to base state policies such as disposition of funds or effort to control NPSP problems.

The model developed is based on the premise that specific land uses have definable associated pollutants. The nonpoint pollutant load resulting from runoff events from these land uses can be determined and the load from other areas with similar conditions can be predicted. The concentration of pollutants contributed by a specific land use was sampled from areas of homogeneous land use to determine the quantities of pollutant load.

Several land use categories were selected for monitoring in each quarter of the state. The monitoring program lasted from January 1976 to August 1977. Local Conservation Districts collected the samples, and the Oklahoma State Department of Health performed the chemical analyses. Data were then compiled by the Oklahoma Conservation Commission, and pollutant loading rates determined.

The model is capable of identifying the extent of pollution at three levels of geographic aggregation. At the largest level, the major basin having the greatest potential for NPSP problems (based on the land use activities in that basin), and the estimated NPSP load from those activities is identified. Next, the sub-basin within that basin (based on the same criteria as above) is identified, and finally, the watershed within the sub-basin. Each level affords more detail than the previous one, so that once the watershed level is reached, a much more detailed survey of the NPSP problems within

that watershed is possible. Computer programs were written to handle the identification (ranking) and evaluation process. Input requirements for these programs vary with the level of detail desired.

Results show a good correlation between predicted and measured NPSP pollutant loading rate values for similar watersheds having the same land use. However, there has not been sufficient data gathered to test correlation between loading rates from watersheds of mixed land use.

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CHAPTER I

INTRODUCTION

General Background

The United States Congress decided in the late 1960s that the Federal Government should expand its role in the control of water pollution, passing "The Federal Water Pollution Control Act of 1965." In October 1972 the 92nd Congress passed the "Federal Water Pollution Control Act Amendments of 1972," Public Law 92-500 to be administered through the Environmental Protection Agency (EPA). A main objective of the act is to "restore and maintain the chemical, physical, and biological integrity of the nation's waters." Briefly, six goals have been set:

1) To eliminate the discharge of pollutants into navigable waters by 1985;
2) An interim goal to be achieved by July 1, 1983 to protect fish, shellfish, wildlife, and recreation (the goal of "fishable swimable);
3) Prohibit the discharge of toxic pollutants;
4) Financially assist construction of publicly owned waste treatment works;
5) Develop and implement an areawide waste treatment management planning process;
6) Establish research and demonstration grants to develop the technology necessary to eliminate the discharge of pollutants.

The act is divided into five areas:

Title I - Research and Related Programs;

Title II - Grants for Construction of Treatment Works;

Title III - Standards and Enforcement;

Title IV - Permits and Licenses;

Title V - General Provisions.

Each of these titles is explained in detail in the law (1). This thesis focuses on Title II of PL 92-500 Section 208, items F through K. This Title requires and provides assistance in the development and assessment of waste treatment management plans to provide the basis for the control or treatment of all point and nonpoint sources of pollution. Section 208 of Title II is the portion dealing with areawide (nonpoint sources) waste treatment management planning. The planning process involves several steps including; 1) the selection of state agencies to carry out various facets of the law for which each agency has jurisdiction or expertise, 2) the establishment of criteria by which pollution problems may be identified, 3) development of alternative means of treating the problems, and 4) the involvement of local citizenry--especially when it comes to problem identification, selection of alternative treatment measures, and the implementation of those measures. Items F through K of section 208 delineate specific nonpoint sources of pollution which will be considered in the planning process. Other portions of section 208 deal with the annual certification of the areawide waste treatment management plan, establishment of the regional operating agencies, setting up procedures for funding and setting appropriations, and providing for technical assistance to state agencies.

The first part of section 208 calls for each state to set up planning agencies and jurisdictional boundaries. For Oklahoma, Governor David Boren designated two agencies to develop areawide waste treatment management plans for large metropolitan areas: the Association of Central Oklahoma Governments (ACOG), in the Oklahoma City area; and the Indian Nations Council of Governments (INCOG), in the Tulsa area. Later, under item (3) of section 208 (a), the Arkoma (Arkansas and Oklahoma) area around Fort Smith was included. These associations of government are responsible for developing their own areawide waste treatment management plans.

Governor David Boren designated the Oklahoma Department of Pollution

Control (ODPC) as the state agency responsible for 208 planning in the remaining portion of the state. Under section 208 (b) (1), the ODPC is to develop a "continuing areawide waste treatment management plan" for areas not designated in section 208 (2). The ODPC developed a list of items covering the state's water quality problems and presented this to other state agencies with water quality interests. The state agencies divided planning responsibilities based on a particular agency's expertise and legal authority. In most cases a "lead" agency was named along with several "support" agencies. The lead agency was to have the primary responsibility for a given program while the support agency was to provide information and other resources as necessary.

The Oklahoma Conservation Commission (OCC) was selected as the lead state agency responsible for that portion of the law (Section 208, Items F-K) dealing specifically with nonpoint sources of pollution. This was based on the Commission's involvement during the past 30 years with the Conservation Districts and their work in soil and water conservation.

Explanation of the Problem

Nonpoint sources of pollution are widely dispersed. The distinction is made between point and nonpoint sources primarily on the basis of transport mechanisms by which pollutants enter a stream, river, lake, or any other body of water. In the case of point sources, an industry or municipality, for example, discharges waste water to the receiving stream. The point at which it is returned (discharged) is called a "point source of pollution." The other mechanism by which pollutants reach the stream system is runoff. As rainfall begins to run off the land it may carry with it any of a variety of pollutants such as sediment, nutrients, or pesticides. Since this occurs over a large and varied area, this is called dispersed or "nonpoint sources of pollution" (NPSP).

Public Law 92-500 initially emphasized cleaning the nation's waters of pollution from point sources such as industrial or municipal outfalls. As the control of point sources has progressed, the Environmental Protection Agency has placed an emphasis on Section 208 as required by law.

Oklahoma's seven major river drainage basins are shown in Figure 1-1. These basins can serve as planning areas in the state's areawide

Basin 1. Middle Arkansas Basin

Basin 2. Lower Arkansas River Basin

Basin 3. Upper Red River Basin

Basin 4. Lower Red River Basin

Basin 5. Canadian River Basin

Basin 6. Upper Arkansas Basin

Basin 7. Panhandle Basin

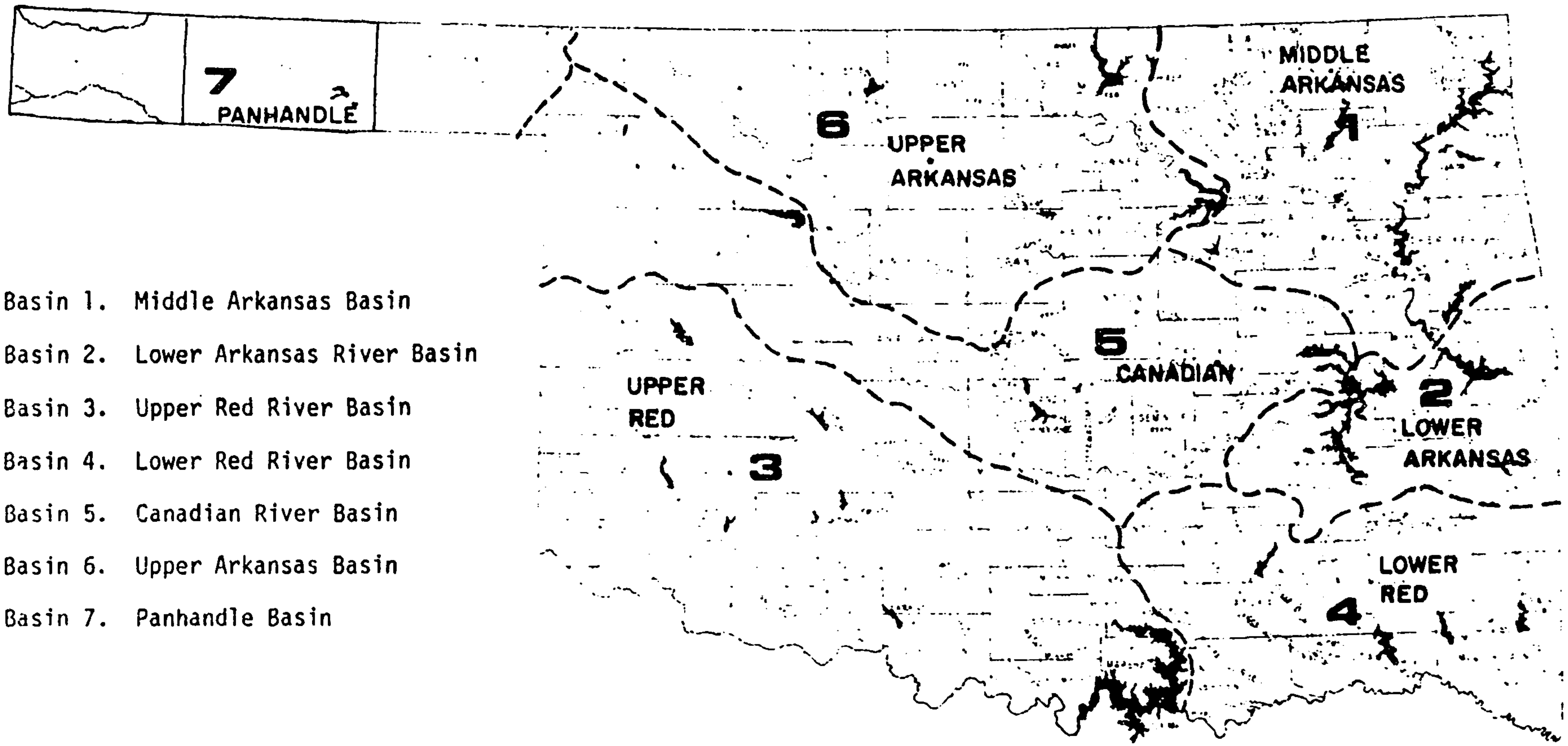


FIGURE 1-1

WATER QUALITY MANAGEMENT PLANNING BASINS water quality management planning efforts. Each basin is further divided into sub-basins, and the sub-basins into watersheds. The objective of this study arises from the need to develop a model for planning to locate and obtain an estimate of the amounts of NPSP being produced in Oklahoma. This will allow a ranking to be made on which to base the disposition of state and federal efforts which may be made to aid in the reduction of NPSP problems. Those basins and sub-basins identified as having potential problems will be studied in more detail and more specific NPSP problems would then be located on the watershed level.

Approach to the Problem

Since the reduction of NPSP has been established as a national goal, guidelines to achieve this goal have been developed by EPA. However, since few states have identified NPSP problems, much of the information is difficult to apply and is untested. This emphasizes the need for a general model which will estimate relative NPSP loads from large areas thereby delineating where future effort can be concentrated. One method to identify NPSP planning problems may be through the use of predictive technology. Land use categories have pollutants associated with each and through a runoff monitoring program, pollutants for each category can be quantified under a variety of conditions. This information can be the basis for a model to predict pollutants from similar land uses. Concentration of pollutants from a specific land use can be estimated by sampling the runoff from homogeneous land use to determine the quantities of pollutant.

The final breakdown of categories of land use for the NPSP monitoring program in this report are as follows: (Also see Chapter II)

Agriculture

1. Irrigated and/or row crops
2. Small grain crops such as wheat, oats, rye, etc.
3. Pasture - areas where predominately introduced species of grasses occur with moderate to heavy grazing
4. Rangeland - areas of natural grasses with light grazing

Silviculture

1. Mature stand
2. 3-4 year old clear cut area

Mining

1. Active site-where the mining of coal is still in progress
2. Inactive site - area where an open pit mining operation has been discontinued

Urban

1. Mixed - an area where a variety of land uses occur, such as commercial, residential, and parks
2. Construction

Conservation Districts in each quarter of the state were consulted to select sites that were typical of these land uses. These district offices gathered background information on soils, drainage patterns, etc., and did the monitoring and data collecting. Final site selection was based on how close the site reflected the land use for that area, e.g., was it typical pasture or was it in poor condition while other pasture in the area was in good condition. Also considered was the accessibility of the monitoring site. A wide range of weather variability across the state made it necessary to monitor the water quality from several land uses common to major quadrants of the state (using Interstate Highway 35 running North and South, and Interstate 40 running East and West as rough boundaries). Following selection of the final site and a collection of background information the monitoring program was established. Monitoring consisted of collecting runoff flowing across representative homogeneous land use at each site. (Details of this monitoring program are given in Chapter III).

The monitoring program emphasized determination of loading rates of selected pollutants. Pollutant build-up occurs as a result of several factors including: man's activities, the normal deposition of waste by animals, and naturally occuring breakdown of matter by microbes in the soil (3). This build-up of potential pollution occurs between runoff events. As rain begins to fall it tends to loosen and dissolve (as a function of rainfall intensity) the accumulated particles in the top layers of the soil. As the water collects and starts to run off, these particles and dissolved components are transported eventually to streams, rivers, lakes, and finally the ocean. The questions that need to be answered by a monitoring program are: 1) what is the rate of accumulation between runoff events, 2) how can this rate be measured, 3) is this rate similar among different land uses and areas, and 4) how does geography, topography, and land use affect these rates. Since more information could be gained by collecting from a variety of events over a longer period of time (through all seasons) than by thoroughly sampling three or four events, fewer samples were taken at each event but every event was sampled.

The total load of pollutant delivered to a waterway during each event was estimated from concentration and the total volume of runoff. The concentrations of the various pollutants were determined analytically in the Oklahoma State Department of Health (OSDH) Water Quality Laboratory. Several models are currently available to estimate the volume of runoff or "water yield." Both the models and runoff water analysis are described in Chapter IV.

Once the amount (in pounds per acre per event) of pollutant each land use produces has been estimated, an estimate of the total weight of pollutant contributed per event can be made. In a watershed, if the land uses and their areas are multiplied by their corresponding "pollutant loading factor," and then summed to provide a total for the watershed, the result is the total load (of a given pollutant) contributed by that watershed. This is expressed by the following formula:

$$L_T = A_1L_1 + \dots + A_nL_n \qquad (1.1)$$

Where: L_T = Total load in pounds of a particular pollutant

A_n = Area in acres of each land use in the drainage basin

L_n = Pollutant loading factor for each land use (lbs./acre)

Once pollutant loads were estimated for all basins comparisons were made to determine which basin had the greatest potential for NPSP problems.

This basin was then divided into sub-basins and the same ranking procedure applied. Once the sub-basin with the greatest potential for NPSP problems was identified the watersheds in that sub-basin were modeled to estimate relative sediment, nutrient, and organic loading rates imposed by individual watersheds. Once the watersheds were ranked, data gathered for the watershed identified as having the greatest potential for NPSP problems were analyzed in order to establish a system of treatment alternatives designed to control a specific problem.

CHAPTER II

RELATIONSHIPS BETWEEN NONPOINT POLLUTION AND LAND USE

General Background

Runoff is the transport mechanism by which NPSP reaches the waterways. During a rainfall event the intensity of the event acts to loosen and dissolve surface materials. As the event continues the ground eventually reaches a level of saturation (depending on antecedent soil moisture, ground cover, etc.) at which point the water begins to run off, carrying with it various pollutants.

The hydrologic cycle (Figure 2-1) determines the timing, volume, frequency, and quality of nonpoint source loadings (4). The watershed responds to this cycle as a system which yields outputs (including nonpoint source pollutants) in response to a series of inputs. Yevjevich (5) described this concept. "Continental surfaces, underground aquifers, inland bodies of water, plants and soils are environments with complex water inputs, environmental compositions, responses, and outputs. This environmental trinity, input-reponse-output, in combinations, mutual dependences, and feedbacks is defined as the hydrologic system." A systems description of agricultural watersheds given by Stewart, et.al. (6) which can be generalized to describe nonurban systems as shown in Figure 2-2 demonstrates the idea (7).

The inputs and outputs in Figure 2-2 have important characteristics that must be understood before an assessment of nonpoint loadings can be made. NPSP control requires knowing the system inputs, properties, and out-

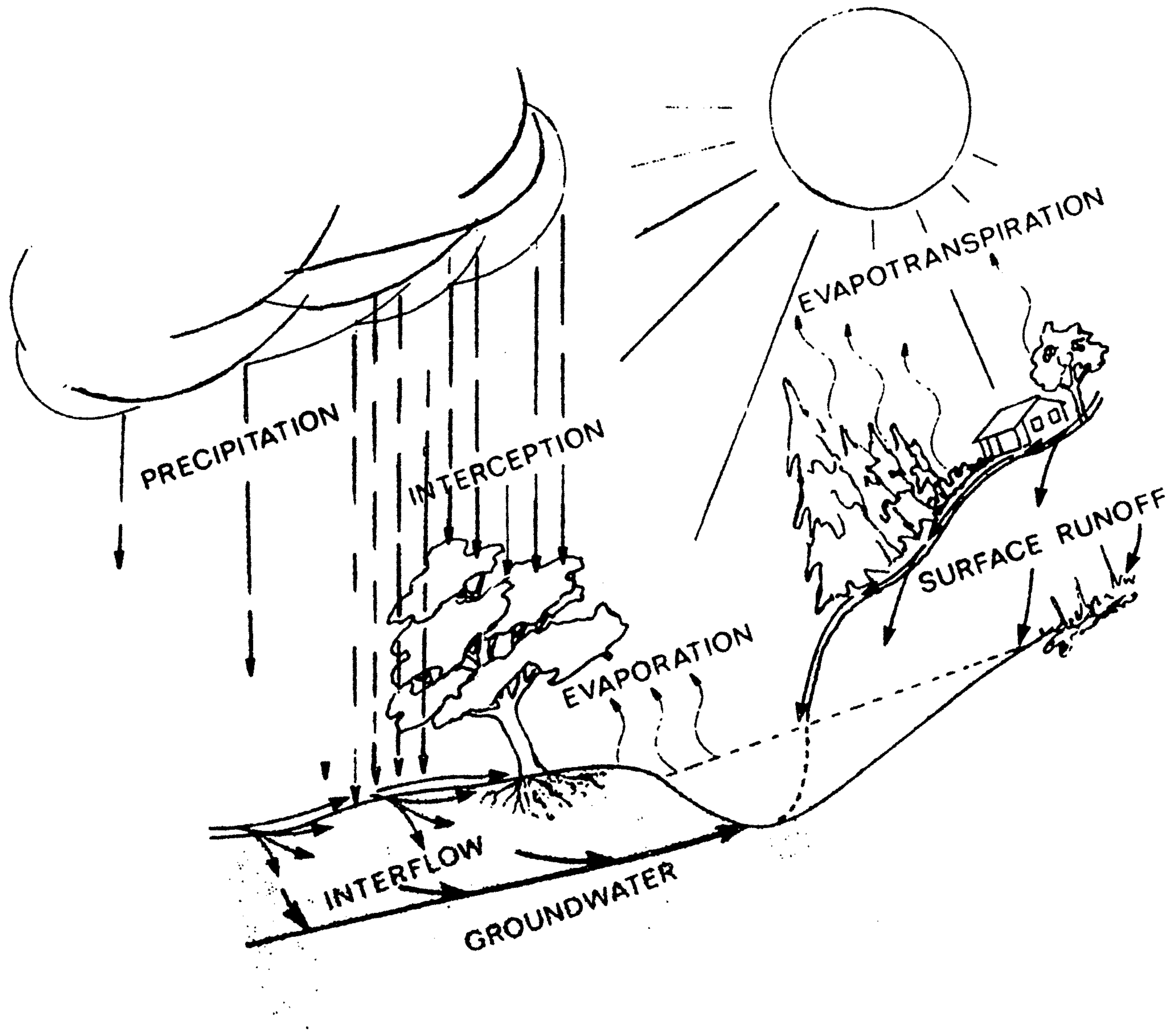


FIGURE 2-1
THE HYDROLOGIC CYCLE

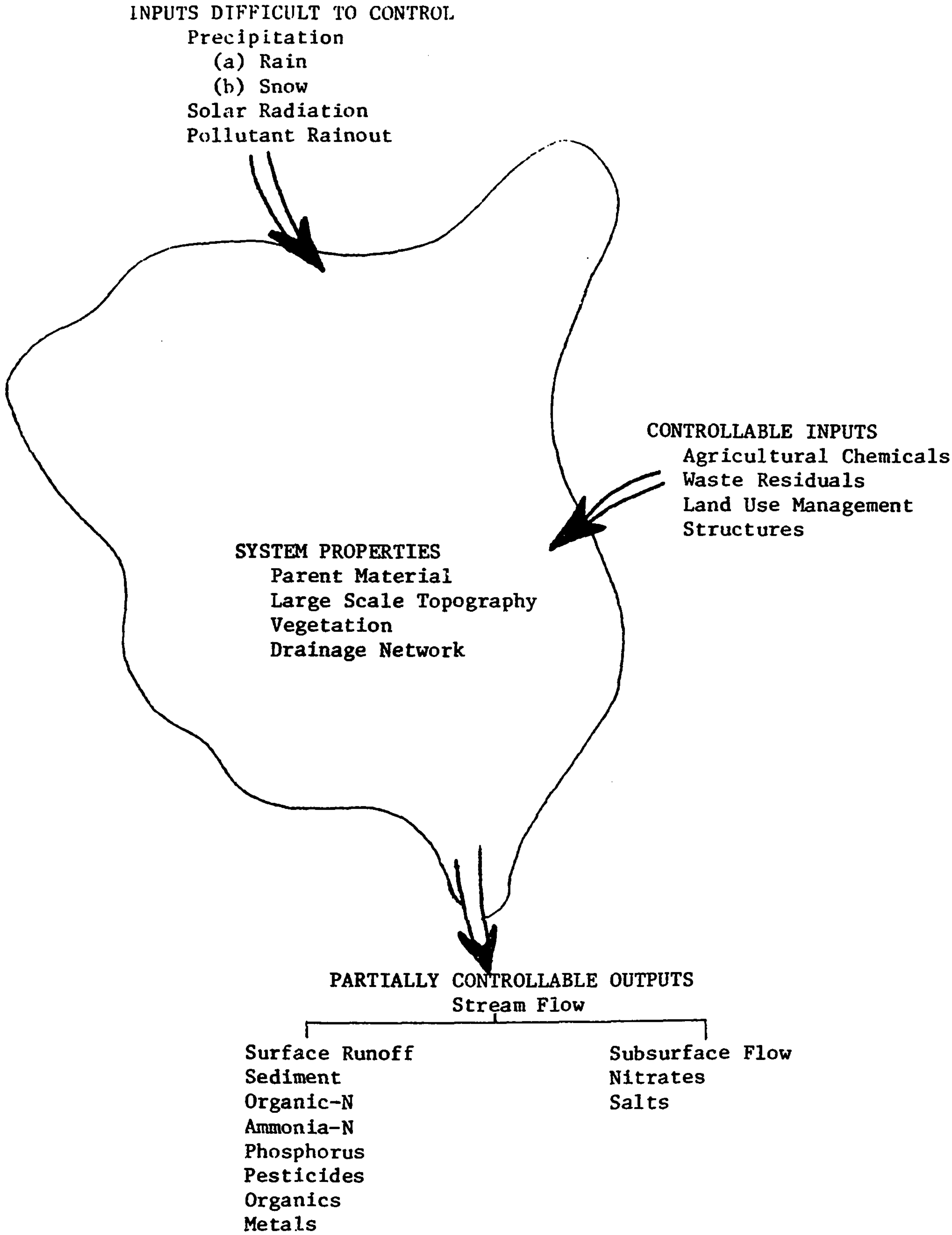


FIGURE 2-2
WATERSHED NPSP LOADING RESPONSE TO HYDROLOGY AND LAND USE

puts. Monitoring to determine the magnitude of NPSP problems or the effectiveness of controls is also keyed to these factors.

Precipitation inputs drive the system and determine the total volume and time distribution of runoff. Precipitation and solar radiation are stochastic and spatially variable. Precipitation measurement with raingage networks is available for many areas of the state.

System inputs classified in Figure 2-2 as controllable are largely those substances or activites introduced by man. Land use activities are some of these inputs. Location of inputs are variable but can be part of the controls introduced to reduce nonpoint source loads.

Most system outputs are partially controllable. Quantification of the degree of controllability possible is not a trivial task and is related to the uncontrollable and stochastic nature of the system inputs. Some absolute standards or goals may be impossible to achieve without violations for certain time periods, however small.

An important feature of the system outputs of Figure 2-2 is the division between surface runoff and subsurface flow. The relative distribution of these flow components varies as a function of surface conditions, watershed size, and geological formations. Estimates of relative magnitudes are important to the correct interpretation of measured water quality data and the allocation of measured loads to their sources. Some of the NPSP models described in a later section are capable of predicting this relative distribution (8,9). Empirical hydrograph analyses for this purpose are available as described by Chow (4), and may also be found in the SCS Engineering Handbook for Hydrology (10).

Division of watershed drainage into surface runoff and/or subsurface flow is important because most pollutants are transported in much greater quantities in one component of flow. The outputs shown in Figure 2-2 classify the major pollutants by their major modes of transport. There are, as always, exceptions to these rules as in those areas where extremely permeable (e.g., sandy) soil profiles exist or where large areas are impermeable. NPSP controls also must be planned in recognition of flow distribution because many candidate practices (e.g., soil conservation practices) result in a shift in the relative distribution of flows and subsequently, a new set of NPSP loads must be analyzed. Interaction of surface and subsurface processes is a major consideration in the selection of agricultural nonpoint source controls developed by Stewart et. al. (11).

The hydrologic system is important in estimating the nature and extent of NPSP loads through field sampling. Intensive, continuous sampling over short periods of time may measure little of the source or extent of the pollution problem. Runoff itself is stochastic as is the time between runoff events. Grab sampling over longer periods may have limited usefulness as peak loads may be missed entirely.

Land Uses

Agriculture

It is extremely difficult to reduce NPSP problems resulting from agricultural activities to a specific set of sources, loads, and potential controls. Pollution can arise due to: 1) pervasiveness of human activities within watersheds; 2) the wide array of activities and practices possible; and 3) the diversity of chemicals, application rates, and farming methods available to individual farmers and ranchers.

Certain activities are common to most crops and can be considered collectively. Most notable among these is the application of fertilizers and pesticides. References are available that give detailed descriptions of pesticide properties, intended use, toxicity data, persistance and relative mobility in soils (9).

Fertilizer technology and environmental behavior have been reviewed in recent publications (11,12). Some of these references are production oriented, but the basic data give useful insights to potential problems and their control. A two-volume report jointly prepared by USDA and EPA gives comprehensive information on control options (11,6). This manual describes controls available for erosion, runoff, nutrients, and pesticides. A methodology for selection of control practices, complete with flow charts and a detailed interpretive review of existing literature is given. These volumes have been designed for use in development of NPSP control plans, and represent the state-of-the-art for agricultural sources. This topic is further discussed in a later section of this chapter under "Management Practices."

Silviculture

For the purposes of this paper silviculture may be defined as the theory and practice of controlling forest establishment, composition, and growth (13). The major types of pollutants from forestlands are sediment, organic matter, applied forest chemicals (pesticides, fertilizers, fire retardants) and plant nutrients. Thermal effects on streams from solar radiation associated with the reduction of shade from streamside vegetation are in some cases detrimental.

The harvesting methods recognized by the forestry profession in the United States are the clearcut, seed tree, shelterwood, and selection systems (14). All of these methods are practiced to some degree in Oklahoma; however, for large commercial operations the two most wide spread methods are the seed tree method, and to a larger extent, clearcutting (14).

Fires can remove protective ground cover and promote erosion. Three major erosion processes which are of concern in forestlands are surface erosion, mass soil movement and channel erosion. This subject has been reviewed in detail by Brown (15). Road construction, logging, fire, and grazing are four factors which affect surface erosion. Soil which is unprotected by vegetation or litter can be detached by the impact of raindrops. The detaching ability of rainfall depends on rain drop size and velocity, and on rainfall intensity. Mechanical compacting of surface soil by machines or animals may reduce infiltration and produce surface runoff. When combined with vegetation removal, mechanical compaction may result in extremely high erosion rates on certain soils and slopes for a short period of time.

In addition to sediment being a NPSP problem in silviculture, other problems exist including:

(1) Nutrient elements: Phosphorus, nitrogen, and other mineral elements which occur naturally in growing or decaying vegetation, and to some extent in soils (phosphorus, for example, attaches readily to clay particles). Other sources include fertilizers (usually nitrogen only), fire retardants and waste from animals.

(2) Pesticides: Here application techniques are most important. Tree by tree ground application is probably the most effective in the control of pests but not the most economical for larger

areas. Aerial application is an often practiced technique but is more apt to contaminate streams directly or as the result of drift.

(3) Thermal pollution: This is the result of the removal of shade cover which exposes waterways and the ground to direct sunlight.

Methods to control these pollution problems which result from silvicultural activities are presented in EPA's publication "Processes, Procedures, and Methods to Control Pollution Resulting from Silvicultural Activities" (13).

Mining

The effects of mining include pollution of water supplies with mine drainage and sediment. Pollution from mining operations arises because the hydrology of surface and subsurface waters is altered when the earth's crust is disturbed to gain access to mineral values held within the crust. The quality of these waters very often deteriorates, and the quantity is often redistributed as a result of mining operations. The degree to which the environment is altered depends upon the size and depth of the disturbance, the method of the disturbance, and the nature of the disturbed materials.

One serious pollutant arising from mining activities is the mine drainage generated by oxidation of pyritic materials with air in the presence of water; this drainage is an acidic mixture of iron salts, other salts and sulfuric acid. The acid can react with clays to yield aluminum concentrations sufficient for fish kills, and with limestone to yield very hard waters. The acid can also selectively extract heavy metals present in trace quantities in mineral and soil formations resulting in toxic conditions in lakes and streams (16).

Mining refuse (waste materials left near the mining site after raw minerals have been cleaned or concentrated) contains pyritic material which can be oxidized to acidic substances. Mining operations also generate wastes, commonly called spoil, in the form of disturbed rock and soil. If this spoil is left in piles, erosion and runoff will carry sediment into streams.

Mining activities can have a pronounced effect on groundwater supplies. Aquifers containing good water can become contaminated because some mining may disturb bedrock formations which permits mixing of contaminated water with good water. Any opening in the earth which causes pyritic materials to be exposed to air and moisture is a potential source of acid mine drainage. Pyritic waste materials in "gob" piles, spoil banks, or tailings ponds will react with air and water to produce acid mine drainage.

Acid mine drainage from pyrite oxidation is generally shown as occurring in three steps: (1) oxidation of pyrite to ferrous sulfate and sulfuric acid, (2) oxidation of ferrous sulfate to ferric sulfate, and (3) hydrolysis of ferric sulfate. The oxidation of pyrite to ferrous sulfate and sulfuric acid, step 1, is rapid if the pyrite is exposed to moist air (16). Moisture condensation, flooding, and natural drainage processes flush the ferrous sulfate-acid mixtures into watercourses where dissolved oxygen in the water will slowly oxidize the ferrous iron to ferric iron, step 2. This oxidation may be catalyzed by other metals (manganese, copper, or aluminum) or by bacteria (Ferrobacillus ferroxidans). In the final step, as the ferric sulfate is diluted by a receiving stream it will be hydrolyzed to form colloidal ferric hydroxide and sulfuric acid, step 3.

Surface mining of coal and other sedimentary minerals, e.g., phosphate and iron ore, create large areas of disturbed land. This disturbed land is highly erodible and can contribute large quantities of sediment to surface waters if the land is not properly reclaimed after mining or if proper techniques for sediment control are not employed in the mining operation.

Mining operations often involve processes which disrupt the flow of groundwater. Blasting operations can fracture local rock strata. These fissures in the bed rock provide entries for mine drainage or saline water to aquifers containing good groundwater. The sinking mine shafts or the digging of deep open pit mines can create depressions which are lower than normal groundwater levels. In this event, groundwater will drain into the depressions.

Leachate, the discharge of polluted water arising from water percolation in waste rock piles, is another serious source of pollution. It occurs in coal mining regions where coal, refuse, gob piles, and mine spoil are exposed to weathering.

Drilling for oil and gas can be considered a form of mining The abandoned oil and gas wells are often contributors of salinity to water supplies. The discharges often arise from inadequate sealing, or from seal deterioration over the years (17).

Land reclaimed from mining operations remains a potential source of pollution even though the reclaimed land may be used for other activities such as agriculture, silviculture, or recreation. Materials potentially capable of creating pollution are still present in the area, and indiscriminate use of the reclaimed land may undo the reclamation operation. It has been noted in some cases that the premature plowing of reclaimed land has exposed buried toxic material. This exposure resulted in plant toxicity together with renewed acid and sediment production (16). Thus, time is required to reestablish an equilibrium in the environment.

The reclamation of land usually requires extensive use of fertilizers to create soil conditions to establish vegetation. This acts to minimize sediment transport. Thus some pollution from reclaimed lands will be similar to agricultural operations.

Construction

Construction operations can generate many types of water pollutants. The amount and type of pollutants generated during construction depends upon the type and time duration of construction practices, location and size of the construction site, rainfall distribution and frequency, pest control measures, resistance of soil or land surface to erosion by water and wind, chemical properties and geology of subsurface soils, the number of people and machines linked with each construction site, and the location of construction activities (18, 19).

Clearing and pest control are operations which may appear initially on any construction site, singly or in combination. Their extent will be greatest in the construction of transportation and energy networks, particularly superhighways, electric transmission lines, and pipelines for oil and natural gas. Vegetation such as trees, shrubs, or tall grasses that constitute a hindrance to the development of the site will be cleared from the right-of-way or the construction site. In some instances, the surface soil may be stripped and stockpiled for use during site restoration. Unwanted buildings or other man-made structures may be demolished or moved to new locations.

Rough grading is characteristic of most construction activities. Heavy construction equipment used in this practice (bulldozers and trucks) becomes both a direct and indirect source of water pollutants. Diesel fuel, oil, and lubricants from vehicles used in construction are direct sources, while the equipment itself is an indirect source, in that it causes severe compaction of clayey soils, thereby curtailing the rate of water infiltration and lowering the rate of soil aeration.

Grading results in the exposure of extensive subsoil areas which characteristically possess soil aggregates that are more easily dispersed by the impact of raindrops and wind than of unexposed soils. Sediment particles (fine sand, silt, clay, and organic particles) caused by the erosion of soil exposed during grading is one of the most serious water pollutants. For example, up to 706 hectares of soil per kilometer of superhighway (30 acres per mile) may be exposed during construction (20). Under heavy rainfall and the lack of proper erosion control measures up to 1,696 metric tons of sediment per kilometer (3,000 tons per mile) can be produced (20). Much of this sediment (fine sand and silt) can be deposited on adjacent properties, in the smaller water bodies, and ultimately in major water bodies. Sediment deposited on the bottom of streams, lakes, and reservoirs threatens the survival of bottom dwelling aquatic species (21, 22). Clay particles of colloidal dimension that remain in suspension, creating water turbidity for long periods of time, can decrease the amount of light in the water column of lakes, and as result, decrease the rate of photosynthesis and the productivity of aquatic species located therein. The turbidity of lakes and reservoirs can increase the absorption of heat, thereby increasing the surface water temperature relative to clear water (21). The warmer surface water is less dense than the cold bottom water and remains confined to the surface strata. If a reservoir discharges only from the surface, this warmer water may have far reaching effects on stream ecology below the damsite (21). Finally, pesticides and other chemicals adsorbed on sediment may be transported to lakes and streams in runoff water where they accumulate in bottom deposits. These chemicals can be released slowly to overlying lake waters and thereby become concentrated at successive levels of the food chain (21). Sediments may serve to transport nutrients, primarily calcium, magnesium, and trace elements such as iron and manganese (23). Trace metals such as copper, cobalt, and chromium are transported in rivers largely by fixation within sediment crystalline structures (23).

Quantification methods for pollution from construction activities are available only for soil erosion and suspended sediment yield. In a U.S.G.S. study of the Scott Run Basin near Washington, D.C., 85% of the sediment transported into the basin came from highway construction which covered only 11% of the 11.6 km^2 (4.5 $miles^2$) basin (31). Under conditions of normal precipitation, sediment yield in the construction area would be about 16,800 metric tons/km^2 (48,000 tons/$mile^2$) annually. This amount is about ten times that normally expected from cultivated land, 200 times that expected from grassland, and 2,000 times that expected from forestland (24).

Construction usually exposes soil to rainfall on slopes steeper than those found in agricultural applications which result in greater quantities of runoff at higher velocities. In the case of highway construction, for example, significant increases in suspended sediment yield may occur in adjacent streams. Younkin (25) developed an equation to compute suspended sediment load of a stream during periods of rainfall induced erosion. The prediction equation based on a graphical multiple regression analysis of 86 sets of data from the White Deer Creek Valley drainage basin in Pennsylvania is:

$$Q_s \text{ in metric tons} = \frac{0.0092R^{1.5}(\log A + 0.392)^{2.45}(3.32)^D}{P^{0.72}}$$

$$Q_s \text{ in tons} = \frac{0.034R^{1.5}(\log A)^{2.45}(3.0)^D}{P^{0.72}} \qquad (2.1)$$

Where: Q_s = the suspended sediment yield at a stream station in metric tons.

A = the area of the exposed surface affected by the rainfall in hectares (acres).

R = a rainfall factor in the Universal Soil Loss Equation in hectare/year (tons/acre/year).

P = a dimensionless proximity factor

D = the average depth, in meters (yards).

Information required for quantification of soil erosion and sediment production from construction sites include the location and area of construction, soil and geologic ground cover condition, as well as suspended sediment level of the surface water.

Streams contribute substantially to the sediment load through channel degradation and bank erosion, and these factors must be taken into consideration in interpreting sediment concentration data as well as in calculating sediment yields from construction sites. Several factors contribute to channel degradations and stream bank erosion: the slope of the stream bed, the characteristics of soil and rock formations, restrictions in the channel, the magnitude of slug flow during rainfall or snowmelt, and vegetative cover on stream banks.

Salt Water Intrusion of Surface Water

Effects of changing land use and soil and water conservation practices on the quantity and quality of downstream flow are being evaluated in Western Oklahoma. In the Washita River Basin in Oklahoma, for example, conservation practices and land uses have enhanced water loss and concentrated salts by evaporation and evapotranspiration or dissolution by causing more water to infiltrate soils and saline geologic deposits. These processes increase stream salinity (26).

Floodwater retarding structures and ponds potentially affect the salinity of downstream waters in two ways. First, water loss by evaporation increases the salinity of water remaining in an impoundment. Second, impounded waters provide greater opportunity for dissolving salts in the saline geologic deposits that comprise much of the surface geology in Western Oklahoma. However, as Mr. Roland Willis, State Conservationist with the Soil Conservation Service pointed out in personal correspondence with the author (27):

> "It should be noted that while evaporation and evapotranspiration tend to produce minor increases in stream salinity, floodwater retarding structures have two very positive influences on reducing

stream salinity. First, floodwater retarding structures are located in areas where they can control the sediment with their attached pollutants, and in some cases, precipitate a portion of the soluble salts (particularly gypsum) from high natural salt producing areas. Part of the rise in reservoir salinity is offset by the fact that the surface area of the reservoir gets a 100% contribution from rainfall which is essentially mineral free. The second major impact of floodwater retarding structures in reducing stream salinity is in the reduction of overbank flows where salts and other forms of stream pollution are contacted."

Continued study is needed to determine the major qualitative and quantitative changes in stream salinity. Whether the salinity increase in impounded or drainage waters from a controlled watershed is economically significant depends on the present or proposed use of this water. The resultant salinity increase will have little effect on usage if the intended use tolerances are great, or if the salinity indigenous to the uncontrolled stream already exceeds tolerances for any high value use. One way to determine the qualitative and quantitative relationships is through modeling. Because the dominant factors influencing the normal salinity are geologic and climatic, the model must incorporate both. The geology controls the potential maximum salinity generally corresponding to the observed salinity of low base flows. The geology also controls the specific salts, which may have to be considered with the total salinity. For instance, sodium and chloride are more destructive to soil structure and plants when applied in irrigation water and more corrosive to metals than are many of the other major salinity constituents. Also, carbonate rich water associated with high sodium or potassium concentrations produces high pHs thus greatly decreasing the value of the water for most uses.

Figure 2-3 illustrates low-flow stream salinity limitations for potential impoundment of streams in the Great Plains (26). Because of the poor resolution created by use of a map of this scale and imposed by the broad definition of these salinity classes, the map boundaries should be interpreted generally. The mapping units reflect geology modified by climate, but does not include the effect of climatic components, i.e., evaporation and runoff.

A model incorporating the effect of both characteristics has been successfully tested on several streams (26). It establishes the normal

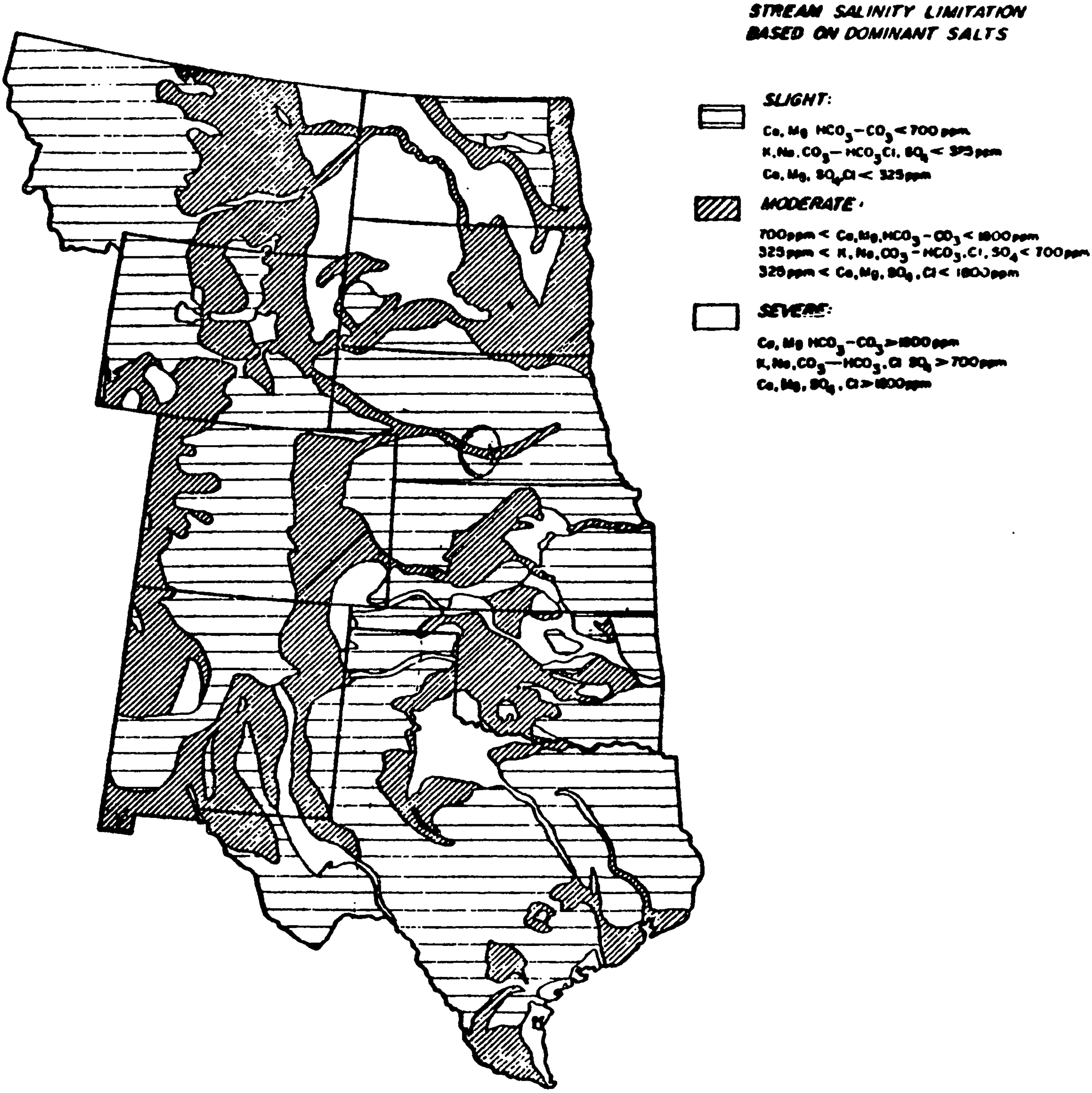


FIGURE 2-3

CLASSIFICATION OF PREDOMINANT LOW-FLOW SALINITY
OF GREAT PLAINS STREAMS FOR IMPOUNDMENT POTENTIAL (26)

stream salinity on a monthly basis by use of base flow, surface runoff, and base flow salinity as follows:

$$\ln s = \ln K - \ln Q_b - Q_s/Q_b \qquad (2.2)$$

Where: s = the monthly salinity expressed in micromhos.

K = a coefficient that can be interpreted as a maximum concentration.

Q_s & Q_b = mean daily surface and base flow in cfs averaged for each month.

An equation of this form is of value because it requires that the base salinity be established and include surface runoff and base flow characteristics. The rate of salinization can be excessive when moderately saline watersheds are characterized by: (1) low water or surface runoff yields, (2) high evaporation rates, and (3) high seepage rates associated with saline geologic deposits.

Under high evaporation rates, the effect of impoundment, and particularly impoundment design, can be critical (28). Obviously, designs that emphasize large reservoir surface areas associated with small volumes enhance this loss. The design should maximize the volume in relation to the surface area of the reservoir. The management option of drawing down the stored waters during periods of maximum evaporative loss may be a useful tool in managing larger reservoirs.

In addition to evaporation losses, evapotranspiration losses from phreatophytes located adjacent to the reservoir or below the dam can be considerable and have been observed to be equivalent to 4 to 7 feet of water during one year (29). In areas where phreatophytes are a problem, control of plants by chemical and/or cultural means or by altering the reservoir level should be considered.

Other Sources

a) Livestock Feedlots

In the case of livestock feedlots EPA declared these operations (within certain guidelines set forth in the federal register for Thursday, March 18, 1976 on "Concentrated Animal Feeding Operations") (30) to be considered as point sources of pollution and are licensed under the National

Pollutant Discharge Elimination System (NPDES) as such.

b) Urban Stormwater

During the past two decades many researchers have shown that stormwater can contain a considerable pollutant loading (31, 32, 33). Representative values for several quality parameters are shown in Table 2-1. It is apparent that the concentration of pollutants in storm sewers usually exceeds the levels found in the effluent from municipal sewage treatment plants (30). The problem of pollution from urban runoff is compounded by the large, irregular quantities of runoff. The amount of domestic sewage from an acre of residential land will be about 1,000 gpd (gallons per day), but one inch of rain falling on the same acre can easily cause 7,000 gallons of runoff. If all rainfall events for the year are figured, this can amount to more than one hundred times the volume of the domestic sewage during the same period. The runoff pollutional loading (flow times concentration) can likewise exceed that of the municipal effluent by a factor of one hundred or more during the period of runoff (31).

Precipitation on urban areas entrains a variety of pollutants before it is finally discharged from the storm sewer system. Air pollutants are washed from the atmosphere. Dust, dirt, and litter are carried from roofs, sidewalks, parking lots, streets, and other impervious surfaces. Chemical pesticides, herbicides, fertilizers, and de-icers are picked up from streets and lawns. Soil is eroded from barren land and construction sites. The impact of stormwater runoff depends on the nature of the receiving water and the relative magnitude of urban runoff when compared with point sources and nonurban runoff. However, the pollution potential is present and urban runoff cannot be ignored when considering water quality.

The understanding of the potential sources of stormwater runoff contaminants is important when considering which basins are potential problem areas and when evaluating source controls. Source controls are methods used to keep pollutants from entering the stormwater system.

The quantities of pollutants that accumulate are a function of the natural physical conditions and development by man. It is very difficult to project the intensity of pollutant loadings from urban sources since they can seldom be isolated for individual study, thus, none of the many studies of stormwater runoff (over the past two decades) have reliably re-

TABLE 2-1
COMPARISON OF QUALITY OF STORM
SEWER DISCHARGES (29)

Type of Wastewater, Location and Year	BOD mg/1 Avg.	COD mg/1 Avg.	Total Nitrogen mg/1 as N Avg.	Total Phosphorus mg/1 as P Avg.	SS mg/1 Avg.
Typical untreated municipal	200	500	40	10	200
Typical treated municipal					
Primary effluent	135	330	35	7.5	80
Secondary effluent	25	55	30	5.0	15
Storm sewer discharges					
Ann Arbor, Mich. (1965)	28	n/a	3.6	1.7	2080
Castro Valley, Calif. (1971)	14	n/a	1.9	n/a	n/a
Des Moines, Iowa (1969)	36	n/a	2.2	0.87	505
Durham, N.C. (1968)	31	224	n/a	0.18	n/a
Los Angeles, Calif. (1967)	9.4	n/a	n/a	n/a	1013
Madison, Wis. (1970)	n/a	n/a	4.8	1.1	81
New Orleans, La. (1967)	12	n/a	n/a	n/a	26
Roanoke, Va. (1969)	7	n/a	n/a	n/a	30
Sacramento, Calif. (1968)	106	58	n/a	n/a	71
Tulsa, Okla. (1968)	11	85	0.3-1.5	0.2-1.2	247
Washington, D.C. (1969)	19	335	2.1	0.4	1697

n/a Information Not Available

lated stormwater characteristics to these sources in a quantitative manner. In the development of basin scale pollutant loading factors one must consider the loading in terms of general land use categories such as residential, commercial, industrial, and open land. The reason these general categories are acceptable is because they are related to specific sources. For example, there is less fallout in residential, commercial areas than in industrial areas; and commercial, industrial areas have more traffic than residential neighborhoods.

c) Hazardous and Solid Waste Disposal

The Oklahoma 208 program has evaluated the pollution potential from sanitary land fills and solid waste disposal needs. The average solid waste collected is 5.3 lbs. solid waste per person per day (33). The most commonly used method of disposal of this waste is the sanitary landfill where waste is covered at least at the end of each day by a layer of earth. This method can still be a potential source of bacteriological and chemical pollutants to ground waters by diffusion and convection of gases produced during decomposition. The leachate produced moves through the soil to the ground water and the contaminants eventually reach surface waters which may be used as water supplies.

Pollution from sanitary land fills can be minimized by correct planning and site selection (34). Sanitary land fills should be located at a safe distance from potable water supplies and areas where conditions allow the leachate from the land fill to come into contact with other water sources. Uses of proper drainage to carry surface waters away from the site is also necessary. The Solid Waste Management Division of the State Health Department provides a permitting system for sanitary land fill operations.

As stated in the Oklahoma Solid Waste Management act of 1970 no hazardous waste is deposited in a solid waste disposal site which is permitted by the State Health Department unless the site is approved by the State Health Department for disposal of hazardous waste (33).

Management Practices

The preceding sections have dealt with the effects land use can have on water quality. "Best Management Practices" are measures which are designed to reduce these effects. The term "best management practice" refers to a practice, or combination of practices, that is determined by a state (or designated areawide planning agency) after problem assessment, examination of alternative practices, and appropriate public participation to be the most effective, practicable (including technological, economic, and institutional considerations) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals (35). A best management practice may consist of agronomic practices or structural measures and more frequently, a combination of each. Agronomic practices are conservation measures which improve crop residue management, cropping sequences, seeding methods, soil treatments, tillage methods, and timing of field operations. Structural practices include contour farming, terraces, diversions, waterways and other control structures. When the land properties such as excessive slope length or slope gradient, very erodible soil, poor drainage, etc. are present, agronomic practices alone are not adequate in controlling nonpoint pollution and other supportive practices such as the structural practices mentioned may be required. A good treatise on the selection of best management practices may be found in an EPA joint publication with the National Association of Conservation Districts entitled "Conservation Districts and 208 Water Quality Management" (35).

In November 1975, a joint publication from the USDA Agricultural Research Service and EPA Office of Research and Development was made available to the states to serve as a guideline for the development of land management strategies which would control pollution resulting from agricultural activities (11). Section four of Volume I deals specifically with pollution control practices and their applicability to different types of nonpoint pollution resulting from agricultural land use. Management practices have likewise been written for different construction, mining and silvicultural activities.

It should be recognized that an important interrelationship exists between these practices. For example, the introduction of an erosion control practice, such as minimal tillage to control sediment loss, may also reduce the amount of runoff as a result of the increase in ground cover and greater absorption capacity of the soil. Nutrient and pesticide loss may also be reduced due to the fact that most nutrient forms and many pesticides adhere to the sediment (11). The loss of soluble forms of nutrients and pesticides may also be reduced as a result of the decreased amount of surface runoff. These might represent some of the positive aspects of the application of a pollution control measure directed toward the control of sediment. Some of the negative aspects which may result from the above sediment control practice might be the increased need for more nutrients or the application of larger amounts of pesticides to control weeds which may occur with minimal tillage. Also, reduced amounts of runoff may result in the leaching of soluble nutrients and pesticides resulting in ground water pollution. Other important factors should be considered. For example, will the pollution control practice affect the farmer's crop yield? Does the farmer have the appropriate implements to accomodate the changes resulting from implementation of the control practices? These are questions which must be answered during the public participation phase of 208.

Information concerning the effectiveness of best management practices are limited since the effectiveness of any type of practice depends on its specific form and on the cropping system and general management level with which it is used.

In the future, the OCC may have the responsibility for seeing that agricultural, silvicultural, mining and construction management practices are implemented, while the OSDH implements practices to control NPSP problems from urban stormwater runoff. However, present state legislation does not provide the necessary authority for either agency to properly regulate these activities.

CHAPTER III

MODELS AVAILABLE IN NONPOINT SOURCE LOAD ESTIMATION

The hydrologic cycle provides the pathways and energy to transport pollutants to surface or groundwater. Pollutants will be transported with the sediment carried by overland flow or dissolved in both overland and sub-surface flow. The physical-chemical processes that determine the relative distribution of pollutants between particulate and dissolved forms are poorly understood and even more difficult to describe mathematically to the point where the theory can be incorporated into NPSP loading models. A recognition of the partitioning phenomenon must be made, however, in both interpreting measured data and predicting loads via models. Models have been designed that assume all pollutants are attached to (or behave as) sediment while others attempt to partition pollutants between the two transporting media (7).

This chapter describes these two major model components, and then reviews input requirements, output, and accuracy of some of the NPSP models presently available. A discussion of ongoing research in this field is included in the final section.

Techniques for the Estimation of Runoff Volume

Because runoff is the transport mechanism for most nonpoint pollutants, the estimation of volumes of runoff becomes important. Many formulas have been developed specifically for this purpose (4,10,36,37,38). However, only those models which deal with the "Water Budget" by considering the effects of such input variables as soil moisture, conservation practices, soil-type, land use and ground cover in addition to the common variables such as meterological and topographical factors, are reviewed.

The "Williams Water Yield Model" developed by the Agricultural Research Service (ARS) (36). is designed to produce a "curve number"[1] based on conservation practices, soil type, land use, ground cover, and slope. Then along with precipitation, evaporation rates, and antecedent soil moisture conditions, an estimated value for water yield is obtained.

This model uses a one day time interval, has easily measurable inputs, and only outputs runoff volume. The model is calibrated on a gaged watershed and can be used to predict water yield on nearby ungaged watersheds. Input requirements are: (1) an estimate of the SCS runoff curve number for the watershed;[1] (2) measured monthly runoff; (3) daily rainfall; and (4) average monthly lake evaporation. The model computes a soil moisture index depletion parameter that forces agreement between measured and predicted average annual runoff. Other optimization schemes, like optimizing on monthly or annual runoff, do not consistently predict the proper average annual runoff and thus, do not provide a good estimate of average curve number. When used on nearby ungaged watersheds, the SCS curve number is adjusted for the ungaged watershed in proportion to the ratio of the estimated curve number to the average predicted curve number for the calibrated watershed.

Test results on about 50 Texas watersheds with areas ranging from .2 to 860 square miles show that the model simulates runoff fairly accurately (36).

The "Sacramento Model," was developed by Robert J.C. Burnash of the United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) as a generalized streamflow simulation system (39). This model is much more complicated than the Williams model due to its

1. Curve Numbers (CN) are determined based on effect of soil conditions, vegetative cover (land use) and whether or not conservation practices are utilized, to represent a relationship between rainfall and runoff. (A CN of 100 represents an impervious surface where all rainfall runs off). Also see page 34.

increased comprehensiveness in describing the "Water Budget" of the stream or river system. Figure 3-1 illustrates the components of a generalized hydrologic model (39). Of primary importance here is that portion of the model labeled "Upper Zone" since this is where surface runoff occurs. However, its interrelationship with the "Lower Zone" must also be considered.

In the Sacramento Model, rainfall occurring over the basin is considered as falling on two basic areas, 1) a permeable portion of the soil mantle, and 2) a portion of the soil mantle covered by streams, lake surfaces, marshes, or other impervious material directly linked to the streamflow network. The permeable area produces runoff when rainfall rates are sufficiently heavy, while the second area produces direct runoff from any rain.

In the permeable portion of the basin, the model presents an initial soil-moisture storage identified as Upper Zone Tension which must be totally filled before moisture becomes available to enter other storages. Tension water is considered as that water which is closely bound to soil particles. Upper Zone Tension represents that volume of precipitation which would be required under dry conditions to meet all interception requirements and to provide sufficient moisture to the upper soil mantle so that percolation to deeper zones and sometimes horizontal drainage can begin. When the Upper Zone Tension volume has been filled, excess moisture above the Upper Zone Tension Water capacity is temporarily accumulated in Upper Zone Free Water. Free Water is that water which is not bound to soil particles. It is free to descend to deeper portions of the soil mantle or to move laterally through the soil in response to gravitational and pressure forces. The upper zone free water storage supplies water for percolation to lower zones and for interflow. Upper Zone Free Water is that volume of moisture in the upper level soil from which lateral drainge, appearing as streamflow, is observable. This lateral drainage is identified as interflow. Upper Zone Free Water not only has the horizontal potential to generate interflow, but more significantly, has a vertical potential. The demands imposed upon the Upper Zone Free Water vary with the amount of water available in the upper zone. Interflow is proportional to the available free water volume after percolation.

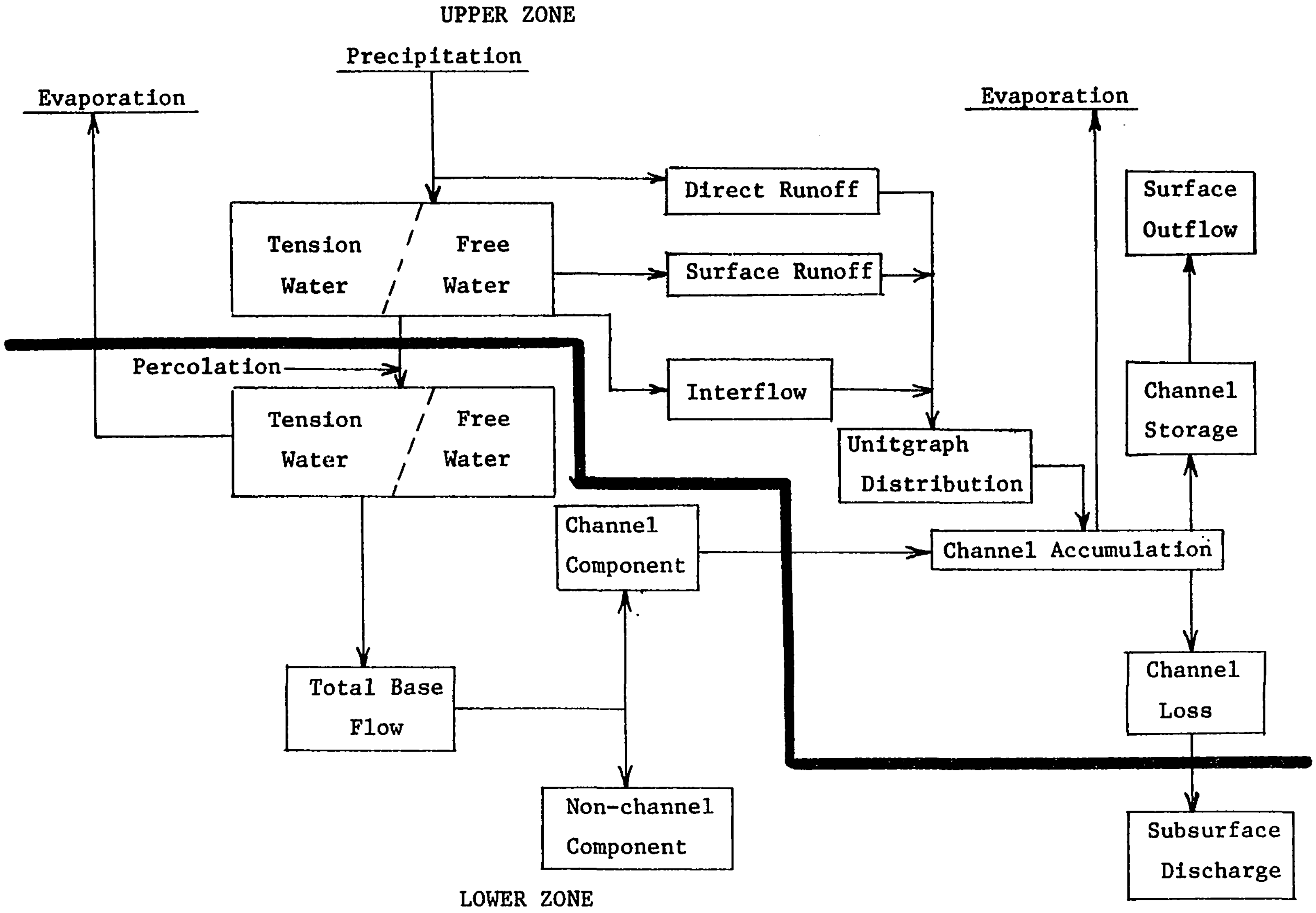


FIGURE 3-1

COMPONENTS OF A GENERALIZED HYDROLOGIC MODEL

From the "Sacremento Model" by J.C. Burnash (39)

The rate of vertical drainage, the percolation to deeper soils, is controlled by the contents of the Upper Zone Free Water and the deficiency of lower zone moisture volumes. The preferred path for moisture in Upper Zone Free Water is considered to be downward as percolation. Horizontal flow in the form of interflow occurs only when the rate of precipitation exceeds the rate at which downward motion can occur from the Upper Zone Free Water. When the precipitation rate exceeds the percolation rate and the maximum interflow drainage capacity, then the Upper Zone Free Water capacity is filled completely and the excess precipitation will result in surface runoff. Under this system, surface runoff is a highly rate-dependant volume with the rate of runoff being determined by the rate of precipitation application (intensity) and the degree of dryness of the different zones.

Lower Zone Tension Water capacity is that depth of water held by the lower zone soil after wetting and drainage which is generally available for evapotranspiration. The lower zone free water storage represents the volume which is available for drainage as baseflow or subsurface outflow not appearing in the channel.

So, in the Sacramento Model, the runoff characteristics of the watershed are considered to be essentially a function of the soil moisture condition and the rate of precipitation. The model expresses the basin as a set of storages of determinable capacities which hold water temporarily and which gradually recede as their contents are diminished by vertical percolation, evapotranspiration and/or lateral drainage.

The last model for estimating runoff volume is known as the Soil Conservation Service (SCS) "Runoff Curve Number Technique" (6). This model makes use of available soil and land use information which makes it possible to identify soils which have high runoff potentials. Since accurate soil and geological maps are now available for the state, areas which contain given soil types and land uses may be identified and the runoff potential calculated through the use of the Soil Conservation Service Curve Number Model (40). Figure 3-2 and Table 3-1 illustrate the use of this information for the six areas of the state where NPSP monitoring sites are located. The SCS runoff equation is:

$$Q = \frac{(P-Ia)^2}{(P-Ia) + S} \qquad (3.3)$$

Where: Q = accumulated volume of runoff inches depth over the drainage area.

P = accumulated rainfall in inches depth over the drainage area.

Ia = initial abstraction including surface storage, interception by vegetation, and infiltration prior to runoff in inches depth over the drainage area.

S = potential maximum retention of water by soil in equivalent inches depth over the drainage area.

Since the potential maximum water retention can range from zero on a smooth impervious service to infinity in a deep gravel, the "S-values" were converted to runoff curve numbers, CN's, for greater convenience by the following transformation:

$$CN = \frac{1000}{10 + S} \; ; \quad S = \frac{1000}{CN} - 10 \qquad (3.4)$$

This narrows the range of CN's between 100, when a smooth impervious surface is present, such as a road or highway when S would equal zero, to near zero as Ia approaches infinity for deep sandy soils.

One limitation of the SCS curve number technique is the procedure

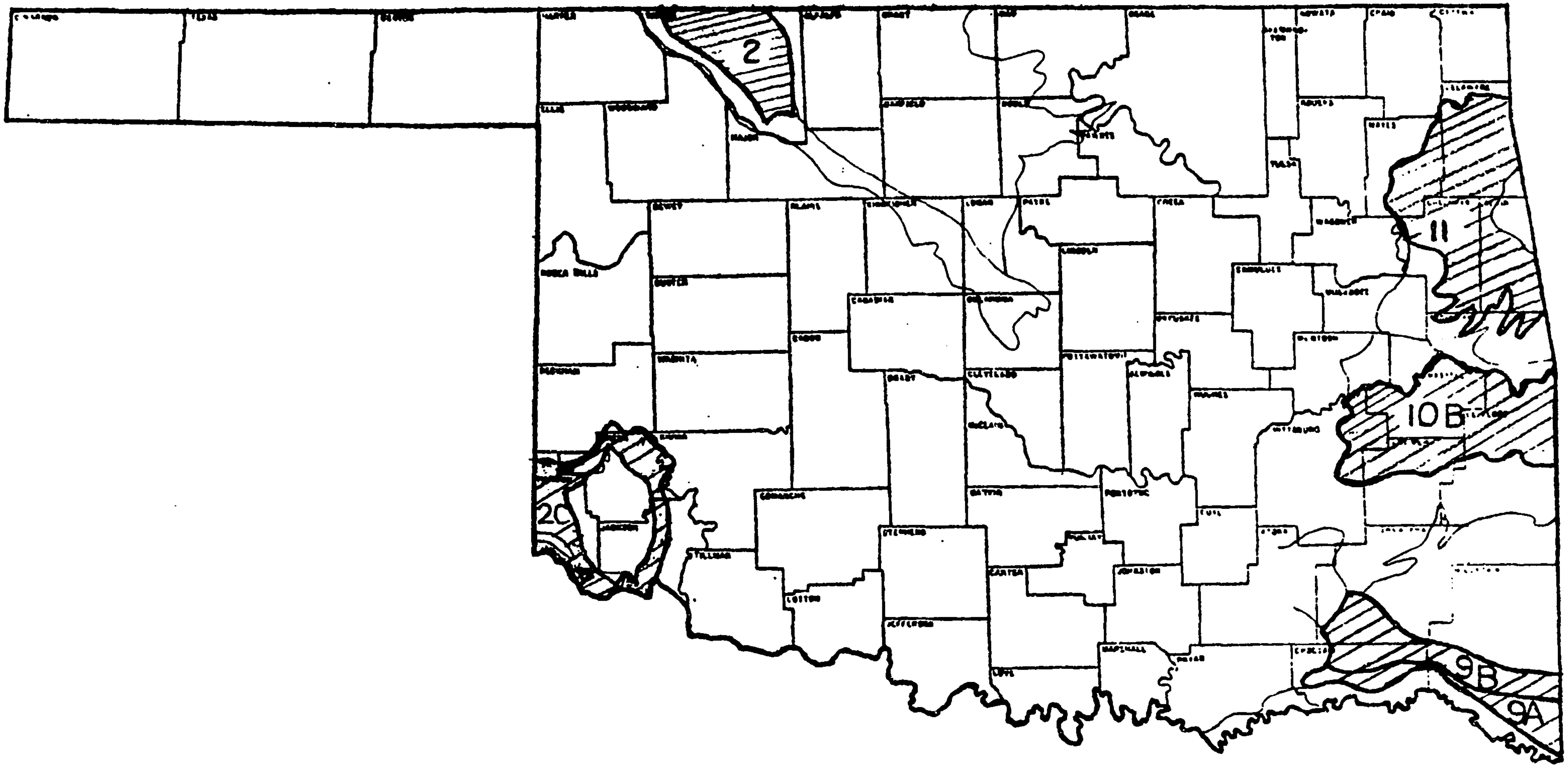


FIGURE 3-2

HYDROLOGICAL SOILS CLASSIFICATION FOR AREAS OF THE STATE WHERE MONITORING SITES ARE LOCATED (40)

TABLE 3-1
MAJOR SOIL COMPLEX AREAS FOR OKLAHOMA (40)

SOIL COMPLEX NUMBER	MEDIAN SLOPE	LAND USE[1]			CURVE NUMBER	SOILS INDEX "S"
		A	B	C		
2	5.5	35	65	0	73.2	3.66
2C	3.0	60	40	0	69.9	4.31
9A	5.0	10	60	30	77.5	2.90
9B	6.0	10	30	60	75.7	3.21
10B	2.0	10	60	30	80.1	2.48
11	10.0	10	25	65	63.7	5.70

[1] A, B and C identifies the Land Use as "A" percent cropland; "B" percent pasture, range and miscellaneous; and "C" percent forest

for antecedent moisture estimations. The antecedent moisture condition (AMC) is grouped into three broad classes wet, dry or average when in reality many intermediate values exist. The William's model utilizes the SCS curve number technique but accounts more accurately for the antecedent moisture condition. This model is therefore more desirable for detailed runoff estimation on the watershed level (36).

Techniques for the Estimation of Soil Erosion

Most nonpoint source models estimate pollutant loads by relating pollutants to sediment. The problem is thus reduced to calculating erosion and sedimentation. The Universal Soil Loss Equation (USLE) is an entrenched analytical tool used for the purpose of soil conservation planning. Because of its wide-spread use and successful testing over the years, many NPSP loading models have been built around it. Both desk-top analyses like the MRI loading functions and computer simulation models like STORM, AGRUN, and ACTMO, make use of the equation in one way or another (these models are described in the next section). Future development of NPSP loading models will likely continue inclusion of USLE variations. For these reasons, a discussion of the basic equation, its limitations, extensions, and associated data bases are included. The descriptions are somewhat abbreviated to avoid needless repetition of excellent references on the subject (6, 11, 41, 42).
The equation is:

$$A = RKLSCP \qquad (3.5)$$

Where: A = average annual soil loss in tons/acre

R = rainfall and runoff erosivity index

K = soil erodability factor

LS = dimensionless topographic factor representing the combined effects of slope length and steepness

C = the cover and management factor

P = factor for supporting practices

Note that Equation (3.5) includes factors for precipitation (and to a lesser extent, runoff), soil type, topography, vegetative cover, and structural controls. Although the form of Equation (3.5) is often argued most of the erosion processes are included. The influence of runoff on erosion is only partially implicit in R because of the way in which the data were correlated. That is, R is calculated directly from rainfall but field data against which R was correlated included the lumped effects of rainfall and runoff. A major weakness still prevails if the size of the area expands beyond a field of a few acres. The influence of runoff in channels on erosion and deposition is not included. When the equation is used for calculating annual average loads at a given location R, K, and LS are fixed, areal properties and yearly variations in sediment loads result solely from changes in management or structural controls.

Perhaps the most attractive feature of the USLE, in addition to its ease of use, is the data base available to aid the user in estimating the equation factors. The U.S. Department of Agriculture's Soil Conservation Service uses the equation on a nation -wide basis and considerable effort has been devoted to determination of factors for a wide array of geographical locations, soil types, cropping systems, topographical configurations, and tillage operations. Detailed guidance on selection of the most appropriate numerical values for each factor is included in several of the references given in the list of references for this paper (for example: (6, 41,43)).

The data base for the USLE has been reduced to a series of maps, nomographs, and tables. These data are reproduced for easy reference. A more detailed description of each factor is given below to aid in parameter selection.

R - The rainfall factor is included in Equation (3.5) to represent the influence of precipitation on erosion. R is numerically defined as the number of EI units (erosivity index) for the specified time period. EI is calculated as the product of two rainstorm parameters: kinetic energy of the storm in hundreds of foot-tons per acre times its maximum 30 minute intensity in inches per hours. Data from weather stations having 22 years or longer of recording raingage records were analyzed to determine the long-term, annual average R values for various locations (42). Results for Oklahoma are shown in Figure 3-3. The R value can be estimated by analysis of local rainfall data. For local data, the kinetic energy can be estimated by the following equation (42):

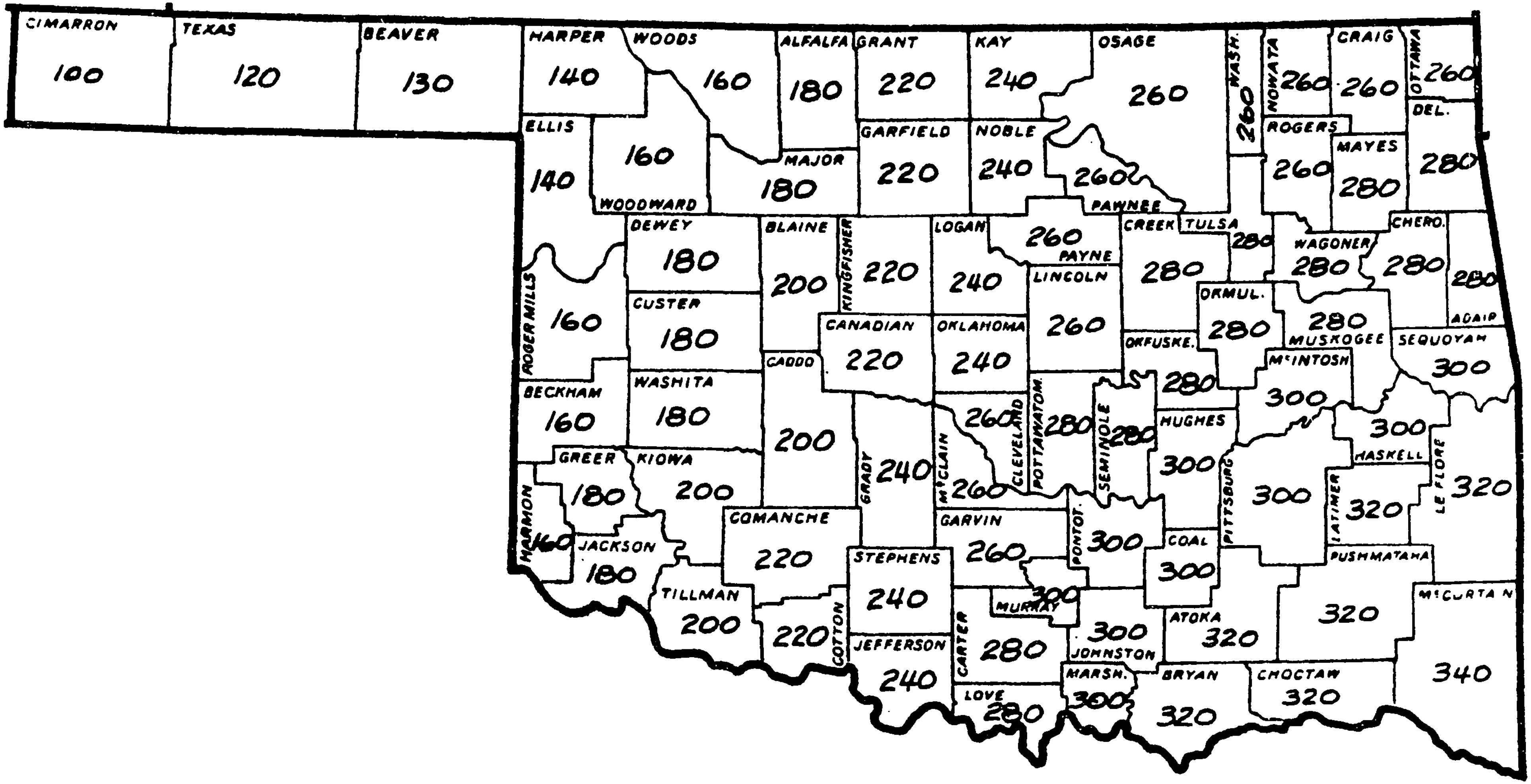


FIGURE 3-3
RAINFALL EROSION INDEX MAP "R" (42)

$$E = 916 + 331 \log X \qquad (3.6)$$

Where: E = kinetic energy, foot-tons/acre

X = rainfall intensity, inches/hour

The product EI is then determined by multiplication of E by the maximum 30 minute rainfall intensity observed for each storm from which X was abstracted.

K - The soil erodability factor reflects soil properties and is a measure of the susceptibility to erosion. Numerical estimates for certain soils were determined by measurements of soil loss per unit of R for a standard set of conditions established on small plots. A generalized procedure for factor estimation was then developed as a function of standard, measurable soil properties. Results are included in Table 3-2 and the nomograph of Figure 3-4. State and local offices of the Soil Conservation Service also have K values tabulated for specific soils.

LS - The steepness and length of slope for a given area impact on erosion rates. The LS factor represents the combined effect of these two variables and numerical estimates have been determined by analysis of experimental data (41). Results are shown by the solid lines in Figure 3-5. Two important features of these data should be noted. First, the data were taken from studies involving slopes with a specific range of steepness and length.

Second, the factors apply to uniform slopes only. Although procedures to correct for the effects of nonuniform slopes have been developed (42), the impact of slope concavity or convexity is not reflected here. The dashed lines of Figure 3-5 represent the extrapolation of the relationship beyond the data base. Validity of this extension is currently unknown.

C - Crop cover and management factors act to mitigate erosion rates. While annual average C value is often used in the USLE, estimated values reflecting crop growth stages can also be used. Values range from 0.001 for undisturbed forests to 1.0 for tilled continuous fallow (open, continuously plowed areas). Tables 3-3 and 3-4 summarize appropriate C values for agricultural and silvicultural systems. In cases where the USLE is applied to other land use activities, the C value is approximated by a comparison of

TABLE 3-2

INDICATIONS OF THE GENERAL MAGNITUDE OF THE SOIL-ERODIBILITY FACTOR, K (42)

	Soil Erodibility Factor, K		
	Organic Matter Content		
Texture Class	0.05%	2%	4%
Sand	0.05	0.03	0.02
Fine sand	0.16	0.14	0.10
Very fine sand	0.42	0.36	0.28
Loamy sand	0.12	0.10	0.08
Loamy fine sand	0.24	0.20	0.16
Loamy very fine sand	0.44	0.38	0.30
Sandy loam	0.27	0.24	0.19
Fine sandy loam	0.35	0.30	0.24
Very fine sandy loam	0.47	0.41	0.33
Loam	0.38	0.34	0.29
Silt loam	0.48	0.42	0.33
Silt	0.60	0.52	0.42
Sandy clay loam	0.27	0.25	0.21
Clay loam	0.28	0.25	0.21
Silty clay loam	0.37	0.32	0.26
Sandy clay	0.14	0.13	0.12
Silty clay	0.25	0.23	0.19
Clay		0.13-0.29	

The values shown are estimated averages of broad ranges of specific-soil values. When a texture is near the borderline of two texture classes, the average of the two K values is used. For specific soils, Soil Conservation Service K-value tables will provide much greater accuracy.

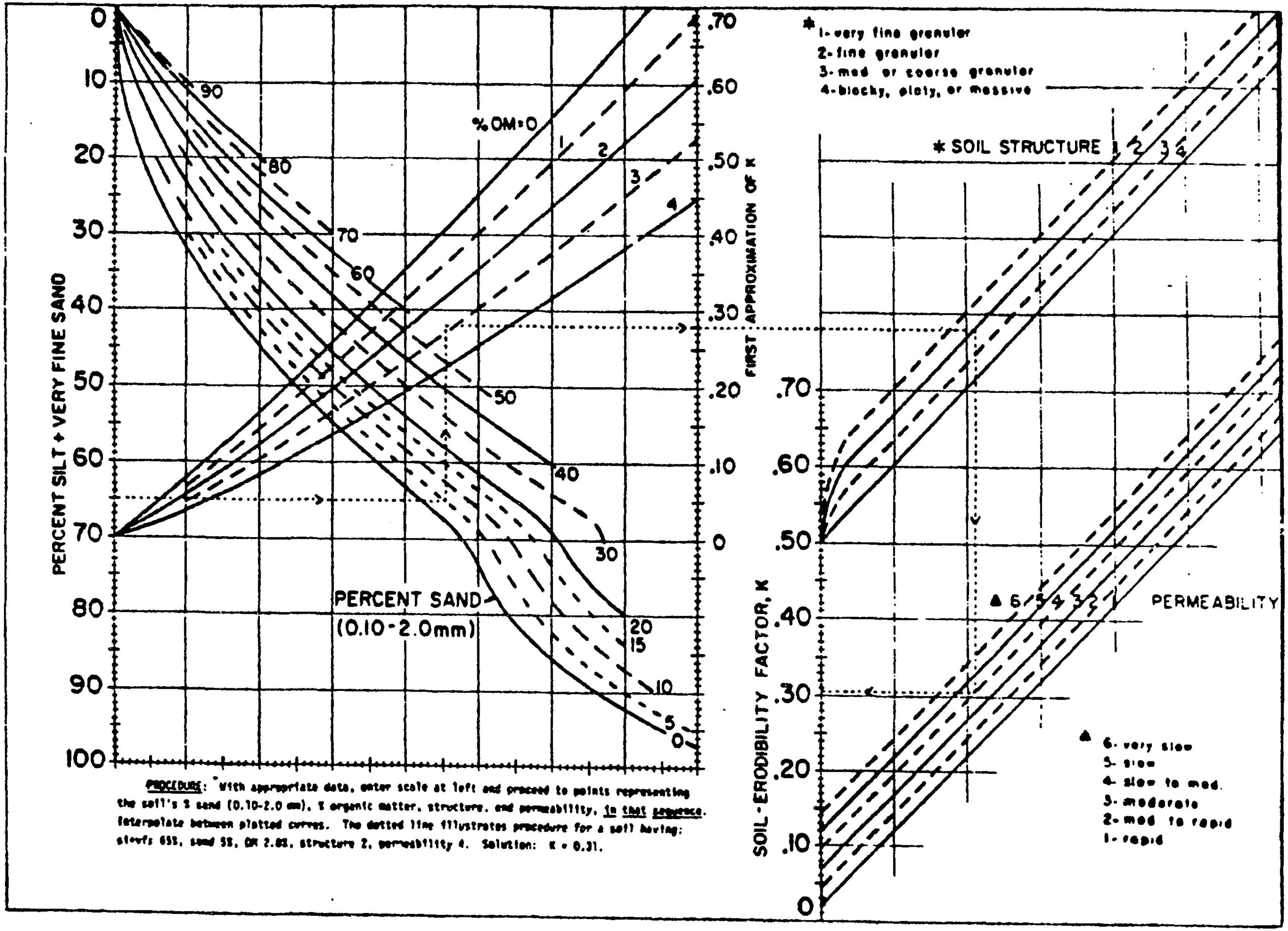
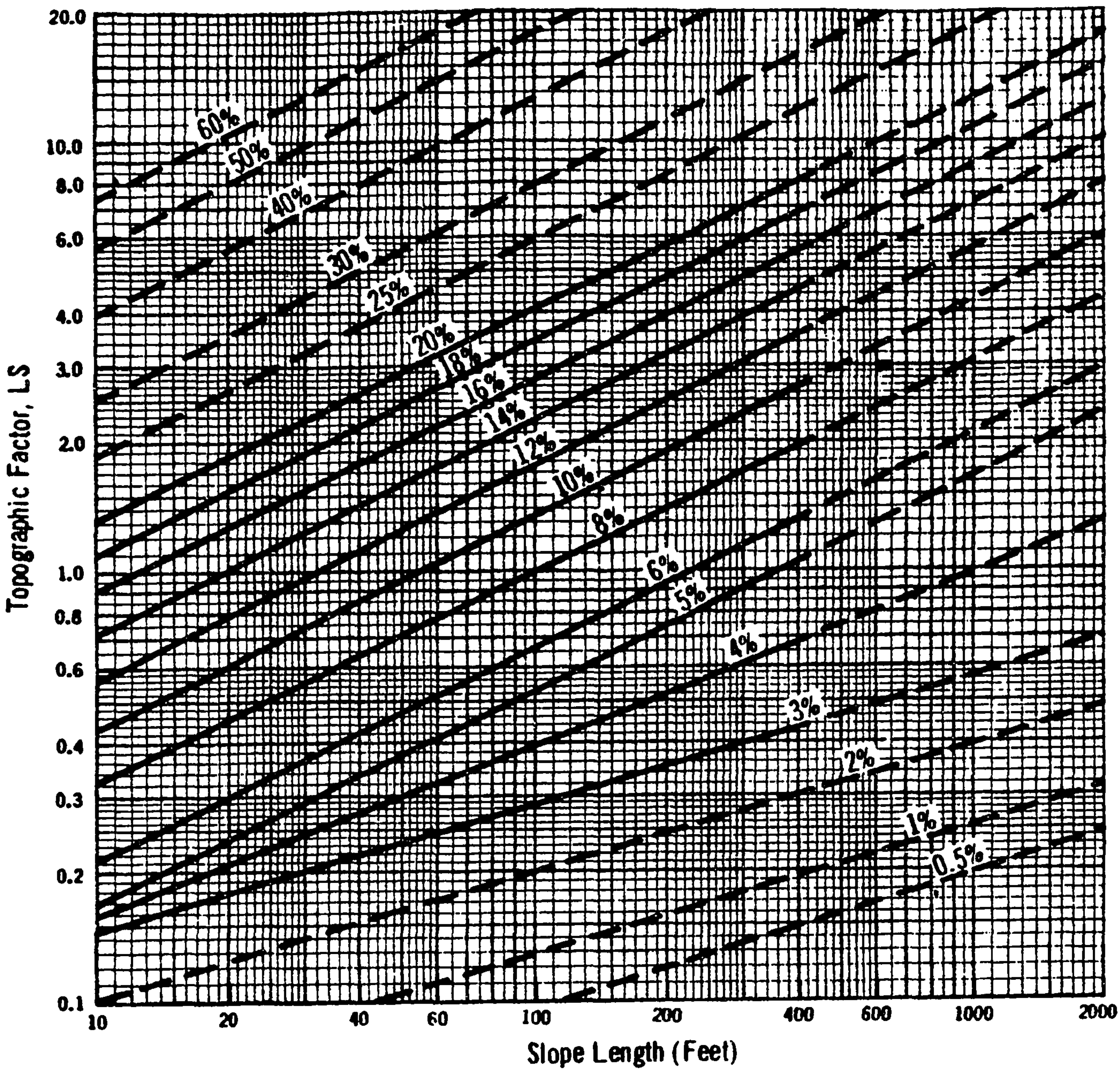


FIGURE 3-4

SOIL ERODIBILITY FACTOR (K) NOMOGRAPH FOR U.S.MAINLAND SOILS (42)



*The dashed lines represent estimates for slope dimensions beyond the range of lengths and steepnesses for which data are available. The curves were derived by the formula:

$$LS = \left(\frac{\lambda}{72.6}\right)^m \left(\frac{430x^2 + 30x + 0.43}{6.57415}\right)$$

where λ = field slope length in feet and m=0.5 if s = 5% or greater, 0.4 if s = 4%, and 0.3 if s = 3% or less; and x = sin θ. θ is the angle of slope in degrees.

FIGURE 3-5
SLOPE EFFECT CHART
(Topographic Factor, LS)

TABLE 3-3

C FACTORS FOR PASTURE, RANGELAND, AND IDLE LAND[1] (42)

Type and Height of Canopy[2]	Percent Cover[3]	Type[4]	Percent Ground Cover 0	40	80	95-100
No appreciable canopy		G	0.45	0.10	0.013	0.003
		W	0.45	0.15	0.043	0.011
Canopy of tall weeds or short brush (0.5 m fall height)	25	G	0.36	0.09	0.012	0.003
		W	0.36	0.13	0.041	0.011
	50	G	0.26	0.07	0.012	0.003
		W	0.26	0.11	0.039	0.011
	75	G	0.17	0.06	0.011	0.003
		W	0.17	0.09	0.038	0.011
Appreciable Brush or bushes (2 m fall height)	25	G	0.40	0.09	0.013	0.003
		W	0.04	0.14	0.042	0.011
	50	G	0.34	0.085	0.012	0.003
		W	0.34	0.13	0.041	0.011
	75	G	0.28	0.08	0.012	0.003
		W	0.28	0.12	0.040	0.011
Trees but appreciable low brush (4 m fall height)	25	G	0.42	0.10	0.013	0.003
		W	0.42	0.14	0.042	0.011
	50	G	0.39	0.09	0.013	0.003
		W	0.39	0.14	0.042	0.011
	75	G	0.36	0.09	0.012	0.003
		W	0.36	0.13	0.041	0.011

[1] All values shown assume: 1) random distribution of mulch or vegetation, 20 mulch of appreciable depth where it exists.

[2] Average fall height of waterdrops from canopy to soil surface, m = meters.

[3] Portion of total area surface that would be hidden from view by canopy in a vertical projection (a bird's-eye view).

[4] G = Cover at surface is grass, grass-like plants, decaying compacted duff, or litter at least 5 cm (2 in.) deep.
W = Cover at surface is mostly broadleaf herbaceous plants (as weeds) with little lateral root network near the surface and/or undecayed residue.

TABLE 3-4

C FACTORS FOR WOODLAND (42)

Stand Condition	Tree Canopy[1] Percent of Area	Forest Litter[2] Percent of Area	Undergrowth[3]	C Factor
Well stocked	100-75	100-90	Managed[4]	0.001
			Unmanaged[4]	0.003-0.011
Medium stocked	70-40	85-75	Managed	0.002-0.004
			Unmanaged	0.01-0.04
Poorly stocked	35-20	70-40	Managed	0.003-0.009
			Unmanaged[5]	0.02-0.09

[1]When tree canopy is less than 20%, the area will be considered as grassland or cropland for estimating soil loss.

[2]Forest litter is assumed to be at least 2 inches deep over the percent ground surface area covered.

[3]Undergrowth is defined as shrubs, weeds, grasses, vines, etc., on the surface area not protected by forest litter. Usually found under canopy openings.

[4]Managed = grazing and fires are controlled.
Unmanaged = stands that are overgrazed or subjected to repeated burning.

[5]For unmanaged woodland with litter cover of less than 75%, C values should be derived by taking 0.7 of the appropriate values in Table 4-19 The factor of 0.7 adjusts for the much higher soil organic matter on permanent woodland.

the cover conditions to similar cover conditions for agricultural situations. For example, construction activities result in bare, exposed, and disturbed soil surfaces and a C value of 1.0 should be used.

P - Certain other structural or management options related to the landscape serve to mitigate erosion. Such practices are collectively known as supporting practices and include contouring, terracing, strip cropping, etc. The impact of these practices on erosion are estimated through P, with values ranging from 0.25 to 1.0. Table 3-5 summarizes the various P values appropriate for each supporting practice.

Statistical analyses of the USLE's predictive capability were performed in 1965, and a paper by the equation's developer summarized the results along with important words of caution for users (43).

The accuracy of the equation was determined by comparing its average annual prediction with measured data from 189 field plots scattered across the country. The overall measured mean soil loss was 11.3 tons per acre. The average prediction error was 1.4 tons with 84% of the predictions within 2 tons of the measured losses. Further analyses also showed that larger errors were associated with measured data collected over shorter periods than the 22-year cycle chosen for the R data base.

Considerable error can result if the equation factors are estimated incorrectly for large areas where watershed sediment yield is the objective. The author states : "Applying the equation to a complex watershed by using overall averages of slope length and gradient with estimated watershed average value for factors K and C would be incorrect. To use the equation correctly, the combination of selected factor values must reflect the manner in which the parameters are associated in each sub-area...Perhaps the greatest potential source of prediction error is superficiality in selecting factor values...If the selected values do not truly represent the conditions to be evaluated, neither will the computed soil loss."

Gross erosion as predicted by the USLE suffers the same limitation as pollutant loss data collected at the outlet of plots or small fields - the load to the stream is significantly less than these values because other components of the hydrologic system act to attenuate their magnitude. For sediment, this attenuation is a function of many variables including soil characteristics, watershed area, slopes, slope length, relief/length

TABLE 3-5

P VALUES FOR EROSION CONTROL PRACTICES ON CROPLANDS (42)

Range of Slope	Erosion Control Practice				
	Up and Down Hill	Cross-Slope Farming Without Strips	Contour Farming	Cross-Slope Farming With Strips	Contour Strip-Cropping
2.0-7	1.0	0.75	0.50	0.37	0.25
7.1-12	1.0	0.80	0.60	0.45	0.30
12.1-18	1.0	0.90	0.80	0.60	0.40
18.1-24	1.0	0.95	0.90	0.67	0.45

ratio, and drainage density. Erosion from gullies or the stream channel itself is a contributor to downstream sediment load but is not included in the USLE predictions.

Correction for the efficiency of a watershed system to yield eroded sediments to a point downstream is made by application of a sediment delivery ratio (SDR). The SDR is defined as the ratio of sediment delivered at a location in the stream system to the gross erosion from the drainage area above that point.

Ideally, one could structure a model using sediment transport theory and route both water and sediment through the system. Failing that, most investigators have chosen to develop empirical relationships (based on data) for sediment delivery including one or more of the variables listed above. The results of a recent development for use with NPSP loading functions are given in Figure 3-6. Drainage density in Figure 3-6 is defined as the ratio of total channel segment lengths to the basin area. Note also the different relationship for each soil particle size class. This distinction is made to accommodate the greater ease with which finer materials are transported.

Application of the SDR to the USLE enables the analyst to estimate loads to a specific point in the stream. A sediment yield equation is thus given by:

$$Y(S)_E = A(RKLSCP)S_d \qquad (3.9)$$

Where: $Y(S)_E$ = sediment loading to stream, tons/yr.

A = area,ac

RKLSCP = factors of USLE

S_d = sediment delivery ratio

If data are available for the area of interest, S_d should be validated, if possible, by analysis of the data. Usually, reservoir sedimentation rates are the most commonly available data sources.

The USLE does not estimate erosion from gullies, stream banks, or head cuts. Delivery ratios based on locally measured data may include the lumped effects of these sources as well as the sources estimated by the

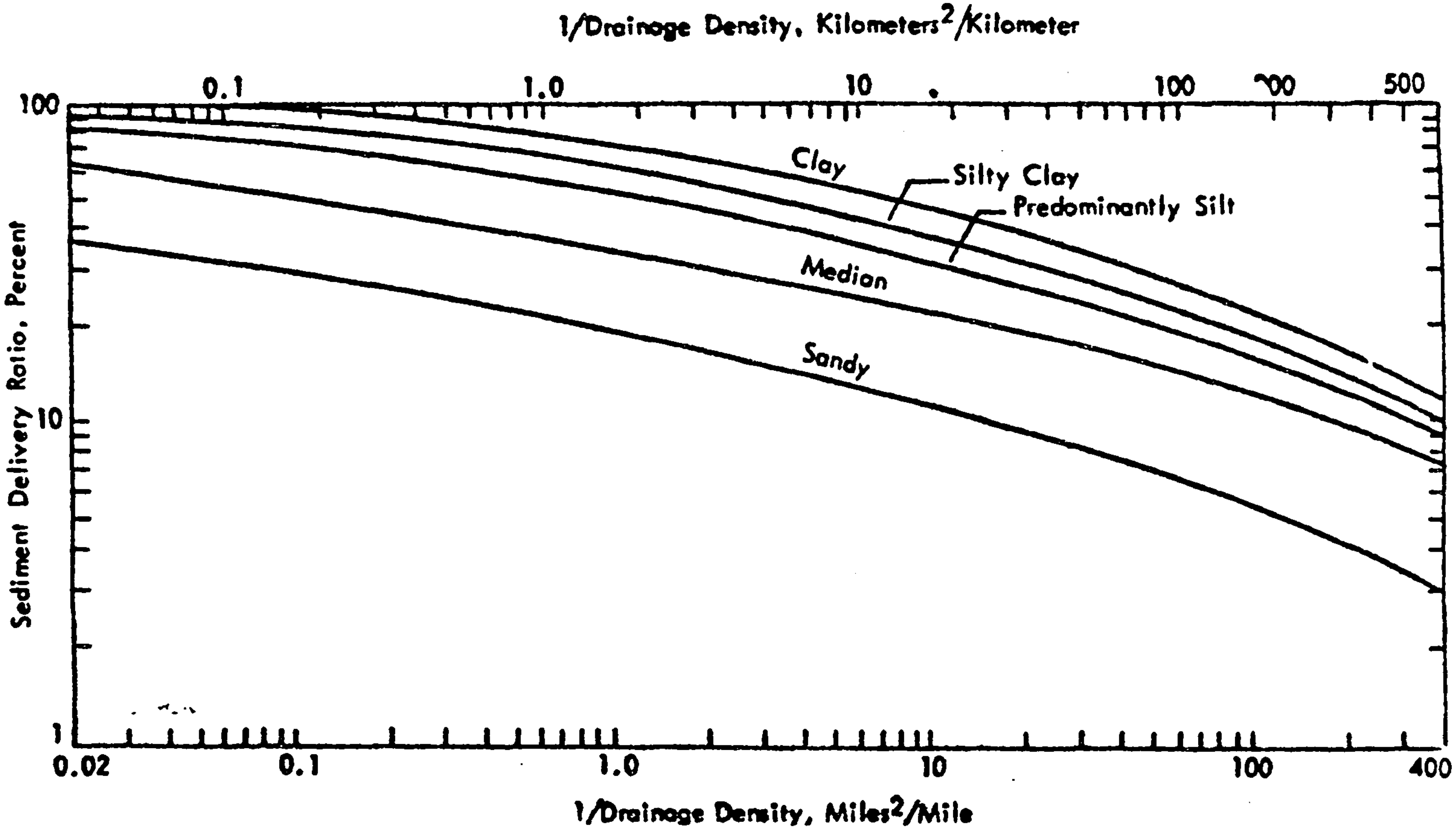


FIGURE 3-6

SEDIMENT DELIVERY RATIO FOR RELATIVELY HOMOGENEOUS BASINS (44)

USLE. The most appropriate value is given by:

$$S_d = \frac{SY}{SH + GU + CH} \qquad (3.10)$$

Where: SY = sediment yield at point of interest

SH = USLE related erosion

GU = gully erosion

CH = channel erosion

Note that if S_d is determined from measured data that accounts for only SH in the denominator of Equation 3.10, the resulting ratio will be too high when applied to new values of SH for prediction of SY.

Sediment-Based Transport

Sediment-based transport models assume pollutant loads are proportional to sediment loads. Loads are calculated by predicting sediment loss and applying the proportionality relationships for each pollutant. Because sediment is transported by direct surface runoff, sediment-based models are more useful in predicting pollutants associated with soil surface conditions. Dissolved constituents are not necessarily ignored, however. Sediment transport is also proportional to runoff volumes and if the relative distribution between water and sediment does not change, total pollutant losses can be estimated. That is, if the relationship between pollutants and sediment is determined by measurements taken for the total runoff (water and sediment) it may be possible to estimate total loads by only predicting sediment losses.

Two problems arise from the sediment-transport assumption. First, much larger quantities of water than sediment appear in the drainage from watersheds. If dissolved constituents are ignored, significant NPSP loads will also be ignored. The fact that subsurface flow accounts for a higher percentage of the total runoff as the watershed size increases further highlights this problem. Nitrate loading estimates are not included in sediment-based models. The second problem arises from the interaction of pollutants and sediment particles. Sorption is a function of surface area which in turn is determined by the particle size. Relationships of surface area to textural classes have been developed by Frere, et.al. (8). Using a three-level distribution, the specific surface area can be calculated by:

$$SS = 200\ (\%Cl) + 40\ (\%Si) + 0.5\ (\%Sa) \qquad (3.11)$$

Where: SS = specific surface

Cl = clay

Si = silt

Sa = sand

Equation 3.11 shows that the clay content of soil largely determines the surface area available for interaction with pollutants.

The impact of Equation 3.11 on sediment based loading models results from the mechanics of the erosion process. Analysis of eroded and *in situ* soil samples for a given area show that erosion is a selective process resulting in a greater percentage of finer material (clays, silts) in the eroded soil than in the original material. The net result is a different relationship between pollutants and sediment in runoff than in the soil profile. Most erosion models predict only gross soil movement; that is, no distinction is made among soil particle size. To accomodate this problem, an "enrichment ratio" is often applied to predicted loads to increase the concentration of pollutants in or on eroded soil.

Sediment-based transport models can also estimate loadings for pollutants that behave like inorganic sediment during transport. Organic matter (plant residues, animal wastes, etc.) and crystalline or precipitated chemicals may not be sorbed to soil particles but may be part of the total suspended solids measured in runoff water. If such materials have specific gravities less than inorganic sediments, their presence will increase the measured enrichment ratio because of preferential movement by runoff water.

Partitioned-Based Transport

Land use activities combined with environmental conditions within a watershed determine the type, form and distribution of pollutants. A whole series of complex processes combine to determine for any given pollutant the relative distribution between dissolved and particulate forms. In some cases the distribution is a simple one-way shift from particulate to dissolved as a result of decay or leaching. Usually, however, equilibrium is reached with shifts dependent on pollutant concentration and environmental conditions.

If partitioning processes are included in loading models, the dissolved and particulate loads can be calculated. For example, ammonium (NH_4^+) is transported in both runoff water and adsorbed on sediment. If partitioning constants for NH_4^+ are known for a given soil, loads in water and sediment can be estimated.

Classification of NPSP Models

Nonpoint source models should be evaluated in the same manner that measured runoff data are analyzed. Namely, how do model properties and capabilities compare with the behavior of the watershed system. A complete analysis of each available model along with sample runs, etc., is beyond the scope of this study but it is possible to classify the key models or techniques to the fundamental properties (spatial, temporal, and transport) of importance. Table 3-6 shows the classification of selected NPSP loading models.

NPS: The Nonpoint Source Pollutant Loading Model (NPS) was developed by Hydrocomp, Inc. for EPA. The model was specifically designed for use in planning studies and is compatible with existing water quality impact models. The model is comprised of subprograms to represent the hydrologic processes in a watershed, including snow accumulation and melt, and the processes of pollutant accumulation, generation, and washoff from the land surface. The hydrologic components, derived from the Stanford Watershed Model, have been previously tested and verified on numerous watersheds across the country. The sediment and pollutant transport components have been tested on several urban and rural watersheds for selected pollutants and are currently undergoing additional testing. The simulation of pollutants is based on sediment as an indicator. Erosion processes are simulated and the resulting loads are converted to pollutant loads by user-specified "potency factors" that indicate the pollutant strength of the sediment for each pollutant simulated.

TABLE 3-6

SELECTED CHARACTERISTICS OF NONURBAN NONPOINT SOURCE MODELS

Characteristic	Model				
	NPS	AGRUN	ACTMO	ARM	MRI
Spatial Resolution					
Field scale	X		X	X	X
First-order watershed	X	X	X	X	X
Basin		X			X
Temporal Resolution					
Runoff event	X	X	X	X	
Annual average	X		X	X	X
Continuous	X		X	X	
Transport Assumption					
Sediment	X	X			X
Partitioned			X	X	

The NPS model can simulate loads from a maximum of five different land uses in a single production run. In addition to runoff, water temperature, dissolved oxygen, and sediment, the NPS model can simulate up to five user-specified pollutants from each land use category.

Documentation of the model, complete with a user manual and program listing, is available from EPA in a report entitled "Modeling Nonpoint Pollution from the Land Surface," (45).

ACTMO: The Agricultural Chemical and Transport Model (ACTMO) was developed by the Agricultural Research Service, U.S. Department of Agriculture. The model consists of three components simulating hydrology, erosion and sedimentation, and interactions of agricultural chemicals (fertilizers and pesticides) with the soil-water-plant system. The USDAHL-74 model was used for the hydrologic component and the universal soil loss equation was modified to generate erosion/sedimentation (46). ACTMO is one of two models (ARM is the other) that simulates the partitioning of pollutants between water and sediment. The hydrologic model has been tested on several watersheds, the sediment model has been tested in two locations and the chemical transport model is essentially untested.

Documentation of the model is available from ARS-USDA in a report entitled, "ACTMO - An Agricultural Chemical Transport Model," (47).

MRI: The Midwest Research Institute (MRI) developed for EPA a series of loading functions for assessment of water pollution from nonpoint sources. These loading functions assume the form of algebraic equations that can be solved analytically without the aid of computers. Functions for essentially all nonpoint sources and pollutants are included. For most cases, modifications of the USLE are used. Daily loads are calculated from annual average estimates. In addition, a methodology is proposed for estimating the maximum and minimum thirty-day loads.

Documentation of each loading function complete with supporting data and references is included in the EPA report entitled "Loading Functions for Assessment of Water Pollution from Nonpoint Sources," (48).

ARM: The Agricultural Runoff Management (ARM) Model simulates runoff (including snow accumulation and melt), sediment, pesticides, and nutrient contributions to stream channels from both surface and subsurface sources. No channel routing procedures are included. Thus, the model is applicable to watersheds that are small enough for channel processes and transformations to be assumed negligible. Although the limiting area will vary with climatic and topographic characteristics, watersheds greater than one to two square miles are approaching the upper limit of applicability of the ARM Model. Channel processes will significantly affect the water quality in larger watersheds.

The major components of the model individually simulate the hydrologic response of the watershed, sediment production, pesticide adsorption/desorption, pesticide degradation, and nutrient transformations. The executive routing controls the overall execution of the program; calling subroutines at proper intervals, transferring information between routines, and performing the necessary input and output functions. Additional information on this model may be obtained from, "Modeling Pesticides and Nutrients on Agricultural Lands," (49). and from "Agricultural Runoff Management (ARM) Model - Version II - Refinement and Testing." (50).

AGRUN: (Water Resources Engineers). AGRUN is a revised version of the RUNOFF block of the Stormwater Management Model (SWMM) which can be used to estimate runoff quantity and quality from agricultural lands. It is included in this list as an example of a model that is useful in rural or semi-rural portions of the 208 area. AGRUN has not been extensively tested, and potential users should be cautioned accordingly. This model, though relatively untested, should prove useful for detailed examination of rural or semi-rural runoff. It may be linked to the SWMM to evaluate such things as storage-treatment options or impacts on receiving water quality. The computer program is written in Fortran IV. The program and associated documentation are available from EPA (51).

Nonpoint Source Pollutant Loading Input Variables

In both the sediment and partition-based transport models discussed in the preceding section, it is necessary to obtain a pollutant loading factor as an input variable. Much work has been accomplished in this area. However, loading values determined for a particular land use in one area are not always applicable to conditions in another. Therefore, it was necessary to establish a nonpoint pollution monitoring program in Oklahoma in order to obtain data reflective of conditions in this area. The details of this monitoring program and a comparison between the values obtained and the values presented in the following tables will be given in the next chapter.

Tables 3-7 through 3-9 represents a comprehensive search of the literature for published results from monitoring programs conducted to study nonpoint pollution and its effects on water quality. Table 3-7 presents the types of loading rates (in pounds per acre per year) which have been measured from a variety of land uses and from a wide range of studies conducted to measure these loading rates. Table 3-8 provides data regarding loading (in lbs./acre/yr.) of nitrogen and phosphorus from geologic formations underlying silvicultural and agricultural land uses. Table 3-9 illustrates the contribution (in pounds per acre) of various pesticides from a variety of application techniques and cropping patterns. Finally, Table 3-10 shows the loading rates (in lbs./acre/yr.) of total nitrogen and total phosphorus from various mixes of different land uses. This information comes from data collected from June, 1972 to December, 1975 in the EPA "National Eutrophication Survey" (75). This survey was conducted nationwide on 928 nonpoint source watersheds (watersheds devoid of all point sources) to study the relationships between land use and nutrient levels in streams. Only total and inorganic forms of phosphorus and nitrogen concentrations and loads were considered. Good correlations were reported between general land use and nutrient concentrations in streams (75).

The loading rates from the above tables are necessary as input variables primarily for the partitioned-based NPSP models. However, the various sediment-based transport models require "Potency Factors" for different pollutants expressed in terms of a percentage of the sediment load to the stream.

Ongoing Research and Data Collection

Tables 3-7 through 3-9 are representative of published work to date. However, it should be noted that here in Oklahoma, there are four ongoing programs which will make significant contributions to these tables, and will hopefully fill in some of the gaps in the data, and narrow the wide range of some of the values. One of these programs is the NPSP monitoring program being conducted by the Oklahoma Conservation Commission. This program is

TABLE 3-7

RESULTS OF MONITORING PROGRAMS CONDUCTED TO STUDY EFFECTS OF NPSP ON WATER QUALITY

LOADING SOURCE	POLLUTANT BY PARAMETER AND LOADING RATE (LB/AC/YR)								
	TOTAL-N	NO_2+NO_3	NH_4	TOTAL PO_4	O-PO_4	BOD	COD	TSS	SS
Cropland	0.3-98 (7)[1] 13.06-80.51 (57) 0.1-13 (58) 6.31-9.82 (55)	0.35-2.19 (53)	0.12-0.88 (53)	0.05-6.9 (7) 13.6-60.93 (57) 0.06-2.9 (58) 0.31 (55)	0.04-0.44 (54) 2.94-10.5 (57) 0.09-0.13 (55)		12-43 (54)		4-255 (54)
Pastureland	2.22-7.6 (7)	0.4 (52) 0.36 (54)	1.0 (52)	0.23-0.57 (7)	0.43 (52)	5.36-15.4 (7)		11-753 (7)	11 (54)
Rangeland	13.06-55.49 (57)	0.7 (58)		6.91-25.02 (57) 0.08 (58)	1.47 (57)				
Woodland	4.5 (13) 0.74-9.13 (7) 3-13 (58)	0.7-8.8 (8)		0.01-0.8 (7) 0.03-0.9 (58) 0.08-0.17 (55)	0.04-0.07 (9)	3.59-6.27 (7)		41-354 (7)	
Urban	7.89 (55) 8.9 (56) 6.0 (33) 7-9 (58)			0.30 (55) 2.5 (56) 5 (31) 1.1-5.6 (58)	0.15 (55)	33 (56) 30-50 (58)	220-310 (58) 240 (56) 938 (7)	6700 (31)	730 (56)
Precipitation	4.4-8.9 (48) 5.6-10 (58)	1.5-4.1 (58)		0.045-0.055 (48) 0.05-0.06 (58)			124 (58)		

[1] Numbers in parentheses denote the referenced source of information

TABLE 3-8
CONTRIBUTION OF NPSP FROM GEOLOGIC SOURCES

Land use	Geologic classification and grouping code(s)	Number of subdrainage areas	Concentrations, mg/l T-P	Concentrations, mg/l O-P	Concentrations, mg/l T-N	Concentrations, mg/l I-N	Export, kg/km^2/yr T-P	Export, kg/km^2/yr O-P	Export, kg/km^2/yr T-N	Export, kg/km^2/yr I-N
Forest		53								
	Sedimentary; some or all limestone	19	0.011	0.006	0.860	0.287	6.4	3.6	498.7	159.6
	Sedimentary; without limestone	11	0.014	0.007	0.766	0.337	9.0	4.5	467.6	192.2
	Sedimentary; all	30	0.012	0.006	0.825	0.306	7.4	3.9	487.3	171.5
	Predominantly sedimentary	31	0.012	0.006	0.818	0.302	7.3	3.9	482.3	169.1
	Igneous; volcanic origin	0	-	-	-	-	-	-	-	-
	Metamorphic	16	0.017	0.007	0.520	0.103	10.3	4.6	337.4	65.2
	Igneous; plutonic origin	0	-	-	-	-	-	-	-	-
	Igneous and metamorphic	18	0.017	0.007	0.533	0.119	10.3	4.6	342.1	74.6
	Predominantly igneous and metamorphic	22	0.016	0.007	0.625	0.135	9.7	4.3	380.7	80.7
Mostly Forest		170								
	Sedimentary; some or all limestone	55	0.037	0.015	1.056	0.488	16.3	6.3	472.1	233.2
	Sedimentary; without limestone	48	0.035	0.014	0.817	0.288	18.0	6.9	441.8	161.2
	Sedimentary; all	103	0.036	0.014	0.945	0.395	17.1	6.6	458.0	194.3
	Predominantly sedimentary	118	0.036	0.014	0.930	0.374	17.1	6.5	456.5	186.7
	Igneous; volcanic origin	0	-	-	-	-	-	-	-	-
	Igneous; volcanic origin (Present but not dominant)	4	0.038	0.018	0.975	0.328	13.1	6.2	332.2	115.5
	Metamorphic	32	0.035	0.014	0.762	0.277	20.7	8.2	452.0	166.0
	Igneous; plutonic origin	1	0.026	0.010	0.951	0.138	7.4	2.8	269.5	39.1
	Predominantly igneous; plutonic origin	6	0.032	0.013	1.049	0.317	13.6	9.1	476.2	134.6
	Igneous and metamorphic	40	0.036	0.014	0.798	0.269	19.2	8.2	427.7	149.8
	Predominantly igneous and metamorphic	52	0.035	0.014	0.827	0.284	18.2	8.1	433.1	152.3
Agriculture		91								
	Sedimentary; some or all limestone	80	0.136	0.059	4.315	3.296	30.5	12.4	996.8	748.3
	Sedimentary; without limestone	11	0.123	0.055	3.497	2.335	23.6	10.3	865.4	660.1
	Sedimentary; all	91	0.135	0.058	4.225	3.190	29.7	12.2	982.3	738.6

Abbreviations: T-P = Total Phosphorus; O-P = Orthophosphorus; T-N = Total Nitrogen; I-N = Inorganic Nitrogen

TABLE 3-9

TYPICAL PESTICIDE LOADINGS MEASURED ON SMALL PLOTS (44-5700 FT^2)

Pesticide	Amount applied (lb/ac)	Type of application [1]	Crop	Pesticide loss in runoff (lb/ac)	Range of pesticide loss in runoff increments
Aldrin	1.3	SR	Cultivated	0.068	
Atrazine	3.0 1.5 2.7 2.0 4.0 2.0	Inc. SR Inc. SR SR S S SR	Fallow Fallow Fallow Corn Corn Corn	0.0741 sediment 0.278 water 0.031 sediment 0.111 water 0.176 0.1 0.19 0.05	5-138 μg/g 500-11,000 μg/l 4-15 μg/g 50-600 ppb 100-10,340 μg/l water 100-200 μg/l 0.5-10 μg/g 100-3800 μg/l 0.5-4 mg/g 50-2000 μg/l
Dicamba	0.18-1.09	SR	Fallow Sod	0.013	0-4800 μg/l
Dichlobenil	6.0	Inc. SR	Fallow	0.117 sediment 0.270 water	4-37 μg/g 100-900 μg/l
Dieldrin	1.3	SR	Cultivated	0.061	1.6-14 μg/g sediment
Diuron	0.75	S Ponded	Cotton	0.0004	1-4 μg/l
2,4-D-Amine	2.0	SR	Cultivated	0.047	
2,4-D-Butylether	2.0	SR	Cultivated	0.7	640 μg/l
2,4-D-Isooctyl	2.0	SR	Cultivated	0.8	1380 μg/l
Endosulfan	0.9 0.9 0.65	S S S	Cont. Potatoes Rot. Potatoes Oats	0.003 0.002 0.00007	1.0-19 μg/l Trace-18 μg/l Trace-3 μg/l
Endrin	1.3 1.3 0.27 0.36	S S S S	Cont. Potatoes Rot. Potatoes Sugarcane Sugarcane	0.012 0.008 0.003 0.001	1.0-49 μg/l Trace-48 μg/l <0.01-2.07 μg/l 0.15-5.0 μg/l
Fenac	3.0	S	Sugarcane	0.086	1-310 μg/l
GS 14254	2.0 4.0	S S	Alfalfa Alfalfa	0.0004 0.0012	100-3800 μg/l 0.5-10 μg/g 100-2000 μg/l 0.75-10 μg/l
Linuron	2.0	S Ponded	Cotton	0.0006	2-124 μg/l
Methoxychlor	22.0	SR	Grass	0.09	0.1-8.8 μg/l
Picloram	0.5 0.25 0.9-1.8	F S SR	Grass Range Fallow Sod	 0.053	349-838 ppb 17 ppb 15-560 μg/l
Prometryne	2.5	S	Cotton	0.013	
Toxaphene	24.6	F	Cotton	0.089	~60 μg/l
Trifluralin	1.25	Inc.	Cotton & Soybeans	0.0005	0.2-1.9 μg/l
2,4,5-T	0.5 10.0 0.9-1.8	F SR SR	Grass Grass Fallow Sod	 0.005 0.03	495-769 ppb 1-380 μg/l 7-3300 μg/l

[1] S=Surface; Inc.=Incorporated; F=Foliar; SR=Simulated Rainfall

TABLE 3-10

LOADING RATES OF TOTAL P AND TOTAL N FROM VARIOUS MIXES OF LAND USE IN THE CENTRAL UNITED STATES (75)

LAND USE	PERCENT MIX	LOADING RATE (LB/AC/YR)	
		TOTAL P	TOTAL N
WOODLAND	$\geq$90[1]	0.8011	3.090
	$\geq$75	0.115	3.158
	$\geq$50	0.148	3.590
AGRICULTURE	$\geq$90	0.237	8.503
	$\geq$75	0.227	4.944
	$\geq$50	0.189	4.778
RANGE	$\geq$75	0.058	0.923
	$\geq$50	0.037	1.065
URBAN	$\geq$40	0.309	6.508

[1] At least 90 percent of the land use in the watersheds sampled was woodland.

discussed in Chapter IV. The other three programs are being conducted by the Agricultural Research Service, by Oklahoma State University, and by the Forestry Division of the Oklahoma Department of Agriculture.

On July 1, 1976, eight 4 acre watersheds were instrumented and put into operation by the Agricultural Research Service in order to measure rainfall, runoff, sediment loss, and N and P discharge. In addition, soil physical properties, i.e., texture, bulk density, moisture content as field capacity and wilt point will be determined. As of the first reporting period, July 1 to December 31, 1976, there had been no runoff (59).

The OSU study is being conducted by the Agronomy Department in cooperation with several other departments. The objectives of this project are briefly stated (60):

(1) To determine the source, transfer and transformation of potential pollutants on a rangeland watershed grazed by beef cows.
(2) To determine and monitor the hydrologic and meteorologic parameters necessary to establish the water budget and movement of potential pollutants from a rangeland watershed in Central Oklahoma.
(3) To determine effects of environmental conditions on the rate of degradation of grazing cattle feces on rangeland.
(4) To determine effects of cattle waste concentration, chemical composition and distribution on levels of potential pollutants in rangeland soils.

As of progress report number five, dated May 23, 1977 and covering the period 9-1-76 to 11-30-76, only two runoff events had occurred. The runoff water quality data was therefore not reported for this period (61).

The Forestry Division of the Oklahoma Department of Agriculture was directed by Governor Boren to conduct an independent study of Nonpoint Sources of Pollution Stemming from Silvicultural Activities in the Southeast portion of the State. The project has been in operation almost one year. However, as of October 1, 1977 no data had been published (62).

The model presented in the following chapter differs from the models described here in that in addition to estimating NPSP loading rates, it also includes a ranking process whereby the various nonpoint sources may be evaluated and compared to determine what areas of the state have the greatest potential for NPSP problems.

CHAPTER IV

DEVELOPMENT OF THE NONPOINT SOURCE RANKING MODEL

The preceding chapter reviewed various nonpoint pollution models, and discussed the components of each. These are sophisticated models which have detailed input requirements. Because these input data are often expensive and difficult to obtain, there exists a need for a more general model which will identify potential NPSP problem areas based on existing information and NPSP loading rate data collected locally. The development of such a model is outlined in this chapter, including formulation of the equations, input requirements, and the sources of input data.

Model Methodology

General Background

This section explains the methodology to rank each of the state's seven major river basins according to their potential NPSP load. The basin with the highest potential load is then further divided into sub-basins which are ranked in the same manner. The sub-basins thus identified as having the highest potential NPSP load are futher divided into "Conservation Needs Inventory"[1] (CNI) watersheds (63), and each watershed ranked as to its potential for nonpoint pollution. By use of this model it is possible to

1. This publication provides an inventory of "Kinds and Amount of Land and Water in Oklahoma, Their Possible Uses, and Their Needs for Management and Improvement" (63).

"converge" on a particular problem area. More sophisticated models (see Chapter III) can then be employed to explore the problem in greater detail.

Major Basins

Problems involved in ranking basins include identifying land use, and determining the hydrological characteristics of each basin. To determine the relative pollutant load from a given basin, the land use areas (acres) are multiplied by the loading factors (pounds/acre/yr.) which are determined through a monitoring program to give pounds/year of a given pollutant. The pounds of each pollutant from all sources (each land use) are then summed and divided by the total land use (acres)which gives the estimated load of that pollutant in pounds per acre per year. The same is done for each pollutant in each basin. This process may be reduced to the following equation:

$$TL_{pn} = \frac{(L_{p1})\ (A_{LU1}) + (L_{P1})\ (A_{LU2}) + \ldots + (L_{P1})\ (A_{LUn})}{TA_B} \qquad (4.1)$$

Where: TL_{Pn} = Total load of each pollutant (lbs/acre/year)
L_{P1} = Loading rate of pollutant one (lbs/acre/year)
$A_{LU1..n}$ = Area of each land use (acres)
TA_B = Total area of basin (acres)

After the total load of each pollutant has been calculated for every basin, the values are ranked from largest to smallest. After each pollutant parameter has been ranked (1 to 7 for each of the seven basins), the assigned ranking numbers are summed. The basin having the lowest ranking number total is then considered as having the greatest potential for NPSP problems. The other basins are ranked in the same manner.

Sub-basins

Essentially the same process is used to rank the sub-basins within the major basin identified as having the highest potential for NPSP problems. However, information on land use becomes slightly more accurate since a smaller area is being dealt with. Equation 4.1 is still applicable to sub-basins with one minor alteration; the denominator "TA_B" now becomes

"TA_{SB}" or, the total area of the sub-basin (acres). The ranking process remains unchanged.

Watersheds

Once the sub-basins have been ranked, and the sub-basin having the greatest potential for NPSP problems identified, the next step is to divide that sub-basin into watersheds, and rank them according to the same criteria as were used in the basin and sub-basin rankings. Since more detailed information on land use, hydrological characteristics and meteorological conditions is available for watersheds than for the larger basins and sub-basins, a slightly different ranking technique was used which allows increased precision.

Assuming the pollutant load from any watershed is a function of several measurable variables, it is possible to take the loading rates from a series of monitored watersheds and apply them to non-monitored watersheds. This can be expressed by the relationship:

$$L_m/X_1 = L_n/X_2 \qquad (4.2)$$

Where: L_m = Measured pollutant load from the monitored watershed (lbs/ac/yr.)

X_1 = A measured constant for the monitored watershed (unitless)

L_n = The estimated pollutant load from the non-monitored watershed (lbs/acre/yr.)

X_2 = A measured constant for the non-monitored watershed (unitless)

Since L_n is the only unknown, the relationship can be rearranged to the following equation which solves for L_n:

$$L_n = \frac{L_m X_2}{X_1} \qquad (4.3)$$

The X values in Equation 4.2 and 4.3 represent a series of variables which account for L (Load). These variables have been reduced to:

$$X = R\ C\ K\ T \qquad (4.4)$$

Where: R = The runoff factor. This factor is based on many variables including rainfall, antecedent soil moisture conditions, evaporation and transpiration rates, etc. However, it has been found that generally, for conditions in Oklahoma, the runoff value for any given watershed (as percent of annual rainfall) may be estimated by two simple formulas (64). These formulas are:

$R = .0042\ (X)^{2.318}$ For Annual Rainfall $\geq$ 21 inches and,

$R = 3.80 \times 10^{-9}\ (X)^{6.884}$ For Annual Rainfall $<$ 21 inches

Where: R = Runoff as a percent of annual rainfall

X = Average annual rainfall in inches

Therefore, by attaining the average annual rainfall for a given watershed from a nearby weather recording station, and utilizing one of these equations, an estimate may be made of the annual runoff from the watershed.

C = The cropping management or plant cover factor is the ratio of soil loss from a field with a specified cropping and management or plant cover to that from the fallow condition on which the factor K is evaluated. This factor measures the combined effect of all the interrelated cover, management variables plus the growth stage and vegetal cover at the time of the rain. This factor may be estimated from Table 3-3 and from tables provided in SCS publications such as reference numbers 10 and 65.

K = The soil erodibility factor. It is the erosion rate per unit of erosion index for a specific soil in cultivated continuous fallow on a 9% slope 72.6 feet long. Soil properties that influence erodibility by water are those that affect the infiltration rate, permeability and total water capacity, and those that resist the dispersion, splashing, abrasion, and transporting forces of the rainfall and runoff. Again, this factor may be found in tables in references 10 and 65.

T = The topography factor. This variable is equivalent to the length-slope factor developed in the Universal Soil Loss Equation in Chapter III. However, since a factor must be developed which represents an average length-slope over an entire watershed, a correlation of average slope to slope length was developed by SCS personnel for Oklahoma (66). This correlation is as follows:

AVERAGE SLOPE (%)	SLOPE LENGTH (FEET)
0-1	500
2	350
3	250
4	200
5	150
6	100
7	80
8	70
9	60
10	50

The average slope may be determined from actual field measurements or from SCS Soil Surveys of the given watershed. Knowing these two values the T Factor may be estimated from Figure 3-9. The pollutant load from any given watershed (monitored or nonmonitored) is assumed to be a function of these four variables.

Solving for Equation 4.3, one obtains an estimate of the pollutant load (lbs/ac/yr.) of a given pollutant for a given land use in a watershed. If the same process is used for each land use in the watershed, a loading rate of the pollutant for that watershed is obtained. This is done for each pollutant on each land use for every watershed within the sub-basin. The resulting loading rates are then ranked using the same process as that for basins and sub-basins.

On the watershed level it also becomes possible to utilize the Universal Soil Loss Equation (Equation 3.5) to establish sediment loading rates. These rates may then be included in the ranking process, allowing still further detailing of potential NPSP problems. The end result of these procedures is the identification of a single watershed which has a high potential for problems associated with nonpoint pollution. This watershed can then be studied in detail to determine what the specific problems might be. Control measures in the form of "Best Management Practices" (as discussed in Chapter III) could then be recommended.

Model Input Requirements

General Background

The two primary model input requirements are land use information and NPSP loading rate data. This section discusses each requirement, emphasizes its importance, and illustrates its use in the model.

Land Use Information

The first step was to select those land use classifications which best characterized the predominant land uses in Oklahoma. It was decided in a meeting of various state agencies with interests in this field that since roughly 95% of all land use in Oklahoma is devoted to some form of agricultural endeavor, the following general classifications would adequately reflect the land uses in Oklahoma (67):

1) Cropland
2) Pastureland
3) Rangeland
4) Woodland
5) Urban
6) Other

1) Cropland consists of all types of crops including small grains, large grains, sorghums, cotton, alfalfa, etc. The land use information available made no distinction between these various types. Monitoring sites were established only on wheat cropland since this is the predominant type (67).

2) Pastureland is usually characterized by an introduced species of cover grass, such as bermuda, and has one or more animal units per ten acres.

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2) Pastureland is usually characterized by an introduced species of cover grass, such as bermuda, and has one or more animal units per ten acres.

3) Rangeland is similar to pasture, but usually consists of native Oklahoma grasses, such as bluestem, and only has one or less animal units per ten acres (67).

4) Woodland areas include forests of oak and pine, along with a variety of other species. The primary characteristic is the presence of "overstory" which acts to reduce the impact of raindrops which in turn reduces erosion. Layers of forest litter also intercepts rainfall and reduces runoff. The present land use information makes no distinction between the different types of forest or between different silvicultural activities (harvesting, logging, road building, etc.) within a forest.

5) Urban areas are the cities and towns scattered across the state. Many different land use activities are classified "urban" including residential areas, industrial complexes, commercial zones, etc.

6) Included in the "other" category are land uses such as mining and construction activities, solid waste disposal areas, unlicensed feedlot operations, and roadside erosion. Also included in this category are all remaining land uses such as lakes, ponds, rivers, etc. It was not possible to monitor all of the activities in this category. However, monitoring was conducted on an active, an inactive, and a reclaimed mining operation to estimate loading rates from these sources.

These six general land use categories were used in Equation 4.1 to estimate NPSP loading rates from major basins, sub-basins, and watersheds. This equation illustrates the importance of obtaining good estimates of the areas of each type of land use since the ranking process relies on a comparison of the NPSP loading rates of each basin, sub-basin, and watershed determined by estimates of the areas of each land use, and the NPSP loading rate from that land use.

NPSP Loading Rate Data

Once general land use categories had been selected it was necessary to locate monitoring stations high enough in a given watershed so that as a runoff event occurred, the runoff water came strictly from a homogeneous land use area. In this manner any synergistic or antagonistic effects by other land use types were eliminated and NPSP loading rates from that particular land use could be determined. The next criteria was to select a watershed which was as representative of that particular land use as possible. Because of funding and other limitations, it was impossible to establish monitoring sites in every watershed. The sites which were selected and detailed information about each site, is included in Appendix A.

The parameters selected for analysis in this program were based on an earlier study by the OSDH which characterized both urban and rural NPSP (68). These parameters also correspond to the OCC contract requirements with the Oklahoma Department of Pollution Control (ODPC). The parameters are:

BOD	(Biochemical Oxygen Demand of the water)
COD	(Chemical Oxygen Demand of the water)
pH	(A measure of the alkalinity or acidity)
Suspended Solids	(The amount of matter remaining in suspension)
SO_4	(Sulfate concentration)
$NO_3 + NO_2$	(Nitrate and nitrite concentration)
NH_4	(Ammonia concentration as nitrogen)
Organic N	(Amount of nitrogen due to organics)
Total N	(The amount of nitrogen from all sources)
Total PO_4	(The amount of phosphate from all sources)

A discussion of these parameters may be found in Appendix B.

a) Sampling Procedures:

Grab sampling techniques established in "Standard Methods" were utilized in all data collection (69). Local conservation district personnel carried out the actual field work. When a runoff event began at a particular monitoring site, a sample was collected to represent the "first flush" effect. As the storm progressed, samples were collected at or near the peak of the runoff event, and toward the end of the event as the flow receded, all as determined by the field man and his knowledge of the watershed. These three samples were then composited and the single sample assumed to represent the average concentration of pollutant over the entire event. This process was repeated at every site during every event for the eighteen month period January 1976 to August 1977.

In addition to water samples, data on changes in cover on the watershed (e.g., plowing, planting, fertilizer or pesticide applications, etc.) and meteorological conditions were collected. (On-site observation at the time of sample collection was used to note changes in cover, while a common glass tube rain gauge located on each watershed was used to collect rainfall information).

b) Sample Preparation and Transport:

The composite sample was thoroughly mixed, and then "split" into equal portions and poured into two neoprene plastic half gallon containers. One container was chilled with ice, and packed in a styrofoam ice chest. Approximately three milliliters of sulfuric acid was added to the other sample. In this way the samples were preserved for the chemical analyses. All samples were shipped by bus to expedite their delivery. These precautions are all as prescibed by EPA in their "Analytical Quality Control Methods" (70).

c) Sample Analysis:

All analyses on the water samples were performed by the Water Quality Laboratory at the Oklahoma State Department of Health. Procedures for the analytical work were followed based on methods established in "Standard Methods" and "Methods for Chemical Analysis of Water and Wastes" (69, 73). A description of the parameters analyzed may be found in Appendix B.

d) Techniques for Data Analysis:

Since the purpose of the monitoring program was to collect data to determine loading rates of NPSP from a variety of land uses, it was necessary to convert the raw data as reported from the OSDH from a concentration in mg/1 to a loading value in pounds contributed per event. This process is not very complex once the volume of runoff for each event has been calculated.

To calculate runoff volume, the Williams Water Yield Model (as outlined in Chapter III) was selected. The selection of this method is based primarily on the facts that:

1) It is a reliable procedure that has been used for many years in the United States.
2) It is computationally efficient.
3) The required input information is readily available.
4) It relates runoff to soil type, land use, and management practices.

Utilizing this model (Equations 3.3 and 3.4) and the information in Figure 3- 2 and Table 3-1, runoff volume for every event at each monitoring location was determined (see Appendix C). This information was then used to estimate the loading rates of various pollutants.

By assuming that the concentrations of the pollutants in each composite sample represent an average concentration for a particular runoff event, and knowing the volume of runoff contribued during that event the pollutant load in pounds per event may be calculated by:

$$L = C\ K\ V_R \qquad (4.1)$$

Where: L = Pollutant load in pounds per event

C = Pollutant concentration in mg/l

K = A conversion constant, 8.34

V_R = Total volume of runoff in million gallons

The techniqes developed thus far may best be demonstrated through the use of an example:

On March 8, 1976, a four inch rain fell over most of the Idabel area in McCurtain County, in Southeastern Oklahoma. One of the monitoring stations in that area was for the land use designated "rangeland" (see Appendix A). Runoff samples were collected at the beginning, peak, and end of the rainfall/runoff event.

The volume of runoff from that event was calculated using the William's Water Yield Model (36). Recall that Equation 3.3 is used to calculate the accumulated volume of runoff (in inches of depth) over the drainage area. The drainage area is determined by planimetering USGS maps in the 7.5 minute series or 1:24,000 scale. This provides the information necessary to calculate the total volume in cubic feet of runoff from the given watershed.

In using this technique the SCS area in which the sample was taken must be determined from Figure 3- 2. This map has been compiled for the areas of interest using the extensive soils, topographic, geologic, and geographic information available from SCS general soils maps from each area (41). Note that for the area near Idabel in McCurtain county, the soil complex designation is 9A. Then, from Table 3- 1 (41) the remaining pertinent information and the information necessary to calculate the runoff volume is obtained:

Median Slope	- 5.0%		
Land Use	- 10,	60,	30
Curve Number	- 77.5		
Soil Index	-2.90		

In Equation 3.3 because the variable "Ia" (the initial abstraction including surface storage, interception by vegetation, and infiltration) is so difficult to calculate, and because it is directly linked to the hydrologic soil classification and the soil index "S", Equation 3.3 has been reduced here to a version which is easier to calculate. It is:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad (4.2)$$

Where: Q = Accumulated volume of runoff in inches of depth over the drainage area

P = Accumulated rainfall (measured in the field).

S = Soils index, i.e., potential maximum rention of water by soil (from Table 3- 1)

Therefore, since 4 inches of rain fell over the experimental watershed, and knowing from Table 3-6 that the S factor is 2.90, the volume of runoff, V_r, may be calculated as follows:

$$V_r = \frac{4.0 - (0.2 \text{ X } 2.90)^2}{4.0 + 0.8(2.90)}$$

$$= 1.85 \text{ inches} \qquad (4.3)$$

Then from Table A-1 in the Appendix, (calculated drainage areas for each monitoring station) the drainage area for station number 1 (rangeland) in McCurtain county is 95 acres or $4.13 \text{ X } 10^6$ square feet. The runoff was calculated to be 1.85 inches or 0.1542 feet. The following equation calculates the total volume of runoff in million gallons.

$$V_t = \frac{4.13 \text{ X } 10^6 \text{ ft.}^2 \text{ X } 0.1542 \text{ ft. X } 7.48052}{10^6} \qquad (4.5)$$

$$= 4.764 \text{ million gallons}$$

This figure, 4.764 million gallons, represents an estimate of the volume of water that ran off the rangeland area during the 4 inch rainfall event of March 8, 1976. By analysis, the concentration of organic nitrogen was found to be 1.1 mg/l. The conversion factor 8.345 (from Equation 3.1) is used to convert mg/l to pounds per million gallons, then multiplying this by the calculated volume an estimate of the pounds contributed was obtained, or the potential load:

1.1 mg/l X 8.345 X 4.764 million gallons
= 44 lbs of organic nitrogen

This figure, 44 pounds is for one event under the stated conditions. The other parameters are calculated the same way and the results of eighteen months of data collection is recorded in Appendix C.

These values and the concentrations from which they were derived were statistically analyzed for the maximum and minimum values, mean and standard deviation, following procedures set out in Statistical Methods (77). These results appear along the bottom of the tables in Appendix C.

From these figures (total pounds contributed per event) one can obtain the total yearly contribution of pollutants by summing the values for the sampling period, and dividing by 1.5 (for 18 months of data). This is possible because every runoff event during that eighteen month period was sampled. By dividing this figure by the number of acres for that monitoring site, one obtains the pounds contributed per acre. (The results of this procedure may be found in Table 4-1).

e) Results of Data Analysis:

A comparison of the land uses monitored (Table 4-1) with similar land uses monitored during other studies (Table 3-7,10) indicates that most parameters measured in this study fall within the ranges found in the literature. Table 4-2 illustrates a comparison of the range of values for concentrations of five parameters from three land uses in the eastern and western areas of the state (as divided by Interstate Highway 35). Table 4-3 shows a similar comparison between the loading rates. As can be seen from these tables, concentrations are significantly higher in the west than in the east, with the exception of cropland, where the range of concentrations of nutrients was higher in the east. This could be due to differences in crops, cropping patterns, and management practices. Loading rates (Table 4-3) were also significantly higher in the west than in the east, again with the exception of nutrients from cropland. In this case, total P loading was nearly the same in the east as in the west. However, total N and NO_2 + NO_3 were much higher in the east.

Table 4-4 compares these findings to a similar nationwide study conducted by EPA. In this study, the National Eutrophication Survey, maps were developed which illustrate various levels of concentrations of total N and P. As can be seen by Table 4-4 a considerably wider range of values was obtained. This could be accounted for by the fact that the Oklahoma study monitored homogeneous land use types on small watersheds, while the EPA study monitored much larger watersheds of mixed land use, thereby averaging their effects.

For this study, it was only necessary to estimate the nonpoint loading rates for a variety of land uses, and determine whether or not these loading rates could be applied to the same land use in different watersheds. The data collected thus far generally indicates that this is possible.

As more detailed land use information becomes available, and as the corresponding loading rates are determined, greater accuracy in predicting

TABLE 4-1

LOADING RATES OF POLLUTANTS BY LAND USE

LOCATION	LAND USE	LOADING RATES OF VARIOUS POLLUTANTS BY LAND USE (LB/AC/YR)[1]								
		BOD	COD	SS	SO_4	$NO_2 + NO_3$	NH_3	ORG-N	TOT-N	TOT-P
Idabel	Rangeland	14.25	34.52	74.89	20.55	.33	.51	1.74	2.45	.22
	Pasture	16.52	56.23	34.31	8.68	.71	.82	1.93	1.80	.68
	Cropland	20.19	57.14	269	13.49	5.04	1.39	2.72	11.64	.26
	Woodland(cc)	16.68	52.22	81.9	9.97	.31	.62	1.18	1.91	.14
	Woodland	14.16	56.38	60.95	18.36	1.06	.58	1.71	.23	.12
Mangum	Cropland	6.49	25.03	392	7.40	.07	.07	1.56	.96	.67
	Rangeland	7.25	21.71	74.85	6.22	.24	.05	.59	1.05	.24
	Pasture	.61	4.13	34.91	2.92	.02	.01	.05	.04	.10
	Heavy Agri.	.57	14.84	282	7.39	.08	.01	.18	.27	.20
Freedom	Cropland	6.23	40.75	666	24.08	.31	.11	1.88	1.67	.23
	Rangeland	4.63	16.07	140	3.99	.23	.09	.89	1.23	.53
	Ungrazed Range	4.51	14.90	59.34	21.02	.14	.09	.72	.97	.12
	Pasture	1.81	12.43	65.16	1.81	.10	.04	.68	.55	.14
Tahlequah	Urban	1.74	5.39	40.54	1.10	.06	.05	.11	.09	.05
	Cropland	.01	.04	.30	.02	.0004	.0005	.001	.002	.001
	Pasture	.21	2.18	3.58	.80	.03	.06	.09	.09	.01
	Rangeland	1.69	5.44	29.1	.95	.02	.08	.06	.06	.02
Muskogee	Active Mine	14.96	42.16	236	1446	54.15	2.03	1.58	32.98	.33
	Inactive Mine	10.37	32.00	44.09	642	16.26	1.20	1.46	2.03	.34
	Reclaimed Mine	4.18	21.12	109.6	1566	46.55	2.87	1.06	41.48	.15

[1] Average Values

TABLE 4-2

A COMPARISON OF THE RANGE OF CONCENTRATIONS (MG/L) OF FIVE POLLUTANTS BETWEEN THREE DIFFERENT LAND USES IN THE EASTERN HALF OF OKLAHOMA TO THE SAME LAND USES AND POLLUTANTS IN THE WESTERN HALF OF THE STATE

PARAMETER	RANGE		CROP		PASTURE	
	EAST	WEST	EAST	WEST	EAST	WEST
TOT P	.07 - .33	.14 - 1.3	.16 - 2.1	.12 - 1.8	.02 - 1.4	.34 - 4.1
TOT N	.90 - 2.1	1.3 - 4.4	1.3 - 15.0	.32 - 4.6	1.1 - 3.5	.75 - 9.3
$NO_2 + NO_3$	.10 - .70	.20 - 1.3	.20 - 12.1	.10 - 1.9	.10 - 2.2	.10 - 2.3
COD	14.0 - 68.0	4.0 - 88.0	21.0 - 171.0	1.6 - 340.0	14.0 - 71.0	35.0 - 402.0
SS	.30 - 455.0	1.0 - 1942.0	17.0 - 958.0	1.0 - 10000.0	.10 - 695.0	1.0 - 2197.0

TABLE 4-3

A COMPARISON OF THE RANGE OF LOADING RATES (LB/AC/YR) OF FIVE POLLUTANTS BETWEEN THREE DIFFERENT LAND USES IN THE EASTERN HALF OF OKLAHOMA TO THE SAME LAND USES AND POLLUTANTS IN THE WESTERN HALF OF THE STATE

PARAMETER	RANGE		CROP		PASTURE	
	EAST	WEST	EAST	WEST	EAST	WEST
TOT P	.0016 - 8	.080- 38	.00019 - 120	.0021 - 150	.0048 - 27	.044 - 440
TOT N	.018 - 56	.22 - 180	.00062 - 2200	.017 - 300	.10 - 81	.40 - 720
$NO_2 + NO_3$	.0022 - 16	.024- 56	.00026 - 1900	.0028 - 14	.0087 - 42	.030 - 320
COD	.58 - 1192	3.0 - 3200	.014 - 5700	.18 - 15000	1.3 -1800	8.1 - 15000
SS	.54 - 3551	29.0 -15000	.17 -77000	2.4 -110000	.30 -1500	4.9 - 620000

TABLE 4-4

COMPARISON OF THE RANGE OF CONCENTRATIONS OF TOTAL N AND P FROM NONPOINT WATERSHEDS[1] IN AN OKLAHOMA STUDY AND IN THE EPA NATIONAL EUTROPHICATION SURVEY (75)

	EAST		WEST	
	OKLA. STUDY	EPA-NES	OKLA. STUDY	EPA-NES
RANGE OF TOTAL N (MG/L)	.9 - 15.0	.501 - 1.70	.32 - 9.3	.901 - 3.0
RANGE OF TOTAL P (MG/L)	.02 - 2.1	.011 - .70	.14 - 4.1	.71 - 2.0

[1]Watersheds devoid of point sources.

CHAPTER V

APPLICATION AND VERIFICATION OF THE MODEL

The methodology for the model to estimate and evaluate NPSP loading from Oklahoma watersheds was presented in Chapter IV. Chapter V applies this model to three levels of geographic aggregation, then verifies the results by comparing loading estimates of various gauged watersheds.

Application of the Model

Major Basin Ranking

The ranking procedure described in Chapter IV is the basis for the computer program presented in Appendix D. This program requires the data presented in the following tables and ranks each of the major basins. Equation 4.1 and the computer program requires the following input:

a) Land use in the basin

b) Area of each land use

c) Total area of the basin

d) Loading rate of each pollutant

Table 5-1 provides information for the first three input requirements from the Conservation Needs Inventory (63) and Table 4-1 provides the fourth input requirement. (The information for Table 4-1 is condensed data from the tables of Appendix C).

TABLE 5-1
LAND USE AND AREAS IN EACH OF THE
SEVEN MAJOR RIVER BASINS IN OKLAHOMA (63)

BASIN NUMBER	BASIN NAME	ESTIMATED TOTAL AREAS OF EACH LAND USE (ACRES)						
		CROPLAND	PASTURE	RANGE	WOODLAND	URBAN	OTHER	TOTAL
1	Middle Arkansas	537,649	1,941,273	1,531,993	1,143,388	338,330	90,331	5,582,964
2	Lower Arkansas	112,654	635,259	267,209	1,166,430	69,853	72,625	2,324,030
3	Upper Red	3,723,591	1,105,400	3,938,335	848,414	258,682	538,572	10,412,974
4	Lower Red	322,314	661,172	1,531,038	2,300,786	85,884	124,535	5,025,729
5	Canadian	1,360,851	1,252,767	1,013,927	3,153,001	246,508	44,930	7,071,984
6	Upper Arkansas	2,787,393	533,439	462,772	2,520,160	369,732	82,815	6,756,311
7	Panhandle	1,696,326	3,171	1,770,336	3,743	25,918	3,191	3,502,685

Table 5-2a is an example of the computer output for ranking the seven major river basins (from Appendix D). This table is for Basin 3 which was identified as having the highest potential for nonpoint pollution problems. The first row identifies each land use in the basin (LD USE). The second row delineates the area in acres of each land use (AOLAUS). These values are summed and the final figure appears under the column heading "SUM". This figure represents the area in acres of Basin 3. The next row is the pollutant loading factor for that pollutant from that land use, as determined from the monitoring sites closest to the basin and reported in Table 4-1. For example, the contribution (CONT) of Pollutant 1 (POL 1) is 6.49 pounds per acre per year of BOD from the monitoring watershed cropland near Mangum, Oklahoma (Table 4-1). By multiplying this figure times the area of land use (according to Equation 4.1) the pounds of "POL 1" (BOD) from cropland is determined and expressed in exponential form as 0.24E08 which is equivalent to 0.24×10^8 or 24,000,000 pounds per year. The same procedure is applied to each of the other land uses, and then the pounds contributed by each is summed. This figure appears in the SUM column as 0.10E09. From this figure the total contribution in pounds per acre per year is calculated by dividing 0.10E09 by 104,412,974 acres, the total land area in the basin. This figure appears in the total column (for POL 1 it is 9.613) for each pollutant, and represents the total contribution of each pollutant in pounds per acre per year from all sources. This value is then ranked 1 to 7 or largest to smallest. In this case, the pollutant BOD (POL 1) is ranked second out of seven.

After loading rates of each of the nine pollutants (a listing of what each pollutant is appears at the beginning of each program) have been estimated and each pollutant ranked, the "RANK" column is summed and compared to the sums of the same column of each of the other basins. At this point, the basins are ranked 1 to 7 based on this figure (the lowest rank column sum representing the basin with the greatest potential for NPSP as determined by this methodology). The overall rank appears at the bottom of each table. A summary of the findings appears in Table 5-2b.

Sub-basin Ranking

In the ranking of sub-basins the same procedures are used as were

TABLE 5-2a
RESULTS OF PROGRAM TO ESTIMATE AND RANK POLLUTANT LOADS
FROM BASIN 3 THE UPPER RED RIVER

BASIN 3 Upper Red

LD USE	CROP	PASTURE	RANGE	FOREST	URBAN	OTHER	SUM	TOTAL	RANK
AOLAUS	3723571.	1105400.	3938335.	848414.	258682.	538572.	10412974.		
CONT	6.4900	0.6100	16.5600	10.2000	1.7400	1.7400			
POL 1	0.24E 08	0.67E 06	0.65E 08	0.87E 07	0.45E 06	0.94E 06	0.10E 09	9.613	2
CONT	25.0300	4.1300	109.7000	12.0600	5.3900	5.3900			
POL 2	0.93E 08	0.46E 07	0.43E 09	0.10E 08	0.14E 07	0.29E 07	0.54E 09	52.274	1
CONT	392.0000	34.9100	1793.0000	8.0100	40.5400	40.5400			
POL 3	0.15E 10	0.39E 08	0.71E 10	0.68E 07	0.10E 08	0.22E 08	0.86E 10	825.775	1
CONT	7.4000	2.9200	156.0000	4.1000	1.1000	1.1000			
POL 4	0.28E 08	0.32E 07	0.61E 09	0.35E 07	0.28E 06	0.59E 06	0.65E 09	62.376	1
CONT	0.0700	0.0200	0.2880	0.0500	0.0600	0.0600			
POL 5	0.26E 06	0.22E 05	0.11E 07	0.42E 05	0.16E 05	0.32E 05	0.15E 07	0.145	4
CONT	0.0700	0.0100	2.1000	0.6500	0.0500	0.0500			
POL 6	0.26E 06	0.11E 05	0.83E 07	0.55E 06	0.13E 05	0.27E 05	0.91E 07	0.877	1
CONT	1.5600	0.0500	1.0600	0.0300	0.1100	0.1100			
POL 7	0.58E 07	0.55E 05	0.42E 07	0.25E 05	0.23E 05	0.59E 05	0.10E 08	0.975	4
CONT	0.9600	0.0400	2.1900	0.0300	0.0900	0.0900			
POL 8	0.36E 07	0.44E 05	0.86E 07	0.25E 05	0.23E 05	0.48E 05	0.12E 08	1.185	4
CONT	0.6700	0.1000	1.7000	0.5700	0.0500	0.0500			
POL 9	0.25E 07	0.11E 06	0.67E 07	0.48E 06	0.13E 05	0.27E 05	0.98E 07	0.943	1

TOTAL RANK = 1

(Information is from Appendix D)

TABLE 5-2b
SUMMARY OF RESULTS OF COMPUTER PROGRAM TO RANK BASINS

BASIN NUMBER	BASIN NAME	OVERALL RANK[1]
3	Upper Red	1
4	Lower Red	2
7	Panhandle	3
6	Upper Arkansas	4
5	Canadian	5
2	Lower Arkansas	6
1	Middle Arkansas	7

[1] From Highest Potential for NPSP Problems to the Lowest

outlined for ranking major basins in the preceding section. However, the input requirements for land use data are different. Table 5-3 provides the necessary land use data, and the computer program in Appendix E provides the tool to rank the sub-basins within Basin 3, (the Upper Red River). Table 5-4a is taken from Appendix E, and is an example of the computer output for ranking sub-basins.

In Basin 3, there are 5 sub-basins. Table 5-4a is for sub-basin 3 B (2). The information in this table follows the same format as that described for basin ranking. The only difference is in land use areas, and in some of the loading rates (which may vary to reflect the proximity to one or another of the monitoring sites -- the closer site to the sub-basin was used to more closely approximate the loading rates from the sub-basin). Table 5-4b summarizes the results of the computer program in Appendix E. Sub-basin 3 B (2) was identified as having the greatest potential for NPSP problems.

Watershed Ranking

The final step in the potential NPSP ranking process is to rank the watersheds in the sub-basin identified as having the highest potential for NPSP problems (sub-basin 3 B (2) from Table 5-4b). This sub-basin has seven CNI watersheds (see Figures 5-1a and b). Much work has been completed in the area of soil erosion from these watersheds by the Soil Conservation Service. The information in Table 5-5 was calculated using Equation 3.5, the tables and figures in the section of Chapter III entitled Techniques for the Estimation of Soil Erosion, and information obtained from on-site investigations of the seven watersheds by SCS personnel.

Ranking of the seven watersheds based on the other loading parameters has again been written in the form of a computer program utilizing Equation 4.3, the land use information in Table 5-6, and the pollutant loading rates from Table 4-1. Information on the R C K and T values used in Equation 4.3 was obtained from field investigations, and is presented in Table 5-7 for the monitored watershed (near the city of Mangum) and Table 5-8 for the test watersheds in sub-basin 3 B (2). The computer program listing and results are presented in Appendix F. Table 5-9a is from the computer printout of the program run in Appendix F. This table gives estimates

TABLE 5-3

LAND USE AND AREAS(in acres) OF EACH OF
THE SUB-BASINS IN BASIN 3

SUB-BASIN NUMBER	NUMBER OF ACRES OF EACH LAND USE						
	CROPLAND	PASTURE	RANGE	WOODLAND	URBAN	OTHER	TOTAL
3-A	1,508,124	564,686	465,842	1,810,087	81,159	369,975	4,799,873
3-B	647,674	97,677	40,400	521,047	66,322	45,248	1,418,368
3-B(1)	99,298	54,836	78,558	210,005	26,296	23,504	492,497
3-B(2)	206,394	170,348	248,893	420,832	51,146	29,171	1,126,784
3-C	865,260	125,528	9,710	716,966	30,319	42,131	1,789,914
3-D	396,841	92,325	5,011	259,398	3,440	28,543	785,558

TABLE 5-4a

RESULTS OF PROGRAM TO ESTIMATE AND RANK POLLUTANT LOADS
FROM SUB-BASIN 3B(2)

SUB-BASIN 3B(2)

LD USE	CROP	PASTURE	RANGE	FOREST	URBAN	OTHER	SUM	TOTAL	RANK
AOLAUS	206394.	170348.	248893.	420832.	51146.	29171.	1126784.		
CONT	0.6450	0.6100	16.5600	10.2000	1.7400	1.7400			
POL 1	0.13E 06	0.10E 06	0.41E 07	0.43E 07	0.89E 05	0.51E 05	0.88E 07	7.802	1
CONT	27.7100	4.1300	109.7000	12.0600	5.3900	5.3900			
POL 2	0.57E 07	0.70E 06	0.27E 08	0.51E 07	0.28E 06	0.16E 06	0.39E 08	34.820	1
CONT	345.0000	34.9100	1793.0000	8.0100	40.5400	40.5400			
POL 3	0.71E 08	0.59E 07	0.45E 09	0.34E 07	0.21E 07	0.12E 07	0.53E 09	470.404	1
CONT	3.3900	2.9200	156.0000	4.1000	1.1000	1.1000			
POL 4	0.70E 06	0.50E 06	0.39E 08	0.17E 07	0.56E 05	0.32E 05	0.42E 08	37.131	1
CONT	0.1000	0.0200	0.2880	0.0500	0.0600	0.0600			
POL 5	0.21E 05	0.34E 04	0.72E 05	0.21E 05	0.31E 04	0.18E 04	0.12E 06	0.108	1
CONT	0.2300	0.0100	2.1000	0.6500	0.0500	0.0500			
POL 6	0.47E 05	0.17E 04	0.52E 06	0.27E 05	0.26E 04	0.15E 04	0.85E 06	0.754	1
CONT	1.8800	0.0500	1.0600	0.0300	0.1100	0.1100			
POL 7	0.39E 06	0.85E 04	0.26E 06	0.13E 05	0.56E 04	0.32E 04	0.68E 06	0.605	5
CONT	2.5800	0.0400	2.1900	0.0300	0.0900	0.0900			
POL 8	0.53E 06	0.63E 04	0.55E 06	0.13E 05	0.46E 04	0.26E 04	0.11E 07	0.980	5
CONT	0.1900	0.1000	1.7000	0.5700	0.0500	0.0500			
POL 9	0.39E 05	0.17E 05	0.42E 06	0.24E 06	0.26E 04	0.15E 04	0.72E 06	0.642	1

TOTAL RANK = 1

(Information from Appendix E)

TABLE 5-4b

SUMMARY OF RESULTS OF COMPUTER PROGRAM TO RANK SUB-BASINS IN BASIN 3

SUB-BASIN	OVERALL RANK [1]
3B(2)	1
3B(1)	2
3A	3
3B	4
3D	5
3C	6

[1]From highest potential for NPSP problems to lowest

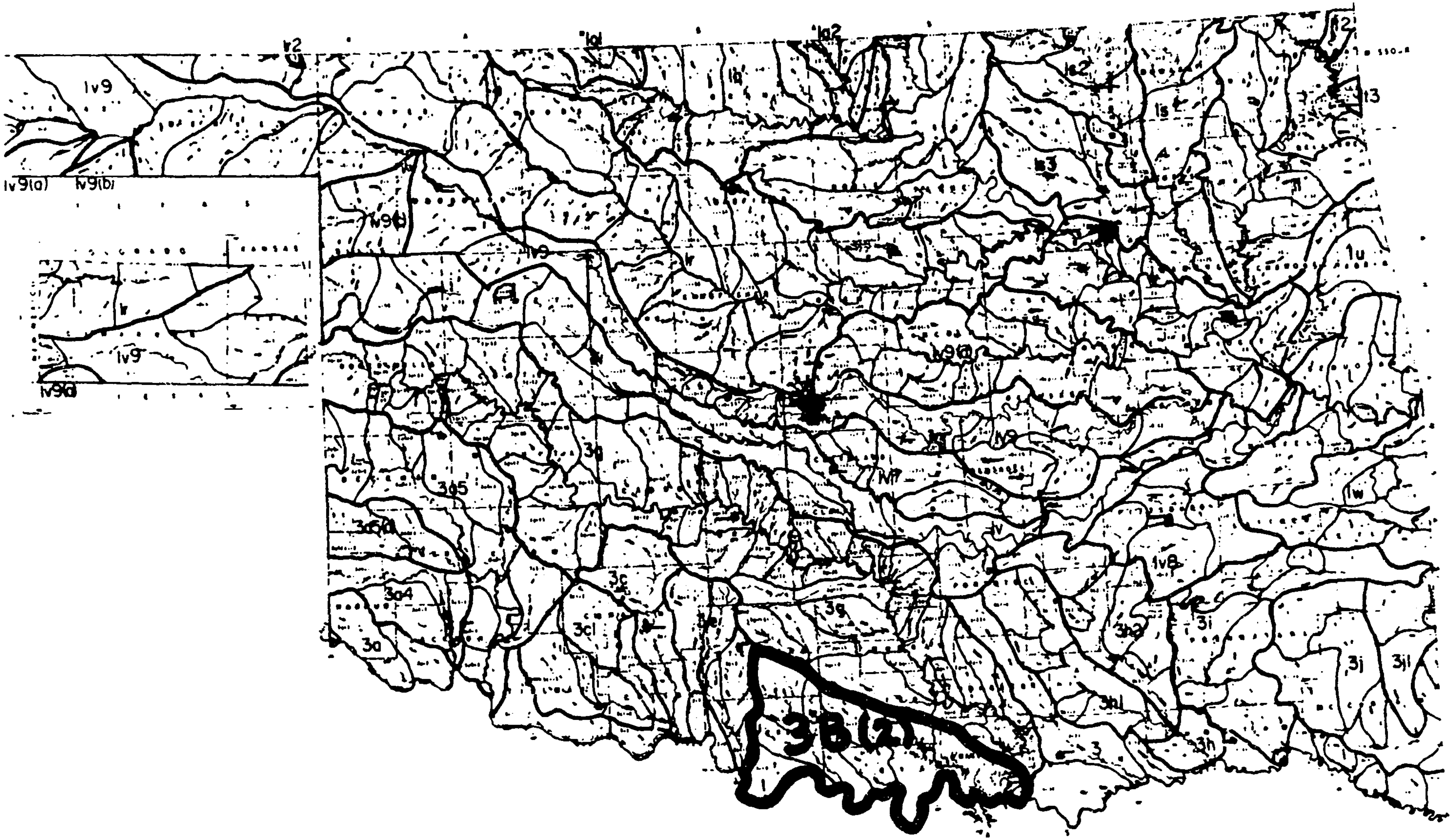
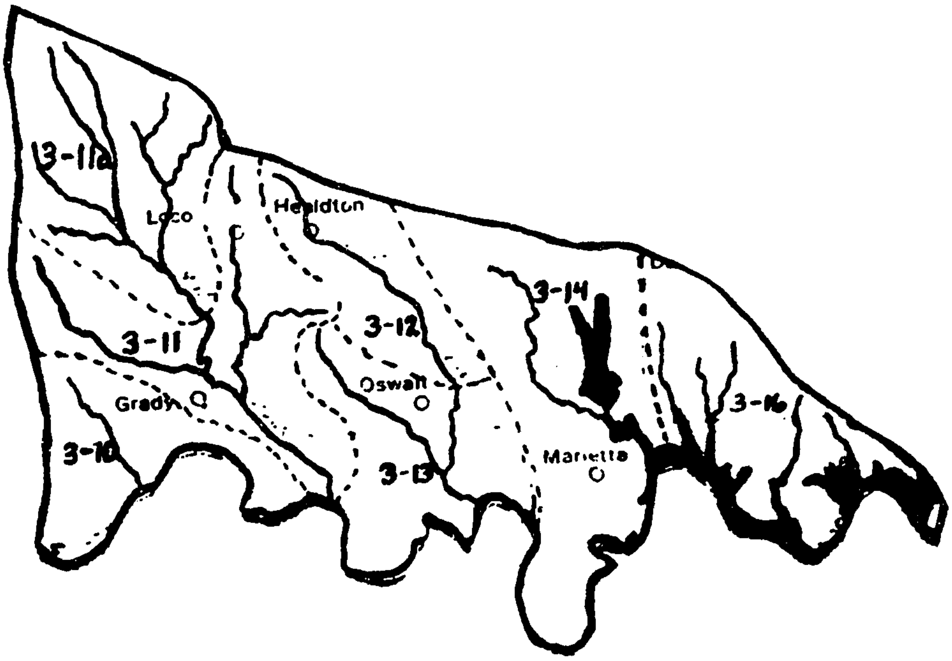


FIGURE 5-1a

CONSERVATION NEEDS INVENTORY (CNI) WATERSHEDS



CNI NUMBER	WATERSHED NAME
3-10	Fleetwood
3-11	Lower Mud
3-11A	Upper Mud
3-12	Upper Bayou
3-13	Lower Bayou
3-14	Hickory
3-16	Texoma Lateral

Figure 5-1b

CNI WATERSHEDS IN SUB-BASIN 3B(2)

TABLE 5-5

SEDIMENT YIELD FROM EACH LAND USE IN EACH
WATERSHED IN SUB-BASIN 3-B(2)

		SEDIMENT YIELD BY LAND USE							
CNI NUMBER	WATERSHED NAME	CROPLAND TOTAL TONS	CROPLAND TONS/AC	RANGE TOTAL TONS	RANGE TONS/AC	PASTURE TOTAL TONS	PASTURE TONS/AC	WOODLAND TOTAL TONS	WOODLAND TONS/AC
3-10	Fleetwood	338,889	6.16	83,092	1.57	83,092	1.10	13,875	0.97
3-11	Lower Mud	335,514	7.26	294,818	1.73	37,838	1.31	48,091	1.11
3-11A	Upper Mud	141,974	5.22	199,450	2.00	39,364	1.67	55,483	1.80
3-12	Upper Bayou	119,532	12.00	278.084	5.41	6,007	2.40	143,766	3.00
3-13	Lower Bayou	90,170	7.01	96,292	2.70	15,951	1.70	53,367	1.50
3-14	Hickory	304,315	8.69	181,864	1.90	88,876	1.41	54,372	1.37
3-16	Texoma Lateral	164,802	7.44	164,802	1.86	54,453	1.18	31,841	1.15
	TOTALS	1,495,197	6.96	1,498,402	2.18	258,223	1.37	400,795	1.66

TABLE 5-6

LAND USE AND AREAS OF EACH

WATERSHED IN SUB-BASIN 3-B(2)

CNI NUMBER	WATERSHED NAME	DRAINAGE AREA (ACRES)	LAND USE (ACRES)			
			CROPLAND	RANGE	PASTURE	WOODLAND
3-10	Fleetwood	143,040	61,508	52,925	14,304	14,304
3-11	Lower Mud	288,840	46,214	170,415	25,884	43,325
3-11A	Upper Mud	181,318	27,198	99,725	23,571	30,824
3-12	Upper Bayou	119,680	9,961	51,379	2,503	47,922
3-13	Lower Bayou	95,488	12,863	35,664	9,383	37,578
3-14	Hickory	233,459	35,019	95,718	63,033	39,688
3-16	Texoma Lateral	184,589	22,151	88,603	46,147	27,688
	TOTALS	1,246,414	214,914	594,429	187,825	241,329

TABLE 5-7

RCK AND T VALUES FOR THE FOUR HOMOGENEOUS LAND USE WATERSHEDS MONITORED NEAR MANGUM

LAND USE	R ·	C ·	K ·	T =	X_1
Cropland	1.33	0.38	0.24	0.29	0.04
Range	1.33	0.08	0.35	1.30	0.05
Pasture	1.33	0.13	0.20	0.46	0.02
Woodland	2.26	0.02	0.28	0.38	0.01

TABLE 5-8

RCK AND T VALUES FOR THE SEVEN CNI TEST WATERSHEDS IN SUB-BASIN 3-B(2)

WATERSHED	R ·	C ·	K ·	T =	X_2
Fleetwood	4.31	0.11	0.33	0.38	0.06
Lower Mud	4.31	0.14	0.32	0.29	0.06
Upper Mud	4.31	0.14	0.30	0.63	0.11
Upper Bayou	7.09	0.14	0.43	0.38	0.16
Lower Bayou	7.09	0.20	0.26	0.46	0.17
Hickory	8.25	0.20	0.27	0.46	0.20
Texoma Lateral	9.57	0.17	0.22	0.38	0.14

TABLE 5-9a
RESULTS OF PROGRAM TO ESTIMATE AND RANK POLLUTANT LOADS
IN THE UPPER BAYOU WATERSHED

WATERSHED 3-12 Upper Bayou

LAND USE	CROP	RANGE	PASTURE	WOODLAND	SUM	TOTAL	RANK
X	0.04	0.05	0.02	0.01			
ACLAUS	9961.	51379.	2503.	47922.	111765.		
POL 1	0.26E 06	0.12E 07	0.12E 05	0.11E 08	0.12E 08	110.231	1
POL 2	0.10E 07	0.36E 07	0.83E 05	0.43E 08	0.48E 08	428.388	1
POL 3	0.16E 08	0.12E 08	0.70E 06	0.47E 08	0.75E 08	674.251	3
POL 4	0.29E 06	0.10E 07	0.58E 05	0.14E 08	0.15E 08	138.268	1
POL 5	0.28E 04	0.39E 05	0.40E 03	0.81E 06	0.86E 06	7.654	1
POL 6	0.28E 04	0.82E 04	0.20E 03	0.44E 06	0.46E 06	4.379	1
POL 7	0.62E 05	0.97E 05	0.10E 04	0.13E 07	0.15E 07	13.164	1
POL 8	0.39E 05	0.17E 06	0.80E 03	0.18E 06	0.39E 06	3.472	1
POL 9	0.27E 05	0.39E 05	0.20E 04	0.92E 05	0.16E 06	1.433	3

X VALUE OF WATERSHED IS 0.16
TOTAL RANK= 1

(Information is from Appendix F)

of pollutant loading rates for nine pollutants from four different land uses.

The first line of Table 5-9a identifies the land use while the third line gives the area of the land use in acres (AOLAUS). The line between (line two) gives the calculated "X_1" value (used in Equation 3.4) for the monitored watersheds (0.04 for cropland from Table 5-7). The corresponding "X_2" value for the test watershed is provided on the next to the last line of Table 5-9a (0.16 from Table 5-8). The fourth through twelfth lines are the loads in pounds of each pollutant from each land use. Loading rates from Table 4-1 were utilized in Equation 4.3 to arrive at these values. For example, "POL 1" is BOD (Biochemical Oxygen Demand). The loading rate from cropland (near Mangum, since this is the monitoring site closest to the watershed) is 6.49. Equation 4.3 is:

$$L_N = \frac{L_M X_2}{X_1} \qquad (4.3)$$

By substituting in the known variables:

$$L_N = \frac{(6.49)\ (0.16)}{0.04} = 25.96 \text{ lbs/ac/yr}$$

Multiplying 25.96 by the number of acres of cropland (9961 acres from Table 5-6) gives the estimated contribution in pounds per year of BOD from cropland. This figure is 258,588 lbs/yr. The remaining contributions are calculated the same way. Totals are obtained by summing the pounds of each pollutant from all sources (the "SUM" column) then dividing by the total area of land use. This figure is then used as the basis for ranking. The ranking procedure is the same as that outlined for basins and sub-basins. A summary of the results of this program is provided in Table 5-9b. Also, in Table 5-9b are the results of ranking each watershed based on its sediment load from all sources to the receiving stream at the mouth of the watershed (Table 5-12). This allows more detail in the ranking process on the watershed level, which increases the accuracy of the results.

As can be seen from Table 5-9b, the Upper Bayou watershed has been

TABLE 5-9b

SUMMARY OF RESULTS OF COMPUTER PROGRAM TO RANK WATERSHEDS

WATERSHED NAME	RANK BY SEDIMENT CONT.	TOTAL OF RANKING BY[1] ALL OTHER POLLUTANTS	GRAND TOTAL	OVERALL RANK
Fleetwood	2	61	63	7
Lower Mud	6	56	62	6
Upper Mud	4	45	49	5
Upper Bayou	1	13	14	1
Lower Bayou	3	17	20	2
Hickory	7	24	31	3
Texoma Lateral	5	36	41	4

[1]From sum of "Rank" column of each table in the computer printout in Appendix F

identified as having the greatest potential for NPSP problems. Because loading rates are used in the ranking process, rather than comparing total pounds of pollutant from each watershed, specific problems within large watersheds may be discriminated against in the ranking process because they are masked by the total area of the watershed. Larger watersheds may actually be contributing greater amounts of pollution in total pounds but are ranked lower than smaller watersheds which contribute less pollution overall, but have a greater concentration per acre. This idea may be tested by taking the total contribution of each pollutant (from the "SUM" column of the tables in Appendix F) and ranking the watersheds based on these figures. Table 5-10 compares the results of ranking the seven watersheds by 1) loading rates; 2) total contribution; and 3) total area. Results show that the Hickory Creek watershed has the greatest total pollutant contribution, and is second in overall size. However, the Upper Bayou watershed has the highest pollutant loading rate, but is sixth in overall size. The value of this information depends on how it is to be used. If the primary concern is protecting the water quality in a downstream reservoir, then effort should be made to control NPSP from the Hickory Creek watershed. But, if protection of instream water quality for the stream segment below each watershed is the objective, as it is here, then the Upper Bayou watershed should receive the treatment. Another point to consider is that it might be less expensive and more effective to implement NPSP control measures on small areas contributing large amounts of pollutants per acre, than to try and treat NPSP problems dispersed over much larger areas, though they may have a greater contribution in total pounds.

The next step is to specify what the problems are, delineate their sources taking into consideration the effects of point source, and recommend treatment alternatives. It is beyond the scope of this paper to do a detailed study of the watershed, but by considering the information made available by the ranking process, it was possible to roughly estimate the source of NPSP problems and thereby prescribe alternative management practices.

Table 5-11 utilizes information in Table 5-5 for the Upper Bayou watershed to illustrate the relative contributions of sediment from each of the identified land uses. From this table it can be seen that cropland is the major sediment contributing land use in the watershed (in tons/acre).

TABLE 5-10

RANKING OF WATERSHEDS BY LOADING RATE, TOTAL CONTRIBUTION AND SIZE

WATERSHED NAME	WATERSHED RANKINGS		
	BY CONTRIBUTION (LB/AC/YR)	BY TOTAL CONTRIBUTION	BY SIZE
Fleetwood	7	7	5
Lower Mud	6	6	1
Upper Mud	5	5	4
Upper Bayou	1	2	6
Lower Bayou	2	4	7
Hickory	3	1	2
Texoma Lateral	4	3	3

TABLE 5-11

RELATIVE CONTRIBUTIONS OF SEDIMENT FROM SHEET EROSION FROM EACH LAND USE IN THE UPPER BAYOU WATERSHED

TOTAL TONS OF SEDIMENT FROM SHEET EROSION ON THE UPPER BAYOU	CONTRIBUTION FROM EACH SOURCE (TON/ACRE)			
	CROPLAND	RANGE	PASTURE	WOODLAND
547,389	12.00	5.41	2.4	3.0

Information for Table 5-12 comes from Table 5-9a. Each estimate of the pounds of pollutant is divided by the area of the corresponding land use to get the loading value in Table 5-9a. 0.26 E 06, is divided by the area of land use for cropland, 9961 acres, to yield 26.1 lbs/ac/yr which is the first value in Table 5-12.

Decisions such as how and what NPSP problems are to be controlled would in reality be made only after a detailed study to determine what water quality standards below the Upper Bayou watershed were being violated, the immediate effect on instream water quality, downstream conditions (reservoir water quality), and what proportion of this violation could be attributed to nonpoint sources. Again, this is beyond the scope of this paper. However, for illustration purposes, if total nitrogen were determined to be the instream standard being violated and instream water quality below the watershed is of primary concern, it would then be necessary to provide alternative measures to try to contain the source of this pollutant. These alternatives would be based on a variety of variables such as 1) effectiveness of the measure, 2) cost benefit relationships, 3) social and political acceptance, and 4) the effect of the measure on the environment.

Disregarding consideration for numbers 2,3, and 4 from the above list, and assuming that there are no point sources which contribute total N to the watershed (i.e., the burden of correcting the total N problem lies solely with nonpoint sources) then a combination of management practices might be as follows: From Table 5-12 it is known that cropland has the greatest relative contribution of total N, and that, at least theoretically, by completely controlling this source, 3.81 lbs/ac/yr could be eliminated from downstream waterways. Likewise, from Table 5-11, it was shown that cropland is also relatively the greatest contributor of sediment in terms of tons contributed per acre. This is not surprising as it has been demonstrated in numerous publications that total N is associated with soil particles (9, 10, 11). Therefore, by controlling sheet erosion from cropland in the Upper Bayou watershed the contribution of total N from this land use will be reduced or eliminated.

TABLE 5-12

RELATIVE POLLUTANT CONTRIBUTION BY LAND USE AND PARAMETER
FROM THE UPPER BAYOU WATERSHED

LAND USE	RELATIVE CONTRIBUTION OF EACH POLLUTANT (LB/AC/YR)								
	BOD	COD	SS	SO_4	NO_2+ NO_3	NH_3	ORG-N	TOT-N	TOT-P
Cropland	26.10	100.39	1606.26	29.11	.28	.28	6.22	3.81	2.71
Range	23.20	69.47	239.52	19.90	.77	.16	1.89	3.36	.77
Pasture	4.79	33.16	279.66	23.17	.16	.08	.40	.32	.80
Woodland	229.54	897.29	980.76	292.14	16.90	9.18	27.13	3.76	1.92

Several management practices are available to control nonpoint pollution. Some are institutional, such as limiting fertilizer application rates, controlling actual application methods to prevent spray drift, spills, etc., and fertilizing only during periods of low rainfall/runoff. Other practices may be structural, and these are covered in more detail.

Structural nonpoint pollution controls which reduce sediment yields and sediment adsorbed pollutants such as nitrogen basically involve:

1) Correcting or adapting to excessive slope and slope length, e.g., contour farming, terraces, and field shaping.
2) Providing avenues for proper drainage of excess water, e.g., diversions, waterways, and tile drains.
3) Maintenance of proper vegetative cover during months in which large quantities of precipitation occur (April, May, June, September, and October are considered critical months for the control of runoff (72)). Examples of best management practices directed toward proper cover are: residue management such as no till planting or conservation tillage, winter cover crops, sod-based rotations, meadowless rotations, improved soil fertility, and timing of field operations (11).
4) When the above measures do not adequately control the pollutants, a change in land use is indicated; e.g., a change from row crops to small grain crops, or a change from small grain crops to pasture.

These practices or a combination thereof should be sufficient to reduce the amount of sediment, and thereby the amount of total N reaching the stream fed by the Upper Bayou watershed. For example, by instituting one of these practices, a lower "C" value used in Equation 5.4 is obtained which reduces "X" in the same equation. If, in Table 5-9a, the X value for the test watershed (0.16) is reduced to 0.10, the result is a reduction in total N loading from 3.81 lbs /ac/yr to 2.4 lbs/ac/yr This would result in a corresponding decrease in the other pollutant parameters.

Model Verification

Discussion

Verification of this model was difficult due to the lack of sufficient data on land use, loading rates, effects of point sources, and background information on instream and watershed conditions, Information on land use, for example, varies from one source to the next because of simple differences in definitions. "Gray areas" exist between definitions of pasture and range, or range and woodland. These problems will hopefully be overcome in future 208 programs which will be designed to update current land use information, and standardize it via data from LANDSAT satellite imagery.

Another problem was the insufficient amount of data on loading rates. At the present time, only a few broad classifications of land use have been monitored. This means that the effects of certain nonpoint sources of pollution such as roadside erosion, roadside dumps, sanitary landfills, unlicensed feedlot operations, etc., as well as seasonal differences are not accounted for in the watershed ranking process. Likewise, there is no consideration for point sources and their effects. The model demonstrated only deals with the ranking of problem areas based on measured loading rates from a limited variety of nonpoint sources.

Yet another problem is the lack of detailed background information on existing watershed conditions. Factors such as in-place conservation practices, small farm ponds, upstream flood control structures, etc., are not accounted for. Likewise, neither is the "straining" effect which one land use next to the receiving stream may have on another land use higher up in the watershed. For example, the effects on the water quality of a receiving stream that a large area of heavily grazed rangeland may have, may be completely negated by a few acres of good pasture or woodland which lies between the rangeland and the receiving stream. This is because any pollutants such as sediment are filtered or "strained" out before they reach the stream. Similarly, there is no accounting for any pollutant degradation or intensification during the time it takes to actually reach the stream.

Finally, information on instream conditions is often inadequate to allow judgements on what parameter or set of parameters ought to be controlled. As an illustration of this problem, many of the sediment based transport models simply state that total N and P may be estimated as a given percent of the sediment transported from the land. However, it is difficult to differentiate in the stream between sediment from sheet erosion, gully erosion, roadside erosion, and sediment from streambank erosion, and scour. The problem is further illustrated by presenting the estimated total tons of sediment yield from the above sources (Table 5-13) and the percent contribution of each source (Table 5-14) (74). As can be seen from these tables, sheet erosion accounts roughly for 75% of the sediment delivered to the mouth of these watersheds (74). Therefore, if only instream sediment figures were used to estimate total N and P, these values would probably be unrealistically high, since these parameters are more closely associated with sheet erosion than with the other sources.

One of the greatest attributes of the model is that it is highly flexible so that as more detailed information becomes available, it may easily be incorporated into the ranking process. But for the present, it is important to bear in mind that the three levels of detail of this model (basin, sub-basin, and watershed) are to be used primarily as a process to converge on a specific nonpoint source problem area. Then at that point, it can be determined whether or not a more detailed study involving the consideration of all the problems discussed is actually warranted.

The Verification Process

Because data on nonpoint pollution loading rates only exist for those areas of the state selected for study to develop those same rates, it is difficult to estimate the effectiveness of the model to predict a given pollutant load level. However, it was possible to take the monitored land uses in one area of the state, and by the process outlined in the preceeding sections, estimate the load of various pollutants from monitored watersheds in another area of the state.

The procedure used was to take the values and loading rates already determined for the test watersheds around Mangum (see Appendix A), and the R C K T values for the monitored watersheds near Freedom and Idabel, and apply Equation 5.3 to predict the load of various pollutants from these six homogeneous watersheds. These predicted values were then compared to

TABLE 5-13

SEDIMENT YIELD (TONS) FROM ALL SOURCES IN EACH WATERSHED

IN SUB-BASIN 3-B (2) (74)

WATERSHED NAME	SEDIMENT YIELD FROM ALL SOURCES (TOTAL TONS)							
	SHEET EROSION	STREAMBANK EROSION	GULLY EROSION	ROADSIDE EROSION	SCOUR	TOTALS	TONS/ACRE	RANK
Fleetwood	451,590	41,825	28,207	28,207	12,309	562,138	3.93	2
Lower Mud	716,261	53,810	65,768	79,719	44,296	959,854	3.32	6
Upper Mud	436,271	46,671	60,814	33,943	38,678	616,377	3.40	4
Upper Bayou	547,389	8,898	133,476	17,797	32,288	739,848	6.18	1
Lower Bayou	255,781	6,820	40,925	10,231	27,283	341,040	3.57	3
Hickory	629,427	13,354	48,559	59,486	10,236	761,062	3.26	7
Texoma Lateral	415,899	55,401	89,037	53,422	1,313	615,072	3.33	5

TABLE 5-14

PERCENT CONTRIBUTION OF SEDIMENT FROM

EACH SOURCE BY WATERSHED

WATERSHED NAME	PERCENT CONTRIBUTION FROM EACH SOURCE				
	SHEET EROSION	STREAMBANK EROSION	GULLY EROSION	ROADSIDE EROSION	SCOUR
Fleetwood	80	8	5	5	2
Lower Mud	75	5	7	8	5
Upper Mud	70	8	10	6	6
Upper Bayou	75	1	18	2	4
Lower Bayou	75	2	12	3	8
Hickory	83	2	6	8	1
Texoma Lateral	68	9	14	9	1

TABLE 5-15

PREDICTED (P) AND MEASURED (M) POLLUTANT LOADS (LB /AC/YR)

AND THE RESULTING CORRELATION COEFFICIENTS

AREA	LAND USE		Pollutant Parameter BOD	COD	SS	SO_4	NO_2+NO_3	NH_3	ORG. N	TOT N	TOT P	r^2 LAND USE	OVERALL r^2
Mangum	Cropland	P	6.23	40.75	666	24.08	.31	.11	1.88	1.67	.23	.99	
vs.		M	6.49	25.03	392	7.4	.07	.07	1.56	.26	.67		
Freedom	Pasture	P	1.81	12.43	65.16	1.81	.10	.04	.68	.55	.14	.99	.93
		M	.61	4.13	34.91	2.92	.02	.01	.05	.04	.10		
	Range	P	4.63	16.07	140	3.99	.23	.09	.89	1.23	.53	.97	
		M	7.25	21.71	74.85	6.22	.24	.05	.05	1.05	.10		
Mangum	Cropland	P	20.19	57.14	269	13.49	5.04	1.39	2.72	11.64	.26	.98	
vs.		M	6.49	25.03	392	7.4	.07	.07	1.56	.26	.67		
Idabel	Pasture	P	16.52	56.23	34.31	8.68	.71	.82	1.93	1.80	.68	.25	.89
		M	2.44	16.52	139.64	11.68	.08	.04	.20	.16	.40		
	Range	P	14.25	34.52	74.89	20.55	.33	.51	1.74	2.45	.22	.95	
		M	7.25	21.71	74.85	6.72	.24	.05	.59	1.05	.24		

measured values (obtained from the monitoring program, and recorded in Appendix C), and the correlation coefficients of the predicted and measured values determined. (Procedures for determining correlation coefficients were followed as outlined in Statistical Methods (77)).

Results of Model Verification

Results of correlating predicted values with measured values (Table 5-15) for six different watersheds was very good. An overall correlation coefficient of r^2 = .93 for the watersheds near Freedom was obtained. This was to be expected since very similar land uses were correlated. The cropland watersheds had an r^2 = .99 as did the pasture watersheds. The rangeland watersheds had an r^2 value of .97 which is also significant.

With the exception of the pasture watershed, there was exceptionally good correlation between predicted and measured pollutant parameters on watersheds in the Idabel area. Pasture only had an r^2 = .25. This was probably due to large differences in R C K T values between the Mangum and Idabel watersheds (see Tables 5-7 and 5-8). The predicted values from the other two watersheds, cropland and rangeland, were much closer to measured values, having r^2 values of .98 and .95 respectively. This gave an overall r^2 value for the Idabel watersheds (predicted and measured values for all parameters, and all three watersheds) of .89.

The SCS information -- obtained independently of this study -- on sediment load contributions from various sources, reflects a concurrence with data collected in this study. The watershed having the greatest amount of sediment load was identified as the watershed having the highest potential for other nonpoint pollution problems. The land use cropland, which had the greatest amount of sediment contributed in terms of tons per acre, was also identified in the previous example as the land use in that watershed (Upper Bayou) with the greatest loading rate (lbs /ac/yr) of total N. Likewise, comparing results of the EPA National Eutrophication Survey to data gathered in this study, the general area where possible NPSP problems might occur was identified as the southwest portion of the state in both studies. This indicates that the methodology presented, based on initial investigations, is a viable tool for locating and evaluating nonpoint sources of pollution.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

The objective of this paper was to develop a model which would allow the user, for planning purposes, to locate and evaluate potential NPSP problem areas. This was accomplished through a ranking process where NPSP loading rates from a variety of land uses within basins, sub-basins, and watersheds were compared. A more sophisticated model could then be applied to these areas identified as having the greatest potential for NPSP problems to determine ways the problem might be handled.

Conclusions

In the development of the methodology, many assumptions were made dealing with the information which was available. The state of the art of nonpoint pollution modeling has not been developed to the point that any one model will apply without alterations to any given set of conditions. This may never be fully achieved but all models developed thus far have enough variables in common that at least a more sufficient data base should be developed.

Of primary importance in any model designed to estimate nonpoint pollution is the hydrology factor. Since runoff is the transport mechanism of NPSP, the amounts, distribution, and flow of water are highly significant in determining when, where, and in what quantities pollution from nonpoint sources occurs. In the model developed in this paper, techniques for estimating runoff or "water yield" from small watersheds developed by the

Soil Conservation Service were used with good results (36). The techniques are simple, straight forward, and have been field tested and shown to be effective in estimating volumes of runoff (36). These techniques were used in determing the loading rates of various pollutants from different land uses.

Land use information is only available, for large areas such as basins and sub-basins, on a limited basis since every area of the state has not yet been mapped. (Future plans call for LANDSAT satellite imagery to be employed in order to complete and update existing landuse data files). Other information on soil types, and meterological and topographical conditions is fairly complete and accurate.

By the methodology presented in this paper, and based on the available data, Basin 3, the Upper Red River, was identified as the basin exhibiting the greatest potential for NPSP problems. Likewise, within that basin, sub-basin 3-B(2) was estimated to be the sub-basin which contributed more pounds of pollutants per acre than any of the other five sub-basins. After increasing the level of detail to rank the watersheds in sub-basin 3-B (2), it was found that the Upper Bayou Watershed ranked highest in terms of pollutant contribution to the stream below that watershed. At this point, a hypothetical situation was presented where, for water quality reasons, it was desireable to reduce the amount of total nitrogen reaching the stream. It was shown that since the major source of total N, in lbs./ac., came from cropland in the Upper Bayou Watershed, a combination of management practices here could do the most good in reducing the quantities of this pollutant reaching the stream.

The process of verifying the methodology consisted of predicting the loading rates from a monitored watershed based on Equation 4.3 utilizing the loading rates established at another monitored watershed. Results showed a good correlation between predicted and measured values. When predictions based on loading rates of monitored watersheds near Mangum were made for three watersheds near Freedom, and three watersheds near Idabel, the resulting correlation coefficients, r^2, were .93 and .89 respectively.

As further verification, in an independent study conducted by the Soil Conservation Service to estimate sediment yield from the same Upper Bayou Watershed, it was found that cropland in the Upper Bayou Watershed contributed the most sediment in lbs./acre of any of the land uses monitored(74).

Since other studies indicate a good correlation between sediment and nitrogen loading (9, 10, 11), it was apparent that the model had correctly identified the major source of total nitrogen as being cropland in the Upper Bayou watershed.

This study has shown that it is possible to utilize existing information on land use types and areas, meteorologicial conditions, and geographic factors, along with NPSP loading rate data obtained through a statewide monitoring program, to estimate and evaluate nonpoint pollution loading from Oklahoma watersheds.

Recommendations

Several areas of the methodology should be refined to improve the accuracy of the model. The following recommendations are listed in order of importance in terms of where additional work is needed to achieve refinement.

1. Loading rate information should receive highest priority since ranking, and possibly future pollutant load allocations will be based on this data. Techniques for estimating runoff from various watersheds are fairly accurate. However, pollutant concentrations fluctuate a great deal, and more monitoring data is needed to study the effects of seasonal variations and antecedent conditions on runoff water quality.
2. Additional monitoring should be conducted on more specific land use categories, i.e., different kinds of forest, or grades of pasture, or conditions of rangeland. It will be desirable in the future to include divisions of "urban" (residential, commercial, industrial, etc.), and to examine the effects these sources have on water quality in combination with point source dischargers and rural nonpoint pollution.
3. More specific land use classifications should be made, and better methods of estimating the areas of each identified land use established. (This may eventually be possible through LANDSAT satellite imagery).
4. The effects of various management practices on water quality should be studied in more detail to determine their effectiveness in

controlling NPSP.

5) The model projects the source and quantities of a pollutant load. The fate of these pollutants in the streams and reservoirs will also be needed. Likewise, it will be necessary to know what effects changes in land use activities have on water quality.

6) Further verification of the model should be conducted for larger watersheds with mixed land uses to test the accuracy of the pollutant load predictions.

Eventually, detailed models such as those described in Chapter III will be utilized to predict NPSP loading rates for every watershed in the state. However, until the time and funding are available for this, the methodology developed in this study shall be used to locate and evaluate potential NPSP problem areas to determine where future funding should be disbursed to control to the extent feasible pollution resulting from nonpoint sources.

LIST OF ABBREVIATIONS

ACOG, Association of Central Oklahoma Governments
ARS, Agricultural Research Service
BMP, Best Management Practice
CN, Curve Number
CNI, Conservation Needs Inventory
EI, Soil Erosivity Index
EPA, Environmental Protection Agency
gpd, Gallons per day
INCOG, Indian Nation Council of Governments
mg/l, Milligrams per liter
NOAA, National Oceanic and Atmospheric Administration
NPDES, National Pollutant Discharge Elimination System
NPSP, Non-point sources of pollution
OCC, Oklahoma Conservation Commission
ODPC, Oklahoma Department of Pollution Control
OSDH, Oklahoma State Department of Health
PL 92-500, Public Law 92-500
SCS, Soil Conservation Service
SDR, Sediment Delivery Ratio
USDA,United States Department of Agriculture
USLE, Universal Soil Loss Equation

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APPENDIX A

Calcualted Areas of Drainage for Each Station

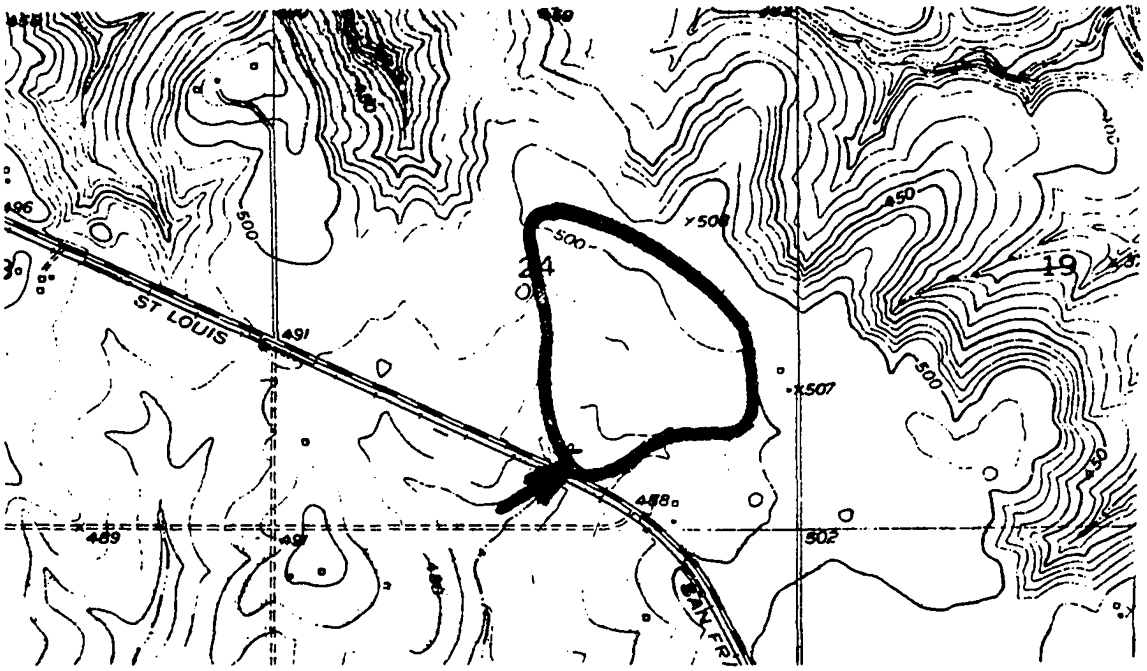
Chapter III described how the various monitoring sites were selected for this study. The following Table A-1 lists the calculated areas of drainage for each station. This was determined by planimetering USGS topographic maps of each area. The section of these maps, and the corresponding legal description of each sampling point follow Table A-1.

From the illustrations it can be seen that each drainage area is homogeneous for a particular land use. This ensures that as a sample is collected, it represents the runoff water quality for that particular land use.

TABLE A-1

Calculated Areas of Drainage for Each
NPSP Monitoring Location

LOCATION	STA. #	MI^2	ACRES	FT^2	SCS AREA	S FACTOR
Idabel (McCurtain Co)	1	0.15	94.89	$4.13x10^6$	9A	2.9
	2	0.15	94.89	$4.13x10^6$	9A	2.9
	3	0.59	376.49	$16.4x10^6$	9A	2.9
	4	0.19	120	$5.23x10^6$	9B	3.21
	5	0.15	93	$4.05x10^6$	9B	3.21
Mangum (Greer Co)	1	0.35	224.98	$9.8x10^6$	2C	4.31
	2	0.13	82.64	$3.6x10^6$	2C	4.31
	3	0.33	211.20	$9.2x10^6$	2C	4.31
	4	0.22	137.74	$5.9x10^6$	2C	4.31
Freedom (Woods Co)	1	0.14	88	$3.83x10^6$	2	3.66
	2	0.50	320	$13.94x10^6$	2	3.66
	3	0.57	365	$15.90x10^6$	2	3.66
	4	0.22	138	$6.01x10^6$	2	3.66
Tahlequah (Cherokee Co)	1	6.91	4420	$192.5x10^6$	11	5.7
	2	.086	55.0	$.024x10^6$	11	5.7
	3	.1453	92.0	$4.0x10^6$	11	5.7
	4	.043	28.0	$1.22x10^6$	11	5.7
Muskogee (Muskogee Co)	1	0.04	25	$1.1x10^6$	10B	2.48
	2	0.09	60	$2.6x10^6$	10B	2.48
	3	0.06	40	$1.7x10^6$	10B	2.48

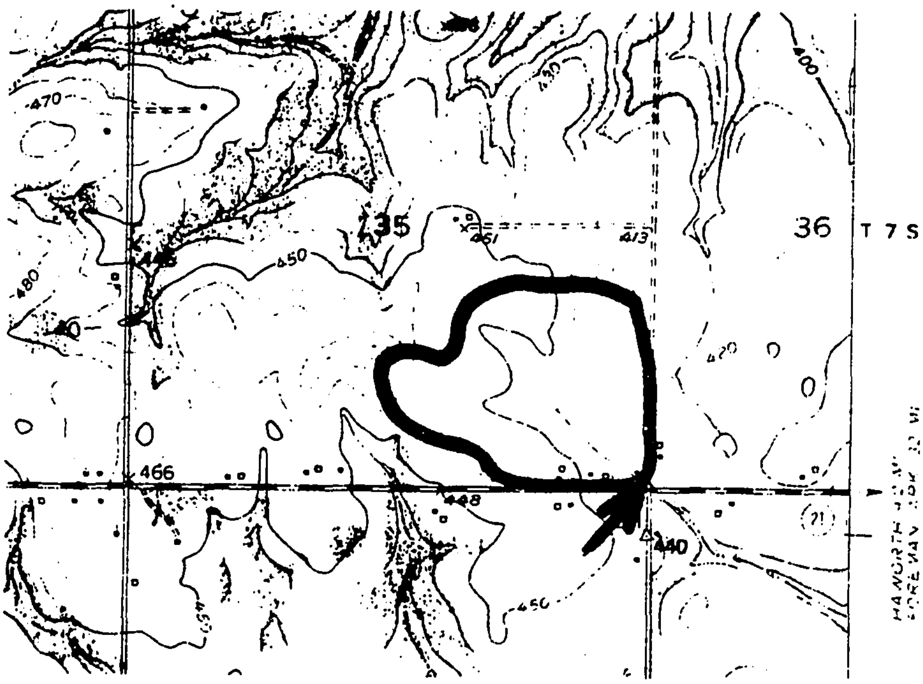


IDABEL STATION 1 RANGE

T7S R23E SEC. 24

SE SW NW

IDABEL 7.5' QUAD

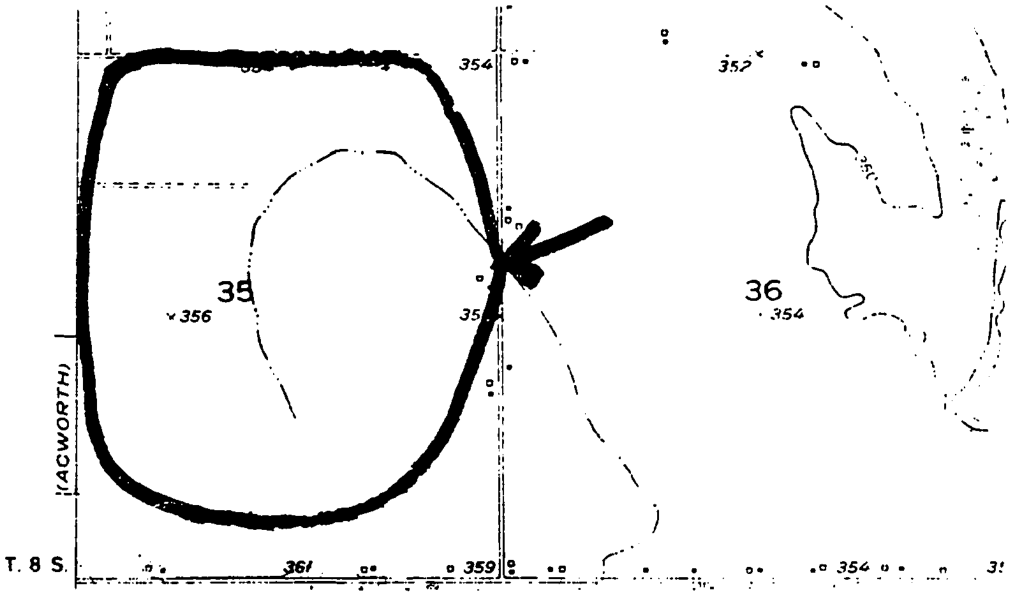


IDABEL STATION 2 PASTURE

T7S R24E SEC 35

SE SE SE

IDABEL 7.5' QUAD



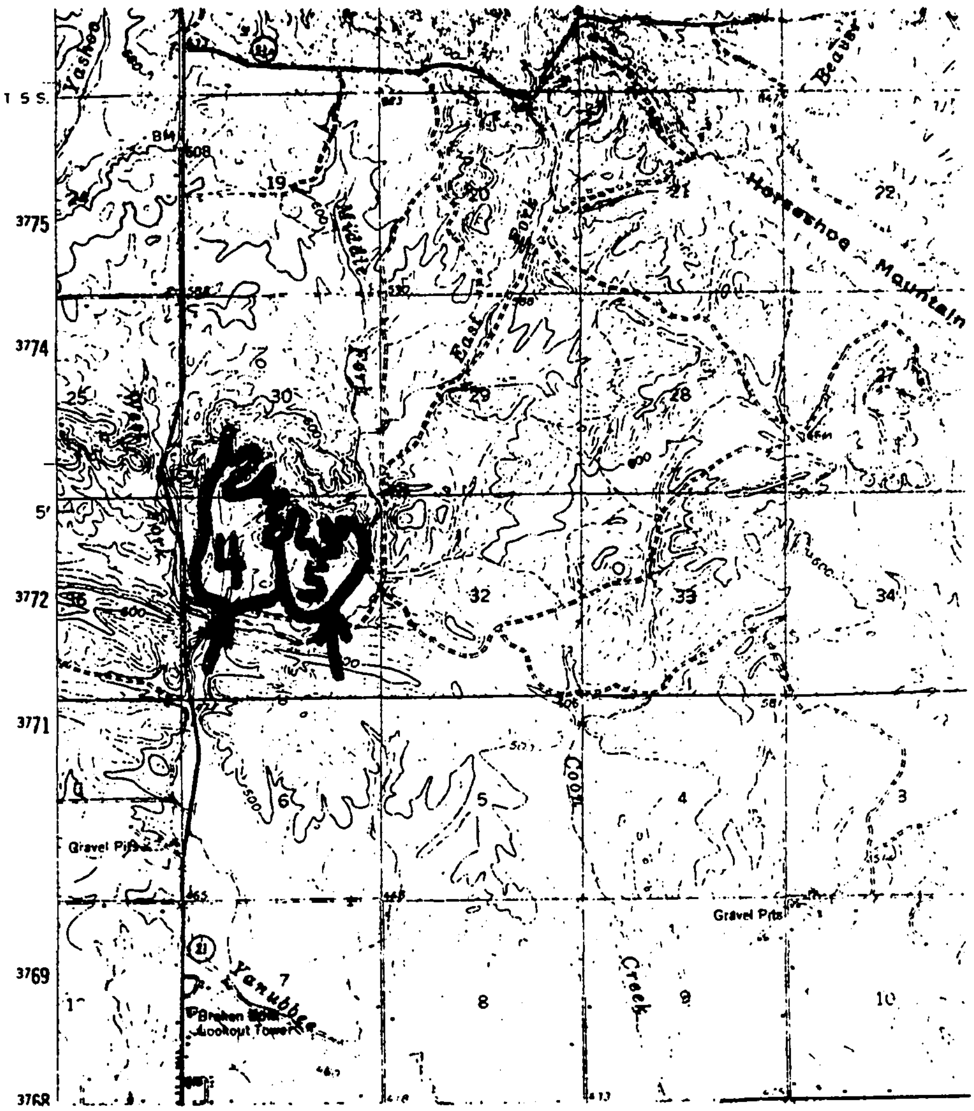
IDABEL STATION 3

T8S R23E SEC. 35

NE SE SE

LIGHT AGRICULTURE

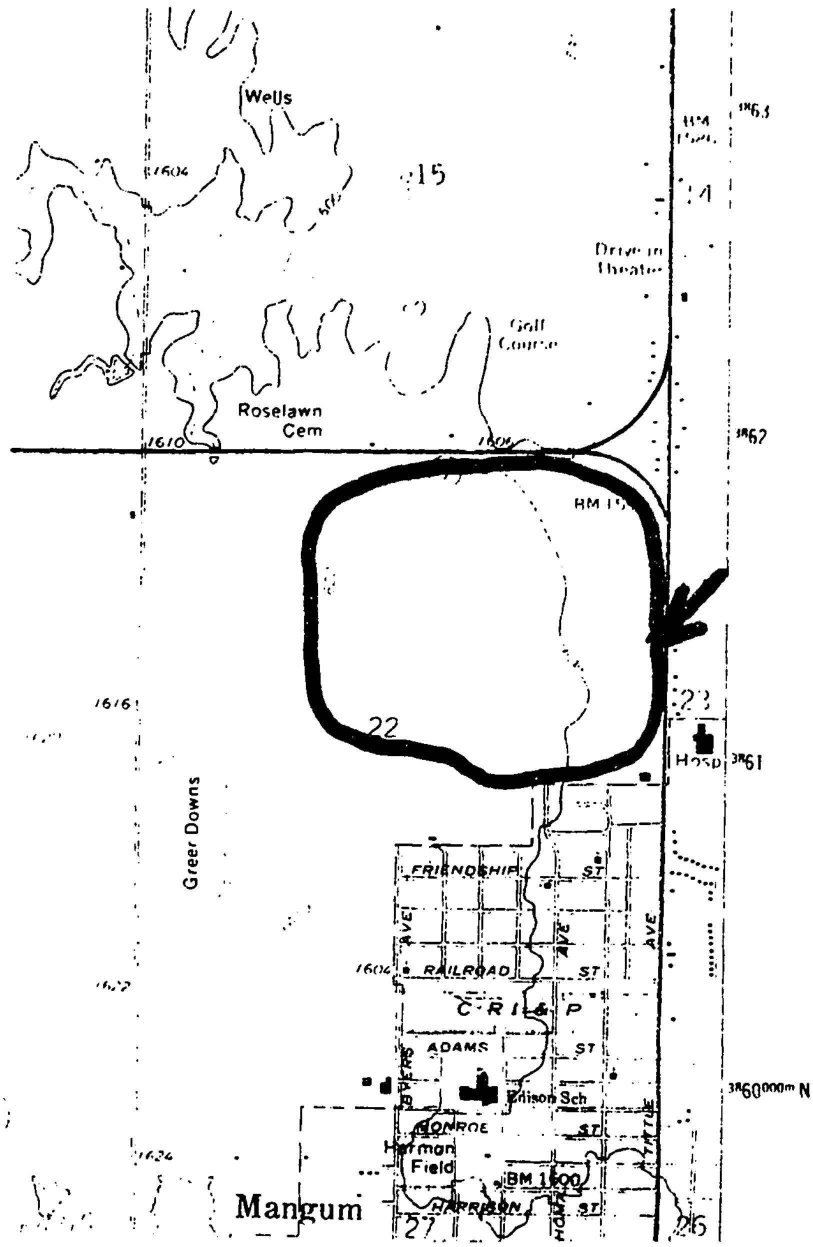
IDABEL SE 7.5' QUAD



BROKEN BOW STATION 4 SILVICULTURE
CLEAR-CUT AREA 4 YEARS OLD

BROKEN BOW STATION 5 SILVICULTURE
20 YEAR OLD STAND

T5S R24E SEC. 31
SW NE NW
BROKEN BOW 15' QUADRANGLE

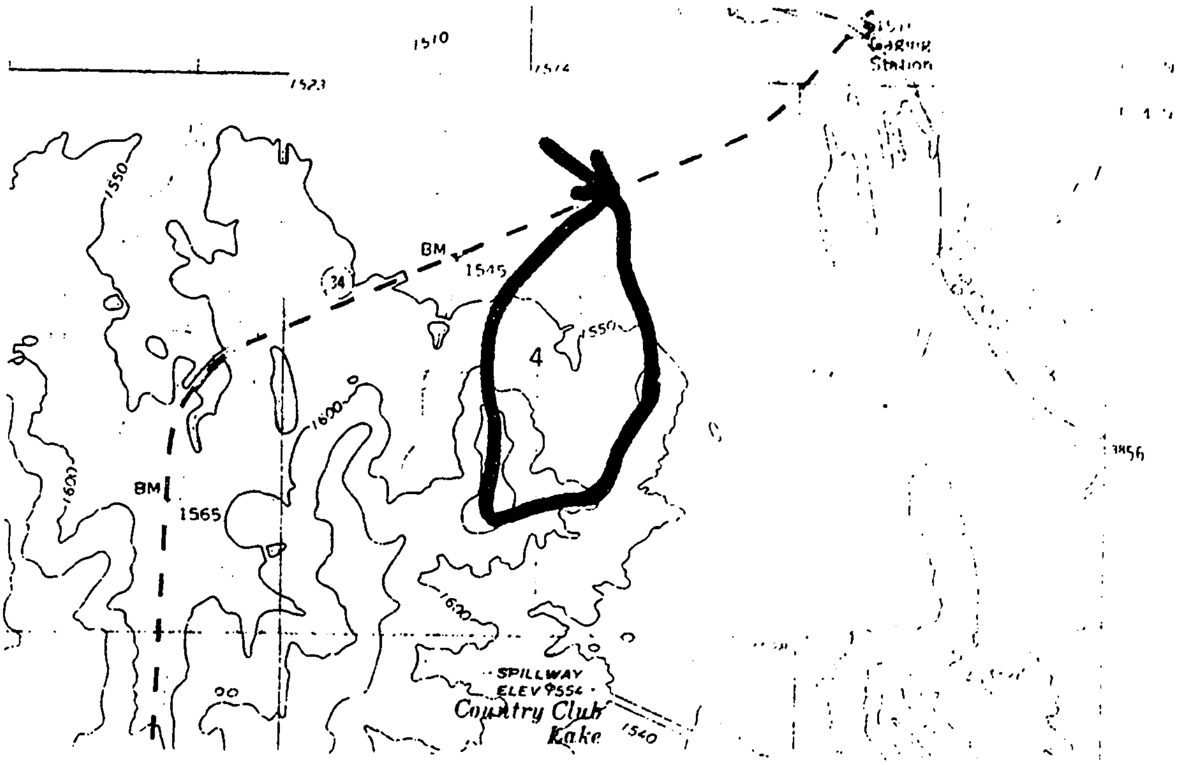


MANGUM STATION 1 LIGHT AGRICULTURE

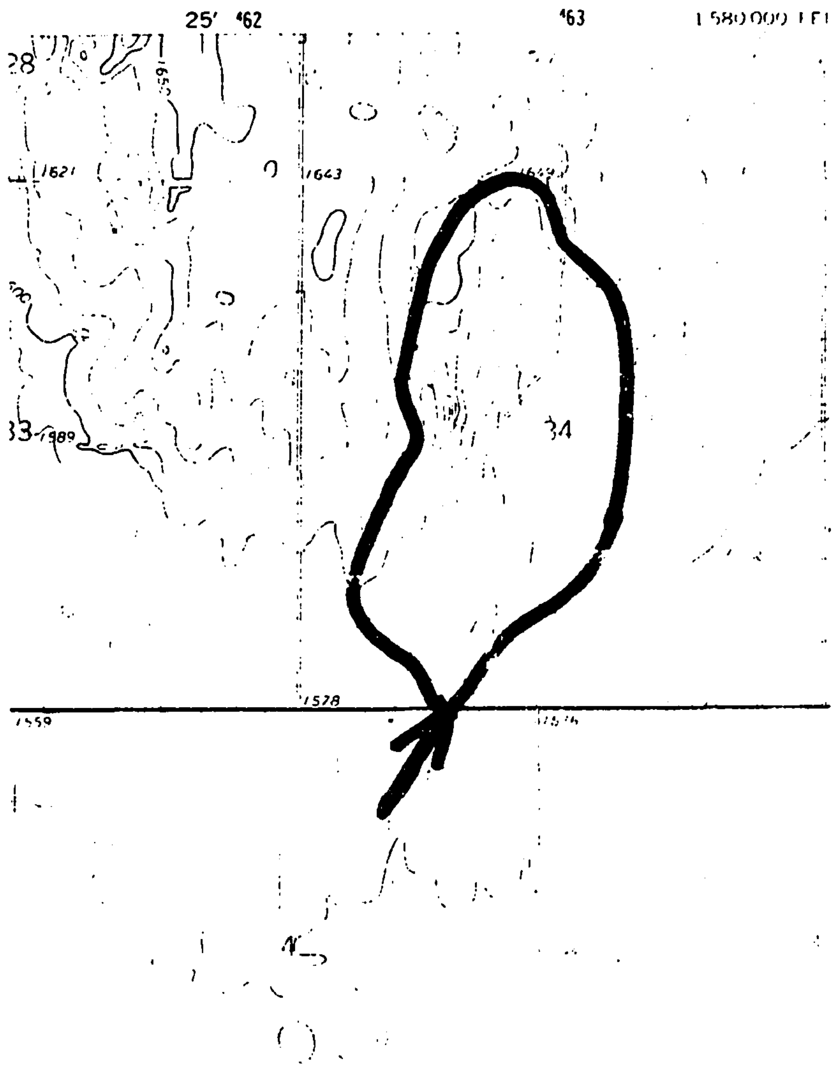
T5N R22W SEC. 22

NE SW NE

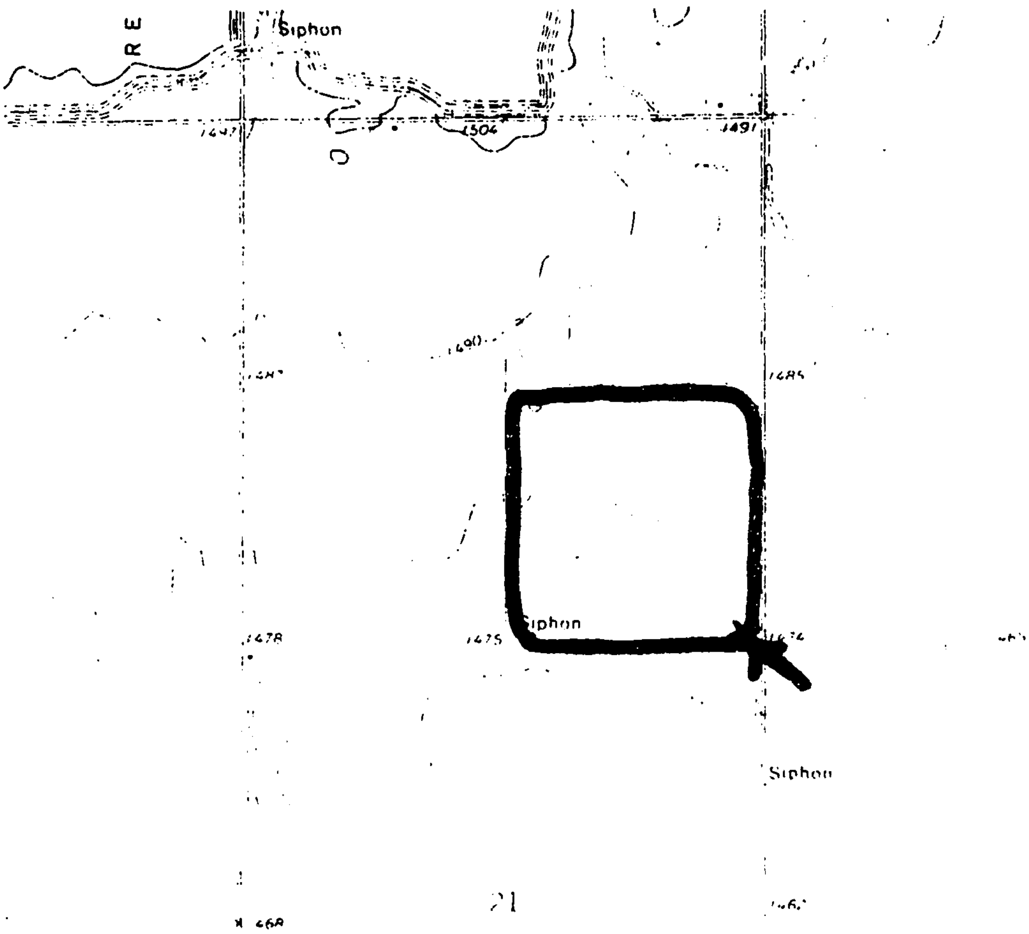
MANGUM.N 7.5' QUAD



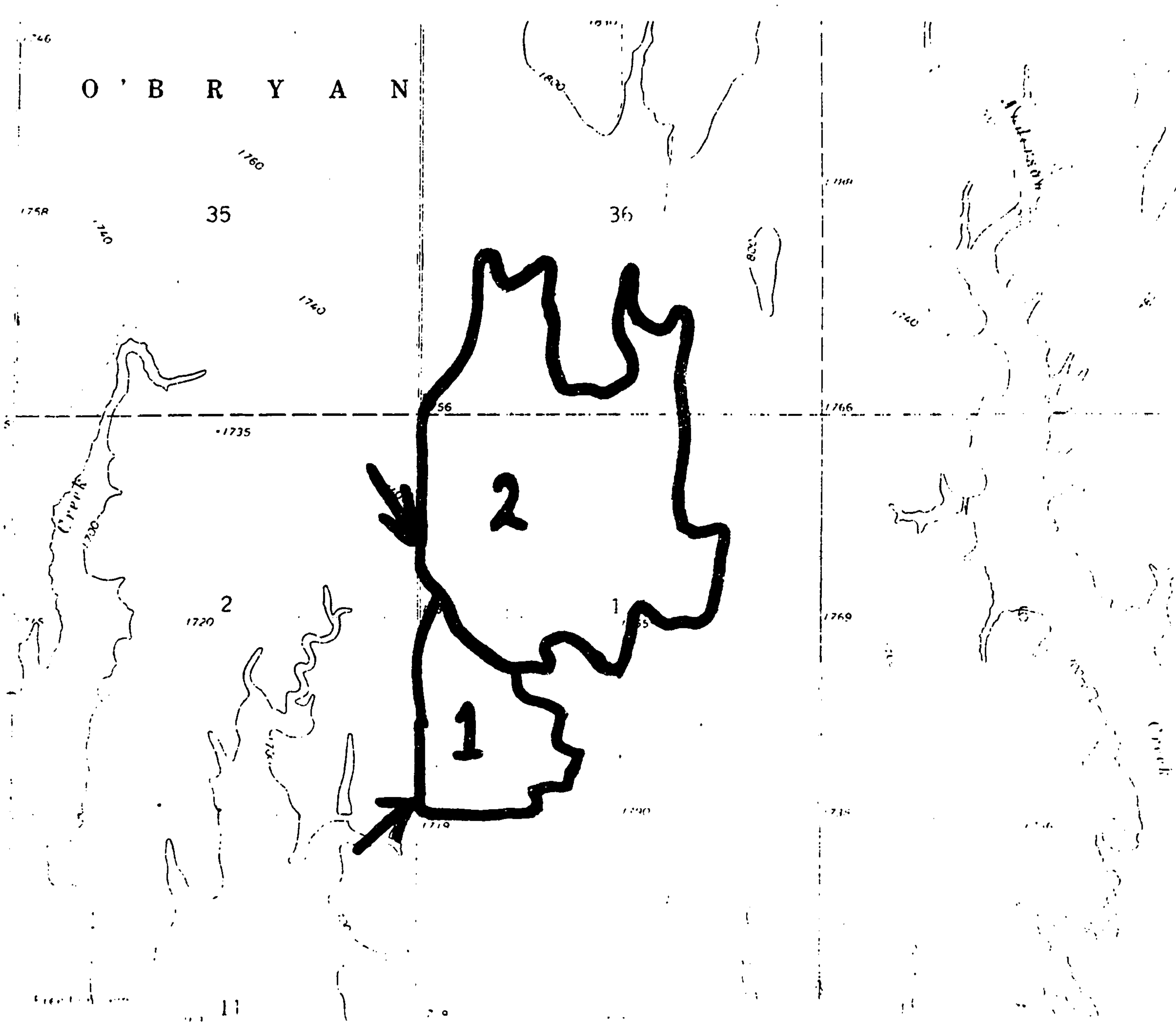
MANGUM STATION 2 RANGE
T4N R22W SEC. 4
NE NW SE
MANGUM 5 7.5' QUAD



MANGUM STATION 3 PASTURE
T4N R21W SEC. 34
SW SW SE
HESTER 7.5' QUAD



MANGUM STATION 4 HEAVY AGRICULTURE
T4N R21W SEC. 16
SE SE SE
HESTER 7.5' QUAD



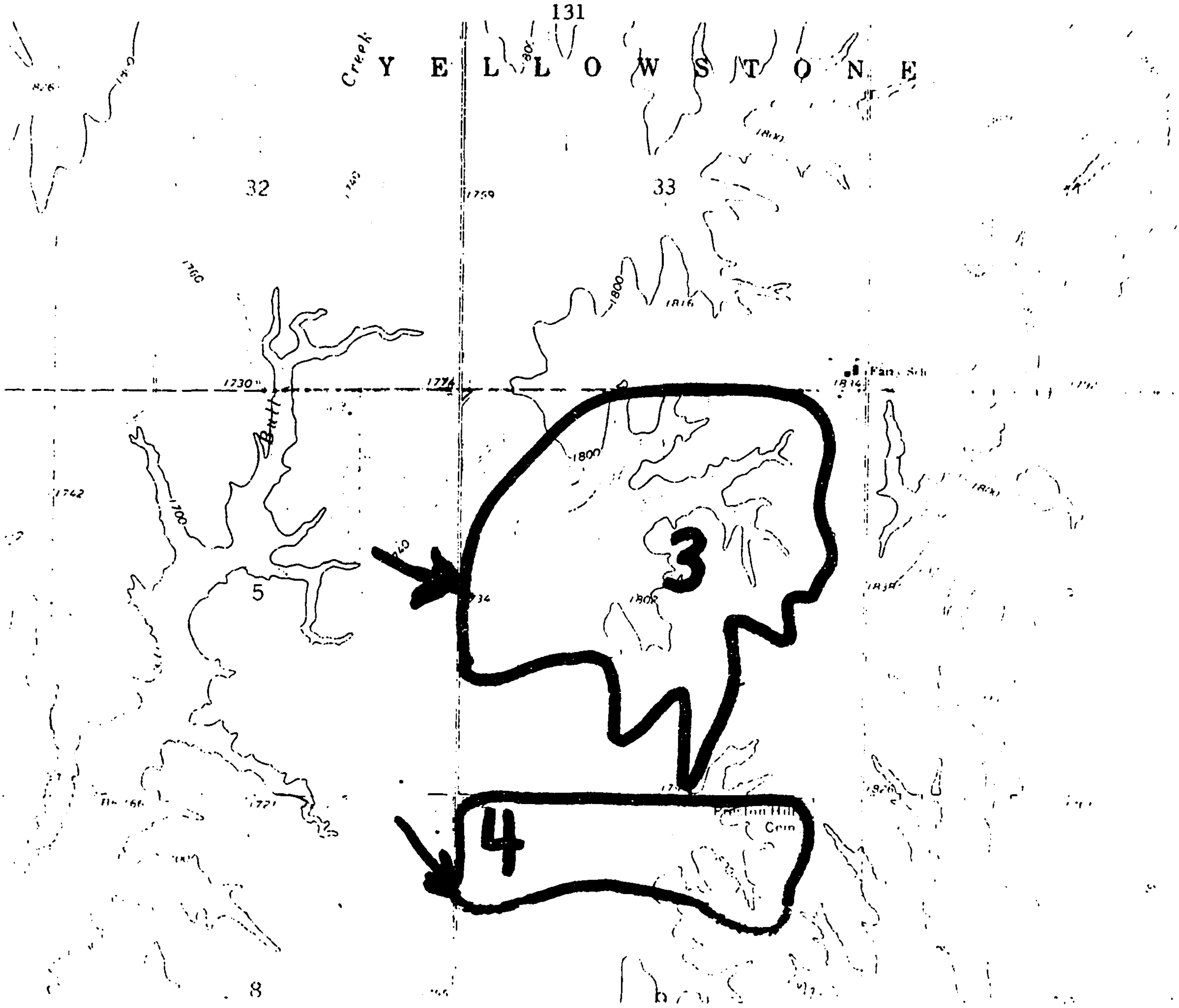
FREEDOM STATIONS 1 AND 2

SITE ONE LIGHT AGRICULTURE

T27N R18W SEC. 1 SW NW NW

SITE TWO RANGELAND

T27N R18W SEC. 1 NW SW SW



FREEDOM STATIONS 3 AND 4

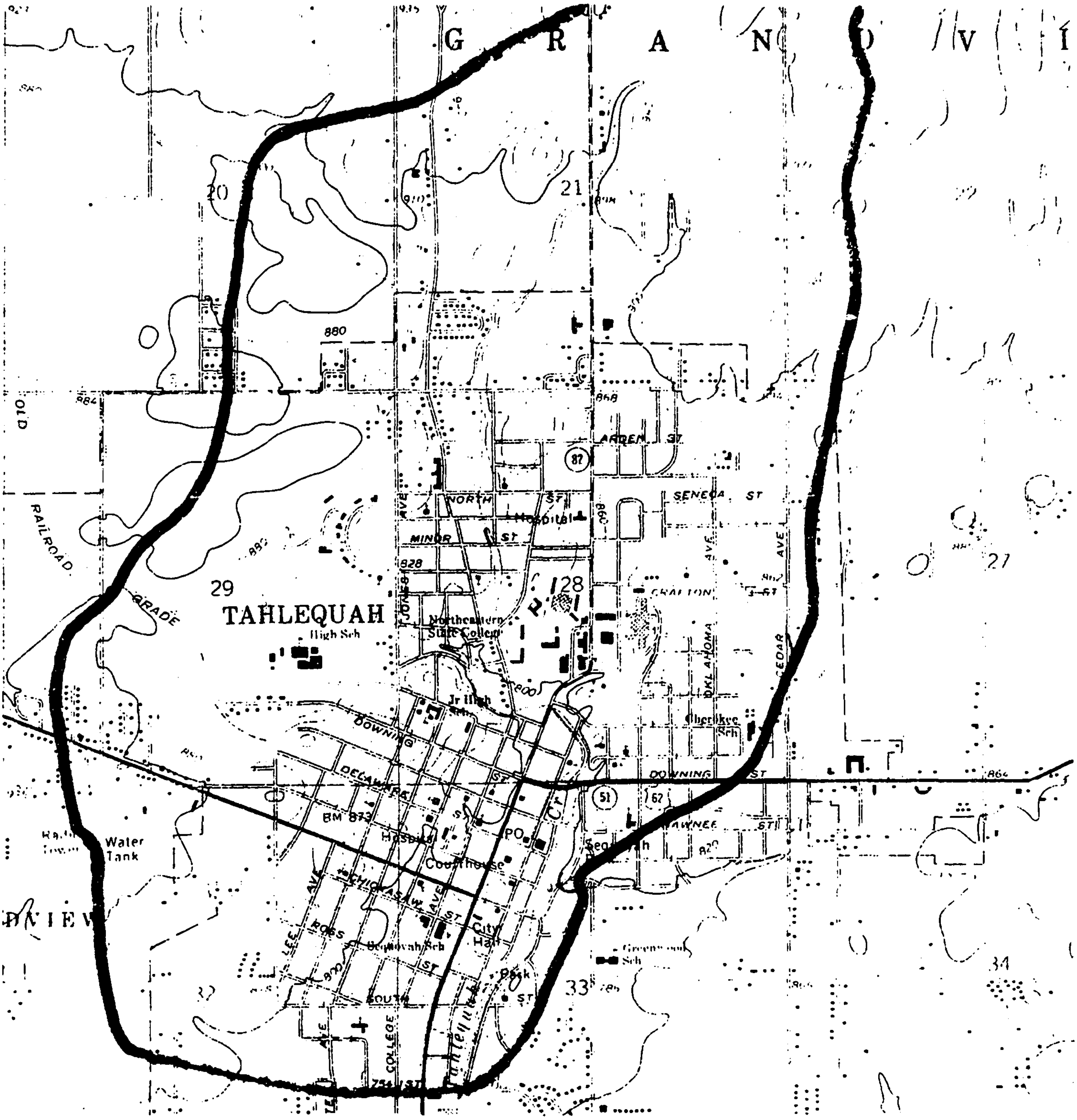
SITE THREE UNGRAZED RANGELAND

T27N R17W SEC. 4 NW SW SW

SITE FOUR PASTURE

T27N R17W SEC. 9 NW NW NW

FREEDOM 7.5' QUAD

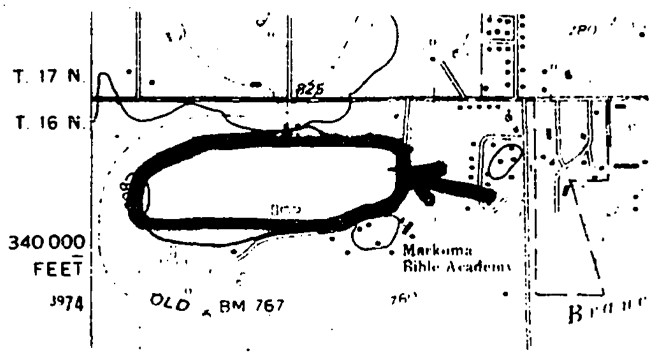


TAHLEQUAH STATION 1 URBAN AREA

T17N R22E SEC. 33

SW NW SE

7.5' TAHLEQUAH QUAD

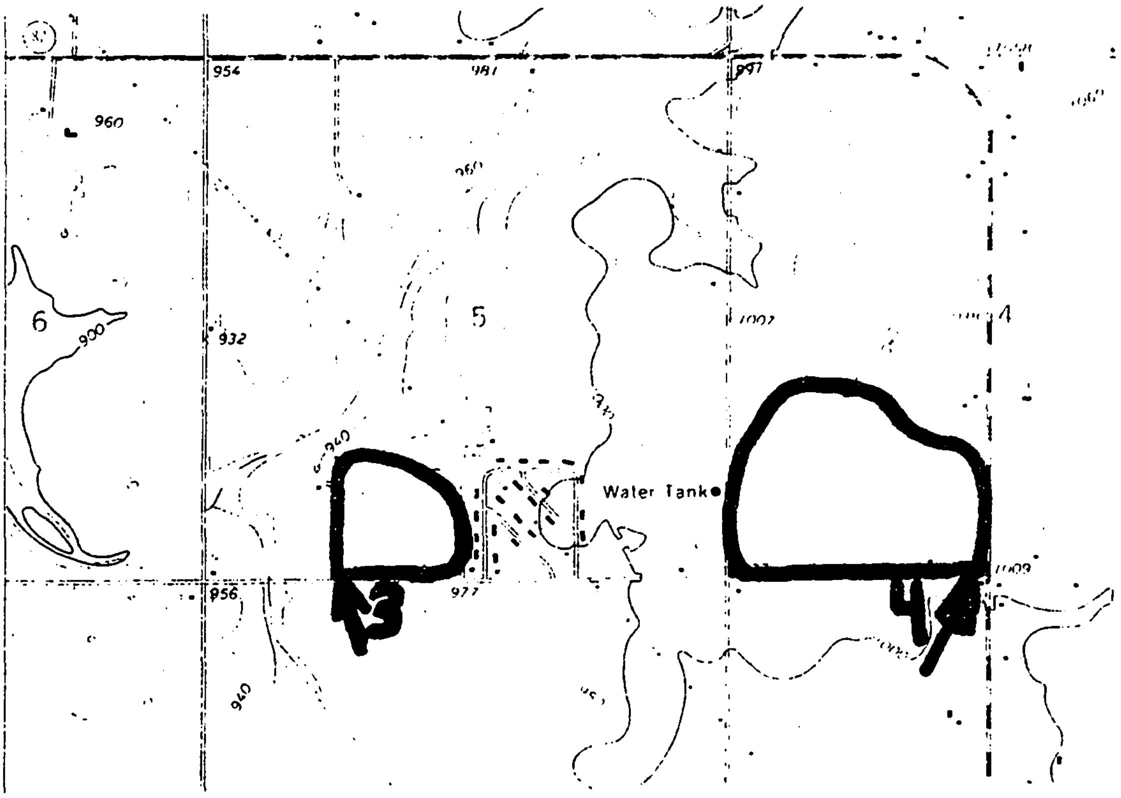


TAHLEQUAH STATION 2 LIGHT AGRICULTURE

T16N R22E SEC. 5

NE SW NE

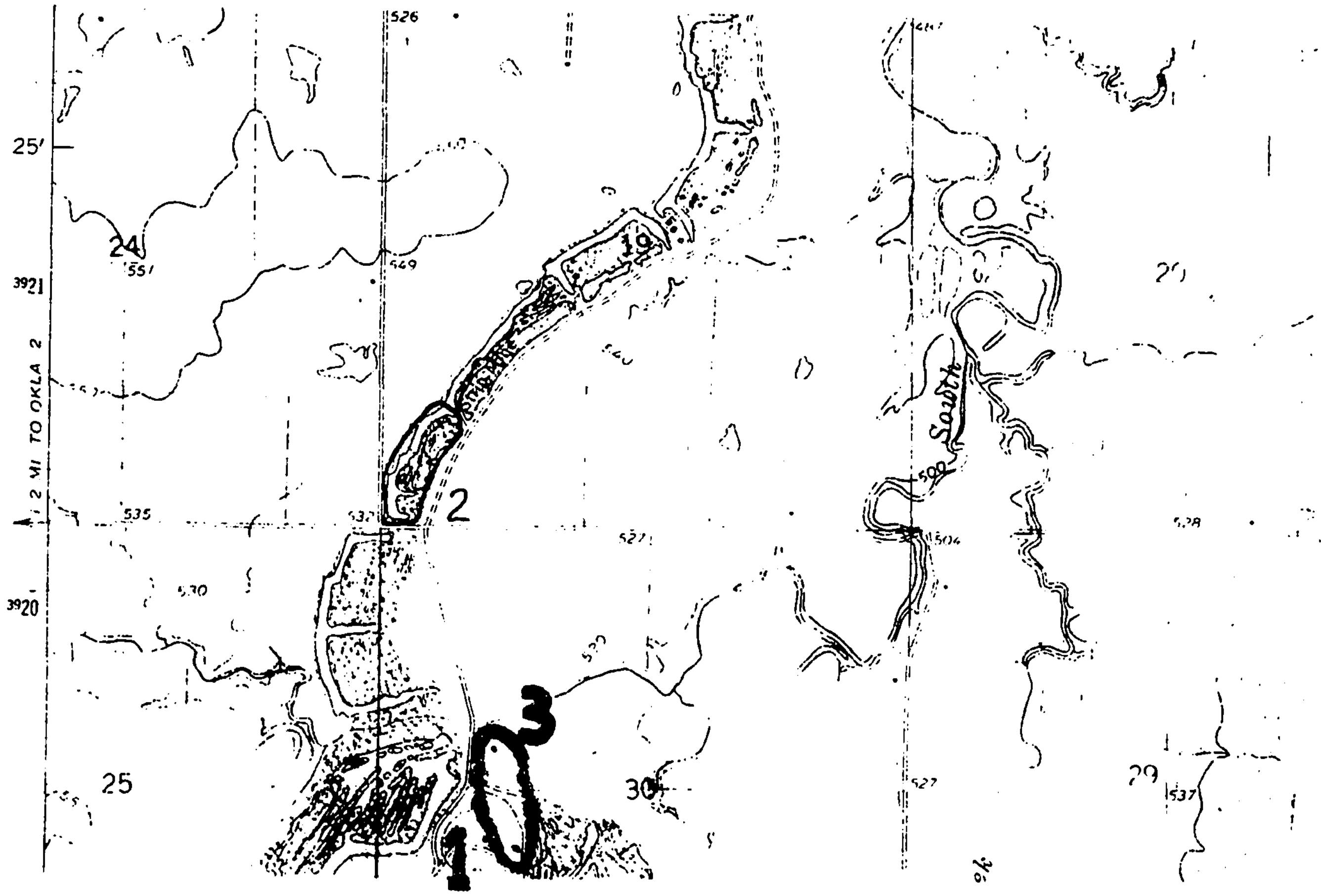
7.5' TAHLEQUAH QUAD



T17N R22E SEC. 5
SW SE SW
TAHLEQUAH RANGE
3

T17N R22E SEC. 4
SE SE SE
TAHLEQUAH PASTURE
4

7.5'
TAHLEQUAH QUAD



MUSKOGEE STA. 1 AND 3
ARE ACTIVE MINING AREAS
STATION 2 IS AN INACTIVE RECLAIMED AREA
SITE 1 IS IN T 11 N R 20E SEC. 30 SW NW SW
SITE 2 IS IN T 11 N R 20E SEC. 19 SW SW SW
SITE 3 IS IN T 11 N R 20E SEC. 30 NW SW NW
HOLT MOUNTAIN 7.5' QUAD

APPENDIX B

A Description of the Parameters Studied

This Appendix briefly describes the various parameters, including the different tests and what they measure. All parameters in this study were selected based on information obtained from past studies in the area of NPSP. The actual chemical analyses were performed by the Oklahoma State Department of Health Water Quality Laboratory following procedures outlined in Standard Methods for the Examination of Water and Wastewater, and various EPA guidelines.

BIOCHEMICAL OXYGEN DEMAND (BOD)

The BOD of a water is the amount of oxygen required by bacteria while stabilizing decomposable organic matter under aerobic conditions. The term "decomposable" means that the organic matter can serve as food and energy for the bacteria. The test is important in the evaluation of the purification capacity of receiving bodies of water. The test is difficult to run in that it takes time and several steps to produce results, and even then in many instances the results are not reproduceable. Many interferences from toxic substances can affect the results. However, the test is valuable as a reference point for the COD test which will be discussed next.

CHEMICAL OXYGEN DEMAND (COD)

The COD test is used extensively in the measurement of the pollutional strength of domestic and industrial wastes. It was used in this study to provide a means of comparing NPSP to other forms of pollution. The COD test allows the measurement of a waste in terms of the total quantity of oxygen required for oxidation to carbon dioxide and water. The test is based on the fact that all organic compounds, with a few exceptions, can be oxidized by the action of strong oxidizing agents under acid conditions. This test is more reliable than the BOD, and results are much more readily reproduceable. It is also an easier test to perform since it can usually be completed in about three hours rather than the five days required for the BOD test.

pH AND ALKALINITY

The alkalinity of water is a measure of its capacity to neutralize acids. In natural waters, alkalinity is due primarily to the salts of weak acids. Generally, if the alkalinity is high, the pH of the water is basic or neutral, which is a good condition. Throughout this study, the pH of the water seldom varied by more than one unit from the neutral condition of 7.0. This is good in that the water is non-corrosive.

SOLIDS

The amount and nature of dissolved matter occuring in liquid materials varies greatly. In potable water, most of the matter is in dissolved form and consists mainly of inorganic salts,small amounts of organic matter, and dissolved gases. The total solids content of potable waters usually ranges from 20 to 1,000 mg/l. As a rule, hardness increases with total solids. The undissolved substances are usually referred to as suspended solids. The term settleable solids is applied to solids is suspension that will settle, under quiescent conditions, because of the influence of gravity. Only the courser suspended solids with a specific gravity greater then that of water will settle.

SULFATE

The sulfate ion is one of the major anions occurring in natural waters. It is of importance in public water supplies because of its cathartic effect on humans when present in excessive amounts. Sulfate is also important in public and industrial water supplies because of its tendency to form hard "scales" in boilers and heat exchangers. The U.S. Public Health Service recommends an upper limit of 250 mg/l in waters intended for human consumption. However, concentrations of about 500 mg/l are recognized as safe for stock watering.

<u>NITROGEN</u> (NO_2,NO_3,NH_4, and ORG-N)

Nitrogen is one of the fertilizing elements essential to the growth of algae. Such growth is often stimulated to an undesireable extent in bodies of water that receive sewage or treatment plant effluents, because of the nitrogen and other fertilizing matter contributed by them. Runoff from stockyards and feedlots is another source of these elements. Nitrogen analyses are an important means of furnishing information on these problems. Nitrogen exists in nature in four basic forms -- ammonia (NH_4), organic nitrogen (ORG-N), nitrite (NO_2), and nitrate (NO_3). By knowing the relative concentration of these various forms in a body of water, the degree of pollution can often be determined. The autotrophic conversion of ammonia to nitrites and nitrates requires oxygen. The discharge of ammonia nitrogen and its subsequent oxidation impact can seriously reduce the dissolved-oxygen levels in rivers and estuaries, especially where long residence times required for the growth of the slow-growing nitrifying bacteria are available.

PHOSPHATE (PO_4)

The greatest sources of phosphate in natural bodies of water are from detergents, fertilizers from agriculture and animal and plant processing wastes. Phosphate is found in most fertilizers, and becomes a problem in lakes and streams when excessive amounts are applied then washed away with a large rainfall/runoff event. Phosphate is a parameter of interest in water quality considerations because of (1) its role in plant productivity such as algal blooms (2) its interference in coagulation (3) the difficulty of removing it from water, and (4) its characteristic of converting to other forms. Phosphate is considered to be the limiting factor in algal production, which may be detrimental to fish if too much algae is produced, resulting in oxygen depletion.

APPENDIX C
Analysis of Data Collected Through the Nonpoint Source Pollution Monitoring Program

Each table contains the background information on the location (City and County), the station number, the land use, the area in square feet, and acres of that land use, and the testing period. In the columns of each table are the date on which the sample was collected (with the number of antecedent days appearing between dates), the total rainfall amount in inches for that event on that date, the volume of runoff in million gallons, and then the concentrations of various pollutants in the runoff. Each parameter, with the exception of pH, has two rows. The first row is the concentration of the pollutant in milligrams per liter. This represents the raw data from the water sample analysis performed by the OSDH Water Quality Laboratory. Notice that many values under the parameters NO_2 and NO_3 are around 0.1 mg/l. This is the detection limit for these parameters, and in some cases, the actual value may have been something less. This holds true for the various detection limits on the other parameters as well. (For a discussion of the parameters see Appendix B).

The second row is the estimated total pounds of pollutant contributed by that land use for that particular event. This calculation is made following the steps and formulas outlined in Chapter IV. Notice that these values are often very small. In these cases it should not be taken to imply that the test is actually that accurate. The values are presented merely to demonstrate the technique and to provide an idea of the total pollutant contribution.

Appearing near the bottom of the table are some statistical calculations which demonstrate the variability of the pollutant concentration and load between events. Caution should be taken in viewing the statistical information since the number values, n, varies with some parameters, and because n may be small for some monitoring stations.

In those instances where inadequate samples were provided, only a portion of the parameters were analyzed. This created gaps in the data. Where these gaps occurred, the mean value of all previous samples was used rather than report zero.

LOCATION:TAHLEQUAH(CHEROKEE CO) STATION:1 LAND USE:URBAN AREA:192.5E 06 SQ FT TESTING PERIOD:JAN 76-AUG 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
9.17	1.75	7.08	7.8	11.000	51.000	9029.000	0.700	211.000	3.000	0.900	0.100	0.800	2.380	0.340
18				0.65E 03	0.30E 04	0.53E 06	0.41E 02	0.12E 05	0.18E 03	0.53E 02	0.59E 01	0.47E 02	0.14E 03	0.20E 02
10.05	2.50	31.44	7.5	4.000	27.000	314.000	0.500	116.000	15.000	0.440	0.100	0.800	2.380	0.260
62				0.10E 04	0.71E 04	0.82E 05	0.13E 03	0.30E 05	0.39E 04	0.12E 03	0.26E 02	0.21E 03	0.62E 03	0.68E 02
12.06	1.50	2.57	7.1	6.000	16.000	52.000	0.100	10.000	4.000	0.200	0.100	1.200	1.400	0.030
95				0.13E 03	0.34E 03	0.11E 04	0.21E 01	0.21E 03	0.86E 02	0.43E 01	0.21E 01	0.26E 02	0.30E 02	0.64E 00
3.11	1.25	0.25	7.9	0.0	59.000	72.000	1.000	277.000	10.000	0.400	0.600	1.370	2.380	0.450
16				0.0	0.12E 03	0.15E 03	0.21E 01	0.58E 03	0.21E 02	0.83E 00	0.13E 01	0.29E 01	0.50E 01	0.94E 00
3.27	2.75	42.55	7.9	22.000	46.000	102.000	1.000	257.000	6.000	0.500	0.700	1.370	2.380	0.510
25				0.78E 04	0.16E 05	0.36E 05	0.35E 03	0.91E 05	0.21E 04	0.18E 03	0.25E 03	0.49E 03	0.84E 03	0.18E 03
4.21	0.75	3.44	7.0	0.0	47.200	250.000	4.500	1201.000	24.000	0.600	0.280	1.370	2.380	1.700
29				0.0	0.14E 04	0.72E 04	0.13E 03	0.34E 05	0.69E 03	0.17E 02	0.80E 01	0.39E 02	0.68E 02	0.49E 02
5.20	1.75	7.08	7.5	7.400	71.000	78.000	1.300	1660.000	3.000	0.500	0.180	2.630	3.310	0.665
100				0.44E 03	0.42E 04	0.46E 04	0.77E 02	0.98E 05	0.18E 03	0.30E 02	0.11E 02	0.16E 03	0.20E 03	0.39E 02
8.28	1.00	0.42	7.3	7.200	60.400	55.000	0.900	431.000	25.000	0.800	0.190	1.440	2.430	0.371
0				0.25E 02	0.21E 03	0.19E 03	0.32E 01	0.15E 04	0.88E 02	0.28E 01	0.67E 00	0.51E 01	0.86E 01	0.13E 01
MINIMUM			7.0	0.0	16.000	52.000	0.100	10.000	3.000	0.200	0.100	0.800	1.400	0.030
				0.0	0.12E 03	0.15E 03	0.21E 01	0.21E 03	0.21E 02	0.83E 00	0.67E 00	0.29E 01	0.50E 01	0.64E 00
MAXIMUM			7.9	22.000	71.000	9029.000	4.500	1660.000	25.000	0.900	0.700	2.630	3.310	1.700
				0.78E 04	0.16E 05	0.53E 06	0.35E 03	0.98E 05	0.39E 04	0.18E 03	0.25E 03	0.49E 03	0.84E 03	0.18E 03
MEAN			7.5	7.200	47.200	1244.000	1.250	520.375	11.250	0.542	0.281	1.372	2.380	0.541
				0.13E 04	0.41E 04	0.83E 05	0.93E 02	0.34E 05	0.91E 03	0.50E 02	0.38E 02	0.12E 03	0.24E 03	0.45E 02
STANDARD DEVIATION			0.4	7.060	18.037	3147.126	1.363	587.767	9.130	0.223	0.237	0.570	0.511	0.504
				0.27E 04	0.55E 04	0.18E 06	0.12E 03	0.40E 05	0.14E 04	0.64E 02	0.85E 02	0.17E 03	0.32E 03	0.60E 02

1. RUNOFF VOLUME CALCULATED BY SCS CURVE NUMBER TECHNIQUE(SEE TEXT FOR EXPLANATION OF USAGE).

2. FIRST LINE IS CONCENTRATION IN MILLIGRAMS PER LITER(AS DETERMINED IN THE OSDH LABORATORY).

3. SECOND LINE IS TOTAL POUNDS OF POLLUTANT PER EVENT(SEE TEXT FOR EXPLANATION OF CALCULATION TECHNIQUE).

LOCATION:TAHLEQUAH(CHEROKEE CO) STATION:2 LAND USE:LT. AGRI AREA: .024E 06 SQ FT TESTING PERIOD:JAN 76-AUG 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
9.17	1.75	0.00	7.2	12.000	59.000	313.000	0.300	288.000	105.000	0.600	0.100	2.400	2.390	1.040
18				0.88E-01	0.43E 00	0.23E 01	0.22E-02	0.21E 01	0.77E 00	0.44E-02	0.74E-03	0.18E-01	0.18E-01	0.77E-02
10.05	2.50	0.00	7.2	3.000	24.000	89.000	0.200	188.000	3.000	0.500	0.100	1.000	1.600	0.460
37				0.98E-01	0.78E 00	0.29E 01	0.65E-02	0.61E 01	0.98E-01	0.16E-01	0.33E-02	0.33E-01	0.52E-01	0.15E-01
11.11	1.50	0.00	6.7	9.000	38.000	136.000	0.100	148.000	3.000	1.500	0.200	1.900	2.390	0.910
25				0.24E-01	0.10E 00	0.36E 00	0.27E-03	0.39E 00	0.80E-02	0.40E-02	0.80E-03	0.51E-02	0.64E-02	0.24E-02
12.06	1.50	0.00	7.3	5.000	34.000	100.000	0.300	233.000	2.000	0.500	0.100	1.700	2.100	0.620
95				0.13E-01	0.91E-01	0.27E 00	0.80E-03	0.62E 00	0.53E-02	0.13E-02	0.27E-03	0.45E-02	0.56E-02	0.17E-02
3.11	1.25	0.00	7.4	0.0	55.000	143.000	1.000	647.000	13.000	1.000	0.800	1.920	2.390	0.740
16				0.0	0.14E-01	0.37E-01	0.26E-03	0.17E 00	0.34E-02	0.26E-03	0.21E-03	0.50E-03	0.62E-03	0.19E-03
3.27	2.75	0.01	7.0	17.000	27.000	79.000	0.400	195.000	10.000	0.300	0.700	1.920	2.390	0.390
25				0.75E 00	0.12E 01	0.35E 01	0.18E-01	0.86E 01	0.44E 00	0.13E-01	0.31E-01	0.85E-01	0.11E 00	0.17E-01
4.21	0.75	0.00	5.5	0.0	45.300	187.000	1.300	958.000	22.000	0.300	0.310	1.920	2.390	2.100
29				0.0	0.16E 00	0.67E 00	0.46E-02	0.34E 01	0.79E-01	0.11E-02	0.11E-02	0.69E-02	0.85E-02	0.75E-02
5.20	1.75	0.00	6.6	4.800	53.000	43.000	0.400	370.000	9.000	0.400	0.250	1.920	2.390	0.518
100				0.35E-01	0.39E 00	0.32E 00	0.29E-02	0.27E 01	0.66E-01	0.29E-02	0.18E-02	0.14E-01	0.18E-01	0.38E-02
8.28	1.00	0.00	6.2	6.350	72.100	55.000	1.000	660.000	15.000	0.700	0.160	2.620	3.480	1.310
0				0.28E-02	0.32E-01	0.24E-01	0.44E-03	0.29E 00	0.66E-02	0.31E-03	0.70E-04	0.12E-02	0.15E-02	0.58E-03
MINIMUM			5.5	0.0	24.000	43.000	0.100	148.000	2.000	0.300	0.100	1.000	1.600	0.390
				0.0	0.14E-01	0.24E-01	0.26E-03	0.17E 00	0.34E-02	0.26E-03	0.70E-04	0.50E-03	0.62E-03	0.19E-03
MAXIMUM			7.4	17.000	72.100	313.000	1.300	958.000	105.000	1.500	0.800	2.620	3.480	2.100
				0.75E 00	0.12E 01	0.35E 01	0.18E-01	0.86E 01	0.77E 00	0.16E-01	0.31E-01	0.85E-01	0.11E 00	0.17E-01
MEAN			6.8	6.350	45.267	127.222	0.556	409.667	20.222	0.644	0.313	1.922	2.391	0.899
				0.11E 00	0.36E 00	0.12E 01	0.40E-02	0.27E 01	0.16E 00	0.49E-02	0.44E-02	0.19E-01	0.24E-01	0.62E-02
STANDARD DEVIATION			0.6	5.5729	15.9250	83.1035	0.4275	280.8330	32.4529	0.3877	0.2623	0.4494	0.4869	0.5398
				0.24	0.40	1.36	0.01	2.95	0.27	0.01	0.01	0.03	0.03	0.01

1. RUNOFF VOLUME CALCULATED BY SCS CURVE NUMBER TECHNIQUE(SEE TEXT FOR EXPLANATION OF USAGE).

2. FIRST LINE IS CONCENTRATION IN MILLIGRAMS PER LITER(AS DETERMINED IN THE OSDH LABORATORY).

3. SECOND LINE IS TOTAL POUNDS OF POLLUTANT PER EVENT(SEE TEXT FOR EXPLANATION OF CALCULATION TECHNIQUE).

LOCATION:TAHLEQUAH(CHEROKEE CO) STATION:3 LAND USE:PASTURE AREA:4.0E 05 SQ FT TESTING PERIOD:JAN 76-AUG 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
9.17	1.50	0.05	7.1	10.000	19.000	78.000	0.100	5.000	3.000	0.200	0.100	1.100	2.370	0.090
18				0.44E 01	0.84E 01	0.35E 02	0.44E-01	0.22E 01	0.13E 01	0.89E-01	0.44E-01	0.49E 00	0.11E 01	0.40E-01
10.05	2.13	0.37	7.2	4.000	17.000	138.000	0.100	0.100	3.000	0.200	0.100	0.800	2.370	0.080
37				0.12E 02	0.52E 02	0.42E 03	0.30E 00	0.30E 00	0.91E 01	0.61E 00	0.30E 00	0.24E 01	0.72E 01	0.24E 00
11.11	1.50	0.05	7.0	3.000	24.000	76.000	0.100	16.000	4.000	0.500	0.200	1.300	2.370	0.020
25				0.13E 01	0.11E 02	0.34E 02	0.44E-01	0.71E 01	0.18E 01	0.22E 00	0.89E-01	0.58E 00	0.11E 01	0.89E-02
12.06	1.50	0.05	7.3	6.000	36.000	44.000	0.100	6.000	2.000	0.300	0.100	1.000	1.200	0.070
95				0.27E 01	0.16E 02	0.20E 02	0.44E-01	0.27E 01	0.89E 00	0.13E 00	0.44E-01	0.44E 00	0.53E 00	0.31E-01
3.11	1.25	0.01	7.3	0.0	31.000	81.000	0.200	39.000	15.000	0.200	0.700	1.380	2.370	0.110
16				0.0	0.13E 01	0.35E 01	0.87E-02	0.17E 01	0.65E 00	0.87E-02	0.30E-01	0.60E-01	0.10E 00	0.48E-02
3.27	2.75	0.88	7.3	15.000	19.000	57.000	0.200	20.000	8.000	0.300	0.900	1.380	2.370	0.150
25				0.11E 03	0.14E 03	0.42E 03	0.15E 01	0.15E 03	0.59E 02	0.22E 01	0.66E 01	0.10E 02	0.17E 02	0.11E 01
4.21	0.38	0.30	6.4	0.0	30.400	107.000	0.200	104.000	14.000	0.400	0.300	1.380	2.370	0.120
29				0.0	0.75E 02	0.26E 03	0.49E 00	0.26E 03	0.35E 02	0.99E 00	0.74E 00	0.34E 01	0.58E 01	0.30E 00
5.20	1.75	0.15	6.8	3.700	28.000	29.000	0.200	21.000	3.000	0.100	0.100	2.710	2.910	0.105
100				0.45E 01	0.34E 02	0.36E 02	0.25E 00	0.26E 02	0.37E 01	0.12E 00	0.12E 00	0.33E 01	0.36E 01	0.13E 00
8.28	1.00	0.01	6.4	5.210	69.600	18.000	1.300	695.000	7.000	0.400	0.230	1.380	3.000	0.585
0				0.38E 00	0.51E 01	0.13E 01	0.95E-01	0.51E 02	0.51E 00	0.29E-01	0.17E-01	0.10E 00	0.22E 00	0.43E-01
MINIMUN			6.4	0.0	17.000	18.000	0.100	0.100	2.000	0.100	0.100	0.800	1.200	0.020
				0.0	0.13E 01	0.13E 01	0.87E-02	0.30E 00	0.51E 00	0.87E-02	0.17E-01	0.60E-01	0.10E 00	0.48E-02
MAXIMUM			7.3	15.000	69.600	138.000	1.300	695.000	15.000	0.500	0.900	2.710	3.000	0.585
				0.11E 03	0.14E 03	0.42E 03	0.15E 01	0.26E 03	0.59E 02	0.22E 01	0.66E 01	0.10E 02	0.17E 02	0.11E 01
MEAN			7.0	5.212	30.444	69.778	0.278	100.678	6.556	0.289	0.333	1.381	2.379	0.148
				0.15E 02	0.38E 02	0.14E 03	0.31E 00	0.55E 02	0.12E 02	0.49E 00	0.89E 00	0.23E 01	0.41E 01	0.21E 00
STANDARD DEVIATION			0.4	4.7740	16.0255	37.8212	0.3866	225.0820	4.9272	0.1269	0.2947	0.5402	0.5071	0.1679
				36.01	45.45	179.62	0.47	89.21	20.60	0.72	2.17	3.24	5.64	0.35

1. RUNOFF VOLUME CALCULATED BY SCS CURVE NUMBER TECHNIQUE(SEE TEXT FOR EXPLANATION OF USAGE).

2. FIRST LINE IS CONCENTRATION IN MILLIGRAMS PER LITER(ASDETERMINED IN THE OSDH LABORATORY).

3. SECOND LINE IS TOTAL POUNDS OF POLLUTANT PER EVENT(SEE TEXT FOR EXPLANATION OF CALCULATION TECHNIQUE).

LOCATION:TAHLEQUAH(CHEROKEE CO) STATION:4 LAND USE:RANGE AREA:1.22E 06 SQ FT TESTING PERIOD:JAN 76-AUG 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
9.17	1.50	0.02	7.2	9.000	22.000	4100.000	0.100	28.000	14.000	0.400	0.100	1.100	1.370	0.090
18				0.12E 01	0.30E 01	0.56E 03	0.14E-01	0.38E 01	0.19E 01	0.54E-01	0.14E-01	0.15E 00	0.19E 00	0.12E-01
10.05	2.13	0.11	7.2	3.000	24.000	196.000	0.100	41.000	3.000	0.200	0.800	0.900	1.370	0.090
37				0.28E 01	0.22E 02	0.18E 03	0.93E-01	0.38E 02	0.28E 01	0.19E 00	0.74E 00	0.84E 00	0.13E 01	0.84E-01
11.11	1.50	0.02	7.0	5.000	46.000	80.000	0.100	140.000	3.000	0.500	0.100	2.400	1.370	0.110
25				0.68E 00	0.62E 01	0.11E 02	0.14E-01	0.19E 02	0.41E 00	0.68E-01	0.14E-01	0.33E 00	0.19E 00	0.15E-01
12.06	1.50	0.02	7.3	6.000	36.000	44.000	0.100	6.000	2.000	0.300	0.100	1.000	1.200	0.070
95				0.81E 00	0.49E 01	0.60E 01	0.14E-01	0.81E 00	0.27E 00	0.41E-01	0.14E-01	0.14E 00	0.16E 00	0.95E-02
3.11	1.25	0.00	6.9	0.0	44.000	77.000	0.600	240.000	13.000	0.500	0.700	1.110	1.370	0.170
16				0.0	0.58E 00	0.10E 01	0.79E-02	0.32E 01	0.17E 00	0.66E-02	0.92E-02	0.15E-01	0.18E-01	0.22E-02
3.27	2.75	0.27	7.0	25.000	68.000	101.000	16.000	455.000	10.000	0.200	1.000	0.0	1.370	0.270
25				0.56E 02	0.15E 03	0.23E 03	0.36E 02	0.10E 04	0.22E 02	0.45E 00	0.22E 01	0.0	0.31E 01	0.61E 00
4.21	0.50	0.06	6.1	0.0	38.100	126.000	0.300	246.000	22.000	0.300	0.380	1.110	1.370	0.330
29				0.0	0.20E 02	0.65E 02	0.15E 00	0.13E 03	0.11E 02	0.15E 00	0.20E 00	0.57E 00	0.70E 00	0.17E 00
5.20	1.75	0.04	6.8	4.500	35.000	30.000	0.100	16.000	3.000	0.200	0.150	1.590	1.940	0.150
100				0.17E 01	0.13E 02	0.11E 02	0.37E-01	0.60E 01	0.11E 01	0.75E-01	0.56E-01	0.59E 00	0.73E 00	0.56E-01
8.28	1.00	0.00	6.6	6.560	30.000	20.000	0.100	24.000	4.000	0.100	0.100	0.780	0.980	0.072
0				0.15E 00	0.67E 00	0.45E 00	0.22E-02	0.54E 00	0.89E-01	0.22E-02	0.22E-02	0.17E-01	0.22E-01	0.16E-02
MINIMUN			6.1	0.0	22.000	20.000	0.100	6.000	2.000	0.100	0.100	0.0	0.980	0.070
				0.0	0.58E 00	0.45E 00	0.22E-02	0.54E 00	0.89E-01	0.22E-02	0.22E-02	0.0	0.18E-01	0.16E-02
MAKIMUM			7.3	25.000	68.000	4100.000	16.000	455.000	22.000	0.500	1.000	2.400	1.940	0.330
				0.56E 02	0.15E 03	0.56E 03	0.36E 02	0.10E 04	0.22E 02	0.45E 00	0.22E 01	0.84E 00	0.31E 01	0.61E 00
MEAN			6.9	6.562	38.122	530.444	1.944	132.889	8.222	0.300	0.381	1.110	1.371	0.150
				0.71E 01	0.25E 02	0.12E 03	0.40E 01	0.14E 03	0.45E 01	0.12E 00	0.37E 00	0.29E 00	0.71E 00	0.11E 00
STANDARD DEVIATION			0.4	7.814	13.824	1339.669	5.274	153.761	6.960	0.141	0.359	0.641	0.251	0.093
				18.46	48.70	184.99	11.98	335.29	7.61	0.14	0.75	0.31	0.98	0.20

1. RUNOFF VOLUME CALCULATED BY SCS CURVE NUMBER TECHNIQUE(SEE TEXT FOR EXPLANATION OF USAGE).

2. FIRST LINE IS CONCENTRATION IN MILLIGRAMS PER LITER(ABSDETERMINED IN THE OSDH LABORATORY).

3. SECOND LINE IS TOTAL POUNDS OF POLLUTANT PER EVENT(SEE TEXT FOR EXPLANATION OF CALCULATION TECHNIQUE).

LOCATION:MANGUM(GREER CO)   STATION:1   LAND USE:LT. AGRI   AREA:9.8E 06 SQ FT   TESTING PERIOD:JAN 76-JUNE 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
4.15	0.70	0.04	6.3	1.500	46.000	119.000	1.400	267.000	3.000	0.200	1.000	2.000	1.810	0.286
13				0.48E 00	0.15E 02	0.38E 02	0.45E 00	0.86E 02	0.97E 00	0.64E-01	0.32E 00	0.64E 00	0.58E 00	0.92E-01
4.28	1.20	0.15	6.0	15.000	43.000	176.000	0.500	96.000	2.000	1.100	0.500	1.500	3.000	0.120
354				0.19E 02	0.54E 02	0.22E 03	0.63E 00	0.12E 03	0.25E 01	0.14E 01	0.63E 00	0.19E 01	0.38E 01	0.15E 00
4.17	3.70	6.88	7.2	20.000	130.000	301.000	1.800	1912.000	35.000	0.200	0.200	4.800	1.810	1.180
16				0.11E 04	0.75E 04	0.17E 05	0.10E 03	0.11E 06	0.20E 04	0.11E 02	0.11E 02	0.28E 03	0.10E 03	0.68E 02
5.03	1.50	0.50	6.4	16.000	51.000	93.000	0.700	412.000	17.000	0.100	0.100	2.230	1.810	0.390
6				0.67E 02	0.21E 03	0.39E 03	0.29E 01	0.17E 04	0.71E 02	0.42E 00	0.42E 00	0.93E 01	0.76E 01	0.16E 01
5.09	1.50	0.50	6.3	19.000	42.700	76.000	0.100	244.000	22.000	0.100	0.150	1.853	1.810	0.338
1				0.80E 02	0.18E 03	0.32E 03	0.42E 00	0.10E 04	0.92E 02	0.42E 00	0.63E 00	0.78E 01	0.76E 01	0.14E 01
5.10	2.00	1.45	6.4	8.000	24.000	63.000	0.100	134.000	25.000	0.200	0.100	1.700	1.810	0.130
10				0.97E 02	0.29E 03	0.76E 03	0.12E 01	0.16E 04	0.30E 03	0.24E 01	0.12E 01	0.21E 02	0.22E 02	0.16E 01
5.20	6.00	17.07	6.4	20.200	137.000	65.000	1.200	205.000	9.000	0.100	0.100	1.954	2.100	0.318
6				0.29E 04	0.15E 05	0.93E 04	0.17E 03	0.30E 05	0.13E 04	0.14E 02	0.14E 02	0.28E 03	0.30E 03	0.45E 02
5.26	4.50	10.17	6.4	9.000	1.600	42.000	0.600	209.000	8.000	0.100	0.100	1.800	0.319	1.800
0				0.76E 03	0.14E 03	0.36E 04	0.51E 02	0.18E 05	0.68E 03	0.85E 01	0.85E 01	0.15E 03	0.27E 02	0.15E 03
MINIMUN			6.0	1.500	1.600	42.000	0.100	96.000	2.000	0.100	0.100	1.500	0.319	0.120
				0.48E 00	0.15E 02	0.38E 02	0.42E 00	0.86E 02	0.97E 00	0.64E-01	0.32E 00	0.64E 00	0.58E 00	0.92E-01
MAXIMUM			7.2	20.200	130.000	301.000	1.800	1912.000	35.000	1.100	1.000	4.800	3.000	1.800
				0.29E 04	0.15E 05	0.17E 05	0.17E 03	0.11E 06	0.20E 04	0.14E 02	0.14E 02	0.28E 03	0.30E 03	0.15E 03
MEAN			6.4	13.587	55.662	116.875	0.800	435.375	15.125	0.262	0.281	2.230	1.909	0.570
				0.63E 03	0.29E 04	0.40E 04	0.41E 02	0.20E 05	0.55E 03	0.49E 01	0.47E 01	0.93E 02	0.59E 02	0.34E 02
STANDARD DEVIATION			0.3	6.7647	42.3089	85.2248	0.6141	604.0852	11.6550	0.3420	0.3206	1.0606	0.7293	0.5990
				1000.20	5585.38	6224.05	64.13	37759.84	735.00	5.67	5.78	127.93	102.63	54.53

1. RUNOFF VOLUME CALCULATED BY SCS CURVE NUMBER TECHNIQUE(SEE TEXT FOR EXPLANATION OF USAGE).

2. FIRST LINE IS CONCENTRATION IN MILLIGRAMS PER LITER(ASDETERMINED IN THE OSDH LABORATORY).

3. SECOND LINE IS TOTAL POUNDS OF POLLUTANT PER EVENT(SEE TEXT FOR EXPLANATION OF CALCULATION TECHNIQUE).

LOCATION:MANGUM(GREER CO)   STATION:2   LAND USE:RANGE   AREA:3.6E 06 SQ FT   TESTING PERIOD:JAN 76-JUNE 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
4.15	0.70	0.01	6.9	17.000	58.000	188.000	1.200	247.000	3.000	0.200	1.900	2.000	2.770	0.676
13				0.20E 01	0.69E 01	0.22E 02	0.14E 00	0.29E 02	0.35E 00	0.24E-01	0.22E 00	0.24E 00	0.33E 00	0.80E-01
4.28	1.20	0.06	7.1	11.000	81.000	235.000	0.200	99.000	2.000	0.600	0.400	1.700	2.600	0.770
57				0.51E 01	0.23E 02	0.11E 03	0.92E-01	0.46E 02	0.92E 00	0.28E 00	0.18E 00	0.78E 00	0.12E 01	0.34E 00
6.24	1.00	0.01	7.4	13.000	37.000	184.000	0.500	518.000	5.000	0.700	0.500	1.400	2.770	1.100
297				0.10E 01	0.30E 01	0.15E 02	0.40E-01	0.42E 02	0.40E 00	0.56E-01	0.40E-01	0.11E 00	0.22E 00	0.99E-01
4.17	3.70	2.53	7.5	22.000	64.800	262.000	0.100	207.000	24.000	1.000	0.080	2.190	2.770	0.750
16				0.46E 03	0.14E 04	0.55E 04	0.21E 01	0.44E 04	0.51E 03	0.21E 02	0.17E 01	0.46E 02	0.58E 02	0.16E 02
5.03	1.50	0.18	6.7	16.000	64.000	157.000	0.800	360.000	24.000	0.300	0.100	2.190	2.770	0.520
6				0.25E 02	0.99E 02	0.24E 03	0.12E 01	0.55E 03	0.37E 02	0.46E 00	0.15E 00	0.34E 01	0.43E 01	0.80E 00
5.09	1.50	0.18	7.1	17.000	42.000	272.000	0.100	192.000	44.000	0.400	0.100	2.750	2.770	0.424
1				0.26E 02	0.65E 02	0.42E 03	0.15E 00	0.30E 03	0.69E 02	0.62E 00	0.15E 00	0.42E 01	0.43E 01	0.65E 00
5.10	2.00	0.53	7.4	10.000	38.000	231.000	0.200	85.000	51.000	0.300	0.100	2.300	2.770	0.270
10				0.44E 02	0.17E 03	0.10E 04	0.89E 00	0.38E 03	0.23E 03	0.13E 01	0.44E 00	0.10E 02	0.12E 02	0.10E 01
5.20	0.60	0.04	7.2	5.000	34.000	169.000	1.500	1623.000	33.000	0.500	0.100	3.910	4.410	1.240
6				0.16E 01	0.11E 02	0.54E 02	0.48E 00	0.52E 03	0.10E 02	0.16E 00	0.32E-01	0.12E 01	0.14E 01	0.39E 00
5.26	4.50	3.74	7.2	10.300	29.900	177.000	0.500	98.000	36.000	0.200	0.100	1.300	1.300	0.320
0				0.32E 03	0.93E 03	0.55E 04	0.16E 02	0.31E 04	0.11E 04	0.62E 01	0.31E 01	0.41E 02	0.41E 02	0.10E 02
MINIMUN			6.7	5.000	29.900	157.000	0.100	85.000	2.000	0.200	0.080	1.300	1.300	0.270
				0.10E 01	0.30E 01	0.15E 02	0.40E-01	0.29E 02	0.36E 00	0.24E-01	0.32E-01	0.11E 00	0.22E 00	0.80E-01
MAXIMUM			7.5	22.000	64.800	272.000	1.500	1623.000	51.000	1.000	1.900	3.910	4.410	1.240
				0.46E 03	0.14E 04	0.55E 04	0.16E 02	0.44E 04	0.11E 04	0.21E 02	0.31E 01	0.46E 02	0.58E 02	0.16E 02
MEAN			7.2	13.478	46.522	208.333	0.567	381.000	24.667	0.467	0.376	2.193	2.770	0.666
				0.99E 02	0.30E 03	0.14E 04	0.23E 01	0.10E 04	0.22E 03	0.34E 01	0.67E 00	0.12E 02	0.14E 02	0.32E 01
STANDARD DEVIATION			0.3	5.0527	13.2674	42.3202	0.5050	486.4355	18.1521	0.2646	0.5923	0.7887	0.7810	0.3389
				170.88	498.00	2336.04	5.03	1566.25	377.57	6.93	1.05	18.17	21.11	5.67

1. RUNOFF VOLUME CALCULATED BY SCS CURVE NUMBER TECHNIQUE(SEE TEXT FOR EXPLANATION OF USAGE).

2. FIRST LINE IS CONCENTRATION IN MILLIGRAMS PER LITER(AS DETERMINED IN THE OSDH LABORATORY).

3. SECOND LINE IS TOTAL POUNDS OF POLLUTANT PER EVENT(SEE TEXT FOR EXPLANATION OF CALCULATION TECHNIQUE).

LOCATION:MANGUM(GREER CO) STATION:3 LAND USE:PASTURE AREA:9.2E 06 SQ FT TESTING PERIOD:JAN 76-JUNE 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
4.15	0.70	0.04	7.5	34.000	402.000	957.000	2.000	454.000	142.000	0.120	1.000	8.000	9.200	1.310
13				0.10E 02	0.12E 03	0.29E 03	0.61E 00	0.14E 03	0.43E 02	0.36E-01	0.30E 00	0.24E 01	0.25E 01	0.40E 00
4.28	0.80	0.01	7.4	57.000	186.000	370.000	0.500	113.000	38.000	0.700	3.600	4.700	9.300	1.020
28				0.25E 01	0.81E 01	0.16E 02	0.22E-01	0.49E 01	0.16E 01	0.30E-01	0.16E 00	0.20E 00	0.40E 00	0.44E-01
5.26	1.00	0.02	7.8	0.0	76.000	359.000	0.800	105.000	13.000	0.200	0.500	1.000	4.790	0.640
342				0.0	0.16E 02	0.74E 02	0.16E 00	0.22E 02	0.27E 01	0.41E-01	0.10E 00	0.20E 00	0.98E 00	0.13E 00
5.03	1.50	0.47	6.8	20.000	193.000	986.000	1.400	2197.000	129.000	0.900	0.400	3.990	4.790	2.510
6				0.79E 02	0.76E 03	0.39E 04	0.55E 01	0.86E 04	0.51E 03	0.35E 01	0.16E 01	0.16E 02	0.19E 02	0.99E 01
5.09	1.50	0.47	7.0	16.000	69.800	487.000	0.100	523.000	80.000	0.600	0.100	3.504	0.896	4.100
1				0.63E 02	0.27E 03	0.19E 04	0.39E 00	0.21E 04	0.31E 03	0.24E 01	0.39E 00	0.14E 02	0.35E 01	0.16E 02
5.10	1.00	0.02	7.2	9.000	42.000	493.000	0.100	237.000	54.000	0.500	0.100	3.990	4.790	0.610
9				0.18E 01	0.86E 01	0.10E 03	0.20E-01	0.49E 02	0.11E 02	0.10E 00	0.20E-01	0.82E 00	0.99E 00	0.12E 00
5.19	1.30	0.23	7.7	18.300	63.600	276.000	0.200	77.000	21.000	0.200	0.100	2.735	0.746	2.940
0				0.35E 02	0.12E 03	0.53E 03	0.39E 00	0.15E 03	0.41E 02	0.39E 00	0.19E 00	0.53E 01	0.14E 01	0.57E 01
MINIMUN			6.8	0.0	42.000	276.000	0.100	77.000	13.000	0.120	0.100	1.000	0.746	0.610
				0.0	0.81E 01	0.16E 02	0.20E-01	0.49E 01	0.16E 01	0.30E-01	0.20E-01	0.20E 00	0.40E 00	0.44E-01
MAXIMUM			7.8	57.000	402.000	986.000	2.000	2197.000	142.000	0.900	3.600	8.000	9.300	4.100
				0.79E 02	0.76E 03	0.39E 04	0.55E 01	0.86E 04	0.51E 03	0.35E 01	0.16E 01	0.16E 02	0.19E 02	0.16E 02
MEAN			7.3	22.043	147.486	561.143	0.729	529.428	68.143	0.460	0.829	3.988	4.787	1.876
				0.27E 02	0.19E 03	0.97E 03	0.10E 01	0.16E 04	0.13E 03	0.93E 00	0.39E 00	0.55E 01	0.41E 01	0.46E 01
STANDARD DEVIATION			0.4	18.5996	127.5679	290.4165	0.7296	756.1174	51.1059	0.2953	1.2645	2.1345	3.2528	1.3332
				32.34	269.55	1442.40	1.99	3202.01	199.52	1.43	0.54	5.59	6.59	6.33

1. RUNOFF VOLUME CALCULATED BY SCS CURVE NUMBER TECHNIQUE(SEE TEXT FOR EXPLANATION OF USAGE).

2. FIRST LINE IS CONCENTRATION IN MILLIGRAMS PER LITER(ABSDETERMINED IN THE OSDH LABORATORY).

3. SECOND LINE IS TOTAL POUNDS OF POLLUTANT PER EVENT(SEE TEXT FOR EXPLANATION OF CALCULATION TECHNIQUE).

LOCATION:MANGUM(GREER CO) · STATION:4 LAND USE:HY. AGRI AREA:5.9E 06 SQ FT TESTING PEJAN 7 6-JUNE 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
4.15	0.70	0.02	6.8	0.22E 02	0.42E 03	0.21E 04	0.0	0.44E 04	0.12E 02	0.50E 00	0.10E 01	0.15E 02	0.15E 02	0.30E 01
13				0.43E 01	0.81E 02	0.40E 03	0.0	0.85E 03	0.23E 01	0.97E-01	0.19E 00	0.29E 01	0.30E 01	0.59E 00
4.28	0.80	0.00	6.7	0.11E 03	0.44E 03	0.15E 04	0.30E 00	0.27E 04	0.90E 01	0.10E 01	0.40E 00	0.31E 01	0.44E 01	0.38E 00
53				0.32E 01	0.12E 02	0.41E 02	0.83E-02	0.75E 02	0.25E 00	0.28E-01	0.11E-01	0.86E-01	0.12E 00	0.11E-01
6.23	1.00	0.02	7.2	0.15E 02	0.22E 02	0.39E 03	0.50E 00	0.33E 04	0.80E 01	0.80E 00	0.50E 00	0.56E 01	0.93E 01	0.15E 01
314				0.20E 01	0.29E 01	0.52E 02	0.66E-01	0.43E 03	0.11E 01	0.11E 00	0.66E-01	0.74E 00	0.12E 01	0.20E 00
5.03	1.50	0.30	7.0	0.16E 02	0.74E 03	0.14E 04	0.40E 00	0.17E 05	0.41E 03	0.40E 01	0.70E 00	0.77E 01	0.93E 01	0.86E 01
6				0.40E 02	0.19E 04	0.35E 04	0.10E 01	0.43E 05	0.10E 04	0.10E 02	0.18E 01	0.19E 02	0.24E 02	0.22E 02
5.09	1.50	0.30	6.8	0.14E 02	0.18E 03	0.59E 03	0.20E 00	0.23E 04	0.99E 02	0.11E 01	0.20E 00	0.69E 01	0.82E 01	0.31E 01
1				0.35E 02	0.44E 03	0.15E 04	0.50E 00	0.58E 04	0.25E 03	0.28E 01	0.50E 00	0.17E 02	0.21E 02	0.77E 01
5.10	1.20	0.09	6.9	0.10E 02	0.17E 03	0.26E 04	0.30E 00	0.59E 03	0.12E 03	0.13E 01	0.23E 00	0.77E 01	0.93E 01	0.27E 01
9				0.75E 01	0.12E 03	0.20E 04	0.23E 00	0.45E 03	0.92E 02	0.98E 00	0.17E 00	0.58E 01	0.70E 01	0.20E 01
5.19	1.30	0.15	7.3	0.21E 02	0.43E 03	0.22E 04	0.40E 00	0.68E 04	0.12E 03	0.16E 01	0.30E 00	0.77E 01	0.93E 01	0.66E 01
0				0.26E 02	0.53E 03	0.28E 04	0.50E 00	0.84E 04	0.15E 03	0.20E 01	0.37E 00	0.95E 01	0.12E 02	0.85E 01
MINIMUN			6.7	0.10E 02	0.22E 02	0.39E 03	0.0	0.59E 03	0.80E 01	0.50E 00	0.20E 00	0.31E 01	0.44E 01	0.38E 00
				0.20E 01	0.29E 01	0.41E 02	0.0	0.75E 02	0.25E 00	0.28E-01	0.11E-01	0.86E-01	0.12E 00	0.11E-01
MAXIMUM			7.3	0.11E 03	0.74E 03	0.26E 04	0.50E 00	0.17E 05	0.41E 03	0.40E 01	0.10E 01	0.15E 02	0.15E 02	0.86E 01
				0.40E 02	0.19E 04	0.35E 04	0.10E 01	0.43E 05	0.10E 04	0.10E 02	0.18E 01	0.19E 02	0.24E 02	0.22E 02
MEAN			7.0	0.30E 02	0.34E 03	0.15E 04	0.30E 00	0.53E 04	0.11E 03	0.15E 01	0.40E 00	0.77E 01	0.93E 01	0.38E 01
				0.17E 02	0.44E 03	0.15E 04	0.33E 00	0.84E 04	0.22E 03	0.23E 01	0.44E 00	0.80E 01	0.96E 01	0.55E 01
STANDARD DEVIATION			0.2	37.151	239.524	830.799	0.163	5493.961	141.099	1.169	0.288	3.639	3.224	2.999
				16.47	667.00	1359.96	0.37	15512.11	369.81	3.60	0.61	7.92	9.43	8.02

1. RUNOFF VOLUME CALCULATED BY SCS CURVE NUMBER TECHNIQUE(SEE TEXT FOR EXPLANATION OF USAGE).

2. FIRST LINE IS CONCENTRATION IN MILLIGRAMS PER LITER(AS DETERMINED IN THE OSDH LABORATORY).

3. SECOND LINE IS TOTAL POUNDS OF POLLUTANT PER EVENT(SEE TEXT FOR EXPLANATION OF CALCULATION TECHNIQUE).

LOCATION:FREEDOM(WOODS CO) STATION:1 LAND USE:LT. AGRI AREA:3.83E 06 SQ FT TESTING PERIOD:JAN 76-JUNE 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
4.17	2.00	0.78	7.6	0.13E 02	0.65E 02	0.53E 03	0.65E 01	0.83E 03	0.13E 03	0.14E 01	0.10E 00	0.31E 01	0.46E 01	0.44E 00
11				0.84E 02	0.42E 03	0.35E 04	0.42E 02	0.54E 04	0.84E 03	0.91E 01	0.65E 00	0.20E 02	0.30E 02	0.29E 01
4.28	1.60	0.40	7.1	0.15E 02	0.27E 02	0.53E 03	0.50E 00	0.66E 03	0.50E 02	0.60E 00	0.10E 01	0.19E 01	0.30E 01	0.33E 00
12				0.50E 02	0.89E 02	0.18E 04	0.17E 01	0.22E 04	0.17E 03	0.20E 01	0.33E 01	0.63E 01	0.98E 01	0.11E 01
5.10	2.30	1.12	8.0	0.31E 02	0.50E 02	0.25E 03	0.20E 00	0.88E 03	0.26E 02	0.30E 00	0.50E 00	0.23E 01	0.25E 01	0.40E 00
2				0.29E 03	0.47E 03	0.24E 04	0.19E 01	0.82E 04	0.24E 03	0.28E 01	0.47E 01	0.22E 02	0.23E 02	0.37E 01
5.12	1.00	0.04	8.1	0.12E 02	0.14E 03	0.30E 03	0.12E 01	0.86E 03	0.19E 02	0.80E 00	0.20E 00	0.32E 01	0.30E 01	0.16E 00
14				0.44E 01	0.50E 02	0.11E 03	0.44E 00	0.31E 03	0.69E 01	0.29E 00	0.73E-01	0.12E 01	0.11E 01	0.58E-01
5.26	1.40	0.25	6.7	0.15E 02	0.40E 01	0.15E 03	0.30E 00	0.12E 03	0.60E 01	0.20E 00	0.82E 00	0.70E 00	0.30E 01	0.43E 00
110				0.31E 02	0.82E 01	0.30E 03	0.62E 00	0.25E 03	0.12E 02	0.41E 00	0.17E 01	0.14E 01	0.61E 01	0.88E 00
9.15	2.00	0.78	7.5	0.50E 01	0.79E 02	0.26E 03	0.50E 00	0.47E 03	0.30E 01	0.50E 00	0.10E 00	0.32E 01	0.30E 01	0.74E 00
9				0.32E 02	0.51E 03	0.17E 04	0.32E 01	0.31E 04	0.19E 02	0.32E 01	0.65E 00	0.21E 02	0.19E 02	0.48E 01
9.24	2.00	0.78	8.7	0.15E 02	0.34E 03	0.30E 03	0.34E 02	0.10E 05	0.76E 02	0.12E 01	0.10E 00	0.13E 02	0.30E 01	0.20E 00
217				0.99E 02	0.22E 04	0.20E 04	0.22E 03	0.66E 05	0.49E 03	0.81E 01	0.65E 00	0.86E 02	0.19E 02	0.13E 01
4.29	2.00	0.78	8.2	0.16E 02	0.16E 03	0.35E 02	0.11E 02	0.36E 03	0.12E 03	0.19E 01	0.22E 01	0.69E 01	0.30E 01	0.16E 01
4				0.10E 03	0.11E 04	0.23E 03	0.71E 02	0.24E 04	0.77E 03	0.12E 02	0.14E 02	0.45E 02	0.19E 02	0.11E 02
5.03	0.70	0.00	7.3	0.13E 02	0.32E 02	0.54E 03	0.40E 00	0.43E 03	0.98E 02	0.50E 00	0.26E 01	0.39E 01	0.30E 01	0.38E 00
17				0.73E-01	0.18E 00	0.30E 01	0.22E-02	0.24E 01	0.55E 00	0.28E-02	0.15E-01	0.22E-01	0.17E-01	0.21E-02
5.20	1.00	0.04	8.1	0.21E 02	0.72E 02	0.14E 03	0.70E 00	0.11E 04	0.40E 02	0.30E 00	0.13E 01	0.16E 01	0.20E 01	0.71E 00
11				0.77E 01	0.26E 02	0.51E 02	0.25E 00	0.40E 03	0.15E 02	0.11E 00	0.47E 00	0.57E 00	0.72E 00	0.26E 00
5.31	2.30	1.12	7.7	0.11E 02	0.55E 02	0.23E 03	0.82E 03	0.10E 01	0.65E 02	0.30E 00	0.10E 00	0.25E 01	0.28E 01	0.46E 00
0				0.99E 02	0.52E 03	0.21E 04	0.76E 04	0.94E 01	0.61E 03	0.28E 01	0.94E 00	0.23E 02	0.26E 02	0.43E 01
MINIMUN			6.7	0.50E 01	0.40E 01	0.35E 02	0.20E 00	0.10E 01	0.30E 01	0.20E 00	0.10E 00	0.70E 00	0.30E 01	0.16E 00
				0.73E-01	0.18E 00	0.30E 01	0.22E-02	0.24E 01	0.55E 00	0.28E-02	0.15E-01	0.22E-01	0.17E-01	0.21E-02
MAXIMUM			8.7	0.31E 02	0.34E 03	0.54E 03	0.82E 03	0.10E 05	0.13E 03	0.19E 01	0.26E 01	0.13E 02	0.46E 01	0.16E 01
				0.29E 03	0.22E 04	0.35E 04	0.76E 04	0.66E 05	0.84E 03	0.12E 02	0.14E 02	0.86E 02	0.30E 02	0.11E 02
MEAN			7.7	0.15E 02	0.93E 02	0.30E 03	0.79E 02	0.14E 04	0.57E 02	0.73E 00	0.82E 00	0.39E 01	0.30E 01	0.54E 00
				0.73E 02	0.49E 03	0.13E 04	0.73E 03	0.80E 04	0.29E 03	0.37E 01	0.25E 01	0.21E 02	0.14E 02	0.27E 01
STANDARD DEVIATION			0.6	0.66E 01	0.95E 02	0.17E 03	0.24E 03	0.29E 04	0.44E 02	0.55E 00	0.89E 00	0.35E 01	0.62E 00	0.41E 00
				0.82E 02	0.66E 03	0.12E 04	0.23E 04	0.19E 05	0.33E 03	0.42E 01	0.42E 01	0.26E 02	0.11E 02	0.32E 01

1. RUNOFF VOLUME CALCULATED BY SCS CURVE NUMBER TECHNIQUE(SEE TEXT FOR EXPLANATION OF USAGE).

2. FIRST LINE IS CONCENTRATION IN MILLIGRAMS PER LITER(AS DETERMINED IN THE OSDH LABORATORY).

3. SECOND LINE IS TOTAL POUNDS OF POLLUTANT PER EVENT(SEE TEXT FOR EXPLANATION OF CALCULATION TECHNIQUE).

LOCATION:FREEDOM(WOODS CO)   STATION:2   LAND USE:PASTURE   AREA:13.94E 06 SQ FT TESTING PERIOD:JAN 76-JUNE 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
4.17	2.00	2.84	6.9	13.000	42.000	336.000	0.0	403.000	3.000	2.300	0.100	2.500	2.500	0.609
11				0.31E 03	0.99E 03	0.79E 04	0.0	0.95E 04	0.71E 02	0.54E 02	0.24E 01	0.59E 02	0.59E 02	0.14E 02
4.28	1.60	1.45	6.5	13.000	50.000	219.000	0.100	734.000	2.000	0.500	1.000	2.400	2.500	0.580
12				0.16E 03	0.60E 03	0.26E 04	0.12E 01	0.89E 04	0.24E 02	0.60E 01	0.12E 02	0.29E 02	0.30E 02	0.70E 01
5.10	2.30	4.09	7.1	21.000	42.000	182.000	0.100	174.000	14.000	0.300	0.500	1.800	2.000	0.470
2				0.72E 03	0.14E 04	0.62E 04	0.34E 01	0.59E 04	0.48E 03	0.10E 02	0.17E 02	0.61E 02	0.68E 02	0.16E 02
5.12	0.60	0.04	7.0	8.000	35.000	182.000	0.200	309.000	5.000	0.600	0.200	1.700	2.500	0.380
133				0.29E 01	0.13E 02	0.65E 02	0.72E-01	0.11E 03	0.18E 01	0.21E 00	0.72E-01	0.61E 00	0.89E 00	0.14E 00
9.24	2.00	2.84	8.0	13.700	63.000	273.000	0.200	1315.000	3.000	0.400	0.100	3.000	2.500	0.890
217				0.32E 03	0.15E 04	0.65E 04	0.47E 01	0.31E 05	0.71E 02	0.95E 01	0.24E 01	0.71E 02	0.59E 02	0.21E 02
4.29	2.00	2.84	7.1	19.000	67.000	167.000	0.800	491.000	17.000	0.500	0.130	2.670	3.300	0.949
4				0.45E 03	0.16E 04	0.39E 04	0.19E 02	0.12E 05	0.40E 03	0.12E 02	0.31E 01	0.63E 02	0.78E 02	0.22E 02
5.03	7.00	34.39	7.8	13.000	52.000	581.000	1.000	2155.000	96.000	1.100	0.200	2.220	2.500	1.550
17				0.37E 04	0.15E 05	0.17E 06	0.29E 03	0.62E 06	0.28E 05	0.32E 03	0.57E 02	0.64E 03	0.72E 03	0.44E 03
5.20	1.00	0.16	8.0	13.900	64.300	66.000	0.300	1022.000	27.000	0.400	0.130	1.170	1.700	0.805
11				0.18E 02	0.85E 02	0.87E 02	0.40E 00	0.14E 04	0.36E 02	0.53E 00	0.17E 00	0.16E 01	0.23E 01	0.11E 01
5.31	2.40	4.54	7.3	8.600	40.000	169.000	133.600	1.000	22.000	0.500	0.100	2.500	3.000	0.940
0				0.33E 03	0.15E 04	0.64E 04	0.51E 04	0.38E 02	0.83E 03	0.19E 02	0.38E 01	0.95E 02	0.11E 03	0.36E 02
MINIMUN			6.5	8.000	35.000	66.000	0.0	1.000	2.000	0.300	0.100	1.170	1.700	0.390
				0.29E 01	0.13E 02	0.65E 02	0.0	0.38E 02	0.18E 01	0.21E 00	0.72E-01	0.61E 00	0.89E 00	0.14E 00
MAXIMUM			8.0	21.000	67.000	581.000	133.600	2155.000	96.000	2.300	1.000	3.000	3.300	1.550
				0.37E 04	0.15E 05	0.17E 06	0.51E 04	0.62E 06	0.28E 05	0.32E 03	0.57E 02	0.64E 03	0.72E 03	0.44E 03
MEAN			7.3	13.689	50.589	241.667	15.144	733.778	21.000	0.733	0.273	2.218	2.500	0.797
				0.67E 03	0.25E 04	0.22E 05	0.60E 03	0.76E 05	0.33E 04	0.47E 02	0.11E 02	0.11E 03	0.13E 03	0.62E 02
STANDARD DEVIATION			0.5	4.204	11.813	147.638	44.422	674.525	29.563	0.630	0.300	0.565	0.472	0.350
				0.12E 04	0.47E 04	0.54E 05	0.17E 04	0.20E 06	0.91E 04	0.10E 03	0.18E 02	0.20E 03	0.22E 03	0.14E 03

1. RUNOFF VOLUME CALCULATED BY SCS CURVE NUMBER TECHNIQUE(SEE TEXT FOR EXPLANATION OF USAGE).

2. FIRST LINE IS CONCENTRATION IN MILLIGRAMS PER LITER(ASDETERMINED IN THE CSDH LABORATORY).

3. SECOND LINE IS TOTAL POUNDS OF POLLUTANT PER EVENT(SEE TEXT FOR EXPLANATION OF CALCULATION TECHNIQUE).

LOCATION:FREEDOM(WOODS CO) STATION:3 LAND USE:RANGE AREA:15.9 E 06 SQ FT TESTING PERIOD:JAN 76-JUNE 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
4.17	2.00	5.17	7.3	12.000	50.000	869.000	1.800	353.000	360.000	1.300	0.100	2.500	2.750	0.566
11				0.52E 03	0.22E 04	0.37E 05	0.78E 02	0.15E 05	0.16E 05	0.56E 02	0.43E 01	0.11E 03	0.12E 03	0.24E 02
4.28	1.60	3.03	6.9	18.000	66.000	297.000	0.300	456.000	2.000	0.400	1.000	1.300	2.760	0.710
12				0.46E 03	0.17E 04	0.75E 04	0.76E 01	0.12E 05	0.51E 02	0.10E 02	0.25E 02	0.33E 02	0.70E 02	0.18E 02
5.10	2.30	7.00	7.8	23.000	42.000	218.000	0.300	172.000	2.000	0.200	0.500	1.900	2.000	0.400
2				0.13E 04	0.25E 04	0.13E 05	0.18E 02	0.10E 05	0.12E 03	0.12E 02	0.29E 02	0.11E 03	0.12E 03	0.23E 02
5.12	1.20	1.33	7.8	21.000	47.000	407.000	0.300	283.000	7.000	0.500	0.100	2.300	2.730	0.510
14				0.23E 03	0.52E 03	0.45E 04	0.33E 01	0.31E 04	0.78E 02	0.55E 01	0.11E 01	0.25E 02	0.31E 02	0.57E 01
5.26	1.40	2.12	7.3	16.200	4.000	207.000	0.500	347.000	27.000	0.300	0.240	0.800	2.760	0.140
119				0.29E 03	0.71E 02	0.37E 04	0.88E 01	0.61E 04	0.48E 03	0.53E 01	0.42E 01	0.14E 02	0.49E 02	0.25E 01
9.24	2.00	5.17	7.8	16.200	58.000	280.000	0.100	126.000	3.000	0.300	0.100	2.100	2.760	0.430
217				0.70E 03	0.25E 04	0.12E 05	0.43E 01	0.54E 04	0.13E 03	0.13E 02	0.43E 01	0.91E 02	0.12E 03	0.19E 02
4.29	1.00	0.69	7.5	15.000	63.000	592.000	0.200	731.000	32.000	0.700	0.072	3.180	3.950	1.280
4				0.87E 02	0.36E 03	0.34E 04	0.12E 01	0.42E 04	0.19E 03	0.41E 01	0.42E 00	0.18E 02	0.23E 02	0.74E 01
5.03	0.70	0.10	7.0	15.000	88.000	1255.000	0.500	1942.000	96.000	0.700	0.100	2.060	2.760	1.300
17				0.12E 02	0.73E 02	0.10E 04	0.41E 00	0.16E 04	0.79E 02	0.58E 00	0.82E-01	0.17E 01	0.23E 01	0.11E 01
5.20	1.00	0.69	7.6	18.800	65.000	242.000	1.200	802.000	35.000	0.400	0.100	2.480	2.880	0.966
11				0.11E 03	0.38E 03	0.14E 04	0.69E 01	0.46E 04	0.20E 03	0.23E 01	0.58E 00	0.14E 02	0.17E 02	0.56E 01
5.31	2.70	9.65	7.4	6.500	40.000	220.000	157.000	1.000	22.000	0.200	0.100	2.000	2.300	0.471
0				0.52E 03	0.32E 04	0.18E 05	0.13E 05	0.80E 02	0.18E 04	0.16E 02	0.80E 01	0.16E 03	0.18E 03	0.38E 02
MINIMUN			6.9	6.500	4.000	207.000	0.100	1.000	2.000	0.200	0.072	0.800	2.000	0.140
				0.12E 02	0.71E 02	0.10E 04	0.41E 00	0.80E 02	0.51E 02	0.58E 00	0.82E-01	0.17E 01	0.23E 01	0.11E 01
MAXIMUM			7.8	23.000	88.000	1255.000	157.000	1942.000	360.000	1.300	1.000	3.180	3.950	1.300
				0.13E 04	0.32E 04	0.37E 05	0.13E 05	0.15E 05	0.16E 05	0.56E 02	0.29E 02	0.16E 03	0.18E 03	0.38E 02
MEAN			7.4	16.170	52.300	458.700	16.220	521.300	58.600	0.500	0.241	2.062	2.759	0.677
				0.43E 03	0.13E 04	0.10E 05	0.13E 04	0.62E 04	0.19E 04	0.12E 02	0.78E 01	0.58E 02	0.72E 02	0.14E 02
STANDARD DEVIATION			0.3	4.6414	22.0960	350.5845	49.4678	558.7578	109.5465	0.3333	0.2965	0.6564	0.5079	0.3866
				391.04	1186.13	11061.50	3990.86	4709.50	4832.01	16.12	10.60	54.97	57.80	11.95

1. RUNOFF VOLUME CALCULATED BY SCS CURVE NUMBER TECHNIQUE(SEE TEXT FOR EXPLANATION OF USAGE).

2. FIRST LINE IS CONCENTRATION IN MILLIGRAMS PER LITER(AS DETERMINED IN THE OSDH LABORATORY).

3. SECOND LINE IS TOTAL POUNDS OF POLLUTANT PER EVENT(SEE TEXT FOR EXPLANATION OF CALCULATION TECHNIQUE).

LOCATION:FREEDOM(WOODS CO)   STATION:4   LAND USE:PASTURE   AREA:6.01E 06 SQ FT   TESTING PERIOD:JAN 76-JUNE 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
9.15	2.00	1.22	7.5	10.000	87.000	199.000	1.300	1135.000	3.000	0.800	0.400	5.200	2.970	1.050
9				0.10E 03	0.89E 03	0.20E 04	0.13E 02	0.12E 05	0.31E 02	0.82E 01	0.41E 01	0.53E 02	0.30E 02	0.11E 02
9.24	2.00	1.22	8.4	13.200	72.000	223.000	2.000	162.000	3.000	0.700	0.200	7.600	2.970	0.890
238				0.13E 03	0.73E 03	0.23E 04	0.20E 02	0.17E 04	0.31E 02	0.71E 01	0.20E 01	0.77E 02	0.30E 02	0.91E 01
5.20	1.00	0.07	6.7	20.200	61.100	53.000	1.000	433.000	11.000	0.100	0.100	2.740	2.840	0.341
11				0.12E 02	0.35E 02	0.30E 02	0.57E 00	0.25E 03	0.63E 01	0.57E-01	0.57E-01	0.16E 01	0.16E 01	0.19E 00
5.31	2.50	2.16	7.5	9.300	51.000	125.000	474.000	1.000	17.000	0.300	0.100	2.800	3.100	0.555
0				0.17E 03	0.92E 03	0.22E 04	0.85E 04	0.10E 02	0.31E 03	0.54E 01	0.18E 01	0.50E 02	0.56E 02	0.10E 02
MINIMUN			6.7	9.300	51.000	53.000	1.000	1.000	3.000	0.100	0.100	2.740	2.840	0.341
				0.12E 02	0.35E 02	0.30E 02	0.57E 00	0.10E 02	0.63E 01	0.57E-01	0.57E-01	0.16E 01	0.16E 01	0.19E 00
MAXIMUM			8.4	20.200	87.000	223.000	474.000	1135.000	17.000	0.800	0.400	5.200	3.100	1.050
				0.17E 03	0.92E 03	0.23E 04	0.85E 04	0.12E 05	0.31E 03	0.82E 01	0.41E 01	0.53E 02	0.56E 02	0.11E 02
MEAN			7.5	13.175	67.775	150.000	119.575	432.750	8.500	0.475	0.200	3.585	2.970	0.709
				0.10E 03	0.64E 03	0.16E 04	0.21E 04	0.34E 04	0.93E 02	0.52E 01	0.20E 01	0.35E 02	0.29E 02	0.75E 01
STANDARD DEVIATION			0.7	4.9815	15.4238	76.5502	236.2836	530.9556	6.8069	0.3304	0.1414	1.1458	0.1061	0.3205
				67.08	413.50	1082.30	4258.61	5513.06	142.16	3.60	1.65	23.67	22.13	4.91

1. RUNOFF VOLUME CALCULATED BY SCS CURVE NUMBER TECHNIQUE(SEE TEXT FOR EXPLANATION OF USAGE).

2. FIRST LINE IS CONCENTRATION IN MILLIGRAMS PER LITER(ABSDETERMINED IN THE OSDH LABORATORY).

3. SECOND LINE IS TOTAL POUNDS OF POLLUTANT PER EVENT(SEE TEXT FOR EXPLANATION OF CALCULATION TECHNIQUE).

LOCATION:IDABEL(MCCURTAIN CO)   STATION:1   LAND USE:RANGE   AREA:4.13E 06 SQ FT   TESTING PERIOD:JAN 76-JUNE 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
3.08	4.00	4.76	7.5	5.0000	14.0000	584.0000	0.1000	22.0000	7.0000	0.4000	0.3000	1.1000	1.4000	0.0800
20				198.68	556.31	23205.90	3.97	874.20	278.15	15.89	11.92	43.71	55.63	3.18
3.28	1.25	0.32	7.6	39.0000	55.0000	228.0000	0.6000	65.0000	30.0000	0.4000	0.3000	0.7000	1.5900	0.1000
9				105.29	148.49	615.56	1.62	175.49	80.99	1.08	0.81	1.89	4.29	0.27
4.06	3.20	3.20	7.7	15.0000	27.0000	126.0000	0.5000	133.0000	14.0000	0.2000	0.7000	1.4000	2.1000	0.3000
13				400.50	720.90	3364.22	13.35	3551.12	373.80	5.34	18.69	37.38	56.07	8.01
4.19	1.25	0.32	7.3	6.0000	38.0000	134.0000	0.2700	81.0000	19.0000	0.3000	1.0000	1.2000	1.5000	0.1800
.38				16.22	102.59	361.77	0.73	218.68	51.30	0.81	2.70	3.24	4.05	0.49
5.27	1.70	0.80	7.8	0.0	23.0000	232.0000	0.1000	0.3000	22.0000	0.2000	0.5000	1.0000	1.5900	0.0820
29				0.0	154.09	1554.35	0.67	2.01	147.40	1.34	3.35	6.70	10.65	0.55
6.25	2.90	2.65	7.7	13.0000	26.0000	231.0000	0.2000	16.0000	24.0000	0.2000	0.3000	1.0000	1.5900	0.0800
102				287.81	575.61	5114.09	4.43	354.22	531.33	4.43	6.64	22.14	35.20	1.77
10.05	4.00	4.76	7.4	6.0000	30.0000	443.0000	0.1000	4.0000	10.0000	0.2000	0.1000	0.8000	0.9000	0.1600
62				238.42	1192.08	17603.11	3.97	158.94	397.36	7.95	3.97	31.79	35.76	6.36
12.06	1.13	0.23	7.5	7.0000	34.0000	149.0000	0.1000	22.0000	0.1000	0.7000	1.1000	1.7000	1.8000	0.1300
28				13.18	64.01	280.51	0.19	41.42	0.19	1.32	2.07	3.20	3.39	0.24
1.03	1.00	0.14	7.3	0.0	30.0000	99.0000	0.1000	38.0000	14.0000	0.2000	0.3000	1.5000	1.8000	0.2100
31				0.0	34.22	112.94	0.11	43.35	15.97	0.23	0.34	1.71	2.05	0.24
2.03	1.00	0.14	7.2	0.0	22.0000	159.0000	0.1000	36.0000	24.0000	0.2000	0.2000	1.2000	1.6000	0.1700
29				0.0	25.10	181.39	0.11	41.07	27.38	0.23	0.23	1.37	1.83	0.19
3.03	3.72	4.20	7.7	5.0000	24.0000	147.0000	0.1000	63.0000	16.0000	0.1000	0.1000	1.4000	1.6000	0.1300
24				175.24	841.17	5152.17	3.50	2208.07	560.78	3.50	3.50	49.07	56.08	4.56
3.27	3.00	2.83	7.5	20.0000	38.0000	116.0000	0.2000	36.0000	13.0000	0.1000	0.7000	1.1000	1.5900	0.1600
91				472.72	898.16	2741.75	4.73	850.89	307.26	2.36	16.55	26.00	37.58	3.78
6.26	2.00	1.20	7.5	12.1000	67.2000	96.0000	1.0000	214.0000	15.1000	0.2000	0.1000	1.1800	1.5900	0.1810
0				121.26	673.46	962.09	10.02	2144.65	150.33	2.00	1.00	11.83	15.93	1.81
MINIMUN			7.2	0.0	14.0000	96.0000	0.1000	0.3000	0.1000	0.1000	0.1000	0.7000	0.9000	0.0800
				0.0	25.10	112.94	0.11	2.01	0.19	0.23	0.23	1.37	1.83	0.19
MAXIMUM			7.8	39.0000	67.2000	584.0000	1.0000	214.0000	30.0000	0.7000	1.1000	1.7000	2.1000	0.3000
				472.72	1192.08	23205.90	13.35	3551.12	560.78	15.89	18.69	49.07	56.08	8.01
MEAN			7.5	9.8538	32.9384	211.0769	0.2669	56.1769	16.0077	0.2615	0.4385	1.1754	1.5885	0.1510
				156.10	460.48	4711.52	3.65	820.31	224.79	3.58	5.52	18.46	24.53	2.42
STANDARD DEVIATION			0.2	10.6854	14.3486	145.1075	0.2749	59.5050	7.9415	0.1609	0.3380	0.2773	0.2691	0.0621
				158.95	393.18	7276.15	4.03	1120.29	196.60	4.33	6.23	17.53	22.23	2.63

LOCATION:IDABEL(MCCURTAIN CO)   STATION:2   LAND USE:PASTURE   AREA:4.13E 06 SQ FT   TESTING PERIOD:JAN 76-JUNE 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
3.08	4.00	4.76	7.0	5.000	14.000	118.000	0.100	37.000	5.000	0.400	0.300	0.800	1.100	0.190
20				0.20E 03	0.56E 03	0.47E 04	0.40E 01	0.15E 04	0.20E 03	0.16E 02	0.12E 02	0.32E 02	0.44E 02	0.75E 01
3.28	1.25	0.32	6.4	44.000	65.000	12.000	0.800	40.000	3.000	1.100	0.600	1.900	3.500	0.270
9				0.12E 03	0.18E 03	0.32E 02	0.22E 01	0.11E 03	0.81E 01	0.30E 01	0.16E 01	0.51E 01	0.94E 01	0.73E 00
4.06	3.20	3.20	6.7	17.000	46.000	102.000	0.400	19.000	7.000	0.200	0.500	1.600	1.700	0.430
13				0.45E 03	0.12E 04	0.27E 04	0.11E 02	0.51E 03	0.19E 03	0.53E 01	0.13E 02	0.43E 02	0.45E 02	0.11E 02
4.19	1.50	0.57	6.9	4.000	54.000	203.000	0.100	33.000	3.000	0.200	1.000	1.900	2.040	0.211
38				0.19E 02	0.26E 03	0.97E 03	0.48E 00	0.16E 03	0.14E 02	0.95E 00	0.48E 01	0.90E 01	0.97E 01	0.10E 01
5.27	1.25	0.32	6.6	0.0	65.000	13.000	0.400	13.000	9.000	2.100	0.500	0.100	2.040	0.140
29				0.0	0.18E 03	0.35E 02	0.11E 01	0.35E 02	0.24E 02	0.57E 01	0.13E 01	0.27E 00	0.55E 01	0.38E 00
6.25	2.90	2.65	6.5	10.000	60.000	98.000	0.200	18.000	5.000	0.300	0.300	1.600	2.000	0.200
102				0.22E 03	0.13E 04	0.22E 04	0.44E 01	0.40E 03	0.11E 03	0.66E 01	0.66E 01	0.35E 02	0.45E 02	0.44E 01
10.05	4.00	4.76	6.7	8.000	46.000	525.000	0.100	2.000	3.000	0.200	0.100	1.600	2.040	0.620
62				0.32E 03	0.18E 04	0.21E 05	0.40E 01	0.79E 02	0.12E 03	0.79E 01	0.40E 01	0.64E 02	0.81E 02	0.25E 02
12.06	1.13	0.23	6.4	11.000	71.000	117.000	0.100	6.000	8.000	0.200	0.100	1.900	2.000	0.630
39				0.21E 02	0.13E 03	0.22E 03	0.19E 00	0.11E 02	0.15E 02	0.38E 00	0.19E 00	0.36E 01	0.38E 01	0.12E 01
1.14	1.20	0.28	6.6	0.0	52.000	95.000	0.100	23.000	10.000	0.200	0.100	1.900	1.900	0.390
20				0.0	0.12E 03	0.22E 03	0.23E 00	0.54E 02	0.23E 02	0.47E 00	0.23E 00	0.45E 01	0.45E 01	0.91E 00
2.03	1.25	0.32	6.7	11.900	46.000	133.000	0.250	22.000	6.400	0.650	0.100	1.500	2.040	0.430
28				0.32E 02	0.12E 03	0.36E 03	0.67E 00	0.59E 02	0.17E 02	0.18E 01	0.27E 00	0.43E 01	0.55E 01	0.12E 01
3.03	3.72	4.20	7.0	12.000	34.000	79.000	0.200	38.000	7.000	0.100	0.900	1.500	2.040	0.260
26				0.42E 03	0.12E 04	0.28E 04	0.70E 01	0.13E 04	0.25E 03	0.35E 01	0.32E 02	0.53E 02	0.71E 02	0.91E 01
3.29	2.70	2.30	6.8	20.000	46.000	101.000	0.300	17.000	10.000	2.200	2.100	1.700	2.040	1.400
0				0.38E 03	0.88E 03	0.19E 04	0.58E 01	0.33E 03	0.19E 03	0.42E 02	0.40E 02	0.33E 02	0.39E 02	0.27E 02
MINIMUN			6.4	0.0	14.000	12.000	0.100	2.000	3.000	0.100	0.100	0.100	1.100	0.140
				0.0	0.12E 03	0.32E 02	0.19E 00	0.11E 02	0.81E 01	0.38E 00	0.19E 00	0.27E 00	0.38E 01	0.38E 00
MAXIMUM			7.0	44.000	71.000	525.000	0.800	40.000	10.000	2.200	2.100	1.900	3.500	1.400
				0.45E 03	0.18E 04	0.21E 05	0.11E 02	0.15E 04	0.25E 03	0.42E 02	0.40E 02	0.64E 02	0.81E 02	0.27E 02
MEAN			6.7	11.908	49.917	133.000	0.254	22.333	6.367	0.654	0.550	1.500	2.040	0.431
				0.18E 03	0.67E 03	0.31E 04	0.34E 01	0.38E 03	0.96E 02	0.78E 01	0.97E 01	0.24E 02	0.30E 02	0.75E 01
STANDARD DEVIATION			0.2	11.8126	15.4535	133.3676	0.2361	12.4779	2.6033	0.7512	0.5776	0.5360	0.5353	0.3458
				175.14	600.17	5783.11	3.26	503.81	89.79	11.68	13.17	22.03	27.70	9.34

LOCATION:IDABEL(MCCURTAIN CO) STATION:3 LAND USE:LT. AGRI AREA:16.4E 06 SQ FT TESTING PERIOD:JAN 76-JUNE 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
3.08	4.00	18.92	6.5	10.000	32.000	233.000	0.100	62.000	5.000	12.100	0.300	1.700	13.700	0.740
20				0.16E 04	0.50E 04	0.37E 05	0.16E 02	0.98E 04	0.79E 03	0.19E 04	0.47E 02	0.27E 03	0.22E 04	0.12E 03
3.28	1.25	1.29	6.5	40.000	171.000	13.000	0.0	17.000	3.000	0.700	0.800	1.600	3.000	0.500
9				0.43E 03	0.18E 04	0.14E 03	0.0	0.18E 03	0.32E 02	0.75E 01	0.86E 01	0.17E 02	0.32E 02	0.54E 01
4.06	3.20	12.71	7.1	20.000	54.000	137.000	0.800	51.000	2.000	0.300	0.700	1.500	2.400	1.090
13				0.21E 04	0.57E 04	0.15E 05	0.85E 02	0.54E 04	0.21E 03	0.32E 02	0.74E 02	0.16E 03	0.25E 03	0.12E 03
4.19	1.50	2.27	7.0	3.000	42.000	122.000	0.500	141.000	22.000	1.100	1.000	1.500	2.500	0.157
38				0.57E 02	0.79E 03	0.23E 04	0.94E 01	0.27E 04	0.42E 03	0.21E 02	0.19E 02	0.28E 02	0.47E 02	0.30E 01
5.27	1.00	0.54	7.0	0.0	88.000	104.000	2.000	69.000	6.000	0.400	0.500	1.000	1.300	0.660
35				0.0	0.40E 03	0.47E 03	0.91E 01	0.31E 03	0.27E 02	0.18E 01	0.23E 01	0.45E 01	0.59E 01	0.30E 01
7.01	2.90	10.54	6.6	11.000	21.000	125.000	0.300	872.000	3.000	0.200	0.500	4.200	5.300	0.400
96				0.97E 03	0.18E 04	0.11E 05	0.26E 02	0.77E 05	0.26E 03	0.18E 02	0.44E 02	0.37E 03	0.47E 03	0.35E 02
10.05	4.00	18.92	7.2	5.000	31.000	581.000	0.200	82.000	3.000	0.200	0.100	1.800	5.300	0.410
62				0.79E 03	0.49E 04	0.92E 05	0.32E 02	0.13E 05	0.47E 03	0.32E 02	0.16E 02	0.28E 03	0.84E 03	0.65E 02
12.06	1.13	0.90	7.1	9.000	60.000	136.000	0.300	97.000	2.000	0.500	0.100	2.000	2.400	0.950
39				0.67E 02	0.45E 03	0.10E 04	0.22E 01	0.73E 03	0.15E 02	0.37E 01	0.75E 00	0.15E 02	0.18E 02	0.71E 01
1.14	1.20	1.12	6.9	0.0	78.000	167.000	0.200	60.000	4.000	0.200	0.100	1.900	2.000	1.100
20				0.0	0.73E 03	0.16E 04	0.19E 01	0.56E 03	0.37E 02	0.19E 01	0.93E 00	0.18E 02	0.19E 02	0.10E 02
2.03	1.00	0.54	6.9	12.700	75.000	189.000	0.460	158.000	8.820	1.800	0.100	4.800	5.300	0.660
28				0.58E 02	0.34E 03	0.86E 03	0.21E 01	0.72E 03	0.40E 02	0.82E 01	0.45E 00	0.22E 02	0.24E 02	0.30E 01
3.03	3.50	14.98	6.8	10.000	39.000	117.000	0.200	94.000	10.000	3.700	4.200	6.900	14.800	0.190
24				0.12E 04	0.49E 04	0.15E 05	0.25E 02	0.12E 05	0.12E 04	0.46E 03	0.52E 03	0.86E 03	0.18E 04	0.24E 02
3.27	3.00	11.25	7.0	26.000	57.000	340.000	0.500	197.000	37.000	1.300	0.500	3.600	5.300	1.080
0				0.24E 04	0.53E 04	0.32E 05	0.47E 02	0.18E 05	0.35E 04	0.12E 03	0.47E 02	0.34E 03	0.50E 03	0.10E 03
MINIMUM			6.5	0.0	21.000	13.000	0.0	17.000	2.000	0.200	0.100	1.000	1.300	0.157
				0.0	0.34E 03	0.14E 03	0.0	0.18E 03	0.15E 02	0.18E 01	0.45E 00	0.45E 01	0.59E 01	0.30E 01
MAXIMUM			7.2	40.000	171.000	581.000	2.000	872.000	37.000	12.100	4.200	6.900	14.800	1.100
				0.24E 04	0.57E 04	0.92E 05	0.85E 02	0.77E 05	0.35E 04	0.19E 04	0.52E 03	0.86E 03	0.22E 04	0.12E 03
MEAN			6.9	12.225	62.333	188.667	0.463	158.333	8.818	1.875	0.742	2.708	5.275	0.661
				0.81E 03	0.27E 04	0.17E 05	0.21E 02	0.12E 05	0.59E 03	0.22E 03	0.65E 02	0.20E 03	0.52E 03	0.41E 02
STANDARD DEVIATION			0.2	11.5989	39.9371	146.5873	0.5296	230.2703	10.4865	3.3732	1.1301	1.7845	4.4481	0.3405
				869.98	2259.45	26568.59	24.72	21363.30	983.67	548.17	146.62	252.16	745.27	46.26

LOCATION:IDABEL(MCCURTAIN CO)   STATION:4   LAND USE:SILVI   AREA:5.23E 06 SQ FT   TESTING PERIOD:JAN 76-JUNE 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
3.08	3.50	4.39	6.2	39.000	46.000	154.000	0.100	21.000	5.000	0.300	0.300	1.100	1.300	0.080
20				0.14E 04	0.17E 04	0.56E 04	0.37E 01	0.77E 03	0.18E 03	0.11E 02	0.11E 02	0.43E 02	0.48E 02	0.29E 01
3.28	1.25	0.32	6.4	3.000	12.000	64.000	0.0	3.000	3.000	0.200	0.300	0.600	1.420	0.020
9				0.79E 01	0.32E 02	0.17E 03	0.0	0.79E 01	0.79E 01	0.53E 00	0.79E 00	0.16E 01	0.37E 01	0.53E-01
4.06	3.00	3.26	6.3	17.000	46.000	93.000	0.200	22.000	4.000	0.200	0.700	1.200	2.000	0.084
11				0.46E 03	0.12E 04	0.25E 04	0.54E 01	0.60E 03	0.11E 03	0.54E 01	0.19E 02	0.33E 02	0.54E 02	0.23E 01
4.17	2.00	1.32	6.6	4.000	38.000	83.000	0.0	88.000	3.000	0.200	1.000	1.000	1.420	0.100
40				0.44E 02	0.42E 03	0.91E 03	0.0	0.97E 03	0.33E 02	0.22E 01	0.11E 02	0.11E 02	0.16E 02	0.11E 01
5.27	3.50	4.39	6.5	0.0	27.000	53.000	0.100	0.200	5.000	0.250	0.500	0.100	1.420	0.080
29				0.0	0.99E 03	0.19E 04	0.37E 01	0.73E 01	0.18E 03	0.92E 01	0.18E 02	0.37E 01	0.52E 02	0.29E 01
6.25	2.90	3.04	6.6	9.000	34.000	76.000	0.100	12.000	3.000	0.200	0.600	0.700	1.420	0.080
102				0.23E 03	0.86E 03	0.19E 04	0.25E 01	0.30E 03	0.76E 02	0.51E 01	0.15E 02	0.18E 02	0.36E 02	0.20E 01
10.05	4.00	5.60	5.9	8.000	42.000	667.000	0.100	29.000	3.000	0.200	0.100	1.000	1.420	0.080
62				0.37E 03	0.20E 04	0.31E 05	0.47E 01	0.14E 04	0.14E 03	0.93E 01	0.47E 01	0.47E 02	0.66E 02	0.37E 01
12.06	1.00	0.12	5.8	4.000	36.000	49.000	0.100	40.000	8.000	0.500	0.100	0.100	1.500	0.180
39				0.39E 01	0.35E 02	0.48E 02	0.98E-01	0.39E 02	0.78E 01	0.49E 00	0.98E-01	0.98E-01	0.15E 01	0.18E 00
1.14	1.20	0.27	5.7	0.0	52.000	29.000	0.100	3.000	3.000	0.200	0.100	1.100	1.100	0.070
20				0.0	0.12E 03	0.65E 02	0.22E 00	0.67E 01	0.67E 01	0.45E 00	0.22E 00	0.25E 01	0.25E 01	0.16E 00
2.03	1.25	0.32	6.1	8.330	33.000	148.000	0.120	84.500	8.500	0.230	0.100	0.830	1.420	0.110
28				0.22E 02	0.87E 02	0.39E 03	0.32E 00	0.22E 03	0.22E 02	0.61E 00	0.26E 00	0.22E 01	0.37E 01	0.29E 00
3.03	2.70	2.62	5.6	5.000	39.000	95.000	0.200	64.000	10.000	0.100	1.000	0.200	1.200	0.120
24				0.11E 03	0.85E 03	0.21E 04	0.44E 01	0.14E 04	0.22E 03	0.22E 01	0.22E 02	0.44E 01	0.26E 02	0.26E 01
3.27	2.50	2.22	5.6	0.0	30.000	59.000	0.100	16.000	11.000	0.100	0.400	1.000	1.420	0.150
81				0.0	0.56E 03	0.11E 04	0.19E 01	0.30E 03	0.20E 03	0.19E 01	0.74E 01	0.19E 02	0.26E 02	0.28E 01
6.26	2.00	1.32	6.1	10.000	51.500	354.000	0.300	716.000	44.000	0.300	0.100	0.830	1.420	0.251
0				0.12E 03	0.57E 03	0.39E 04	0.33E 01	0.79E 04	0.48E 03	0.33E 01	0.11E 01	0.91E 01	0.16E 02	0.28E 01
MINIMUM			5.6	0.0	12.000	29.000	0.0	0.200	3.000	0.100	0.100	0.100	1.100	0.020
				0.0	0.32E 02	0.48E 02	0.0	0.67E 01	0.67E 01	0.45E 00	0.98E-01	0.98E-01	0.15E 01	0.53E-01
MAXIMUM			6.6	39.000	52.000	667.000	0.300	716.000	44.000	0.500	1.000	1.200	2.000	0.251
				0.14E 04	0.20E 04	0.31E 05	0.54E 01	0.79E 04	0.48E 03	0.11E 02	0.22E 02	0.47E 02	0.66E 02	0.37E 01
MEAN			6.1	8.325	37.423	145.000	0.117	84.515	8.500	0.229	0.408	0.751	1.420	0.108
				0.22E 03	0.72E 03	0.40E 04	0.23E 01	0.11E 04	0.13E 03	0.40E 01	0.85E 01	0.15E 02	0.27E 02	0.18E 01
STANDARD DEVIATION			0.4	10.4409	10.8969	176.7862	0.0799	192.0424	11.0491	0.1010	0.3328	0.2895	0.2058	0.0581
				394.64	626.30	8317.87	2.01	2100.85	133.22	3.73	8.36	15.77	22.39	1.30

LOCATION:IDABEL(MCCURTAIN) STATION:5 LAND USE:SILVI AREA:4.05E 06 SQ FT TESTING PERIOD:JAN 76-JUNE 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
3.08	3.50	3.40	5.6	5.000	19.000	165.000	0.100	122.000	5.000	0.500	0.800	0.400	1.600	0.140
20				0.14E 03	0.54E 03	0.47E 04	0.28E 01	0.35E 04	0.14E 03	0.14E 02	0.23E 02	0.11E 02	0.45E 02	0.40E 01
3.28	1.25	0.24	5.5	5.000	16.000	142.000	0.110	35.000	21.000	0.400	0.300	0.800	1.400	0.050
9				0.10E 02	0.33E 02	0.29E 03	0.22E 00	0.71E 02	0.43E 02	0.82E 00	0.61E 00	0.16E 01	0.29E 01	0.10E 00
4.06	3.00	2.52	5.6	18.000	46.000	83.000	0.100	51.000	11.000	0.200	0.500	1.100	2.250	0.091
13				0.38E 03	0.97E 03	0.17E 04	0.21E 01	0.11E 04	0.23E 03	0.42E 01	0.11E 02	0.23E 02	0.47E 02	0.19E 01
4.19	2.00	1.02	5.7	11.000	42.000	80.000	0.110	148.000	3.000	0.100	1.000	1.000	2.250	0.146
38				0.94E 02	0.36E 03	0.68E 03	0.94E 00	0.13E 04	0.26E 02	0.85E 00	0.85E 01	0.85E 01	0.19E 02	0.12E 01
5.27	3.50	3.40	5.2	0.0	46.000	48.000	0.100	8.000	3.000	0.400	0.300	0.600	2.250	0.080
29				0.0	0.13E 04	0.14E 04	0.28E 01	0.23E 03	0.85E 02	0.11E 02	0.85E 01	0.17E 02	0.64E 02	0.23E 01
6.25	2.90	2.35	5.7	9.000	30.000	106.000	0.100	44.000	3.000	0.300	0.500	2.300	2.250	0.080
102				0.18E 03	0.59E 03	0.21E 04	0.20E 01	0.86E 03	0.59E 02	0.59E 01	0.98E 01	0.45E 02	0.44E 02	0.16E 01
10.05	4.00	4.33	6.6	6.000	54.000	751.000	0.100	3.000	3.000	0.200	0.100	1.200	1.300	0.170
62				0.22E 03	0.20E 04	0.27E 05	0.36E 01	0.11E 03	0.11E 03	0.72E 01	0.36E 01	0.43E 02	0.47E 02	0.61E 01
12.06	1.00	0.09	6.3	3.000	34.000	78.000	0.100	20.000	6.000	0.160	0.100	1.300	1.400	0.140
39				0.23E 01	0.26E 02	0.59E 02	0.76E-01	0.15E 02	0.45E 01	0.12E 00	0.76E-01	0.98E 00	0.11E 01	0.11E 00
1.14	1.20	0.21	6.6	0.0	37.000	34.000	0.100	3.000	7.000	0.200	0.100	1.300	1.300	0.100
23				0.0	0.64E 02	0.59E 02	0.17E 00	0.52E 01	0.12E 02	0.35E 00	0.17E 00	0.23E 01	0.23E 01	0.17E 00
2.03	1.25	0.24	6.0	9.730	33.000	142.000	0.110	41.400	7.530	0.660	0.100	1.110	2.250	0.130
28				0.20E 02	0.67E 02	0.29E 03	0.22E 00	0.84E 02	0.15E 02	0.13E 01	0.20E 00	0.23E 01	0.46E 01	0.27E 00
3.03	2.70	2.03	6.4	7.000	46.000	81.000	0.100	28.000	10.000	5.300	0.100	1.100	6.500	0.280
24				0.12E 03	0.78E 03	0.14E 04	0.17E 01	0.47E 03	0.17E 03	0.90E 02	0.17E 01	0.19E 02	0.11E 03	0.47E 01
3.27	2.50	1.72	6.5	40.000	37.000	64.000	0.200	1.000	10.000	0.100	1.000	1.110	2.250	0.230
91				0.57E 03	0.82E 03	0.92E 03	0.29E 01	0.14E 02	0.14E 03	0.14E 01	0.14E 02	0.16E 02	0.32E 02	0.33E 01
6.26	2.00	1.32	6.3	12.730	43.200	67.000	0.130	34.000	8.000	0.100	0.130	1.110	2.250	0.073
0				0.11E 03	0.37E 03	0.57E 03	0.85E 00	0.29E 03	0.68E 02	0.85E 00	0.85E 00	0.94E 01	0.19E 02	0.62E 00
MINIMUN			5.2	0.0	16.000	34.000	0.100	1.000	3.000	0.100	0.100	0.400	1.300	0.050
				0.0	0.26E 02	0.59E 02	0.76E-01	0.52E 01	0.45E 01	0.12E 00	0.76E-01	0.98E 00	0.11E 01	0.10E 00
MAXIMUM			5.6	40.000	57.000	751.000	0.200	148.000	21.000	5.300	1.000	2.300	6.500	0.200
				0.57E 03	0.20E 04	0.27E 05	0.36E 01	0.35E 04	0.23E 03	0.90E 02	0.23E 02	0.45E 02	0.11E 03	0.61E 01
MEAN			6.0	9.725	39.705	141.615	0.110	41.415	7.500	0.663	0.385	1.110	2.250	0.132
				0.14E 03	0.60E 03	0.32E 04	0.16E 01	0.61E 03	0.85E 02	0.11E 02	0.63E 01	0.15E 02	0.34E 02	0.23E 01
STANDARD DEVIATION			0.5	10.3938	12.2356	187.0951	0.0274	45.0822	4.5749	1.4037	0.3484	0.4443	1.3458	0.0656
				169.63	568.36	7307.97	1.23	956.06	69.88	24.18	6.93	14.67	31.11	1.97

LOCATION:MUSKOGEE(MUSKOGEE CO)   STATION:1   LAND USE:AVT MINE   AREA:1.1E 06 SQ FT   TESTING PERIOD:JAN 76-AUG 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
5.14	1.85	0.33	7.2	11.000	20.000	186.000	0.200	25.000	62.000	0.400	0.800	0.400	25.400	0.100
2				0.30E 02	0.55E 02	0.51E 03	0.55E 00	0.68E 02	0.17E 03	0.11E 01	0.22E 01	0.11E 01	0.59E 02	0.27E 00
5.16	0.50	0.00	7.0	2.000	4.000	27.000	0.100	15.000	1560.000	26.100	0.800	0.400	25.400	0.082
10				0.74E-04	0.15E-03	0.99E-03	0.37E-05	0.55E-03	0.57E-01	0.96E-03	0.29E-04	0.15E-04	0.94E-03	0.30E-05
5.26	0.50	0.00	9.7	0.0	8.000	405.000	0.400	73.000	174.000	6.850	0.800	0.100	25.400	0.082
4				0.0	0.29E-03	0.15E-01	0.15E-04	0.27E-02	0.64E-02	0.25E-03	0.29E-04	0.37E-05	0.94E-03	0.30E-05
5.30	0.60	0.00	7.5	0.0	19.000	228.000	0.100	9.000	100.000	0.180	0.500	1.000	25.400	0.082
19				0.0	0.45E 00	0.55E 01	0.24E-02	0.22E 00	0.24E 01	0.43E-02	0.12E-01	0.24E-01	0.61E 00	0.20E-02
6.18	0.90	0.04	8.1	1.000	4.000	361.000	0.100	17.000	970.000	43.900	0.400	0.100	25.400	0.090
12				0.32E 00	0.13E 01	0.12E 03	0.32E-01	0.55E 01	0.31E 03	0.14E 02	0.13E 00	0.32E-01	0.82E 01	0.29E-01
7.01	0.60	0.00	8.0	10.000	4.000	2519.000	0.100	11.000	1360.000	45.700	0.200	1.200	47.100	0.080
0				0.24E 00	0.96E-01	0.60E 02	0.24E-02	0.26E 00	0.33E 02	0.11E 01	0.48E-02	0.29E-01	0.11E 01	0.19E-02
7.01	0.60	0.00	8.3	7.000	15.000	2302.000	0.100	25.000	1250.000	60.300	0.400	0.800	25.400	0.080
0				0.17E 00	0.36E 00	0.55E 02	0.24E-02	0.60E 00	0.30E 02	0.14E 01	0.96E-02	0.19E-01	0.61E 00	0.19E-02
7.01	0.60	0.00	7.9	11.000	11.000	1840.000	0.100	7.000	780.000	29.600	0.400	0.800	25.400	0.080
7				0.26E 00	0.26E 00	0.44E 02	0.24E-02	0.17E 00	0.19E 02	0.71E 00	0.96E-02	0.19E-01	0.61E 00	0.19E-02
7.08	0.80	0.02	7.8	10.000	14.000	3925.000	0.100	50.000	2190.000	58.900	1.500	1.100	25.400	0.090
14				0.19E 01	0.27E 01	0.75E 03	0.19E-01	0.95E 01	0.42E 03	0.11E 02	0.28E 00	0.21E 00	0.48E 01	0.17E-01
7.22	1.62	0.24	7.5	10.000	9.000	3782.000	3.500	156.000	1790.000	47.100	0.900	0.800	25.400	0.080
41				0.20E 02	0.18E 02	0.76E 04	0.70E 01	0.31E 03	0.36E 04	0.94E 02	0.18E 01	0.16E 01	0.51E 02	0.16E 00
9.01	1.40	0.17	7.3	8.000	3.000	3981.000	2.200	16.000	174.000	32.200	1.000	2.100	25.400	0.080
15				0.11E 02	0.41E 01	0.55E 04	0.30E 01	0.22E 02	0.24E 03	0.44E 02	0.14E 01	0.29E 01	0.35E 02	0.11E 00
9.16	0.50	0.00	7.4	14.000	0.630	4351.000	20.000	2828.000	76.000	37.100	0.400	4.200	25.400	0.090
1				0.52E-03	0.23E-04	0.16E 00	0.74E-03	0.10E 00	0.28E-02	0.14E-02	0.15E-04	0.15E-03	0.94E-03	0.33E-05
9.17	1.40	0.17	2.9	3.000	23.000	3344.000	10.000	285.000	2120.000	25.100	0.600	1.500	25.400	0.090
19				0.41E 01	0.32E 02	0.46E 04	0.14E 02	0.40E 03	0.29E 04	0.35E 02	0.83E 00	0.21E 01	0.35E 02	0.12E 00
10.06	2.10	0.43	8.1	0.0	5.000	1708.000	0.100	29.000	1800.000	24.500	0.700	0.600	25.800	0.110
15				0.0	0.18E 02	0.62E 04	0.36E 00	0.10E 03	0.65E 04	0.88E 02	0.25E 01	0.22E 01	0.93E 02	0.40E 00
10.31	4.50	1.70	7.7	0.0	34.000	2764.000	0.100	0.030	1065.000	64.100	0.700	0.700	25.400	0.030
12				0.0	0.48E 03	0.39E 05	0.14E 01	0.42E 00	0.15E 05	0.91E 03	0.99E 01	0.99E 01	0.36E 03	0.42E 00
11.12	1.30	0.13	7.8	3.000	14.000	3862.000	0.100	10.000	2353.000	68.600	0.700	0.400	25.400	0.010
26				0.34E 01	0.16E 02	0.43E 04	0.11E 00	0.11E 02	0.26E 04	0.77E 02	0.34E 00	0.45E 00	0.29E 02	0.11E-01

Msukogee Station 1 continued

12.08	1.30	0.13	7.3	2.000	2.000	932.000	0.100	20.000	576.000	9.900	0.400	0.700	10.900	0.030
48				0.23E 01	0.23E 01	0.10E 04	0.11E 00	0.23E 02	0.65E 03	0.11E 02	0.45E 00	0.79E 00	0.12E 02	0.34E-01
1.25	1.10	0.08	7.9	19.000	19.000	2465.000	0.100	32.000	1145.000	54.200	13.000	13.000	80.200	0.180
19				0.13E 02	0.13E 02	0.17E 04	0.68E-01	0.22E 02	0.77E 03	0.37E 02	0.88E 01	0.88E 01	0.54E 02	0.12E 00
2.13	1.10	0.08	8.2	0.0	15.000	760.000	0.100	9.000	476.000	3.000	0.600	0.900	4.400	0.070
10				0.0	0.10E 02	0.51E 03	0.68E-01	0.61E 01	0.32E 03	0.20E 01	0.41E 00	0.64E 00	0.30E 01	0.47E-01
2.23	1.50	0.20	3.3	0.0	10.000	3719.000	0.100	37.000	2073.000	63.000	3.100	1.490	25.400	0.190
32				0.0	0.17E 02	0.62E 04	0.17E 00	0.61E 02	0.34E 04	0.10E 03	0.51E 01	0.25E 01	0.42E 02	0.31E 00
3.27	4.60	1.75	7.2	19.000	38.000	291.000	0.600	408.000	113.000	2.500	1.500	1.490	25.400	0.540
22				0.28E 03	0.56E 03	0.43E 04	0.88E 01	0.60E 04	0.17E 04	0.37E 02	0.22E 02	0.22E 02	0.37E 03	0.79E 01
4.18	0.80	0.02	8.0	13.000	8.200	314.000	0.100	3.000	1477.000	59.000	0.130	1.490	25.400	0.050
3				0.25E 01	0.16E 01	0.60E 02	0.19E-01	0.57E 00	0.28E 03	0.11E 02	0.25E-01	0.28E 00	0.48E 01	0.95E-02
4.21	1.40	0.17	7.9	0.0	6.000	3060.000	0.100	1.000	135.000	63.500	0.100	1.490	25.400	0.040
29				0.0	0.83E 01	0.42E 04	0.14E 00	0.14E 01	0.19E 03	0.88E 02	0.14E 00	0.21E 01	0.35E 02	0.55E-01
5.20	2.30	0.52	7.7	14.900	8.200	1736.000	0.100	32.000	911.000	23.800	0.290	1.010	24.100	0.065
2				0.65E 02	0.36E 02	0.75E 04	0.43E 00	0.14E 03	0.40E 04	0.10E 03	0.13E 01	0.44E 01	0.11E 03	0.28E 00
5.22	0.60	0.00	8.0	13.700	7.100	2351.000	0.100	12.000	1281.000	30.500	0.100	0.782	31.300	0.039
35				0.33E 00	0.17E 00	0.56E 02	0.24E-02	0.29E 00	0.31E 02	0.73E 00	0.24E-02	0.19E-01	0.75E 00	0.93E-03
6.26	1.70	0.27	7.5	3.800	29.900	1853.000	0.100	66.000	929.000	30.200	2.500	1.490	25.400	0.024
3				0.86E 01	0.67E 02	0.42E 04	0.23E 00	0.15E 03	0.21E 04	0.68E 02	0.56E 01	0.34E 01	0.57E 02	0.54E-01
6.29	1.30	0.13	7.5	14.000	4.700	787.000	0.100	17.000	368.000	17.800	1.800	1.490	25.400	0.063
28				0.16E 02	0.53E 01	0.89E 03	0.11E 00	0.19E 02	0.41E 03	0.20E 02	0.20E 01	0.17E 01	0.29E 02	0.71E-01
7.27	3.00	0.86	6.9	6.680	3.000	645.000	0.100	157.000	203.000	22.500	1.200	1.490	25.400	0.125
17				0.48E 02	0.22E 02	0.46E 04	0.72E 00	0.11E 04	0.15E 04	0.16E 03	0.86E 01	0.11E 02	0.18E 03	0.90E 00
8.13	0.75	0.02	8.3	6.680	17.900	961.000	0.600	133.000	623.000	0.500	0.560	0.961	2.020	0.056
10				0.90E 00	0.24E 01	0.13E 03	0.81E-01	0.18E 02	0.84E 02	0.67E-01	0.76E-01	0.13E 00	0.27E 00	0.76E-02
8.23	2.30	0.52	8.5	6.680	10.000	844.000	0.200	61.000	739.000	4.700	0.110	1.360	6.170	0.158
6				0.29E 02	0.43E 02	0.37E 04	0.87E 00	0.27E 03	0.32E 04	0.20E 02	0.48E 00	0.59E 01	0.27E 02	0.69E 00
8.29	2.40	0.57	7.5	6.680	35.800	1237.000	0.100	28.000	731.000	19.500	0.340	1.000	20.800	0.055
0				0.32E 02	0.17E 03	0.58E 04	0.47E 00	0.13E 03	0.35E 04	0.92E 02	0.16E 01	0.47E 01	0.98E 02	0.26E 00

Muskogee Station 1 Continued

MINIMUN	2.9	0.0	0.630	27.000	0.100	0.030	62.000	0.180	0.100	0.100	2.020	0.010
		0.0	0.23E-04	0.99E-03	0.37E-05	0.55E-03	0.28E-02	0.25E-03	0.15E-04	0.37E-05	0.94E-03	0.30E-05
MAXIMUM	9.7	19.000	38.000	4351.000	20.000	2828.000	2353.000	68.600	13.000	13.000	80.200	0.540
		0.28E 03	0.56E 03	0.39E 05	0.14E 02	0.60E 04	0.15E 05	0.91E 03	0.22E 02	0.22E 02	0.37E 03	0.79E 01
MEAN	7.5	6.972	12.982	1856.129	1.287	147.614	955.613	31.459	1.165	1.492	25.393	0.095
		0.18E 02	0.51E 02	0.37E 04	0.12E 01	0.29E 03	0.17E 04	0.66E 02	0.25E 01	0.28E 01	0.55E 02	0.40E 00
STANDARD DEVIATION	1.3	5.9468	10.2782	********	3.9451	505.4041	706.4680	22.2704	2.3029	2.2606	13.0356	0.0923
		50.73	129.35	7069.63	3.07	1076.69	3009.76	161.95	4.58	6.61	92.67	1.41

1. RUNOFF VOLUME CALCULATED BY SCS CURVE NUMBER TECHNIQUE(SEE TEXT FOR EXPLANATION OF USAGE).

2. FIRST LINE IS CONCENTRATION IN MILLIGRAMS PER LITER(AS DETERMINED IN THE OSDH LABORATORY).

3. SECOND LINE IS TOTAL POUNDS OF POLLUTANT PER EVENT(SEE TEXT FOR EXPLANATION OF CALCULATION TECHNIQUE).

LOCATION:MUSKOGEE(MUSKOGEE CO)   STATION:2   LAND USE:CLSD MINE   AREA:2.6E 06 SQ FT   TESTING PERIOD:JAN 76-AUG 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
5.14	1.85	0.77	7.5	4.000	12.000	1561.000	0.100	3.000	875.000	46.000	0.900	0.200	1.230	0.082
2				0.26E 02	0.78E 02	0.10E 05	0.65E 00	0.19E 02	0.57E 04	0.30E 03	0.58E 01	0.13E 01	0.79E 01	0.53E 00
5.16	0.50	0.00	7.2	0.0	16.000	237.000	0.100	37.000	55.000	0.300	0.700	1.300	1.230	0.082
10				0.0	0.14E-02	0.21E-01	0.87E-05	0.32E-02	0.48E-02	0.26E-04	0.61E-04	0.11E-03	0.11E-03	0.71E-05
5.26	0.50	0.00	7.5	0.0	19.000	231.000	0.200	11.000	83.000	0.150	0.500	1.000	1.230	0.082
4				0.0	0.17E-02	0.20E-01	0.17E-04	0.96E-03	0.72E-02	0.13E-04	0.44E-04	0.87E-04	0.11E-03	0.71E-05
5.30	0.60	0.01	8.4	0.0	15.000	255.000	0.100	4.000	136.000	41.000	0.600	1.000	1.230	0.082
19				0.0	0.85E 00	0.14E 02	0.57E-02	0.23E 00	0.77E 01	0.23E 01	0.34E-01	0.57E-01	0.70E-01	0.46E-02
6.18	0.90	0.09	7.9	10.000	4.000	291.000	0.100	9.000	112.000	0.300	0.500	0.900	1.600	0.080
12				0.76E 01	0.31E 01	0.22E 03	0.76E-01	0.69E 01	0.86E 02	0.23E 00	0.38E 00	0.69E 00	0.12E 01	0.61E-01
6.30	0.50	0.00	7.7	2.000	4.000	278.000	0.100	12.000	106.000	0.400	0.500	0.300	1.230	0.090
1				0.17E-03	0.35E-03	0.24E-01	0.87E-05	0.10E-02	0.92E-02	0.35E-04	0.44E-04	0.26E-04	0.11E-03	0.78E-05
7.01	0.60	0.01	7.7	10.000	11.000	283.000	0.100	13.000	115.000	0.500	0.400	1.000	1.230	0.080
0				0.57E 00	0.62E 00	0.16E 02	0.57E-02	0.74E 00	0.65E 01	0.28E-01	0.23E-01	0.57E-01	0.70E-01	0.45E-02
7.01	0.60	0.01	7.9	11.000	11.000	281.000	0.100	5.000	109.000	0.500	0.500	0.700	1.230	0.080
7				0.62E 00	0.62E 00	0.16E 02	0.57E-02	0.28E 00	0.62E 01	0.28E-01	0.28E-01	0.40E-01	0.70E-01	0.45E-02
7.08	0.80	0.05	7.9	8.000	21.000	288.000	0.100	7.000	128.000	0.700	0.100	1.400	1.230	0.090
14				0.36E 01	0.94E 01	0.13E 03	0.45E-01	0.31E 01	0.57E 02	0.31E 00	0.45E-01	0.63E 00	0.55E 00	0.40E-01
7.22	1.62	0.57	7.8	0.0	164.000	326.000	0.100	4.000	121.000	0.400	0.100	1.600	1.230	0.080
41				0.0	0.78E 03	0.15E 04	0.47E 01	0.19E 02	0.57E 03	0.19E 01	0.47E 00	0.76E 01	0.58E 01	0.38E 00
9.01	1.40	0.39	7.9	10.000	10.000	354.000	0.100	9.000	67.000	0.300	0.300	1.800	1.230	0.080
15				0.33E 02	0.33E 02	0.12E 04	0.33E 00	0.29E 02	0.22E 03	0.98E 00	0.98E 00	0.59E 01	0.40E 01	0.26E 00
9.16	0.50	0.00	7.6	8.000	11.000	185.000	0.100	2.000	105.000	0.400	0.100	1.100	1.230	0.090
1				0.70E-03	0.96E-03	0.16E-01	0.87E-05	0.17E-03	0.91E-02	0.35E-04	0.87E-05	0.96E-04	0.11E-03	0.78E-05
9.17	1.40	0.39	8.0	7.000	10.000	370.000	0.100	6.000	146.000	0.300	0.100	1.000	1.230	0.090
19				0.23E 02	0.33E 02	0.12E 04	0.33E 00	0.20E 02	0.48E 03	0.98E 00	0.33E 00	0.33E 01	0.40E 01	0.29E 00
10.06	2.10	1.02	7.7	0.0	12.000	396.000	0.100	34.000	172.000	0.300	0.200	1.100	1.500	0.110
24				0.0	0.10E 03	0.34E 04	0.85E 00	0.29E 03	0.15E 04	0.26E 01	0.17E 01	0.94E 01	0.13E 02	0.94E 00
10.31	4.50	4.01	8.1	0.0	2.000	2348.000	0.100	4.000	1055.000	32.700	0.200	0.800	1.230	0.040
12				0.0	0.67E 02	0.78E 05	0.33E 01	0.13E 03	0.35E 05	0.11E 04	0.67E 01	0.27E 02	0.41E 02	0.13E 01
11.12	1.30	0.32	7.7	2.000	9.000	378.000	0.100	13.000	139.000	0.200	0.100	0.900	1.230	0.010
26				0.53E 01	0.24E 02	0.10E 04	0.27E 00	0.35E 02	0.37E 02	0.53E 00	0.27E 00	0.24E 01	0.33E 01	0.27E-01

Muskogee Station 2 Continued

12.08	1.30	0.32	7.9	5.000	10.000	377.000	0.100	25.000	150.000	0.300	0.100	0.900	1.100	0.050
48				0.13E 02	0.27E 02	0.10E 04	0.27E 00	0.67E 02	0.40E 03	0.80E 00	0.27E 00	0.24E 01	0.29E 01	0.13E 00
1.25	1.10	0.19	6.8	16.000	33.000	125.000	0.100	53.000	34.000	1.100	1.100	7.200	1.230	0.270
19				0.26E 02	0.53E 02	0.20E 03	0.16E 00	0.85E 02	0.54E 02	0.18E 01	0.18E 01	0.12E 02	0.20E 01	0.43E 00
2.13	1.10	0.19	8.0	0.0	13.000	336.000	0.100	16.000	157.000	0.100	0.100	1.100	1.200	0.070
10				0.0	0.21E 02	0.54E 03	0.16E 00	0.26E 02	0.25E 03	0.16E 00	0.16E 00	0.18E 01	0.19E 01	0.11E 00
2.23	1.50	0.47	7.8	0.0	16.000	364.000	0.100	39.000	169.000	0.100	1.000	1.220	1.230	0.090
32				0.0	0.63E 02	0.14E 04	0.39E 00	0.15E 03	0.66E 03	0.39E 00	0.39E 01	0.48E 01	0.48E 01	0.35E 00
3.27	4.60	4.15	7.4	14.000	27.000	205.000	0.200	48.000	62.000	0.200	1.600	1.220	1.230	0.220
22				0.48E 03	0.93E 03	0.71E 04	0.69E 01	0.17E 04	0.21E 04	0.69E 01	0.55E 02	0.42E 02	0.43E 02	0.76E 01
4.18	0.80	0.05	8.0	13.000	20.200	254.000	0.100	107.000	135.000	0.100	0.052	0.600	1.230	0.080
3				0.58E 01	0.91E 01	0.11E 03	0.45E-01	0.46E 02	0.61E 02	0.45E-01	0.28E-01	0.27E 00	0.55E 00	0.36E-01
4.21	1.40	0.39	7.4	0.0	13.000	300.000	0.100	25.000	203.000	0.100	0.100	1.220	1.230	0.070
29				0.0	0.42E 02	0.98E 03	0.33E 00	0.82E 02	0.66E 03	0.33E 00	0.33E 00	0.40E 01	0.40E 01	0.23E 00
5.20	2.30	1.23	7.6	12.100	15.400	280.000	0.100	13.000	151.000	0.100	0.180	1.120	1.230	0.046
2				0.12E 03	0.16E 03	0.29E 04	0.10E 01	0.12E 03	0.16E 04	0.10E 01	0.18E 01	0.12E 02	0.13E 02	0.47E 00
5.22	0.60	0.01	8.2	14.600	3.000	290.000	0.100	6.000	154.000	0.100	0.100	0.784	1.230	0.032
35				0.83E 00	0.17E 00	0.16E 02	0.57E-02	0.34E 00	0.87E 01	0.57E-02	0.57E-02	0.44E-01	0.70E-01	0.18E-02
6.26	1.70	0.64	7.8	4.400	11.200	336.000	0.100	23.000	173.000	0.100	0.100	1.450	1.450	0.027
3				0.23E 02	0.60E 02	0.18E 04	0.53E 00	0.12E 03	0.92E 03	0.53E 00	0.53E 00	0.77E 01	0.77E 01	0.14E 00
6.29	1.30	0.32	7.8	13.000	10.000	348.000	60.100	10.000	165.000	0.100	0.600	1.220	1.230	0.044
28				0.35E 02	0.27E 02	0.93E 03	0.16E 03	0.27E 02	0.44E 03	0.27E 00	0.21E 01	0.32E 01	0.33E 01	0.12E 00
7.27	3.00	2.04	8.0	6.080	5.000	349.000	0.100	15.000	166.000	0.100	1.400	1.220	1.230	0.059
17				0.10E 03	0.85E 02	0.59E 04	0.17E 01	0.26E 03	0.28E 04	0.17E 01	0.24E 02	0.21E 02	0.21E 02	0.10E 01
8.13	0.75	0.04	8.5	6.080	8.300	377.000	0.200	13.000	183.000	0.100	0.260	0.793	1.050	0.037
10				0.19E 01	0.26E 01	0.12E 03	0.64E-01	0.41E 01	0.58E 02	0.32E-01	0.83E-01	0.25E 00	0.33E 00	0.12E-01
8.23	2.30	1.23	8.1	6.080	12.000	404.000	0.100	32.000	172.000	0.100	0.050	1.050	1.150	0.089
6				0.62E 02	0.12E 03	0.41E 04	0.10E 01	0.33E 03	0.18E 04	0.10E 01	0.51E 00	0.11E 02	0.12E 02	0.91E 00
8.29	2.40	1.34	7.7	6.080	13.300	344.000	0.100	38.000	161.000	0.100	0.050	0.570	0.750	0.060
0				0.68E 02	0.15E 03	0.38E 04	0.11E 01	0.42E 03	0.18E 04	0.11E 01	0.89E 00	0.64E 01	0.84E 01	0.67E 00
MINIMUN			6.8	0.0	2.000	125.000	0.100	2.000	34.000	0.100	0.050	0.200	0.750	0.010
				0.0	0.35E-03	0.16E-01	0.87E-05	0.17E-03	0.48E-02	0.13E-04	0.87E-05	0.26E-04	0.11E-03	0.71E-05
MAXIMUM			8.5	16.000	164.000	2348.000	60.100	107.000	1055.000	46.000	1.600	7.200	1.600	0.270
				0.48E 03	0.93E 03	0.78E 05	0.16E 03	0.17E 04	0.35E 05	0.11E 04	0.55E 02	0.42E 02	0.43E 02	0.76E 01
MEAN			7.8	6.078	17.464	411.323	2.045	20.484	185.774	4.105	0.414	1.219	1.229	0.080
				0.34E 02	0.93E 02	0.41E 04	0.58E 01	0.13E 03	0.19E 04	0.46E 02	0.35E 01	0.60E 01	0.66E 01	0.52E 00
STANDARD DEVIATION			0.3	5.2235	27.9870	429.2488	10.7746	21.3834	213.1658	12.0379	0.4189	1.1609	0.1348	0.0500
				89.18	209.38	14000.98	28.63	304.55	6309.33	201.50	10.58	9.22	10.62	1.36

LOCATION:MUSKOGEE(MUSKOGEE CO)   STATION:3   LAND USE:OPEN MINE   AREA:1.7E 06 SQ FT   TESTING PERIOD:JAN 76-AUG 77

DATE	RF AMT (IN)	RO VOL (GAL*E6)	PH	BOD	COD	DISS SOLD	SETT SOLD	SS	SO4	NO2+NO3	NH4	ORG N	TOT N	TOT PO4
9.16	0.50	0.00	7.5	6.000	7.000	3364.000	0.100	3.000	52.000	36.200	0.100	0.800	45.000	0.090
1				0.34E-03	0.40E-03	0.19E 00	0.57E-05	0.17E-03	0.30E-02	0.21E-02	0.57E-05	0.46E-04	0.26E-02	0.51E-05
9.17	1.40	0.26	7.8	5.000	5.000	2992.000	0.100	11.000	1050.000	31.800	0.100	0.600	45.000	0.090
19				0.11E 02	0.11E 02	0.64E 04	0.21E 00	0.23E 02	0.22E 04	0.68E 02	0.21E 00	0.13E 01	0.96E 02	0.19E 00
10.06	2.10	0.67	8.0	0.0	5.000	3000.000	0.100	41.000	3550.000	37.000	0.100	0.500	45.000	0.110
25				0.0	0.28E 02	0.17E 05	0.56E 00	0.23E 03	0.20E 05	0.21E 03	0.56E 00	0.23E 01	0.25E 03	0.61E 00
10.31	4.50	2.62	8.0	0.0	6.000	364.000	0.100	19.000	120.000	0.200	0.200	0.800	45.000	0.030
12				0.0	0.13E 03	0.80E 04	0.22E 01	0.42E 03	0.26E 04	0.44E 01	0.44E 01	0.17E 02	0.98E 03	0.66E 00
11.12	1.30	0.21	8.0	2.000	6.000	2450.000	0.100	3.000	1221.000	35.200	0.100	0.400	45.000	0.010
26				0.35E 01	0.10E 02	0.43E 04	0.17E 00	0.52E 01	0.21E 04	0.61E 02	0.17E 00	0.70E 00	0.78E 02	0.17E-01
12.08	1.30	0.21	8.1	2.000	2.000	2640.000	0.100	19.000	1162.000	32.600	0.100	0.600	33.200	0.030
48				0.35E 01	0.35E 01	0.46E 04	0.17E 00	0.33E 02	0.20E 04	0.57E 02	0.17E 00	0.10E 01	0.58E 02	0.52E-01
1.25	1.10	0.13	7.2	15.000	10.000	1409.000	0.100	69.000	11.000	13.400	0.900	2.000	45.000	0.100
19				0.16E 02	0.10E 02	0.15E 04	0.10E 00	0.72E 02	0.12E 02	0.14E 02	0.94E 00	0.21E 01	0.47E 02	0.10E 00
2.13	1.10	0.13	8.1	0.0	8.000	2564.000	0.100	5.000	1365.000	30.000	2.200	0.900	33.100	0.040
10				0.0	0.84E 01	0.27E 04	0.10E 00	0.52E 01	0.14E 04	0.31E 02	0.23E 01	0.94E 00	0.35E 02	0.42E-01
2.23	1.50	0.31	8.0	0.0	82.000	2647.000	0.100	37.000	1317.000	29.300	0.800	0.960	45.000	0.050
32				0.0	0.21E 03	0.68E 04	0.26E 00	0.95E 02	0.34E 04	0.75E 02	0.20E 01	0.25E 01	0.12E 03	0.13E 00
3.27	4.60	2.71	7.2	0.0	8.000	1382.000	0.100	43.000	706.000	40.800	4.000	0.960	45.000	0.130
25				0.0	0.18E 03	0.31E 05	0.23E 01	0.97E 03	0.16E 05	0.92E 03	0.90E 02	0.22E 02	0.10E 04	0.29E 01
4.21	1.40	0.26	7.5	0.0	8.000	4068.000	0.500	10.000	2240.000	51.500	0.100	0.960	45.000	0.070
29				0.0	0.17E 02	0.87E 04	0.11E 01	0.21E 02	0.48E 04	0.11E 03	0.21E 00	0.20E 01	0.96E 02	0.15E 00
5.20	2.30	0.81	8.3	19.800	9.600	3497.000	0.100	23.000	1893.000	57.000	0.100	1.300	58.300	0.044
2				0.13E 03	0.64E 02	0.23E 05	0.67E 00	0.15E 03	0.13E 05	0.38E 03	0.67E 00	0.87E 01	0.39E 03	0.30E 00
5.22	0.60	0.00	3.8	16.900	12.100	5760.000	0.100	94.000	3347.000	63.000	0.100	1.300	64.300	0.093
35				0.63E 00	0.45E 00	0.21E 03	0.37E-02	0.31E 01	0.12E 03	0.23E 01	0.37E-02	0.48E-01	0.24E 01	0.34E-02
6.26	1.70	0.42	7.4	4.800	48.000	2803.000	1.400	377.000	1467.000	60.500	0.900	0.549	62.000	0.084
3				0.17E 02	0.17E 03	0.97E 04	0.49E 01	0.13E 04	0.51E 04	0.21E 03	0.31E 01	0.19E 01	0.22E 03	0.29E 00
6.29	1.30	0.21	7.4	5.110	3.000	3554.000	0.100	12.000	1838.000	65.000	0.160	0.960	45.000	0.025
28				0.89E 01	0.52E 01	0.62E 04	0.17E 00	0.21E 02	0.32E 04	0.11E 03	0.28E 00	0.17E 01	0.78E 02	0.43E-01
7.27	3.00	1.33	6.9	5.110	21.000	573.000	0.900	142.000	203.000	0.800	3.500	0.960	45.000	0.239
17				0.57E 02	0.23E 03	0.64E 04	0.10E 02	0.16E 04	0.23E 04	0.89E 01	0.39E 02	0.11E 02	0.50E 03	0.27E 01

Muskogee Station 3 Continued

8.13	0.75	0.03	8.1	5.110	29.300	3142.000	0.300	49.000	1118.000	26.500	0.640	2.280	29.400	0.025
10				0.11E 01	0.61E 01	0.66E 03	0.63E-01	0.10E 02	0.23E 03	0.55E 01	0.13E 00	0.48E 00	0.61E 01	0.52E-02
8.23	2.30	0.81	6.2	5.110	18.300	1653.000	1.200	217.000	996.000	29.000	3.000	1.160	33.200	0.130
6				0.34E 02	0.12E 03	0.11E 05	0.81E 01	0.15E 04	0.67E 04	0.19E 03	0.20E 02	0.78E 01	0.22E 03	0.87E 00
8.29	2.40	0.88	7.7	5.110	8.000	2300.000	0.100	22.000	1279.000	44.800	1.100	0.210	46.100	0.021
0				0.37E 02	0.58E 02	0.17E 05	0.73E 00	0.16E 03	0.93E 04	0.33E 03	0.80E 01	0.15E 01	0.34E 03	0.15E 00
MINIMUN			3.8	0.0	2.000	364.000	0.100	3.000	11.000	0.200	0.100	0.210	29.400	0.010
				0.0	0.40E-03	0.19E 00	0.57E-05	0.17E-03	0.30E-02	0.21E-02	0.57E-05	0.46E-04	0.26E-02	0.51E-05
MAXIMUM			8.3	19.800	82.000	5760.000	1.400	377.000	3550.000	65.000	4.000	2.280	64.300	0.239
				0.13E 03	0.23E 03	0.31E 05	0.10E 02	0.16E 04	0.20E 05	0.92E 03	0.90E 02	0.22E 02	0.10E 04	0.29E 01
MEAN			7.4	5.108	15.595	2640.105	0.300	62.421	1312.368	36.032	0.958	0.958	44.975	0.074
				0.17E 02	0.67E 02	0.87E 04	0.17E 01	0.25E 03	0.49E 04	0.15E 03	0.91E 01	0.45E 01	0.24E 03	0.49E 00
STANDARD DEVIATION			1.0	5.914	19.465	1249.042	0.407	93.277	977.193	18.611	1.262	0.509	9.138	0.055
				32.28	90.22	8240.11	2.67	542.66	5638.85	218.79	21.90	6.14	302.64	0.85

1. RUNOFF VOLUME CALCULATED BY SCS CURVE NUMBER TECHNIQUE(SEE TEXT FOR EXPLANATION OF USAGE).

2. FIRST LINE IS CONCENTRATION IN MILLIGRAMS PER LITER(ABSDETERMINED IN THE OSDH LABORATORY).

3. SECOND LINE IS TOTAL POUNDS OF POLLUTANT PER EVENT(SEE TEXT FOR EXPLANATION OF CALCULATION TECHNIQUE).

APPENDIX D

Computer Program for Ranking Oklahoma's Seven Major River Basins by Estimated Pollutant Loading Rates

This computer program is written in Basic Fortran for the IBM 360/370 computer. Loading rates of nine different pollutants (as determined from a monitoring program) from six different land uses, and based on the areas of these six land uses within each basin are used to estimate the pollutant load from the basin. The estimate is then compared to the loading rates of the other basins in a ranking routine to determine which basin has the greatest potential for problems due to nonpoint sources of pollution. Step by step procedures, and an explanation of the formulas used may be found in Chapter V of the text. (Comment cards within the program listing provide a guide).

```
      REAL LOAD
      DIMENSION AOLAUS(6,7),CONT(6,9,7),SOALU(7),LOAD(6,9,7),IIRANK(7),S
     1UMLOD(9,7),TOT(9,7),IRANK(9,7),ITRANK(7),IPOL(9)
C
C     INPUT AREA OF LAND USE IN ACRE
      READ(5,7)((AOLAUS(I,J),I=1,6),J=1,7)
    7 FORMAT(10X,6F10.0)
C
C     INPUT CONTRIBUTION IN LBS/ACRE/YR
      READ(5,12)(((CONT(I,N,J),I=1,6),N=1,9),J=1,7)
   12 FORMAT(10X,6F10.4)
      DO 14 J=1,7
      SOALU(J)=0.
      DO 9 I=1,6
C
C     COMPUTE SUM OF AREA OF LAND USE
    9 SOALU(J)=SOALU(J)+AOLAUS(I,J)
      DO 14 N=1,9
      SUMLOD(N,J)=0.
      DO 14 I=1,6
C
C     COMPUTE POLLUTION LOAD IN LBS/YR
      LOAD(I,N,J)=AOLAUS(I,J)*CONT(I,N,J)
C
C     COMPUTE SUM OF POLLUTION LOAD
      SUMLOD(N,J)=SUMLOD(N,J)+LOAD(I,N,J)
C
C     COMPUTE TOTAL CONTRIBUTION IN LBS/ACRE/YR
      TOT(N,J)=SUMLOD(N,J)/SOALU(J)
      JJ=J
   14 TOT(N,JJ)=TOT(N,J)
C
C     RANK POLLUTION CONTRIBUTED TO EACH BASIN BY EACH POLLUTANT
      DO 18 N=1,9
      DO 18 J=1,7
      IRK=0
      DO 17 JJ=1,7
      IF(TOT(N,J)-TOT(N,JJ)) 15,16,16
   15 IRK=IRK+0
      GO TO 17
   16 IRK=IRK+1
      GO TO 17
   17 CONTINUE
   18 IRANK(N,J)=8-IRK
C
C     RANK TOTAL POLLUTION CONTRIBUTED TO EACH BASIN
      DO 19 J=1,7
      ITRANK(J)=0
      DO 91 N=1,9
   91 ITRANK(J)=IRANK(N,J)+ITRANK(J)
      JJ=J
   19 ITRANK(JJ)=ITRANK(J)
```

```
      DO 23 J=1,7
      IRK=0
      DO 22 JJ=1,7
      IF(ITRANK(J)-ITRANK(JJ))20,21,21
   20 IRK=IRK+0
      GO TO 22
   21 IRK=IRK+1
      GO TO 22
   22 CONTINUE
   23 IIRANK(J)=IRK
C
C     ARRANGE THE ORDER OF POLLUTANT
      DO 32 N=2,9
      IPOL(1)=1
   32 IPOL(N)=IPOL(N-1)+1
C
C     OUTPUT
      WRITE(6,200)
  200 FORMAT(30X,'DEFINITION',//,4X,'LD=LAND, AOLAUS=AREA OF LAND USE(AC
     1RE), SOALU=SUM OF AREA OF LAND USE, CONT=CONTRIBUTION,',/,4X,'POL
     21=BOD, POL 2=COD, POL3=SS, POL 4=SO4, POL5=NO2+NO3, POL 6=NH4, POL
     3 7=ORG-N, POL 8=TOT-N, POL 9=PO4')
      DO 30 J=1,7
      WRITE(6,3)
    3 FORMAT(1H1,///////,6X,'     BASIN',//,3X,'LD USE',4X,'CROP',4X,'PAS
     1TURE',4X,'RANGE',5X,'FOREST',4X,'URBAN',5X,'OTHER',6X,'SUM',5X,'TO
     2TAL',6X,'RANK')
      WRITE(6,8)(AOLAUS(I,J),I=1,6),(SOALU(J))
    8 FORMAT(2X,'AOLAUS',2X,6(1X,F8.0,1X),1X,F9.0)
      DO 31 N=1,9
      WRITE(6,24)(CONT(I,N,J),I=1,6)
   24 FORMAT(//,3X,'CONT',3X,6(F9.4,1X))
      WRITE(6,25)IPOL(N),(LOAD(I,N,J),I=1,6),SUMLOD(N,J),TOT(N,J),IRANK(
     1N,J)
   25 FORMAT(2X,'POL',1X,I2,2X,6(1X,E8.2,1X),1X,E8.2,2X,F8.3,5X,I2)
   31 CONTINUE
      WRITE(6,26)IIRANK(J)
   26 FORMAT(//,5X,'TOTAL RANK= ',I2)
   30 CONTINUE
      END
```

DEFINITION

LD....................................	LAND
AOLAUS................................	AREA OF LAND USE (ACRE)
SOALU.................................	SUM OF AREA OF LAND USE
CONT..................................	CONCENTRATION
POL 1.................................	BOD
POL 2.................................	COD
POL 3.................................	SS
POL 4.................................	SO_4
POL 5.................................	$NO_2 + NO_3$
POL 6.................................	NH_4
POL 7.................................	ORG-N
POL 8.................................	TOT-N
POL 9.................................	PO_4

BASIN 1 Middle Arkansas

LD USE	CROP	PASTURE	RANGE	FOREST	URBAN	OTHER	SUM	TOTAL	RANK
ADLAUS	537649.	1941273.	1531993.	1143388.	338330.	90331.	5582964.		
CONT	0.0100	0.2100	1.6500	10.2000	1.7400	1.7400			
POL 1	0.54E 04	0.41E 06	0.26E 07	0.12E 08	0.59E 06	0.16E 06	0.15E 08	2.760	7
CONT	0.0400	2.1800	5.4400	12.0600	5.3900	5.3900			
POL 2	0.22E 05	0.42E 07	0.83E 07	0.14E 08	0.18E 07	0.49E 06	0.29E 08	5.138	7
CONT	0.3000	3.5800	29.1000	8.0100	40.5400	40.5400			
POL 3	0.16E 06	0.69E 07	0.45E 08	0.92E 07	0.14E 08	0.37E 07	0.78E 08	14.012	6
CONT	0.0200	0.8000	0.9500	4.1000	1.1000	1.1000			
POL 4	0.11E 05	0.16E 07	0.15E 07	0.47E 07	0.37E 06	0.99E 05	0.82E 07	1.465	7
CONT	0.0004	0.0300	0.0200	0.0500	0.0600	0.0600			
POL 5	0.22E 03	0.58E 05	0.31E 05	0.57E 05	0.20E 05	0.54E 04	0.17E 06	0.031	7
CONT	0.0005	0.0600	0.0800	0.6500	0.0500	0.0500			
POL 6	0.27E 03	0.12E 06	0.12E 06	0.74E 06	0.17E 05	0.45E 04	0.10E 07	0.160	4
CONT	0.0010	0.0900	0.0600	0.0300	0.1100	0.1100			
POL 7	0.54E 03	0.17E 06	0.92E 05	0.34E 05	0.37E 05	0.99E 04	0.35E 06	0.062	6
CONT	0.0020	0.0900	0.0600	0.0300	0.0900	0.0900			
POL 8	0.11E 04	0.17E 06	0.92E 05	0.34E 05	0.30E 05	0.81E 04	0.34E 06	0.061	6
CONT	0.0010	0.0100	0.0200	0.5700	0.0500	0.0500			
POL 9	0.54E 03	0.19E 05	0.31E 05	0.65E 06	0.17E 05	0.45E 04	0.72E 06	0.130	7

TOTAL RANK= 7.

BASIN 2 Lower Arkansas

LD USE	CROP	PASTURE	RANGE	FOREST	URBAN	OTHER	SUM	TOTAL	RANK
ACLAUS	112654.	635259.	267209.	1164430.	69853.	72625.	2322030.		
CONT	0.0100	0.2100	1.6900	10.2000	1.7400	1.7400			
POL 1	0.11E 04	0.13E 06	0.45E 06	0.12E 08	0.12E 06	0.13E 06	0.13E 08	5.474	4
CONT	0.0400	2.1800	5.4400	12.3600	5.3900	5.3900			
POL 2	0.45E 04	0.14E 07	0.15E 07	0.14E 08	0.38E 06	0.39E 06	0.18E 08	7.603	6
CONT	0.3000	3.5800	29.1000	8.0100	40.5400	40.5400			
POL 3	0.34E 05	0.23E 07	0.78E 07	0.93E 07	0.28E 07	0.29E 07	0.25E 08	10.847	7
CONT	0.0200	0.8000	0.9500	4.1000	1.1000	1.1000			
POL 4	0.23E 04	0.51E 06	0.25E 06	0.48E 07	0.77E 05	0.80E 05	0.57E 07	2.453	6
CONT	0.0004	0.0300	0.0200	0.0500	0.0600	0.0600			
POL 5	0.45E 02	0.19E 05	0.53E 04	0.58E 05	0.42E 04	0.44E 04	0.91E 05	0.039	6
CONT	0.0005	0.0600	0.0800	0.6500	0.0500	0.0500			
POL 6	0.56E 02	0.38E 05	0.21E 05	0.76E 06	0.35E 04	0.36E 04	0.82E 06	0.355	3
CONT	0.0010	0.0900	0.0600	0.0300	0.1100	0.1100			
POL 7	0.11E 03	0.57E 05	0.16E 05	0.35E 05	0.77E 04	0.80E 04	0.12E 06	0.053	7
CONT	0.0020	0.0900	0.0600	0.0300	0.0900	0.0900			
POL 8	0.23E 03	0.57E 05	0.16E 05	0.35E 05	0.63E 04	0.65E 04	0.12E 06	0.052	7
CONT	0.0010	0.0100	0.0200	0.5700	0.0500	0.0500			
POL 9	0.11E 03	0.64E 04	0.53E 04	0.66E 06	0.35E 04	0.36E 04	0.68E 06	0.294	6

TOTAL RANK= 6

BASIN 3 Upper Red

LD USE	CROP	PASTURE	RANGE	FOREST	URBAN	OTHER	SUM	TOTAL	RANK
ACLAUS	3723571.	1105400.	3938335.	848414.	258682.	538572.	10412974.		
CONT	6.4900	0.6100	16.5600	10.2000	1.7400	1.7400			
POL 1	0.24E 08	0.67E 06	0.65E 08	0.87E 07	0.45E 06	0.94E 06	0.10E 09	9.613	2
CONT	25.0300	4.1300	109.7000	12.0600	5.3900	5.3900			
POL 2	0.93E 08	0.46E 07	0.43E 09	0.10E 08	0.14E 07	0.29E 07	0.54E 09	52.274	1
CONT	392.0000	34.9100	1793.0000	8.0100	40.5400	40.5400			
POL 3	0.15E 10	0.39E 08	0.71E 10	0.68E 07	0.10E 08	0.22E 08	0.86E 10	825.775	1
CONT	7.4000	2.9200	156.0000	4.1000	1.1000	1.1000			
POL 4	0.28E 08	0.32E 07	0.61E 09	0.35E 07	0.28E 06	0.59E 06	0.65E 09	62.376	1
CONT	0.0700	0.0200	0.2880	0.0500	0.0600	0.0600			
POL 5	0.26E 06	0.22E 05	0.11E 07	0.42E 05	0.16E 05	0.32E 05	0.15E 07	0.145	4
CONT	0.0700	0.0100	2.1000	0.6500	0.0500	0.0500			
POL 6	0.26E 06	0.11E 05	0.83E 07	0.55E 06	0.13E 05	0.27E 05	0.91E 07	0.877	1
CONT	1.5600	0.0500	1.0600	0.0300	0.1100	0.1100			
POL 7	0.58E 07	0.55E 05	0.42E 07	0.25E 05	0.28E 05	0.59E 05	0.10E 08	0.975	4
CONT	0.9600	0.0400	2.1900	0.0300	0.0900	0.0900			
POL 8	0.36E 07	0.44E 05	0.86E 07	0.25E 05	0.23E 05	0.48E 05	0.12E 08	1.185	4
CONT	0.6700	0.1000	1.7000	0.5700	0.0500	0.0500			
POL 9	0.25E 07	0.11E 06	0.67E 07	0.48E 06	0.13E 05	0.27E 05	0.98E 07	0.943	1

TOTAL RANK= 1

BASIN 4 Lower Red

LD USE	CROP	PASTURE	RANGE	FOREST	URBAN	OTHER	SUM	TOTAL	RANK
ADLAUS	322314.	661172.	1531038.	2300786.	85884.	124535.	5025729.		
CONT	20.1900	16.5200	14.2500	10.2000	1.7400	1.7400			
POL 1	0.65E 07	0.11E 08	0.22E 08	0.23E 08	0.15E 06	0.22E 06	0.63E 08	12.552	1
CONT	57.1400	56.2300	34.5200	12.0600	5.3900	5.3900			
POL 2	0.18E 08	0.37E 08	0.53E 08	0.28E 08	0.46E 06	0.67E 06	0.14E 09	27.325	3
CONT	269.0000	34.3100	74.8900	8.0100	40.5400	40.5400			
POL 3	0.87E 08	0.23E 08	0.11E 09	0.18E 08	0.35E 07	0.50E 07	0.25E 09	49.944	5
CONT	13.4900	8.6800	20.5500	4.1000	1.1000	1.1000			
POL 4	0.43E 07	0.57E 07	0.31E 08	0.94E 07	0.94E 05	0.14E 06	0.51E 08	10.190	4
CONT	5.0400	0.7100	0.3300	0.0500	0.0600	0.0600			
POL 5	0.16E 07	0.47E 06	0.51E 06	0.12E 06	0.52E 04	0.75E 04	0.27E 07	0.543	1
CONT	1.3900	0.8200	0.5100	0.6500	0.0500	0.0500			
POL 6	0.45E 06	0.54E 06	0.78E 06	0.15E 07	0.43E 04	0.62E 04	0.33E 07	0.652	2
CONT	2.7200	1.9300	1.7400	0.0300	0.1100	0.1100			
POL 7	0.88E 06	0.13E 07	0.27E 07	0.69E 05	0.94E 04	0.14E 05	0.49E 07	0.977	3
CONT	11.6400	1.8000	2.4500	0.0300	0.0900	0.0900			
POL 8	0.38E 07	0.12E 07	0.38E 07	0.69E 05	0.77E 04	0.11E 05	0.88E 07	1.747	1
CONT	0.2600	0.6800	0.2200	0.5700	0.0500	0.0500			
POL 9	0.84E 05	0.45E 06	0.34E 06	0.13E 07	0.43E 04	0.62E 04	0.22E 07	0.436	2

TOTAL RANK= 2

BASIN 5 Canadian River

LD USE	CROP	PASTURE	RANGE	FOREST	URBAN	OTHER	SUM	TOTAL	RANK
ADLAUS	1360851.	1252767.	3153001.	1013927.	246508.	44930.	7071984.		
CONT	6.4900	0.6100	7.2500	10.2000	1.7400	1.7400			
POL 1	0.88E 07	0.76E 06	0.23E 08	0.10E 08	0.43E 06	0.78E 05	0.43E 08	6.123	3
CONT	25.0300	4.1300	21.7100	12.0600	5.3900	5.3900			
POL 2	0.34E 08	0.52E 07	0.68E 08	0.12E 08	0.13E 07	0.24E 06	0.12E 09	17.179	5
CONT	392.0000	34.9100	74.8500	8.0100	40.5400	40.5400			
POL 3	0.53E 09	0.44E 08	0.24E 09	0.81E 07	0.10E 08	0.18E 07	0.83E 09	117.806	4
CONT	7.4000	2.9200	6.2200	4.1000	1.1000	1.1000			
POL 4	0.10E 08	0.37E 07	0.20E 08	0.42E 07	0.27E 06	0.49E 05	0.38E 08	5.348	5
CONT	0.0700	0.0200	0.2400	0.0500	0.0600	0.0600			
POL 5	0.95E 05	0.25E 05	0.76E 06	0.51E 05	0.15E 05	0.27E 04	0.95E 06	0.134	5
CONT	0.0700	0.0100	0.0500	0.6500	0.0500	0.0500			
POL 6	0.95E 05	0.13E 05	0.16E 06	0.66E 06	0.12E 05	0.22E 04	0.94E 06	0.133	5
CONT	1.5600	0.0500	0.5900	0.0300	0.1100	0.1100			
POL 7	0.21E 07	0.63E 05	0.19E 07	0.30E 05	0.27E 05	0.49E 04	0.41E 07	0.581	5
CONT	0.2600	0.0400	1.0500	0.0300	0.0900	0.0900			
POL 8	0.35E 06	0.50E 05	0.33E 07	0.30E 05	0.22E 05	0.40E 04	0.38E 07	0.533	5
CONT	0.6700	0.1000	0.2400	0.5700	0.0500	0.0500			
POL 9	0.91E 06	0.13E 06	0.76E 06	0.58E 06	0.12E 05	0.22E 04	0.24E 07	0.337	5

TOTAL RANK= 5

BASIN 6 Upper Arkansas

LD USE	CROP	PASTURE	RANGE	FOREST	URBAN	OTHER	SUM	TOTAL	RANK
POLAUS	2787393.	533439.	2520160.	462772.	369732.	82815.	6756311.		
CONT	6.2300	1.8100	4.6300	10.2000	1.7400	1.7400			
POL 1	0.17E 08	0.97E 06	0.12E 08	0.47E 07	0.64E 06	0.14E 06	0.36E 08	5.255	6
CONT	40.7500	12.4300	16.0700	12.0600	5.3900	5.3900			
POL 2	0.11E 09	0.66E 07	0.40E 08	0.56E 07	0.20E 07	0.45E 06	0.17E 09	24.975	4
CONT	666.0000	65.1600	140.0000	8.0100	40.5400	40.5400			
POL 3	0.19E 10	0.35E 08	0.35E 09	0.37E 07	0.15E 08	0.34E 07	0.23E 10	335.396	3
CONT	24.0800	1.8100	3.9900	4.1000	1.1000	1.1000			
POL 4	0.67E 08	0.97E 06	0.10E 08	0.19E 07	0.41E 06	0.91E 05	0.81E 08	11.920	3
CONT	0.3100	0.1000	0.2300	0.3500	0.3600	0.0600			
POL 5	0.86E 06	0.53E 05	0.58E 06	0.23E 05	0.22E 05	0.50E 04	0.15E 07	0.229	3
CONT	0.1100	0.0400	0.0900	0.6500	0.0500	0.0500			
POL 6	0.31E 06	0.21E 05	0.23E 06	0.30E 06	0.18E 05	0.41E 04	0.88E 06	0.130	6
CONT	1.8800	0.6800	0.8900	0.0300	0.1100	0.1100			
POL 7	0.52E 07	0.36E 06	0.22E 07	0.14E 05	0.41E 05	0.91E 04	0.79E 07	1.171	2
CONT	1.6700	0.5500	1.2300	0.0300	0.0900	0.0900			
POL 8	0.47E 07	0.29E 06	0.31E 07	0.14E 05	0.33E 05	0.75E 04	0.81E 07	1.199	3
CONT	0.2300	0.1400	0.5300	0.5700	0.0500	0.0500			
POL 9	0.64E 06	0.75E 05	0.13E 07	0.26E 06	0.18E 05	0.41E 04	0.23E 07	0.346	4

TOTAL RANK= 4

BASIN 7 Panhandle

LD USE	CROP	PASTURE	RANGE	FOREST	URBAN	OTHER	SUM	TOTAL	RANK
ADLAUS	1696326.	3171.	1770336.	3743.	25918.	3191.	3502685.		
CONT	6.2300	1.8100	4.6300	10.2000	1.7400	1.7400			
POL 1	0.11E 08	0.57E 04	0.82E 07	0.38E 05	0.45E 05	0.56E 04	0.19E 08	5.384	5
CONT	40.7500	12.4300	16.0700	12.0600	5.3900	5.3900			
POL 2	0.69E 08	0.39E 05	0.28E 08	0.45E 05	0.14E 06	0.17E 05	0.98E 08	27.926	2
CONT	666.0000	65.1600	140.0000	8.0100	40.5400	40.5400			
POL 3	0.11E 10	0.21E 06	0.25E 09	0.30E 05	0.11E 07	0.13E 06	0.14E 10	393.703	2
CONT	24.0800	1.8100	3.9900	4.1000	1.1000	1.1000			
POL 4	0.41E 08	0.57E 04	0.71E 07	0.15E 05	0.29E 05	0.35E 04	0.48E 08	13.694	2
CONT	0.3100	0.1000	0.2300	0.0500	0.0600	0.0600			
POL 5	0.53E 06	0.32E 03	0.41E 06	0.19E 03	0.16E 04	0.19E 03	0.94E 06	0.267	2
CONT	0.1100	0.0400	0.0900	0.6500	0.0500	0.0500			
POL 6	0.19E 06	0.13E 03	0.16E 06	0.24E 04	0.13E 04	0.16E 03	0.35E 06	0.100	7
CONT	1.8800	0.6800	0.8900	0.0300	0.1100	0.1100			
POL 7	0.32E 07	0.22E 04	0.16E 07	0.11E 03	0.29E 04	0.35E 03	0.48E 07	1.362	1
CONT	1.6700	0.5500	1.2300	0.0300	0.0900	0.0900			
POL 8	0.28E 07	0.17E 04	0.22E 07	0.11E 03	0.23E 04	0.29E 03	0.50E 07	1.432	2
CONT	0.2300	0.1400	0.5300	0.5700	0.0500	0.0500			
POL 9	0.39E 06	0.44E 03	0.94E 06	0.21E 04	0.13E 04	0.16E 03	0.13E 07	0.380	3

TOTAL RANK= 3

APPENDIX E

Computer Program for Ranking of Sub-Basins by Estimated Pollutant Loading Rates

This computer program is written in Basic Fortran for the IBM 360/370 computer. Land use information on the sub-basin within the basin identified by the program in Appendix D, and based on the loading rates for each of the land uses (determined in a monitoring program) are used to calculate the pollutant loading rate for each sub-basin (in this case, the six sub-basins within Basin 3). The loading rates from each sub-basin are then compared through a ranking routine to determine which sub-basin has the greatest potential for nonpoint pollution problems. Step by step procedures, and explanation of the formulas used may be found in Chapter V of the text. (Comment cards within the program listing provide a guide).

```
      REAL LOAD
      DIMENSION AOLAUS(6,6),CONT(6,9,6),SOALU(6),LOAD(6,9,6),IIRANK(6),S
     1UMLOD(9,6),TOT(9,6),IRANK(9,6),ITRANK(6),IPOL(9)
C
C     INPUT AREA OF LAND USE IN ACRE
      READ(5,7)((AOLAUS(I,J),I=1,6),J=1,6)
    7 FORMAT(10X,6F10.0)
C
C     INPUT CONTRIBUTION IN LBS/ACRE/YR'
      READ(5,12)(((CONT(I,N,J),I=1,6),N=1,9),J=1,6)
   12 FORMAT(10X,6F10.4)
      DO 14 J=1,6
      SOALU(J)=0.
      DO 9 I=1,6
C
C     COMPUTE SUM OF AREA OF LAND USE
    9 SOALU(J)=SOALU(J)+AOLAUS(I,J)
      DO 14 N=1,9
      SUMLOD(N,J)=0.
      DO 14 I=1,6
C
C     COMPUTE POLLUTION LOAD IN LBS/YR
      LOAD(I,N,J)=AOLAUS(I,J)*CONT(I,N,J)
C
C     COMPUTE SUM OF POLLUTION LOAD
      SUMLOD(N,J)=SUMLOD(N,J)+LOAD(I,N,J)
C
C     COMPUTE TOTAL CONTRIBUTION IN LBS/ACRE/YR
      TOT(N,J)=SUMLOD(N,J)/SOALU(J)
      JJ=J
   14 TOT(N,JJ)=TOT(N,J)
C
C     RANK POLLUTION CONTRIBUTED TO EACH SUB-BASIN BY EACH POLLUTANT
      DO 18 N=1,9
      DO 18 J=1,6
      IRK=0
      DO 17 JJ=1,6
      IF(TOT(N,J)-TOT(N,JJ)) 15,16,16
   15 IRK=IRK+0
      GO TO 17
   16 IRK=IRK+1
      GO TO 17
   17 CONTINUE
   18 IRANK(N,J)=7-IRK
C
C     RANK TOTAL POLLUTION CONTRIBUTED TO EACH SUB-BASIN
      DO 19 J=1,6
      ITRANK(J)=0
      DO 91 N=1,9
   91 ITRANK(J)=IRANK(N,J)+ITRANK(J)
      JJ=J
   19 ITRANK(JJ)=ITRANK(J)
```

DEFINITION

LD....................................LAND

AOLAUS................................AREA OF LAND USE (ACRE)

SOALU.................................SUM OF AREA OF LAND USE

CONT..................................CONCENTRATION

POL 1.................................BOD

POL 2.................................COD

POL 3.................................SS

POL 4.................................SO_4

POL 5.................................$NO_2 + NO_3$

POL 6.................................NH_4

POL 7.................................ORG-N

POL 8.................................TOT-N

POL 9.................................PO_4

```
      DO 23 J=1,6
         IRK=0
      DO 22 JJ=1,6
      IF(ITRANK(J)-ITRANK(JJ))20,21,21
   20 IRK=IRK+0
      GO TO 22
   21 IRK=IRK+1
      GO TO 22
   22 CONTINUE
   23 IIRANK(J)=IRK
C
C     ARRANGE THE ORDER OF POLLUTANT
      DO 32 N=2,9
      IPOL(1)=1
   32 IPOL(N)=IPOL(N-1)+1
C
C     OUTPUT
      WRITE(6,200)
  200 FORMAT(30X,'DEFINITION',//,4X,'LD=LAND, AOLAUS=AREA OF LAND USE(AC
     1RE), SOALU=SUM OF AREA OF LAND USE, CONT=CONTRIBUTION,',/,4X,'POL
     21=BOD, POL 2=COD, POL3=SS, POL 4=SO4, POL5=NO2+NO3, POL 6=NH4, POL
     3 7=ORG-N, POL 8=TOT-N, POL 9=PO4')
      DO 30 J=1,6
      WRITE(6,3)
    3 FORMAT(1H1,///////,6X,'SUB-BASIN',//,3X,'LD USE',4X,'CROP',4X,'PAS
     1TURE',4X,'RANGE',5X,'FOREST',4X,'URBAN',5X,'OTHER',6X,'SUM',6X,'TO
     2TAL',6X,'RANK')
      WRITE(6,8)(AOLAUS(I,J),I=1,6),(SOALU(J))
    8 FORMAT(2X,'AOLAUS',2X,6(1X,F8.0,1X),1X,F9.0)
      DO 31 N=1,9
      WRITE(6,24)(CONT(I,N,J),I=1,6)
   24 FORMAT(//,3X,'CONT',3X,6(F9.4,1X))
      WRITE(6,25)IPOL(N),(LOAD(I,N,J),I=1,6),SUMLOD(N,J),TOT(N,J),IRANK(
     1N,J)
   25 FORMAT(2X,'POL',1X,I2,2X,6(1X,E8.2,1X),1X,E8.2,2X,F8.3,5X,I2)
   31 CONTINUE
      WRITE(6,26)IIRANK(J)
   26 FORMAT(//,5X,'TOTAL RANK= ',I2)
   30 CONTINUE
      END
```

SUB-BASIN 3A

LD USE	CROP	PASTURE	RANGE	FOREST	URBAN	OTHER	SUM	TOTAL	RANK
ACLAUS	1508124.	564686.	465842.	1810087.	81159.	369975.	4799873.		
CONT	0.6450	0.6100	16.5600	10.2000	1.7400	1.7400			
POL 1	0.97E 06	0.34E 06	0.77E 07	0.18E 05	0.14E 06	0.64E 06	0.28E 08	5.892	3
CONT	27.7100	4.1300	139.7000	12.0600	5.3900	5.3900			
POL 2	0.42E 08	0.23E 07	0.51E 08	0.22E 08	0.44E 06	0.20E 07	0.12E 09	24.894	3
CONT	345.0000	34.9100	1793.0000	8.0100	40.5400	40.5400			
POL 3	0.52E 09	0.20E 08	0.84E 09	0.14E 08	0.33E 07	0.15E 08	0.14E 10	293.353	3
CONT	3.3900	2.9200	156.0000	4.1000	1.1000	1.1000			
POL 4	0.51E 07	0.16E 07	0.73E 08	0.74E 07	0.89E 05	0.41E 06	0.87E 08	18.198	3
CONT	0.1000	0.0200	0.2880	0.0500	0.0600	0.0600			
POL 5	0.15E 06	0.11E 05	0.13E 06	0.91E 05	0.49E 04	0.22E 05	0.41E 06	0.086	3
CONT	0.2300	0.0100	2.1000	0.6500	0.0500	0.0500			
POL 6	0.35E 06	0.56E 04	0.98E 06	0.12E 07	0.41E 04	0.18E 05	0.25E 07	0.527	3
CONT	1.8800	0.0500	1.0600	0.0300	0.1100	0.1100			
POL 7	0.28E 07	0.28E 05	0.49E 06	0.54E 05	0.89E 04	0.41E 05	0.35E 07	0.721	4
CONT	2.5800	0.0400	2.1900	0.0300	0.0900	0.0900			
POL 8	0.39E 07	0.23E 05	0.10E 07	0.54E 05	0.73E 04	0.33E 05	0.50E 07	1.048	4
CONT	0.1900	0.1000	1.7000	0.5700	0.0500	0.0500			
POL 9	0.29E 06	0.56E 05	0.79E 06	0.10E 07	0.41E 04	0.18E 05	0.22E 07	0.456	3

TOTAL RANK= 3

SUB-BASIN 3B

LD USE AOLAUS	CROP 647674.	PASTURE 97677.	RANGE 40400.	FOREST 521047.	URBAN 66322.	OTHER 45248.	SUM 1419368.	TOTAL	RANK
CONT	0.6450	0.6100	16.5600	10.2000	1.7400	1.7400			
POL 1	0.42E 06	0.60E 05	0.67E 06	0.53E 07	0.12E 06	0.79E 05	0.67E 07	4.692	4
CONT	27.7100	4.1300	109.7000	12.0600	5.3900	5.3900			
POL 2	0.18E 08	0.40E 06	0.44E 07	0.63E 07	0.36E 06	0.24E 06	0.30E 08	20.917	4
CONT	345.0000	34.9100	1793.0000	8.0100	40.5400	40.5400			
POL 3	0.22E 09	0.34E 07	0.72E 08	0.42E 07	0.27E 07	0.18E 07	0.31E 09	217.144	4
CONT	3.3900	2.9200	156.0000	4.1000	1.1000	1.1000			
POL 4	0.22E 07	0.29E 06	0.63E 07	0.21E 07	0.73E 05	0.50E 05	0.11E 08	7.785	4
CONT	0.1000	0.0200	0.2880	0.0500	0.0600	0.0600			
POL 5	0.65E 05	0.20E 04	0.12E 05	0.26E 05	0.40E 04	0.27E 04	0.11E 06	0.078	4
CONT	0.2300	0.0100	2.1000	0.6500	0.0500	0.0500			
POL 6	0.15E 06	0.98E 03	0.85E 05	0.34E 06	0.33E 04	0.23E 04	0.58E 06	0.438	4
CONT	1.8800	0.0500	1.0600	0.0300	0.1100	0.1100			
POL 7	0.12E 07	0.49E 04	0.43E 05	0.16E 05	0.73E 04	0.50E 04	0.13E 07	0.912	3
CONT	2.5800	0.3400	2.1900	0.0300	0.0900	0.0900			
POL 8	0.17E 07	0.39E 04	0.88E 05	0.16E 05	0.60E 04	0.41E 04	0.18E 07	1.261	3
CONT	0.1900	0.1000	1.7000	0.5700	0.0500	0.0500			
POL 9	0.12E 06	0.98E 04	0.69E 05	0.30E 06	0.33E 04	0.23E 04	0.53E 06	0.355	4

TOTAL RANK= 4

SUB-BASIN 3b(1)

LD USE	CROP	PASTURE	RANGE	FOREST	URBAN	OTHER	SUM	TOTAL	RANK
ADLAUS	59298.	54836.	78558.	210005.	26296.	23504.	492497.		
CONT	0.6450	0.6100	16.5600	10.2000	1.7400	1.7400			
POL 1	0.64E 05	0.33E 05	0.13E 07	0.21E 07	0.46E 05	0.41E 05	0.36E 07	7.365	2
CONT	27.7100	4.1300	109.7000	12.0600	5.3900	5.3900			
POL 2	0.28E 07	0.23E 06	0.86E 07	0.25E 07	0.14E 06	0.13E 06	0.14E 08	29.232	2
CONT	345.0000	34.9100	1793.0000	8.0100	40.5400	40.5400			
POL 3	0.34E 08	0.19E 07	0.14E 09	0.17E 07	0.11E 07	0.95E 06	0.18E 09	366.962	2
CONT	3.3900	2.9200	156.0000	4.1000	1.1000	1.1000			
POL 4	0.34E 06	0.16E 06	0.12E 08	0.86E 06	0.29E 05	0.26E 05	0.14E 08	27.752	2
CONT	0.1000	0.0200	0.2880	0.0500	0.0600	0.0600			
POL 5	0.99E 04	0.11E 04	0.23E 05	0.11E 05	0.16E 04	0.14E 04	0.47E 05	0.096	2
CONT	0.2300	0.0100	2.1000	0.6500	0.0500	0.0500			
POL 6	0.23E 05	0.55E 03	0.16E 06	0.14E 06	0.13E 04	0.12E 04	0.33E 06	0.665	2
CONT	1.8800	0.0500	1.0600	0.0300	0.1100	0.1100			
POL 7	0.19E 06	0.27E 04	0.83E 05	0.63E 04	0.29E 04	0.26E 04	0.28E 06	0.578	6
CONT	2.5800	0.0400	2.1900	0.0300	0.0900	0.0900			
POL 8	0.26E 06	0.22E 04	0.17E 06	0.63E 04	0.24E 04	0.21E 04	0.44E 06	0.896	6
CONT	0.1900	0.1000	1.7000	0.5700	0.0500	0.0500			
POL 9	0.19E 05	0.55E 04	0.13E 06	0.12E 06	0.13E 04	0.12E 04	0.28E 06	0.569	2

TOTAL RANK= 2

SUB-BASIN 3B(2)

LD USE	CROP	PASTURE	RANGE	FOREST	URBAN	OTHER	SUM	TOTAL	RANK
ADLAUS	206394.	170348.	248893.	420832.	51146.	29171.	1126784.		
CONT	0.6450	0.6100	16.5600	10.2000	1.7400	1.7400			
POL 1	0.13E 06	0.10E 06	0.41E 07	0.43E 07	0.89E 05	0.51E 05	0.68E 07	7.802	1
CONT	27.7100	4.1300	109.7000	12.0600	5.3900	5.3900			
POL 2	0.57E 07	0.73E 06	0.27E 08	0.51E 07	0.28E 06	0.16E 06	0.39E 08	34.820	1
CONT	345.0000	34.9100	1793.0000	8.0100	40.5400	40.5400			
POL 3	0.71E 08	0.59E 07	0.45E 09	0.34E 07	0.21E 07	0.12E 07	0.53E 09	470.404	1
CONT	3.3900	2.9200	156.0000	4.1000	1.1000	1.1000			
POL 4	0.70E 06	0.50E 06	0.39E 08	0.17E 07	0.56E 05	0.32E 05	0.42E 08	37.131	1
CONT	0.1000	0.0200	0.2880	0.0500	0.0600	0.0600			
POL 5	0.21E 05	0.34E 04	0.72E 05	0.21E 05	0.31E 04	0.18E 04	0.12E 06	0.108	1
CONT	0.2300	0.0100	2.1000	0.6500	0.0500	0.0500			
POL 6	0.47E 05	0.17E 04	0.52E 06	0.27E 06	0.26E 04	0.15E 04	0.85E 06	0.754	1
CONT	1.8800	0.0500	1.0600	0.0300	0.1100	0.1100			
POL 7	0.39E 06	0.85E 04	0.26E 06	0.13E 05	0.56E 04	0.32E 04	0.68E 06	0.605	5
CONT	2.5800	0.0400	2.1900	0.0300	0.0900	0.0900			
POL 8	0.53E 06	0.68E 04	0.55E 06	0.13E 05	0.46E 04	0.26E 04	0.11E 07	0.980	5
CONT	0.1900	0.1000	1.7000	0.5700	0.0500	0.0500			
POL 9	0.39E 05	0.17E 05	0.42E 06	0.24E 06	0.26E 04	0.15E 04	0.72E 06	0.642	1

TOTAL RANK= 1

SUB-BASIN 3C

LD USE	CROP	PASTURE	RANGE	FOREST	URBAN	OTHER	SUM	TOTAL	RANK
ACLAUS	865260.	125528.	9710.	716966.	30319.	42131.	1789914.		
CONT	0.6450	0.6100	16.5600	10.2000	1.7400	1.7400			
POL 1	0.56E 06	0.77E 05	0.16E 06	0.73E 07	0.53E 05	0.73E 05	0.82E 07	4.601	5
CONT	27.7100	4.1300	109.7000	12.0600	5.3900	5.3900			
POL 2	0.24E 08	0.52E 06	0.11E 07	0.86E 07	0.16E 06	0.23E 06	0.35E 08	19.329	6
CONT	345.0000	34.9100	1793.0000	8.0100	40.5400	40.5400			
POL 3	0.30E 09	0.44E 07	0.17E 08	0.57E 07	0.12E 07	0.17E 07	0.33E 09	183.800	6
CONT	3.3900	2.9200	156.0000	4.1000	1.1000	1.1000			
POL 4	0.29E 07	0.37E 06	0.15E 07	0.29E 07	0.33E 05	0.46E 05	0.78E 07	4.377	6
CONT	0.1000	0.0200	0.2880	0.0500	0.0600	0.0600			
POL 5	0.87E 05	0.25E 04	0.28E 04	0.36E 05	0.18E 04	0.25E 04	0.13E 06	0.074	5
CONT	0.2300	0.0100	2.1000	0.6500	0.0500	0.0500			
POL 6	0.20E 06	0.13E 04	0.20E 05	0.47E 06	0.15E 04	0.21E 04	0.69E 06	0.386	5
CONT	1.8800	0.0500	1.0600	0.0300	0.1100	0.1100			
POL 7	0.16E 07	0.63E 04	0.10E 05	0.22E 05	0.33E 04	0.46E 04	0.17E 07	0.935	2
CONT	2.5800	0.0400	2.1900	0.0300	0.0900	0.0900			
POL 8	0.22E 07	0.53E 04	0.21E 05	0.22E 05	0.27E 04	0.38E 04	0.23E 07	1.278	2
CONT	0.1900	0.1000	1.7000	0.5700	0.0500	0.0500			
POL 9	0.16E 06	0.13E 05	0.17E 05	0.41E 06	0.15E 04	0.21E 04	0.61E 06	0.338	5

TOTAL RANK= 6

SUB-BASIN 3D

LD USE	CROP	PASTURE	RANGE	FOREST	URBAN	OTHER	SUM	TOTAL	RANK
ACLAUS	396841.	92325.	5011.	259398.	3440.	28543.	785558.		
CONT	0.6450	0.6100	16.5600	10.2000	1.7400	1.7400			
POL 1	0.26E 06	0.56E 05	0.83E 05	0.26E 07	0.60E 04	0.50E 05	0.31E 07	3.942	6
CONT	27.7100	4.1300	109.7000	12.0600	5.3900	5.3900			
POL 2	0.11E 08	0.38E 06	0.55E 06	0.31E 07	0.19E 05	0.15E 06	0.15E 08	19.385	5
CONT	345.0000	34.9100	1793.0000	8.0100	40.5400	40.5400			
POL 3	0.14E 09	0.32E 07	0.90E 07	0.21E 07	0.14E 06	0.12E 07	0.15E 09	194.120	5
CONT	3.3900	2.9200	156.0000	4.1000	1.1000	1.1000			
POL 4	0.13E 07	0.27E 06	0.78E 06	0.11E 07	0.38E 04	0.31E 05	0.35E 07	4.449	5
CONT	0.1000	0.0280	0.2880	0.0500	0.0600	0.0600			
POL 5	0.40E 05	0.18E 04	0.14E 04	0.13E 05	0.21E 03	0.17E 04	0.58E 05	0.074	6
CONT	0.2300	0.0100	2.1000	0.6500	0.0500	0.0500			
POL 6	0.91E 05	0.92E 03	0.11E 05	0.17E 06	0.17E 03	0.14E 04	0.27E 06	0.347	6
CONT	1.8800	0.0500	1.0600	0.0300	0.1100	0.1100			
POL 7	0.75E 06	0.46E 04	0.53E 04	0.78E 04	0.38E 03	0.31E 04	0.77E 06	0.977	1
CONT	2.5800	0.0400	2.1900	0.0300	0.0900	0.0900			
POL 8	0.10E 07	0.37E 04	0.11E 05	0.78E 04	0.31E 03	0.26E 04	0.10E 07	1.336	1
CONT	0.1900	0.1000	1.7000	0.5700	0.0500	0.0500			
POL 9	0.75E 05	0.92E 04	0.85E 04	0.15E 06	0.17E 03	0.14E 04	0.24E 06	0.309	6

TOTAL RANK= 5

APPENDIX F

Computer Program for Ranking of Watersheds by Estimated Pollutant Loading Rates

This computer program is written in Basic Fortran for the 360/370 computer. Loading rates of nine different pollutants from four different land uses (as determined from a monitoring program) and based on the areas of these land uses within each watershed, and on the relationship of the R C K and T values of the monitored and non-monitored watersheds are used to estimate the pollutant load from each watershed. (In this case, the watersheds within Sub-Basin 3-B(2)---the sub-basin identified in Appendix E). These loading rates are then compared, and ranked highest to lowest through a ranking routine to determine which watershed contributes the relatively greatest amounts of pollution and approximately in what quantities. Step by step procedures, and an explanation of the formulas used may be found in Chapter V of the text. (Comment cards within the program listing provide a guide).

```
      DIMENSION XUSLD(4),XWTSHD(7),USLD(4,7),RTLD(4,9),CONT(4,9,7),TUSLD
     1(7),TCONT(9,7),IRANK(9,7),IPOL(9),TTCONT(9,7),IIRANK(7),ITRANK(7)
C
C     INPUT X VALUE FOR EACH LAND USE
      READ(5,1)(XUSLD(I),I=1,4)
    1 FORMAT(4F10.4)
C
C     INPUT X VALUE FOR EACH WATERSHED
      READ(5,2)(XWTSHD(J),J=1,7)
    2 FORMAT(7F10.4)
C
C     INPUT AREA OF LAND USE OF EACH WATERSHED
      READ(5,3)((USLD(I,J),I=1,4),J=1,7)
    3 FORMAT(4F10.2)
C
C     INPUT LOADING RATE OF EACH LAND USE ON EACH POLLUATANT
      READ(5,4)((RTLD(I,N),I=1,4),N=1,9)
    4 FORMAT(4F10.4)
      DO 5 J=1,7
      DO 5 N=1,9
      DO 5 I=1,4
C
C     COMPUTE EACH POLLUTION CONTRIBUTED BY EACH  LAND USE WITHIN EACH
C     WATERSHED IN LBS/YR
    5 CONT(I,N,J)=(XWTSHD(J)*(RTLD(I,N)/XUSLD(I)))*USLD(I,J)
      DO 6 J=1,7
      TUSLD(J)=0.
      DO 6 I=1,4
C
C     COMPUTE TOTAL AREA OF EACH WATERSHED
    6 TUSLD(J)=TUSLD(J)+USLD(I,J)
      DO 7 J=1,7
      DO 777 N=1,9
      TCONT(N,J)=0.
      DO 77 I=1,4
C
C     COMPUTE TOTAL CONTRIBUTION OF EACH POLLUTANT IN EACH WATERSHED IN
C     LBS/YR
   77 TCONT(N,J)=TCONT(N,J)+CONT(I,N,J)
C
C     COMPUTE TOTAL CONTRIBUTION IN LBS/ACRE/YR
  777 TTCONT(N,J)=TCONT(N,J)/TUSLD(J)
      JJ=J
    7 TTCONT(N,JJ)=TTCONT(N,J)
C
C     RANK EACH WATERSHED BY SPECIFIC POLLUTANT
      DO 10 N=1,9
      DO 10 J=1,7
      IRK=0
      DO 9 JJ=1,7
      IF(TTCONT(N,J)-TTCONT(N,JJ))9,8,8
    8 IRK=IRK+1
```

```
    9 CONTINUE
   10 IRANK(N,J)=8-IRK
C
C     RANK EACH WATERSHED BY ALL POLLUTANTS
      DO 12 J=1,7
      ITRANK(J)=0
      DO 11 N=1,9
   11 ITRANK(J)=ITRANK(J)+IRANK(N,J)
      JJ=J
   12 ITRANK(JJ)=ITRANK(J)
      DO 15 J=1,7
      IRK=0
      DO 14 JJ=1,7
      IF(ITRANK(J)-ITRANK(JJ))14,13,13
   13 IRK=IRK+1
   14 CONTINUE
   15 IIRANK(J)=IRK
C
C     ARRANGE THE ORDER OF POLLUTANT
      DO 16 N=2,9
      IPOL(1)=1
   16 IPOL(N)=IPOL(N-1)+1
C
C     OUTPUT
      WRITE(6,26)
   26 FORMAT(40X,'DEFINITION',//,4X,'X=PRODUCT OF R*C*K*T, AOLAUS=AREA O
     1F LAND USE(ACRES)',/,4X,'POL1=BCD, POL2=COD, POL3=SS, POL4=SO4, PO
     2L5=NO2+NO3, POL6=NH4, POL7=ORG-N, POL8=TOT-N, POL9=PO4')
      DO 22 J=1,7
      WRITE(6,17)
   17 FORMAT(1H1,///////,6X,'WATERSHED',///,1X,'LAND USE',4X,'CROP',5X,'
     1RANGE',4X,'PASTURE',3X,'WOODLAND',5X,'SUM',5X,'TOTAL',6X,'RANK')
      WRITE(6,18)(XUSLD(I),I=1,4)
   18 FORMAT(4X,'X',5X,4(3X,F4.2,3X))
      WRITE(6,19)(USLD(I,J),I=1,4),(TUSLD(J))
   19 FORMAT(2X,'AOLAUS',2X,4(1X,F8.0,1X),1X,F8.0)
      DO 222 N=1,9
  222 WRITE(6,20)(IPOL(N)),(CONT(I,N,J),I=1,4),(TCONT(N,J)),(TTCONT(N,J)
     1),(IRANK(N,J))
   20 FORMAT(//,3X,'POL',I2,2X,4(1X,E8.2,1X),1X,E8.2,2X,F9.3,4X,I2)
      WRITE(6,21)(XWTSHD(J)),(IIRANK(J))
   21 FORMAT(///,4X,'X VALUE OF WATERSHED IS ',F4.2,/,4X,'TOTAL RANK= ',
     1I2)
   22 CONTINUE
      END
```

DEFINITION

LD	LAND
AOLAUS	AREA OF LAND USE (ACRE)
SOALU	SUM OF AREA OF LAND USE
CONT	CONCENTRATION
POL 1	BOD
POL 2	COD
POL 3	SS
POL 4	SO_4
POL 5	$NO_2 + NO_3$
POL 6	NH_4
POL 7	ORG-N
POL 8	TOT-N
POL 9	PO_4

WATERSHED 3-10 Fleetwood

LAND USE	CROP	RANGE	PASTURE	WOODLAND	SUM	TOTAL	RANK
X	0.04	0.05	0.02	0.01			
AOLAUS	61508.	52925.	14304.	14304.	143041.		
POL 1	0.60E 06	0.46E 06	0.26E 05	0.12E 07	0.23E 07	15.084	7
POL 2	0.23E 07	0.14E 07	0.18E 06	0.48E 07	0.87E 07	60.850	7
POL 3	0.36E 08	0.48E 07	0.15E 07	0.52E 07	0.48E 08	333.117	6
POL 4	0.68E 06	0.40E 06	0.13E 06	0.16E 07	0.28E 07	19.427	7
POL 5	0.65E 04	0.15E 05	0.86E 03	0.91E 05	0.11E 06	0.794	7
POL 6	0.65E 04	0.32E 04	0.43E 03	0.50E 05	0.60E 05	0.418	7
POL 7	0.14E 06	0.37E 05	0.21E 04	0.15E 06	0.33E 06	2.309	7
POL 8	0.89E 05	0.67E 05	0.17E 04	0.20E 05	0.18E 06	1.235	6
POL 9	0.62E 05	0.15E 05	0.43E 04	0.10E 05	0.92E 05	0.641	6

X VALUE OF WATERSHED IS 0.06
TOTAL RANK= 7

WATERSHED 3-11 Lower Mud

LAND USE	CROP	RANGE	PASTURE	WOODLAND	SUM	TOTAL	RANK
X	0.04	0.05	0.02	0.01			
ADLAUS	46214.	170415.	25884.	43325.	285838.		
POL 1	0.45E 06	0.15E 07	0.47E 05	0.37E 07	0.57E 07	19.834	6
POL 2	0.17E 07	0.44E 07	0.32E 06	0.15E 08	0.21E 08	73.998	6
POL 3	0.27E 08	0.15E 08	0.27E 07	0.16E 08	0.61E 08	213.531	7
POL 4	0.51E 06	0.13E 07	0.23E 06	0.48E 07	0.68E 07	23.735	6
POL 5	0.49E 04	0.49E 05	0.16E 04	0.28E 06	0.33E 06	1.158	5
POL 6	0.49E 04	0.10E 05	0.78E 03	0.15E 06	0.17E 06	0.583	6
POL 7	0.11E 06	0.12E 06	0.39E 04	0.44E 06	0.68E 06	2.369	6
POL 8	0.67E 05	0.21E 06	0.31E 04	0.60E 05	0.34E 06	1.204	7
POL 9	0.46E 05	0.49E 05	0.78E 04	0.31E 05	0.13E 06	0.470	7

X VALUE OF WATERSHED IS 0.06
TOTAL RANK= 6

WATERSHED 3-11A Upper Mud

LAND USE	CROP	RANGE	PASTURE	WOODLAND	SUM	TOTAL	RANK
X	0.04	0.05	0.02	0.01			
AOLAUS	27198.	99725.	23571.	30824.	181318.		
POL 1	0.49E 06	0.16E 07	0.79E 05	0.48E 07	0.70E 07	38.365	5
POL 2	0.19E 07	0.48E 07	0.54E 06	0.19E 08	0.26E 08	144.977	5
POL 3	0.29E 08	0.16E 08	0.45E 07	0.21E 08	0.71E 08	391.207	5
POL 4	0.55E 06	0.14E 07	0.38E 06	0.62E 07	0.85E 07	47.000	5
POL 5	0.52E 04	0.53E 05	0.26E 04	0.36E 06	0.42E 06	2.316	5
POL 6	0.52E 04	0.11E 05	0.13E 04	0.20E 06	0.21E 06	1.181	5
POL 7	0.12E 06	0.13E 06	0.65E 04	0.58E 06	0.83E 06	4.591	5
POL 8	0.72E 05	0.23E 06	0.52E 04	0.78E 05	0.39E 06	2.125	5
POL 9	0.50E 05	0.53E 05	0.13E 05	0.41E 05	0.16E 06	0.863	5

X VALUE OF WATERSHED IS 0.11
TOTAL RANK= 5

WATERSHED 3-12 Upper Bayou

LAND USE	CROP	RANGE	PASTURE	WOODLAND	SUM	TOTAL	RANK
X	0.04	0.05	0.02	0.01			
AOLAUS	9961.	51379.	2503.	47922.	111765.		
POL 1	0.26E 06	0.12E 07	0.12E 05	0.11E 08	0.12E 08	110.231	1
POL 2	0.10E 07	0.36E 07	0.83E 05	0.43E 08	0.48E 08	428.388	1
POL 3	0.16E 08	0.12E 08	0.70E 06	0.47E 08	0.75E 08	674.251	3
POL 4	0.29E 06	0.10E 07	0.58E 05	0.14E 08	0.15E 08	138.268	1
POL 5	0.28E 04	0.39E 05	0.40E 03	0.81E 06	0.86E 06	7.654	1
POL 6	0.28E 04	0.82E 04	0.20E 03	0.44E 06	0.46E 06	4.079	1
POL 7	0.62E 05	0.97E 05	0.10E 04	0.13E 07	0.15E 07	13.164	1
POL 8	0.38E 05	0.17E 06	0.80E 03	0.18E 06	0.39E 06	3.472	1
POL 9	0.27E 05	0.39E 05	0.20E 04	0.92E 05	0.16E 06	1.433	3

X VALUE OF WATERSHED IS 0.16
TOTAL RANK= 1

WATERSHED 3-13 Lower Bayou

LAND USE	CROP	RANGE	PASTURE	WOODLAND	SUM	TOTAL	RANK
X	0.04	0.05	0.02	0.01			
ADLAUS	12863.	35664.	9383.	37578.	95488.		
POL 1	0.35E 06	0.88E 06	0.49E 05	0.90E 07	0.10E 08	108.164	2
POL 2	0.14E 07	0.26E 07	0.33E 06	0.36E 08	0.40E 08	422.537	2
POL 3	0.21E 08	0.91E 07	0.28E 07	0.39E 08	0.72E 08	756.394	1
POL 4	0.40E 06	0.75E 06	0.23E 06	0.12E 08	0.13E 08	137.404	2
POL 5	0.38E 04	0.29E 05	0.16E 04	0.68E 06	0.71E 06	7.453	2
POL 6	0.38E 04	0.61E 04	0.80E 03	0.37E 06	0.38E 06	3.992	2
POL 7	0.85E 05	0.72E 05	0.40E 04	0.11E 07	0.13E 07	13.124	2
POL 8	0.52E 05	0.13E 06	0.32E 04	0.15E 06	0.33E 06	3.455	2
POL 9	0.37E 05	0.29E 05	0.80E 04	0.77E 05	0.15E 06	1.575	1

X VALUE OF WATERSHED IS 0.17
TOTAL RANK= 2

WATERSHED 3-14 Hickory

LAND USE	CROP	RANGE	PASTURE	WOODLAND	SUM	TOTAL	RANK
X	0.04	0.05	0.02	0.01			
ACLAUS	35019.	95718.	63033.	39688.	233458.		
POL 1	0.11E 07	0.28E 07	0.38E 06	0.11E 08	0.16E 08	66.549	3
POL 2	0.44E 07	0.83E 07	0.26E 07	0.45E 08	0.60E 08	257.220	3
POL 3	0.69E 08	0.29E 08	0.22E 08	0.48E 08	0.17E 09	718.243	2
POL 4	0.13E 07	0.24E 07	0.18E 07	0.15E 08	0.20E 08	86.059	3
POL 5	0.12E 05	0.92E 05	0.13E 05	0.84E 06	0.96E 06	4.104	3
POL 6	0.12E 05	0.19E 05	0.63E 04	0.46E 06	0.50E 06	2.134	3
POL 7	0.27E 06	0.23E 06	0.32E 05	0.14E 07	0.19E 07	8.087	3
POL 8	0.17E 06	0.40E 06	0.25E 05	0.18E 06	0.78E 06	3.332	3
POL 9	0.12E 06	0.92E 05	0.63E 05	0.95E 05	0.37E 06	1.574	2

X VALUE OF WATERSHED IS 0.20
TOTAL RANK= 3

WATERSHED 3-16 Texoma Lateral

LAND USE	CROP	RANGE	PASTURE	WOODLAND	SUM	TOTAL	RANK
X	0.04	0.05	0.02	0.01			
ACLAUS	22151.	88603.	46417.	27688.	184859.		
POL 1	0.50E 06	0.18E 07	0.20E 06	0.55E 07	0.80E 07	43.216	4
POL 2	0.19E 07	0.54E 07	0.13E 07	0.22E 08	0.31E 08	165.116	4
POL 3	0.30E 08	0.19E 08	0.11E 08	0.24E 08	0.84E 08	454.020	4
POL 4	0.57E 06	0.15E 07	0.95E 06	0.71E 07	0.10E 08	55.083	4
POL 5	0.54E 04	0.60E 05	0.65E 04	0.41E 06	0.48E 06	2.609	4
POL 6	0.54E 04	0.12E 05	0.32E 04	0.22E 06	0.25E 06	1.330	4
POL 7	0.12E 06	0.15E 06	0.16E 05	0.66E 06	0.95E 06	5.120	4
POL 8	0.74E 05	0.26E 06	0.13E 05	0.89E 05	0.44E 06	2.364	4
POL 9	0.52E 05	0.60E 05	0.32E 05	0.47E 05	0.19E 06	1.030	4

X VALUE OF WATERSHED IS 0.14
TOTAL RANK= 4