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THE SELECTION OF BEST MANAGEMENT PRACTICES FOR CONTROLLING THE NON-POINT SOURCE POLLUTION IN OKLAHOMA

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THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

THE SELECTION OF BEST MANAGEMENT PRACTICES FOR CONTROLLING THE NON-POINT SOURCE POLLUTION IN OKLAHOMA

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

By

S-LEN RICHARD CHIN

Norman, Oklahoma

1984

THE SELECTION OF BEST MANAGEMENT PRACTICES

FOR CONTROLLING THE NON-POINT SOURCE

POLLUTION IN OKLAHOMA

A DISSERTATION

APPROVED FOR THE DEPARTMENT OF CIVIL ENGINEERING

AND ENVIRONMENTAL SCIENCE

By

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CHAPTER I

INTRODUCTION

1.1 General

This dissertation provides two effective computer models by which an objective evaluation can be obtained for selecting the Best Management Practice (BMP) for Non-Point Source Pollution (NPSP) control. This evaluation compares cost effectiveness, treatment efficiency and environmental impact among alternative management practices.

Until recently, pollution generated from runoff has essentially been overlooked by the public. Nutrients, pesticides, and herbicides originally applied to the soil are washed into streams beyond their assimilative capacities thereby lowering stream water quality. Approaches to control NPSP are based on the control of soil loss since most pollutants are absorbed on soil particles. The suitability of these approaches is largely dependent upon local geological, geographical, climatological and soil conditions. However, when several management practices meet these conditions, further analysis is needed to determine the BMP. This dissertation provides a comparative analysis to determine the BMP based on three criteria: cost effectiveness, treatment efficiency and environmental impact.

The present management practices generally overlook environmental impact, and in many cases are not the most efficient practices. For example, when considering a management practice, farmers may emphasize loss of land through the application of the management practice without considering the efficiency of the management practice or the decrease in beneficial environmental impact. At construction sites, contractors may fail to recognize the importance of diverting runoff around construction sites to control erosion and the associated NPSP.

NPSP is generated whenever rainfall intensity is great enough to dislodge and transport soil particles over land surfaces and into a waterway. Since most nutrients adhere to soil particles, streams can become polluted and aquatic species endangered. The best way to prevent NPSP is to decrease the raindrop impact on land surface and prevent the transport of soil particles through runoff.

Management practices can be grouped into five fundamental categories:

(a) Covering and stabilizing the topsoil by plant leaves and roots.

(b) Inhibiting surface runoff by ridges, furrows and terraces.

(c) Diverting runoff.

(d) Lining waterways.

(e) Trapping sediment.

Vegetation with grass or plants, no-till farming and rotation with densely grown crops are three examples employed in Category (a). Contour and terrace farming are the two employed in Category (b). Diversion ditches or terraces to prevent runon are examples in Category (c). Grassed or concrete waterways are employed in Category (d). Sediment basin and floodwater retarding structures are employed in Category (e). In many cases management practices in several categories may be used jointly to optimally control the NPSP.

It is simple to evaluate management practices and select a BMP for an area with single land use. However, it is difficult to select several BMP's for a large watershed with several different land uses because the selection depends on interrelationships between project cost, treatment efficiency and environmental impact among numerous BMP combinations. This difficulty was the impetus for the development of computer models to simulate actual conditions and to quickly and reliably compare alternatives.

1.2 Purpose

The purpose of this study is to develop the procedure for selecting the BMP to control the NPSP from vast areas of land and to adapt the procedure for computer processing. Evaluations are based on three criteria: cost effectiveness, treatment efficiency and environmental impact.

Two models were developed for different purposes. Model BMP1 was developed to determine the optimum combination of cropping management and land treatment practices for control of NPSP. Seven most common cropping management and land treatment practices used in this dissertation are: (1) terrace-contour, (2) rotation-contour, (3) terrace-rotation-contour, (4) terrace-no-till-contour, (5) no-till-contour, (6) no-till-rotation-contour, and (7) pasture. Since each combination results in different construction and operation costs which affect the product cost, each source of cost variation should be evaluated in detail to minimize costs and maximize revenues.

When combinations of cropping management and land treatment practices are not applicable, the NPSP can be controlled by construction management practices such as diversion, sediment basins and floodwater retarding structures. Model BMP2 can be used on small watersheds with single land uses or large ones with multiple land uses. When modeling a large watershed with changes of cropping management and land treatment practices as well as construction practices, Model BMP2 can incorporate Model BMP1 as a subroutine to select a combination of cropping management, land treatment and construction practices to minimize pollution and maximize benefits.

The models compute and display the efficiency of each practice or combination of practices and evaluate the environmental impact from each practice. The results of these comparisons are incorporated with the cost analysis to determine the BMP for each area from among several alternative management practices.

Water quality data are provided for each area before and after the use of management practices. They are represented as Suspended Solids (SS), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). The change in the computed annual loading rates of these pollutants is used to estimate the severity of degradation in streams or other receiving waters.

CHAPTER II

LITERATURE SURVEY

Relevant literature was reviewed and summarized in three major sections: (1) sediment routing, (2) non-point source pollution modeling, and (3) a case study covering BMP application. Part (1) summarizes the literature available on sediment suspension, transport, actual delivery into a stream, entrapment by a sediment basin, the degree of pollution associated with the sediment and the tolerance limit of soil loss.

In Part (2), several computer models which use the Universal Soil Loss Equation (USLE) and other hydraulic measures to simulate runoff generation, transport, quantity and quality are summarized. These models represent extensive efforts and widely differing approaches to modeling and analysis of NPSP.

The Black Creek Project in Part (3) summarizes a full-scale study in which various BMP's were applied. From this comprehensive study, relationships between comparative costs and effectiveness of various BMP's were evaluated.

2.1 Sediment Routing

Sediment routing consists of four subsections: (1) sediment suspension, (2) sediment transport, (3) sediment entrapment, (4) sediment associated pollution, and an additional subsection giving the review of soil tolerance limit.

In Subsection (1), sediment is initially suspended as a result of energy transfer from raindrop impact and subsequent runoff. However, rainfall is not the only factor affecting sediment suspension. A statistical equation, USLE, was developed through long term efforts of many researchers to estimate sediment suspension as a function of local precipitation, soil erodibility, topographic factors and vegetation cover. In Subsection (2), sediment delivery ratio is reviewed to reflect that the suspended sediment is only partially delivered to streams or lakes because impoundment due to uneven ground surface retains part of the sediment. In Subsection (3), trap efficiency is reviewed to estimate the sediment retained or trapped in artificial sediment basins or floodwater retarding structures, which then allow only small amounts of sediment to be discharged into a stream. In Subsection (4), potency factor is reviewed to estimate pollutants associated with sediment entering the receiving waters. In Subsection (5), tolerance limit is reviewed for the fact that soil loss exceeding the tolerance limit over a long period of time will deplete the surface soil layer resulting in a decrease in crop production. These five subsections are displayed along with routing order in Figure 2-1.

2.1.1 Sediment Suspension

The USLE is the most commonly used equation to estimate sediment suspension or soil loss. It is an empirical statistical equation which is the result of many studies performed by several researchers over a forty year period.

Development began about 1940 in the Corn Belt when Zingg (79) published an equation relating soil loss rate to length and percentage of slope. In the following year, Smith (45,47) added crop and conservation practice factors and the concept of a specific soil loss limit to develop a graphical method for determining conservation practices on Shelby and associated soils of the Midwest. Browing and Associates (4) added soil and management factors and prepared a set of tables to simplify field use of the equation in Iowa. Soil Conservation Service (SCS) scientists cooperated to develop the slope-practice equation for use throughout the Corn Belt.

A national committee met in Ohio in 1946 to reappraise the Corn Belt factor value and added a rainfall factor to develop the so-called Musgrave Equation (34).

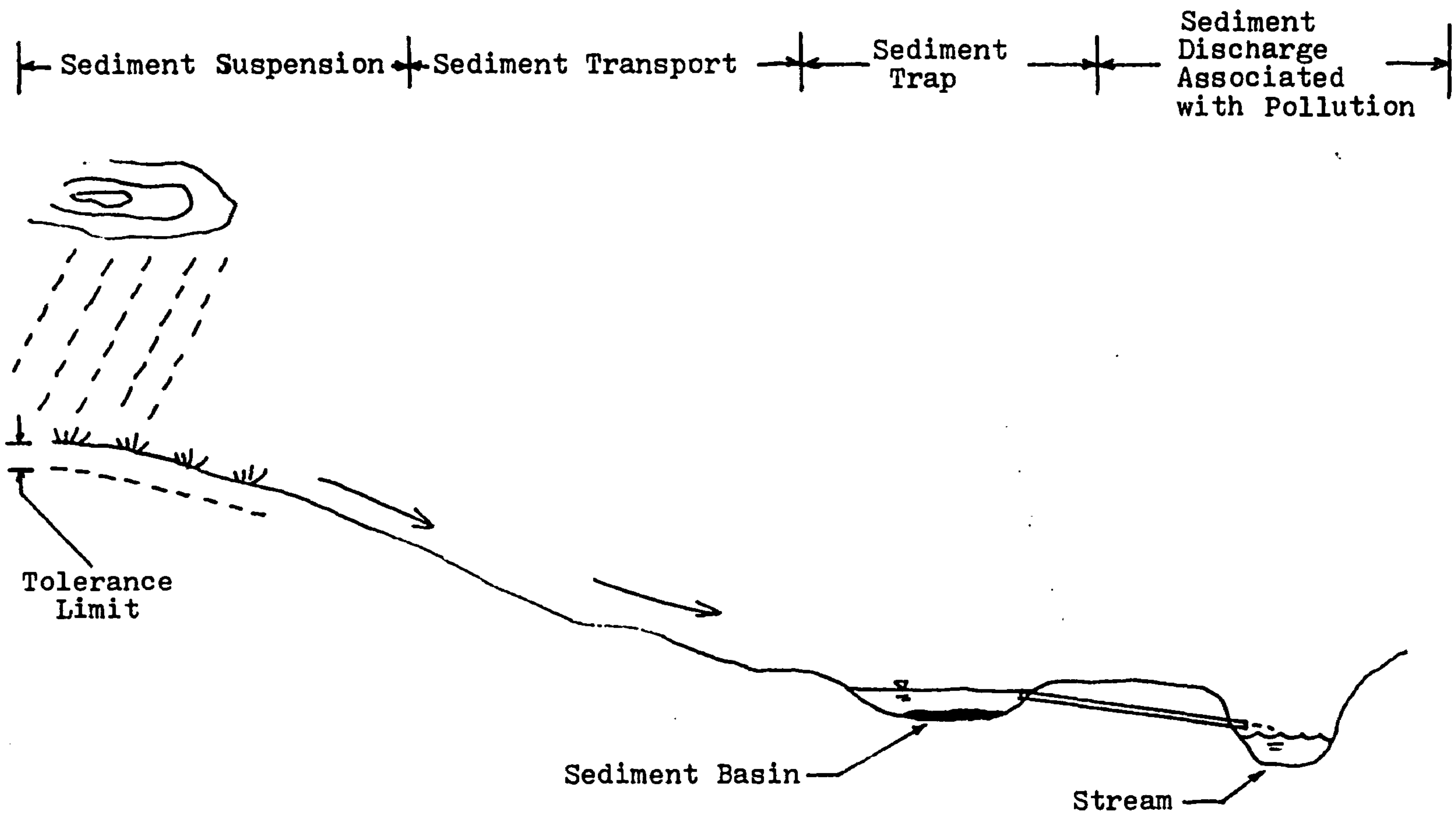


Figure 2-1 Sediment Routing Procedure

Finally in 1954, the USLE was further developed through a joint venture by the Agricultural Research Service and Purdue University. Federal-State cooperative research projects at 49 locations contributed more than 10,000 plot-years of basic runoff and soil loss data for synthesis and overall statistical analyses. After 1960, more complete data were developed state-by-state so that the USLE could be used nationwide.

The USLE is expressed as follows:

$$A = RKLSCP$$

Where:

A = The computed soil loss per unit area, expressed in the units selected for "K" and for the period selected for "R". In practice, these are usually so selected that they compute "A" in tons per acre per year, but other units can be selected.

R = The rainfall and runoff factor, is the number of rainfall erosion index units, plus a factor for runoff from snowmelt or applied water where such runoff is significant. The erosion index is a measure of the erosion force of specific rainfall. When other factors are constant, soil losses from rainfall are directly proportional to the product of the total kinetic energy of the storm times its maximum 30-minute intensity.

K = The soil erodibility factor, is the soil loss rate per erosion index unit for a specified soil as measured on a unit plot, which is defined as a 72.6 ft. length of uniform and continuous 9-percent slope in clean-tilled fallow.

L = The slope-length factor, is the ratio of soil loss from the field slope length to that from a 72.6 ft. length under identical conditions.

S = The slope-steepness factor, is the ratio of soil loss from the field slope gradient to that from a 9-percent slope under other identical conditions.

C = The cover and management factor, is the ratio of soil loss from an area with specified cover and management to that from an identical area in tilled continuous fallow.

P = The support practice factor, is the ratio of soil loss with a support practice like contouring, stripcropping, or terracing to that with straight-row farming up and down the slope.

Rainfall Erosion Index (R)

The numerical value used for "R" in the soil loss equation must quantify the raindrop impact effect and must also provide relative information on the amount and rate of runoff likely to be associated with the rainfall. The rainfall erosion index derived by Wischmeier (75) appears to meet these requirements better than any other rainfall parameters. The local value of this index generally equals "R" for the USLE, and is listed in publications of local SCS units, with unique values by county.

Soil Erodibility Factor (K)

The soil erodibility factor, "K", in the USLE is a quantitative value experimentally determined. Due to its complexity, a nomograph was developed to provide a more general applicable working tool under the condition that soils contain less than 70 percent silt and very fine sand. This nomograph (see Figure 2, Appendix A) was derived from the following equation:

$$100K = 21M^{1.14}(10^{-4})(12 - a) + 3.25(b - 2) + 2.5(c - 3)$$

where M = the particle-size parameter which equals percent silt (0.10 - 2.00 mm) times the quantity 100-minus-percent-clay,

a = percent organic matter,

b = the soil-structure code used in soil classification, and

c = the profile-permeability class.

More detailed information on the data and relationships underlying this equation appears in journal articles by Wischmeier (76,77).

Topographic Factor (LS)

Factors "L" and "S" have been evaluated separately in research but are combined as a single topographic factor, LS in field applications. A formulation suggested for LS is (56):

$$LS = \left(\frac{\lambda}{72.6}\right)^{m} \left(\frac{430X^2 + 30X + 0.43}{6.67415}\right)$$

where: λ = field slope length in feet,

m = 0.5 if slope equals 5% or greater,

= 0.4 if slope equals 4%,

= 0.3 if slope equals 3% or less,

X = $\sin\theta$, where θ is the angle of slope in degrees

Figure 3 in Appendix A is a chart derived from this equation. It displays the value of LS for specified combinations of field slope and length at a uniform gradient.

Cover and Management Factor (C)

Factor "C" is usually given in terms of its average annual value for a particular combination of crop management and rainfall patterns. Ratios of soil losses for each cropstage period for specified cropping and management systems to corresponding losses from the basic long-term fallow condition were derived from analysis of about a quarter million plot soil loss observations. The ratios are given in Table 5 and its supplemental Tables 5-A, 5-B, 5-C, and 5-D in Reference (57). These ratios are used to compute the "C" factor and they can be evaluated for six cropstage periods defined as follows:

Period F (rough fallow) - Inversion plowing to secondary tillage.

Period SB (seedbed) - Secondary tillage for seedbed preparation until the crop has developed 10 percent canopy cover.

Period 1 (establishment) - End of SB until crop has developed a 50 percent canopy cover. (Exception: period 1 for cotton ends at 35 percent canopy cover.)

Period 2 (development) - End of period 1 until canopy cover reaches 75 percent. (60 percent for cotton.)

Period 3 (maturing crop) - End of period 2 until crop harvest. This period was evaluated for three levels of final crop canopy.

Period 4 (residue or stubble) - Harvest to plowing or new seeding.

The procedure used to derive a "C" value is complicated because the Erosion Index (EI) value is also involved. The evaluation of "EI" value is discussed in detail in Reference (57). Besides Table 5 and its subsidiary tables in Reference (57), "C" values for construction areas in terms of mulching methods are listed in Table 1, Appendix A; those for permanent pasture, range and idle land are listed in Table 2; and those for woodland are listed in Table 3.

Support Practice Factor (P)

The support practice is used to decrease the runoff rate whenever sloping land is to be cultivated and exposed to erosive rains. The most important of these supporting cropland practices are contour tillage, stripcropping on the contour, and terracing. Tables 4, 5 and 6 in Appendix A list "P" factor values separately for these three supporting cropland practices. These values are average values for the factor on the specified slopes. They are based on available data and field observations supplemented by group judgement (57).

2.1.2 Sediment Transport

USLE computes sheet and rill erosion but not deposition when sediment travels along ground surface. Therefore, theories concerning sediment transport have been developed. Negev (36) developed soil fines transport equations which simulate instantaneous sediment delivery through overland flow. They have been successfully employed in computer models PTR(10), NPS(68) and ARM(13) as later mentioned in Section 2.2. In addition, Model WASCH(5) employed the sediment transport capacity, which also correlates to overland flow, and is only used for the small watershed. Both theories consider only sediment delivered with instantaneous overflow. To estimate a long term effect of sediment delivery, a sediment delivery ratio was introduced.

The sediment delivery ratio is defined as the ratio of sediment delivered at a location in a stream system to the gross erosion from the drainage area above that point. Where this ratio is known or can be closely approximated from known parameters, the sediment yield is estimated by computing the gross erosion and multiplying it by the sediment delivery ratio.

The delivery ratio is generally directly related to the amount of runoff and inversely related to soil particle size. It is also directly related to slope steepness and amount of channel-type erosion, and inversely related to distance of the source area from a stream, density of vegetation at ground level, and number of flow obstructions such as field boundaries and culverts. The complexity of these factors makes it difficult to formulate a general equation covering all the relationships. However, Gottschalk, Bruce, et al., have assembled data to derive a curve relating the sediment delivery ratio to watershed size which is published in the Sedimentation Section of the National Engineering Handbook (60). This curve relates the delivery ratio to the negative 0.2 power of drainage-area size. There are indications that the 0.1 power would be more accurate for large drainage areas.

Analyzing data from fourteen Texas Blackland Prairie drainage areas that ranged from 0.42 to 97.4 square miles, Renfro (40) computed delivery ratios ranging from 0.62 for a drainage area of 0.5 square miles to 0.28 for an area of 100 square miles. These are significantly larger than would have been estimated from the SCS general relationship curve, and emphasize the need to consider the other factors as previously mentioned.

From available data, SCS has developed a table to crudely estimate the delivery ratio from the size of drainage area (74). These data are shown in Table 2-1. The accuracy of sediment delivery ratio can be improved by incorporating other factors such as soil texture, relief, type of erosion, delivery route and areas of deposition within the watershed which may be studied in

Table 2-1 Sediment Delivery Ratio (74)

Drainage Area (sq. mile)	Sediment Delivery Ratio
0.5	0.33
1	.30
5	.22
10	.18
50	.12
100	.10
200	.08

further research work.

2.1.3 Sediment Entrapment

A sediment basin is most commonly used to trap sediment in a channel and its efficiency can be measured by the Trap Efficiency (TE) which is the percentage of incoming sediment trapped and deposited in a reservoir. Brune (5) found that the ratio of reservoir capacity (volume) to the average annual inflow (volume/year), "C/I", is the most important parameter. This factor yields the average detention time (years) of stored runoff.

Gottschalk (17) studied 19 floodwater retarding structures. The trap efficiencies he acquired agreed reasonably well with Brune's. However, the estimated "TE" was usually higher than the actual ones.

Heinemann and Reynolds (20) extensively studied three of the 17 reservoirs surveyed by Gottschalk and found that "TE" values for each reservoir varied considerably between sedimentation surveys. This fluctuation was attributed to changes in runoff erosion and storage capacity.

In 1974, Dendy (12) investigated 17 reservoirs scattered throughout the United States and combined the data with Brune's to get the best-fit curve between the C/I ratio and "TE" (see Figure 2-2). The equation is stated

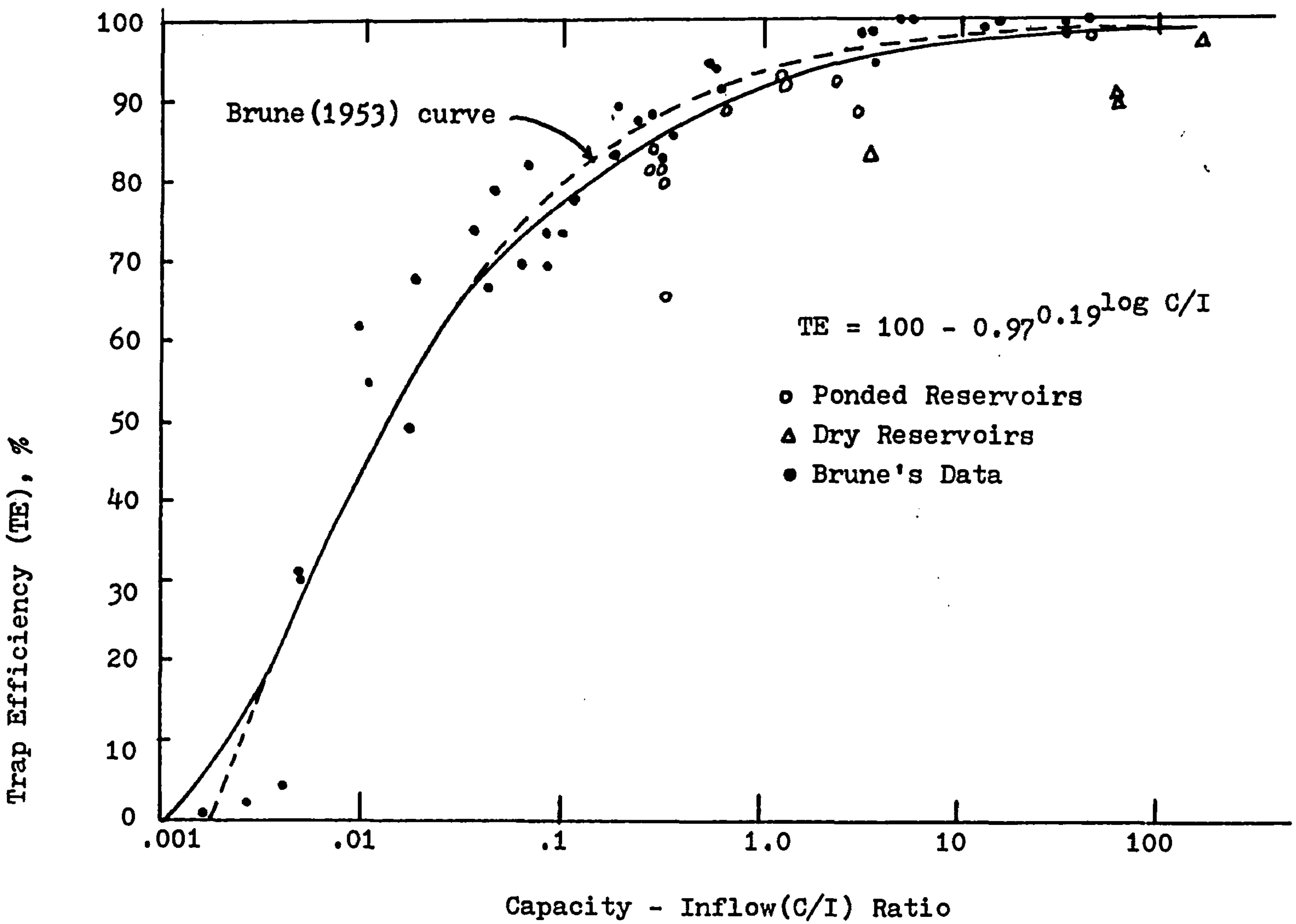


Figure 2-2 Trap Efficiency Curve (12)

as follows:

$$TE = 100 - 0.97^{0.19^{\log C/I}}$$

where TE = Trap Efficiency, present.

C/I = Capacity-Average Annual Inflow Ratio, acre-ft per acre-ft.

2.1.4 Sediment Pollution

Most NPSP in streams is associated with soil loss which occurs in the upper stream watersheds. This pollution was observed to be directly proportional to the amount of soil loss. The potency factor was developed which when multiplied by the concentration of sediment in suspension gives the mass of pollutant discharged to the receiving stream or lake.

Sarter and Boyd (43) sampled cities nationwide to obtain potency factors to represent different cities and various land uses. Hydrocomp Inc. used these data in their NPS Model to compute water quality data for the test site (68). The similar pollutant/sediment ratio has been used in computer Models SWMM (33) and STORM (54) to serve the same purpose.

Table 2-2 summarizes the most relevant available data for the evaluation of potency factors for various pollutants and land uses. Obviously, any available water quality data on a watershed should be used to evaluate and adjust the potency factors obtained from this table.

Table 2-2 Representative Potency Factors for BOD, COD, and SS for Various Land Uses and Locations

Land Use/Location		Potency Factors (% of sediment)		
		BOD	COD	SS
Residential:	Low/old/single	0.86	2.70	15
	Low/old/multi	2.00	2.30	20
	Medium/new/single	1.06	3.54	25
	Medium/old/multi	0.77	2.62	20
Industrial:	Light	1.70	8.26	20
	Medium	1.11	5.89	30
	Heavy	0.33	1.49	40
Commercial:	Suburban shopping	0.86	2.07	20
	Central business	0.86	3.11	30
Sites Sampled by Sartor and Boyd (43):				
	San Jose I	1.70	34.00	
	Phoenix I	1.00	4.60	
	Milwaukee	0.44	1.80	9.2
	Bucyrus	0.21	2.10	46.2
	Baltimore	6.10	2.00	29.5
	San Jose II	0.89	6.80	
	Atlanta	0.45	3.00	18.2
	Tulsa	4.30	9.10	14.7
	Phoenix II	1.10	5.80	
	Seattle	1.00	3.80	
numerical mean		1.70	7.30	
average deviation		1.30	6.80	
NPS Model Test Sites:				
	Durham, North Carolina	4.0		71.0
	Seattle, Washington	3.6		38.0

Notes:

1. For residential land use: low or median density/old or new area/single or multi housing
2. These values should be used only as guidelines for estimation of initial values of potency factors. Water quality data on the watershed should pre-empt the table values.
3. The BOD and COD potency factors for the individual land uses and cities were obtained from Tables 7 and C-7 in Sartor and Boyd (43).
4. The SS potency factors for the individual cities were obtained from Table 5 in Sartor and Boyd (43) assuming SS are particle sizes less than 104 microns, while those for the separate land uses are gross estimates based on the judgment of the authors. Specific sites may vary significantly from the above values.

Although large variations may exist in potency factors obtained from recorded data, relative stable relationships can be found when the recorded data is categorized by land use and season of the year.

2.1.5 Soil Loss Limit

NPSP can be alleviated by decreasing the soil loss. Soil loss becomes serious to farmers when the substrata soil renewal rate is less than the surface soil erosion rate. Without applying proper management practices, the surface soil layer will soon be depleted and leave sterile substrata soil for cultivation. Therefore, a soil loss limit, called the tolerance limit, was set up as a standard for different soil conditions so the seriousness of soil erosion can be evaluated and proper management practices be applied.

Stamey and Smith (49) developed a mathematical expression describing soil tolerance in relation with soil depth, soil erosion and soil renewal. They suggest that the present measure of the soil characteristic such as soil depth minus the net change, which is the difference between soil loss and soil renewal, should be greater than or equal to the minimum soil depth which allows crop growth. This expression requires: (a) specific inventory of present soil resources; (b) expression of essential soil-property requirements for the future; (c) data on soil erosion with time; and (d) data on soil renewal with time. These data are difficult to acquire, and therefore leave the establishment of tolerance limits largely as a matter of judgement, as stated by Smith and Wischmeier (48).

Past records in the United States indicate that soil losses range from 0 to 3.08 ton/acre/year under native vegetation (46). Referring to the entire earth, Branson and Tarr (3) calculated that the total amount of earth material emptied into the sea annually averages 0.72 ton per acre. These erosion figures in most cases exceed the soil renewal rate from rock weathering which is 2 tons per acre annually (46). This rate was derived from Chamberlin's (7) 1909 statement that the mean rate of soil formation would be smaller than 1 foot in 10,000 years based on observations since the glacial period.

Soil loss tolerances ranging from 5 to 12 tons/-acre/year for the soils of the United States were derived by soil scientists, agronomists, geologists, soil conservationists, and Federal and State research leaders at six regional workshops in 1961 and 1962 (57). Factors considered in defining these limits included soil depth, physical properties and other characteristics affecting root development, gully prevention, on-field sediment problems, seeding losses, soil organic matter reduction, and plant nutrient losses.

Soil tolerance limits are subjectively evaluated, based on the following guidelines (63):

(1) Maintenance of an adequate rooting depth for crops. For soils that are shallow over hard rock it is important to maintain the remaining soil. Therefore, the soil loss tolerance limit should be less on such soils than for soils of similar depth overlaying soft substrata that can be renewed by management practices. Table 2-3 gives the general guideline on how to select the tolerance limit for different rooting depths.

(2) Crop yield reduction. Soils that have significant yield reductions when the surface layers are removed by erosion are given lower soil tolerance limits.

(3) Maintenance of water-control structures such as open ditches, ponds, and other structures affected by sediment.

(4) Prevention of gullies.

(5) Value of nutrients lost. The average value of nitrogen and phosphorus in a ton of soil is about $2. Plant nutrient losses of more than $10 per acre per year is considered excessive which suggests a maximum soil loss of 5 tons/-acre/year.

Table 2-3 Guides for Selecting Soil Tolerance Limits According to Rooting Depth (63)

Rooting Depth	Annual Soil-Loss Per Acre	
	Renewable Soil(1)	Non-Renewable Soil(2)
(inches)	(tons)	(tons)
0–10	1	1
10–20	2	1
20–40	3	2
40–60	4	3
60+	5	5

(1) Substrata that may be removed by tillage, fertilizer, organic matter, and other management practices. Soft shales and other rocks that shatter easily are renewable.

(2) Substrata such as hard rock or soft rock with unfavorable chemical composition that cannot be renewed by economical means.

2.2 Non-Point Source Pollution Modeling

Several computer models were developed in the past by different government agencies and private consulting firms trying to simulate at least one of the six processes: (1) runoff, (2) sediment suspension, (3) sediment transport, (4) sediment associated pollution, (5) nutrient pollution, and (6) pesticide pollution. For each process, different approaches derived from different theories were applied. However, the same processes may appear repeatedly in different models. As shown in Table 2-4, eleven computer models were selected and listed which relate to this study. Each of these models provides an estimate of at least one of the following: (1) sediment suspension, (2) sediment transport, and (3) sediment associated pollution which were mentioned in Section 2.1.

2.3 A Case Study Covering BMP Application

Computer modeling simulates natural processes to predict soil loss and associated pollution in terms of statistical methods or empirical equations.

The Black Creek Study (66) was an Environmental Protection Agency funded project to determine the environmental impact of land use on water quality. This project began in October 1972 and lasted until September 1977, and was funded at 1.8 million dollars. It was designed

Table 2-4 Functions of Models on Monitoring the NPSP

Model	Sediment Suspension	Runoff Simulation	Sediment Transport	Sediment Associate Pollution	Pesticide Simulation	Nutrient Simulation
PTR(10)		X	X		X	
ACTMO(15)	X	X			X	X
WASCH (5)		X	X		X	
NPS(68)		X	X	X		
ARM(13)		X			X	X
STORM(54)		X		X		X
SWMM(33)		X		X		X
WASRRHAT(53)	X			X		X
CREAMS(55)	X	X		X	X	X
ANSWERS (1)	X	X	X			
NWA(74)	X		X			

and developed by a consortium consisting of the U.S. Environmental Protection Agency, U.S. Congressman J. Edward Roush, and Allen County, Indiana.

The Black Creek Watershed is one of 200 to 300 similar agricultural watersheds in the Maumee Basin. The goal of this project is to determine whether a concentrated application of existing methods of land treatment in the Maumee Basin could achieve a targeted reduction in sediment. The cost of a basin-wide program was also of interest. Concurrently, the project was designed to discover the type of basin-wide program which would convince individual landowners to apply BMP's to improve water quality.

Conclusions from this project which provide partial answers for the above goals are:

(a) Protecting soil surface from raindrop impact is one of the most effective means of minimizing sediment concentrations in runoff.

(b) Shallow tillage or no-till planting for corn-after-corn or corn-after-beans should not limit production on well or moderately well drained soils where perennial weeds are not a serious problem.

(c) No-till treatment after corn is more effective than that after soybeans because the latter has less surface cover.

(d) Fall chiseling after corn, although not as effective as the no-till treatment, significantly reduces erosion compared to moldboard plowing.

(e) 50 feet of bluegrass sod buffer could achieve as much as 54% reduction of sediment when runoff water passes over the sod.

(f) Channel stabilization structures such as rock drop structure and bank stabilization eliminate many erosion problems from stream channels and banks.

(g) The sediment pond had a measurable and beneficial impact on water quality but would require difficult cleanout for continued effectiveness.

(h) Selection of BMP's must emphasize the goal of improving water quality but minimize negative effects on production.

(i) The most cost effective method of achieving improved water quality through BMP's is to concentrate remedial efforts on those critical areas within watersheds where maximum benefit can be obtained. It may not be necessary to treat every acre of every watershed to achieve realistic water quality goals.

(j) Twelve out of 32 practices were selected as BMP's.

(k) The total project cost was $945,016 which included land owners' contribution of $190,915, district payment of $518,876 and Soil Conservation Service (SCS) technical assistance cost of $235,225. For 12,038 acres of Black Creek Watershed, a unit treatment cost of $78.5 per acre was derived which can be used to estimate the BMP cost for Maumee Basin.

(l) Cost of treating a watershed such as the Black Creek can be categorized into four classification: (1) those which benefit water quality; (2) those which protect the soil resource; (3) those which enhance projection capability; and (4) those which accomplish other conservation purposes. All of these goals should be considered in a watershed program. However, attempts should be made to assign costs to the appropriate category. All BMP costs for a particular watershed cannot be considered only for the water quality criterion.

(m) A given level of water quality can be provided at the least cost to participating farmers when they are provided as many alternatives as possible in selecting BMP's to achieve that required level of quality.

(n) Government agencies make an important contribution in encouraging the adoption of BMP's by providing information to farmers about the practices.

(o) The favorable attitude of farmers and the high level of participation indicate adoption of BMP's can be achieved in most cases without coercive legislation.

CHAPTER III

MODEL DEVELOPMENT

Cropping Management Model BMP1 and Construction Management Model BMP2 were developed for different uses. Model BMP1 is used to evaluate the effect of changing cropping management and land treatment practices. For example, a corn field with up-and-down slope farming is considered for use of cropping management practices such as contouring, terracing or rotation in order to reduce the NPSP. Model BMP1 can be used to compare these management practices in terms of their performances, costs and environmental impacts. If this corn field is converted to hay or range land, Model BMP1 can provide an analysis to evaluate the adequacy of this change.

Model BMP2 evaluates construction management practices such as diversion, sediment basins and floodwater retarding structures to further control the NPSP from upstream eroded areas with or without change of cropping management and land treatment practices. Construction management practices are selected to control NPSP at locations within a watershed. Each management practice is then evaluated based on cost, performance, and environmental impact. The BMP or BMP's thus selected are the most appropriate ones to control the NPSP in that watershed. Model BMP2 can also be applied to subbasins or basins comprised of several watersheds. In this case, several series of construction management practices at different locations can be compared to determine the best series of BMP's.

Model BMP1 and Model BMP2 can be used jointly when a watershed is being analyzed to determine the combination of land treatment cropping management and construction management practices to control the NPSP. Under this condition, Model BMP1 can be incorporated as a subroutine in Model BMP2 so that these different management practices can be analyzed simultaneously.

It is noteworthy that in most cases these models will not provide a combination of BMP's which is an optimal solution for all three criteria-performance, cost and environmental impact. This is because a BMP is not likely to have optimal performance, least cost and least negative environmental impact simultaneously. However, by using a ranking method accompanied with proper weights for these three criteria, the final selection of a BMP can be determined. These weights vary with individual interests, government policies and socioeconomic considerations.

3.1 Model Structure

Both Models BMP1 and BMP2 are comprised of five major components: (1) soil loss, (2) water quality, (3) treatment efficiency, (4) cost effectiveness, and (5) environmental impact. Component 1 computes annual soil loss to compare with the tolerance limit before and after the installation of management practices. Component 2 computes soil loss into a stream and resultant pollutant loadings in receiving waters before and after the installation of management practices. Component 3 computes treatment efficiencies. Component 4 computes costs for several cost elements. Component 5 provides numerical indices for management practices to compare environmental impacts.

The functional structure of Model BMP1 is shown in Figure 3-1. Subroutine SOLWTQ is called to estimate soil loss and water quality before and after the installation of cropping management and land treatment practices. The soil loss before the installation is estimated by the USLE. When it is greater than the designated tolerance limit, the number of years of depleting the surface soil layer can be determined by their difference. Treatment efficiencies of management practices are determined by the difference of the "C" values in the USLE before and after the installation of management practices. From the known treatment efficiency, the soil loss after the

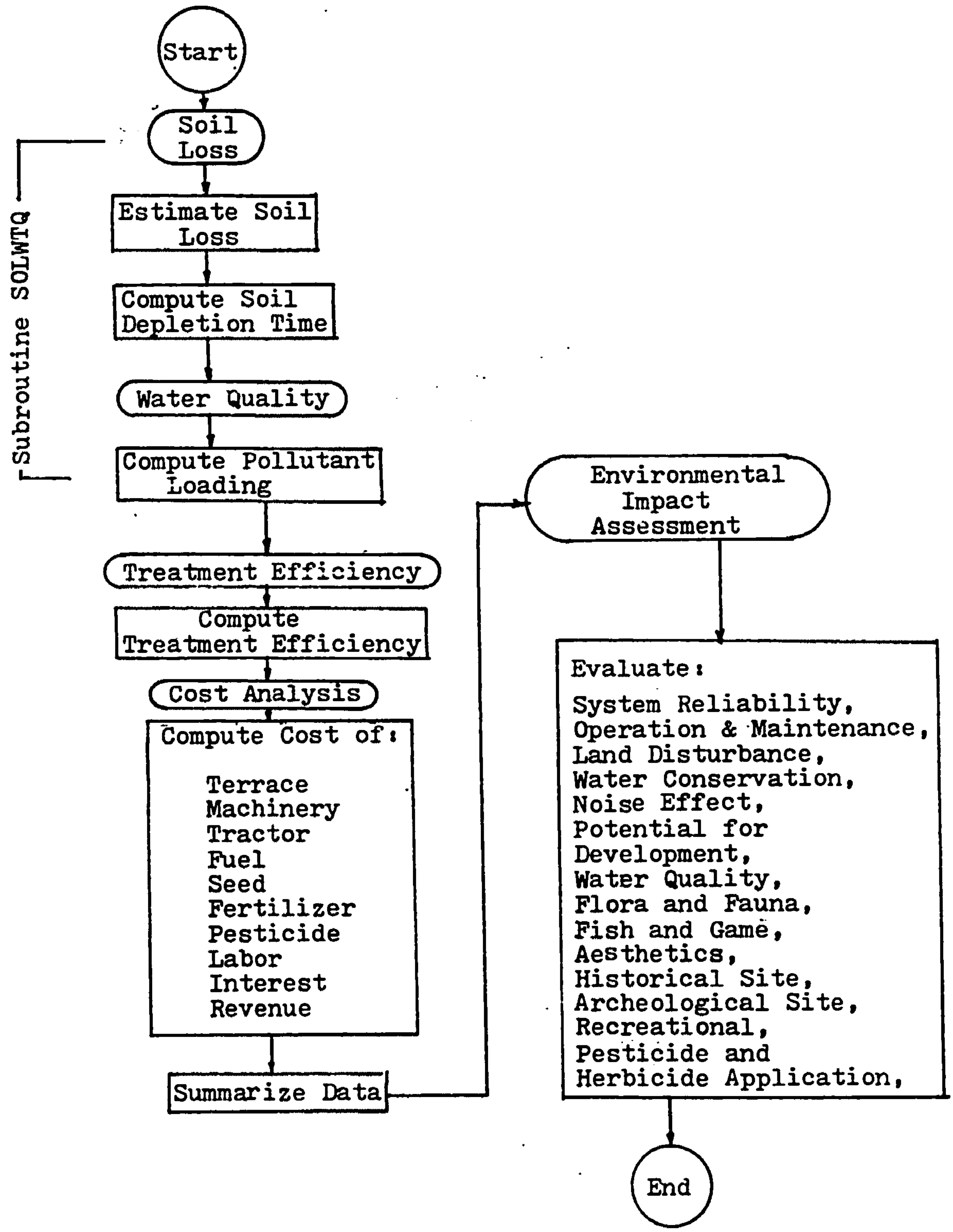


Figure 3-1 Flow Chart of BMP1

installation of management practice is determined. This soil loss, less the amount of sediment retained at the ground surface, times potency factors for various pollutants, determines water quality in the receiving waters. The flow chart of Subroutine SOLWTQ is exhibited in Figure 3-2. Twelve elements of cost are computed for every management practice, to determine cost effectiveness. Fourteen environmental impact elements are evaluated for every management practice.

The functional structure of Model BMP2 is shown in Figure 3-3. When there is a change of cropping management and land treatment practice, Subroutine BMP1 is called in to evaluate management practices. If not, then only Subroutine SOLWTQ is called in to evaluate the soil loss and water quality of upstream watersheds. Diversion, sediment basin and floodwater retarding structures are three parallel methods used at various locations to determine individual cost, performance and environmental impact. For diversion, flow rate is computed using the rational method and size of channel determined by using Manning's equation. The cost is then estimated according to channel size. For sediment basins and floodwater retarding structures, after flow rate and size are determined, trap efficiency is computed according to Dendy's equation. Following the cost analysis based on size, Subroutine DPLET is called to determine adequate

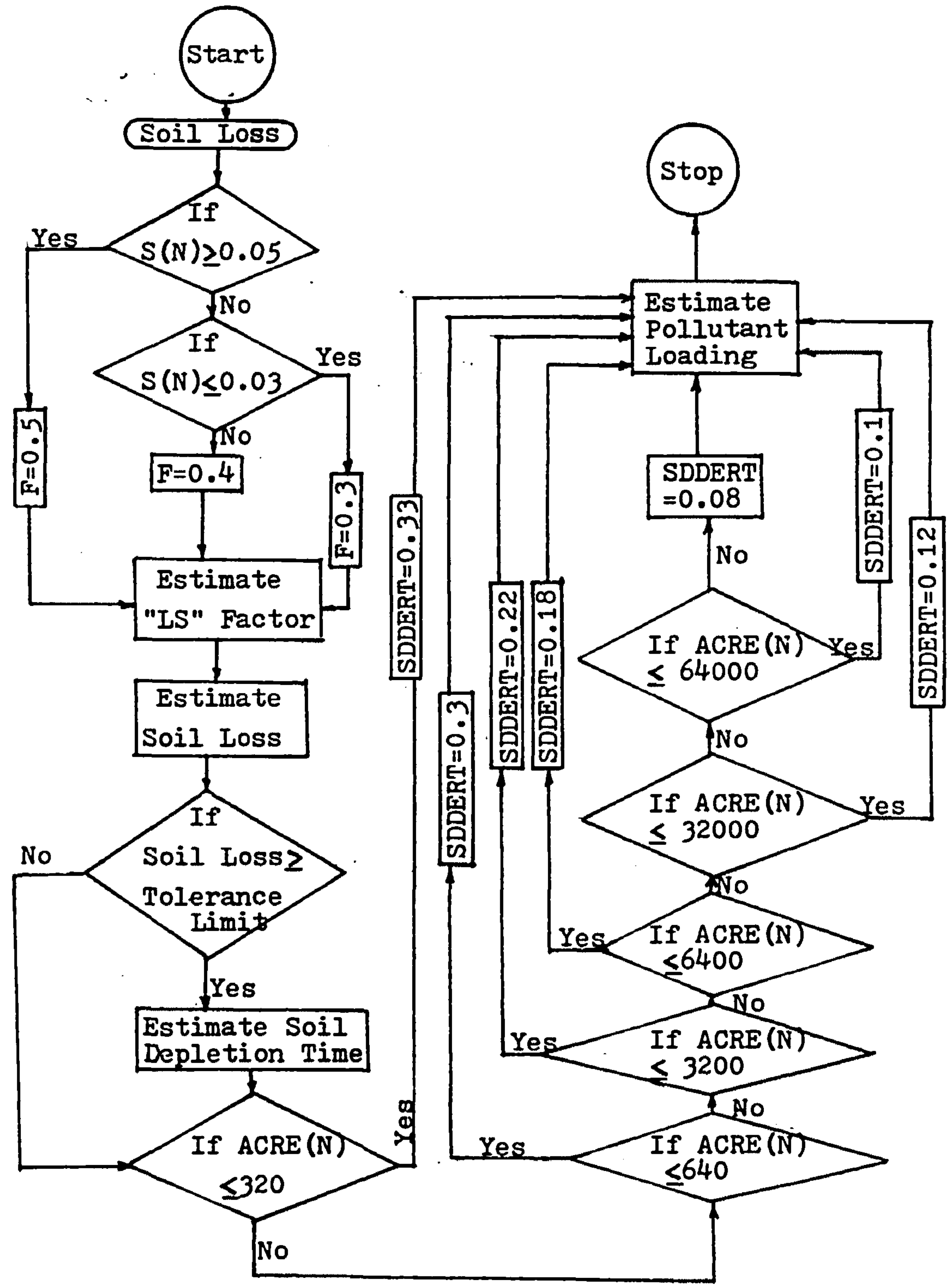


Figure 3-2 Flow Chart of Subroutine SOLWTQ

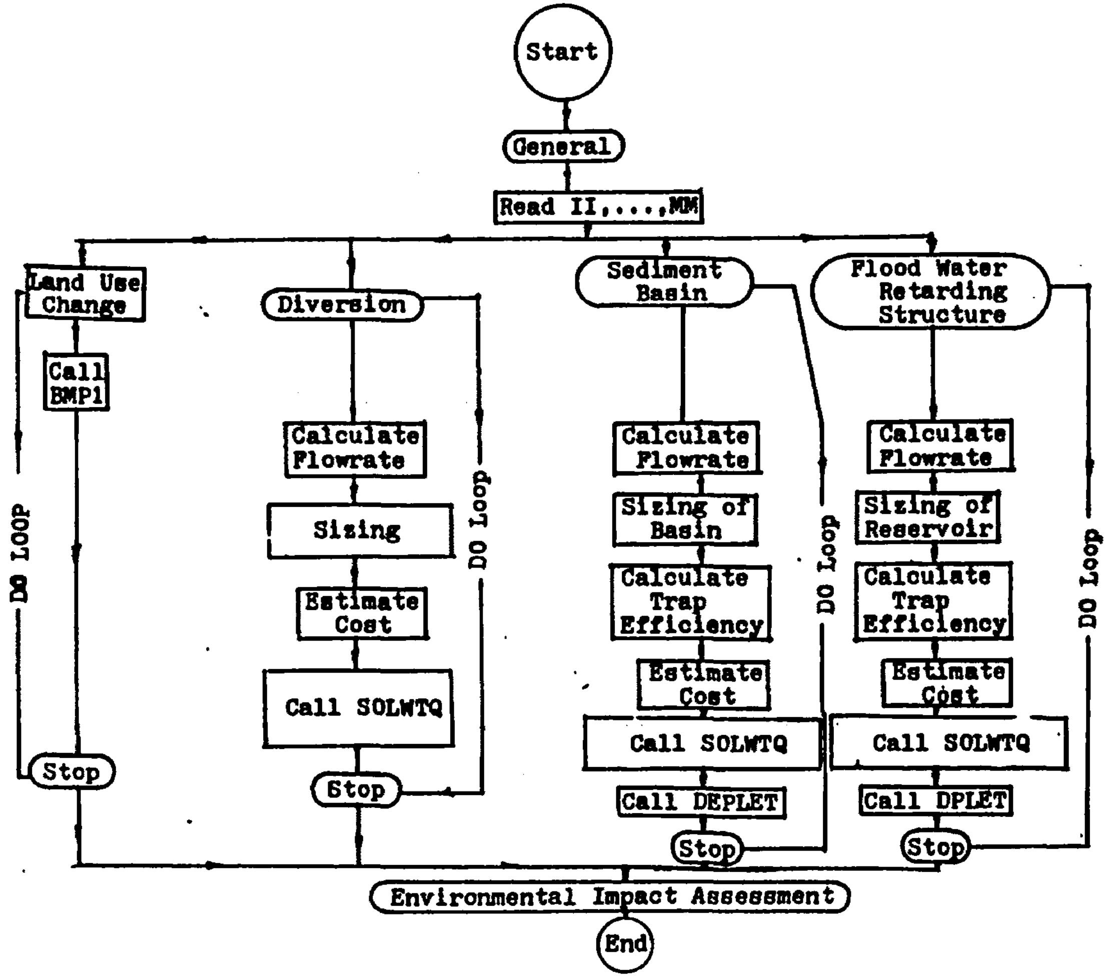


Figure 3-3 BMP2 Main Program

outlet structure for either sediment basins or floodwater retarding structures according to flow rate and hydraulic head. After the determination of the type and size of the outlet structure, the cost is estimated. This cost is added to the cost of the basin (or reservoir) to develop the completed construction costs. A flow diagram for the Subroutine DPLET is shown in Figure 3-4. All methods are evaluated for environmental impact by 14 parameters. A numerical value for each parameter is multiplied by a weight to provide weighted assessments.

Both main programs and subroutines are written in FORTRAN IV. Model BMP1 requires 74 input parameters to initiate the program. Up to eleven cropping management practices can be stored and compared simultaneously. Within each practice, up to sixteen machinery units can be operated. The program printout of Model BMP1 is exhibited in Appendix C. Model BMP2 requires 105 input parameters to initiate the process. For each of three construction management practices, up to ten areas can be evaluated. The program printout of Model BMP2 is exhibited in Appendix D.

3.2 Component of Soil Loss

The soil loss component is used in both Model BMP1 and BMP2. Within this component, the USLE is the fundamental equation to estimate soil loss from a parcel of

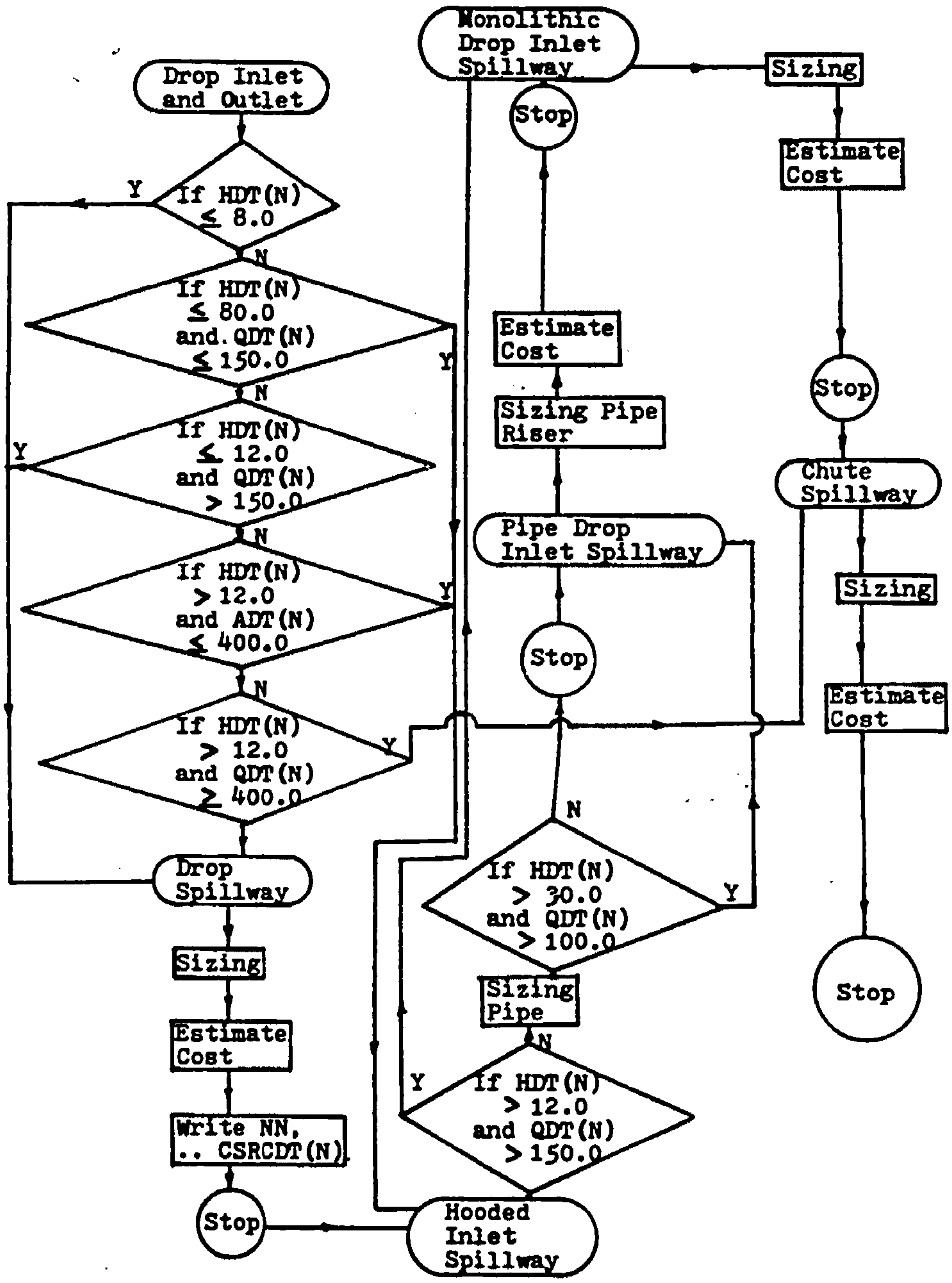


Figure 3-4 BMP2 Subroutine DPLET

land. It has been used successfully in many computer models such as ACTMO, WASRRHAT, CREAMS, ANSWERS and NWA. The successful use of this equation depends completely on selecting proper values for five factors; rainfall and runoff factor (R), soil erodibility factor (K), slope-length factor (L), slope-steepness factor (S), cover and management factor (C), and support practice factor (P). The description of these factors and their value selection has been discussed in detail in Section 2.1.1.

The purposes of estimating soil loss are two fold: (1) to compare with the tolerance limit to evaluate the seriousness of soil erosion; (2) to determine the impact of soil erosion on water quality in receiving waters. The former will be discussed in this section and the latter in the following section.

Tolerance limits for soils nationwide have been determined and data are listed in the publications by SCS branch offices. If soil loss is greater than the tolerance limit for a tract of land, the fertile soil surface layer will be depleted eventually. The greater the amount by which the soil loss exceeds the tolerance limit, the sooner the surface soil layer will be depleted. Therefore, the time for depletion can be estimated in terms of this excess soil loss. The soil density may range from approximately 76 to 146 lb/cu ft. (31). An average of 111 lb/cu ft. was selected as the general soil density to estimate soil surface depletion time. The equation thus formed was:

$$SDY = \frac{DSSL}{\dfrac{SL - TL}{201}}$$

Where: SDY = Soil surface depletion time, years

DSSL = Depth of surface soil layer, inches

SL = Soil loss, tons/acre-year

TL = Tolerance limit, tons/acre-year

This equation is not applicable when soil loss is smaller than or equal to the tolerance limit.

3.3 Component of Water Quality

Water quality component is mainly used in Model BMP1 and can be used as a subroutine in Model BMP2. This component contains two major factors: (1) the sediment delivery ratio which estimates the amount of sediment delivered into a stream, and (2) the potency factor which is used to estimate the water quality by multiplying the potency factor by the sediment loss. To estimate sediment delivered from the watershed to a stream, a sediment delivery ratio which is a function of watershed size was developed as mentioned in Section 2.1.2 to be used in this component. This ratio, times the soil loss estimated from the last component, becomes the sediment delivered into a stream.

As mentioned in Section 2.1.4, potency factors are used to estimate quantities for various pollutants associated with sediments. This factor, being selected according to geographic location and land use, times the amount of sediment delivered into a stream, gives the amount of pollutant discharged to the stream. This mass of pollutant, represented as pounds of pollutant per year, is estimated before and after the installation of management practices.

3.4 Component of Treatment Efficiency

The change of "C" and "P" factors in the USLE is used to evaluate the treatment efficiency for cropping management practices in Model BMP1. Factors "C" and "P" change with changes in management practices. These changes result in corresponding changes in the amount of sediment loss. The relation can be illustrated as follows:

Treatment Efficiency (REMEFF, %)

$$= \frac{\left(\text{Soil Loss before the Installation}\right) - \left(\text{Soil Loss after the Installation}\right)}{\text{Soil Loss before the Installation}} \times 100\%$$

$$= \frac{R_b K_b L_b S_b C_b P_b - R_a K_a L_a S_a C_a P_a}{R_b K_b L_b S_b C_b P_b} \times 100\%$$

where: "b" denotes "before the installation"

"a" denotes "after the installation"

Since: $R_b = R_a,\ K_b = K_a,\ L_b = L_a,\ S_b = S_a$

$$\text{REMEFF} = \frac{R_b K_b L_b S_b (C_b P_b - C_a P_a)}{R_b K_b L_b S_b C_b P_b} \times 100\%$$

$$= \frac{C_b P_b - C_a P_a}{C_b P_b} \times 100\%$$

For diversion in Model BMP2, the treatment efficiency is evaluated in terms of the change of "LS" factor in the USLE before and after the installation of management practice. This is because the diversion ditch intercepts and diverts runoff without letting it wash farther downslope which shortens the slope length when estimating the soil loss. As the previous development of treatment efficiency through the change of "C", "P" factors, the equation is acquired as follows:

$$\text{REMEFF} = \frac{L_b S_b - L_a S_a}{L_b S_b} \times 100\%$$

$$= \frac{\left(\frac{\lambda_b}{72.6}\right)^m - \left(\frac{\lambda_a}{72.6}\right)^m}{\left(\frac{\lambda_b}{72.6}\right)^m}$$

$$= \frac{\lambda_b^m - \lambda_a^m}{\lambda_b^m}$$

where: λ = field slope length in feet,

m = 0.5 if slope equals 5% or greater,

= 0.4 if slope equals 4%,

= 0.3 if slope equals 3% or less,

and "b" denotes "before the installation"

"a" denotes "after the installation".

For sediment basins and floodwater retarding structures in Model BMP2, the treatment efficiency is estimated by the equation developed by Dendy (12) in terms of a capacity/average annual inflow ratio. The equation with detailed description is contained in Section 2.1.3.

3.5 Component of Cost Analysis

In Model BMP1, the change of cropping management practice and/or land use involves not only the cost change of the cropping method but also the change in revenues. However, only the actual project cost is used in Model BMP2 to select the most economical construction management practice. The intangible benefits created by construction management practices are estimated by environmental impact assessment.

3.5.1 Cost Analysis of Model BMP1

Model BMP1 considers ten operational costs and product revenues. These ten operational costs are the costs of terraces, machinery, tractors, fuel, seed, fertilizer, pesticide, labor, drying and interest. These costs are all estimated on an annual basis. Although their values fluctuate with current market price, their relative costs are assumed to remain unchanged. The following paragraphs provide general information concerning the structure for each cost. The appropriate formulas and parameters are described in Appendix B.

Terrace Cost

The terrace cost includes construction and maintenance costs annualized using an eight year life time. The steps to establish construction cost includes: (1) estimating the maximum allowable horizontal spacing for terraces according to kind of terrace, land slope, soil erodibility, cropping systems and crop management practices, (2) determining the number of terraces which can be constructed on the sloped land, (3) determining how many feet of terraces can be constructed within an acre, (4) estimating initial capital cost of terrace per acre, (5) prorating yearly construction costs excluding government subsidy. Yearly maintenance cost is estimated directly from the estimated yearly maintenance cost per foot of terrace.

Machinery Cost

The machinery cost includes both fixed and repair costs. The machinery fixed cost includes yearly depreciation, taxes, insurance, housing and interests. Yearly depreciation cost is derived from the difference between initial and salvage costs then divided by machine's economic life. Since the owner may use machinery for cultivating his land outside the watershed of interest, this fixed cost should be prorated within the watershed by its percentage to the owner's total acreage of land. Taxes, insurance and housing are estimated as a lump sum by a suggested 2.8% (25) of the average machinery cost. Interest cost is estimated through annual interest rate based on the average machinery cost.

The machinery repair cost is determined by the product of total annual operation hours and repair cost per 100 hours. The total hours of operation is developed by the product of three parameters: (1) annual hours of operation per acre, (2) acreage on which the machine or implement is used, and (3) number of trips the machine or implement travels on the field.

Tractor Cost

The tractor is the basic piece of mobile equipment used in every practice along with various implements. The cost development procedure is similar to that used to develop the "Machinery Cost". However, the tractor yearly operation hours is usually 10% more than the sum of operation hours of associated implements to cover the time for idling and traveling to field. It is assumed that the hours of operation for the tractor for harvest hauling is in equivalent to that for the combine. The initial tractor cost is also prorated according to the percentage of time that the tractor is used in the land within the watershed.

Fuel Cost

Fuel Cost is estimated for all fuel powered engines and vehicles. It includes fuel consumption cost and lubrication cost which is assumed to be 15% of fuel consumption cost (25). The fuel consumption cost is the product of fuel unit cost, total operation hours of the tractor or combine and fuel consumption rate which is based on the Power Take Off (PTO) horse power of the engine.

Seed Cost

The seedling rate is determined on the basis of kind of seed and soil condition. The seed cost is derived by knowing seed rate, seeding acreage and unit cost of seed.

Fertilizer Cost

Nitrogen (N), phosphate (P_2O_5) and potassium (K_2O) are the three most common fertilizers for agricultural use and, hence, are used in this program. The recommended fertilizer application rate is based on the assumption of: (a) unlimited resources, (b) adequate but not excessive plant population for soil area, (c) above-average crop and soil management, and (f) favorable price relationships between fertilizer and crops (71). The fertilizer cost is determined by knowing the rate of application, applied acreage and fertilizer unit cost. Also, the cost of equipment such and NH_3 applicator and bulk spreader is included on the rental basis.

Pesticide Cost

Pesticide cost includes herbicide and insecticide costs. Their determination is based on the recommended application rate. The recommended herbicide application rate is governed by environmental and managerial factors. Environmental factors include rainfall, temperature and relative humidity. Managerial factors include depth of planting, time of planting, time of application, type of seed bed preparation, weed species in the field, and rate and kind of chemicals (29).

The insecticide should be applied by or under the supervision of certified insecticide applicator because insecticides have been classified as being for restricted use by the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1972 (51). The application rate is primarily based upon kind of pest and type of chemicals.

Labor Cost

The labor cost is estimated from the current wage and the total direct labor hours which is the sum of total tractor and combine operation hours. A reasonable 30% overhead is included in the cost.

Drying Cost

The drying cost is considered for grains which require drying and it is estimated from the unit drying cost and the predicted grain harvest amount which is derived from the "Revenue" section of this dissertation.

Interest Cost

Interest is calculated based on five operational costs with different borrowing periods. The current interest rate is used for eight months of fertilizer cost, eight months of seed cost, six months of pesticide cost, three months of fuel cost and three months of labor cost.

Revenue

Revenue is generated from agricultural products such as crops, beef cattle, dairy cattle, etc. The amount of these products is estimated from past statistical records published by the state government. The current market value of products should be carefully selected to obtain meaningful comparison with previously mentioned expenses.

3.5.2 Cost Analysis of Model BMP2

All cost information is estimated from structures which are typically designed for comparison purpose.

Structures which are included are diversion, sediment basins, and floodwater retarding structures. They are discussed separately in the following paragraphs.

Diversion

A diversion may be structures as small as terraces or as large as stream channels which divert runoff away from the site to reduce erosion. The Manning's equation is used to size the channel. However, in order to use the Manning's equation, flow rate (Q) should be estimated by the Rational Method. From Reference (37), parameter "I" in Rational Method can be estimated by the following equations:

$$I = F(Tc + 18.5)^{-0.843}$$

where F = Coefficient which varies with the rain fall intensity corresponding to a return period of "n" years. (see Table 3-1)

Tc = Tov + Tch

Tov = Runoff overland time

Tch = Channel flow time

$$Tov = 1.4(L')^{0.5}$$

$$L' = 0.25nL(S)^{-0.5}$$

where n = Surface characteristic coefficient. (see Table 3-2)

L = Slope length in ft.

S = Slope in ft./ft.

Table 3-1 Value of "F" for Rains at Different Frequencies (37)

Year	F Value
2	77
5	100
10	117
25	134
50	148
100	167

Table 3-2 Value of Surface Characteristics "n" (65)

Surface	n Value
Paved	0.02
Bare Soil	0.10
Poor Grass	0.25
Ave. Grass	0.40
Dense Grass	0.80

Table 3-3 Value of Channel Characteristics "B" (37)

Channel Characteristics	B Value
Straight, Clean Stream	0.00592
Ave. Stream	0.00835
Meandering Stream	0.01020
V-Ditch	0.01252

$$Tch = BL^{0.77}S^{-0.385}$$

where B = Channel characteristic coefficient. (see Table 3-3)

The size of the diversion can be computed by rearranging the Manning's equation. In this case, "R" can be computed by knowing slope and choosing proper velocity and the Manning's coefficient:

$$R = \left(\frac{Vn}{1.486}\right)^{1.5} X \left(\frac{1}{S^{0.75}}\right)$$

For a grassed diversion channel, the proper velocity can be selected from Table 3-4 based on known channel slope and selected type of grass.

Chow (8) indicated that trapezoid is the most common shape for unlined open channels for it provides side slopes for stability. Therefore, this shape is selected as the typical design for diversion for cost analysis.

Lining is added to protect the channel bottom and banks from erosion. It may either be artificial material such as concrete or natural grasses. The lining area is computed as (see Figure 3-5):

$$A_1 = PL$$

where A_1 = Lining area in ft^2

L = Length of diversion ditch in ft.

$$P = B + 2Y\sqrt{1 - Z^2}$$

Also, excavation or hauling quantity is derived by the

Table 3-4 Permissible Velocities for Channels Lined with Vegetation (61)

Cover	Slope range 2/ (percent)	Permissible velocity 1/	
		Erosion Resistant soils (ft per sec.)	Easily eroded soils (ft per sec.)
Bermudagrass	0-5 5-10 over 10	8 7 6	6 5 4
Bahia Buffalograss Kentucky bluegrass Smooth brome Blue grama Tall fescue	0-5 5-10 over 10	7 6 5	5 4 3
Grass mixtures Reed canarygrass	2/ 0-5 5-10	5 4	4 3
Lespedeza sericea Weeping lovegrass Yellow bluestem Redtop Alfalfa Red fescue	3/ 0-5	3.5	2.5
Common lespedeza 4/ Sudangrass 4/	5/ 0-5	3.5	2.5

1/ Use velocities exceeding 5 feet per second only where good covers and proper maintenance can be obtained.

2/ Do not use on slopes steeper than 10 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

3/ Do not use on slopes steeper than 5 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

4/ Annuals-- use on mild slopes or as temporary protection until permanent covers are established.

5/ Use on slopes steeper than 5 percent is not recommended.

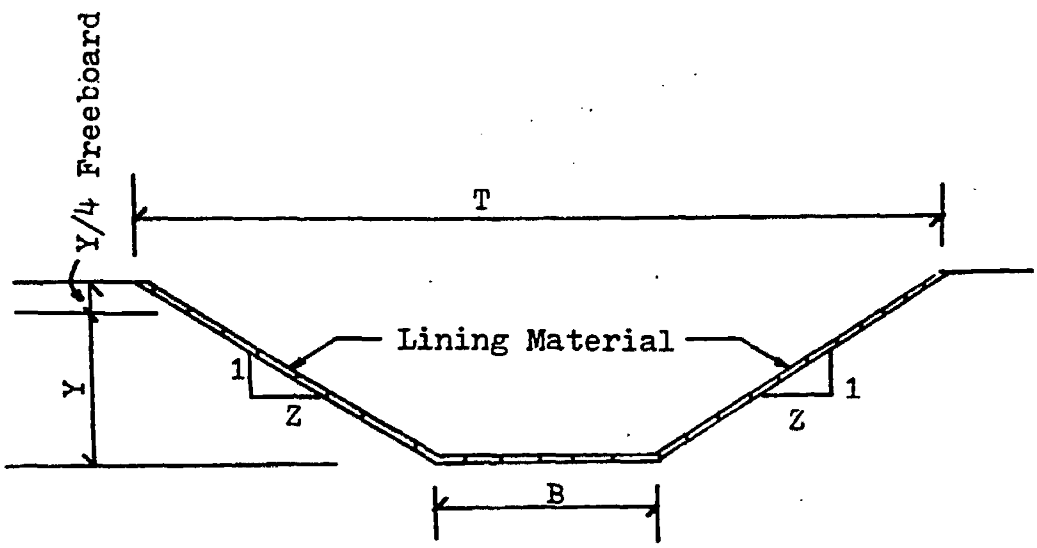


Figure 3-5 Dimension of Diversion. (No Scale)

product of "A" (cross section of diversion ditch) and "L". The total construction cost is the sum of these three costs: lining, excavation and hauling, which can be obtained by knowing their unit costs by area or volume.

Sediment Basin

The area of the upstream watershed above a sediment basin has been used to estimate the flow rate in terms of the Rational Method as discussed previously. The necessary minimum surface area of a sediment basin can be calculated as:

$$AREA_{SB} = \frac{Q_{SB}}{SV_{SB}}$$

where $AREA_{SB}$ = Surface area of sediment basin in ft^2

Q_{SB} = Flow rate into the basin in cfs

SV_{SB} = Settling velocity of silt particles in fps

Table 3-5 gives several settling velocities of different sized soil particles.

By using the USLE, the annual soil loss in tons per acre per year can be estimated from the upstream watershed. Since bottom silt deposit is a mixture of water and soil, its density should range from 62.4 to 111 lb/cu ft. (as mention in Section 3.2), which depends on the deposition period. By using the medium figure of 85 lb/cu ft., the average depth of the sediment basin in feet is:

Table 3-5 Settling Velocities of Selected Particles (70)

Kind of Material	Particle Diameter (microns)	Settling Velocity (cm/sec)	(fps)
Coarse Sand	1000	10.0	0.33
Coarse Sand	200	2.1	0.069
Fine sand	100	0.8	0.026
Fine sand	60	0.38	0.012
Fine sand	40	0.21	0.0069
Silt	10	0.015	0.00049
Coarse clay	1	0.00015	4.9×10^{-6}
Fine clay	0.1	1.5×10^{-6}	4.9×10^{-8}

$$DEP_{SB} = \frac{LF_{SB} \cdot SOLS_{SB} \cdot ACRE_{SB} \cdot 2000}{85 \cdot AREA_{SB}}$$

where LF_{SB} = Expected useful life of basin in years.

$SOLS_{SB}$ = Soil loss in tons/acre/yr.

$ACRE_{SB}$ = The area of upstream watershed above a sediment basin in acres.

To construct a sediment basin, usually, a dike is constructed downstream of the watershed to collect the water. A survey using a contour map must be performed to select the location and determine the length of the dike to provide the required surface area and depth of sediment basin. Using the cross section as shown on Figure 3-6, the volume of the dike can be computed as:

$$VLD_{SB} = \frac{[3+(DEP_{SB}+1).6].(DEP_{SB}+1).LEDK_{SB}}{2.27}$$

where VLD_{SB} = Volume of the dike in yd^3

LED_{SB} = Length of the dike in ft.

The excavation of a basin and fill of dike are dependent upon site topographic conditions because it is most economic to excavate an equal amount of soil from the basin to construct the dike so that the hauling expense can be minimized. By using this assumption, the unit cost of excavation, hauling and fill (including compaction) can be estimated and multiplied by the dike

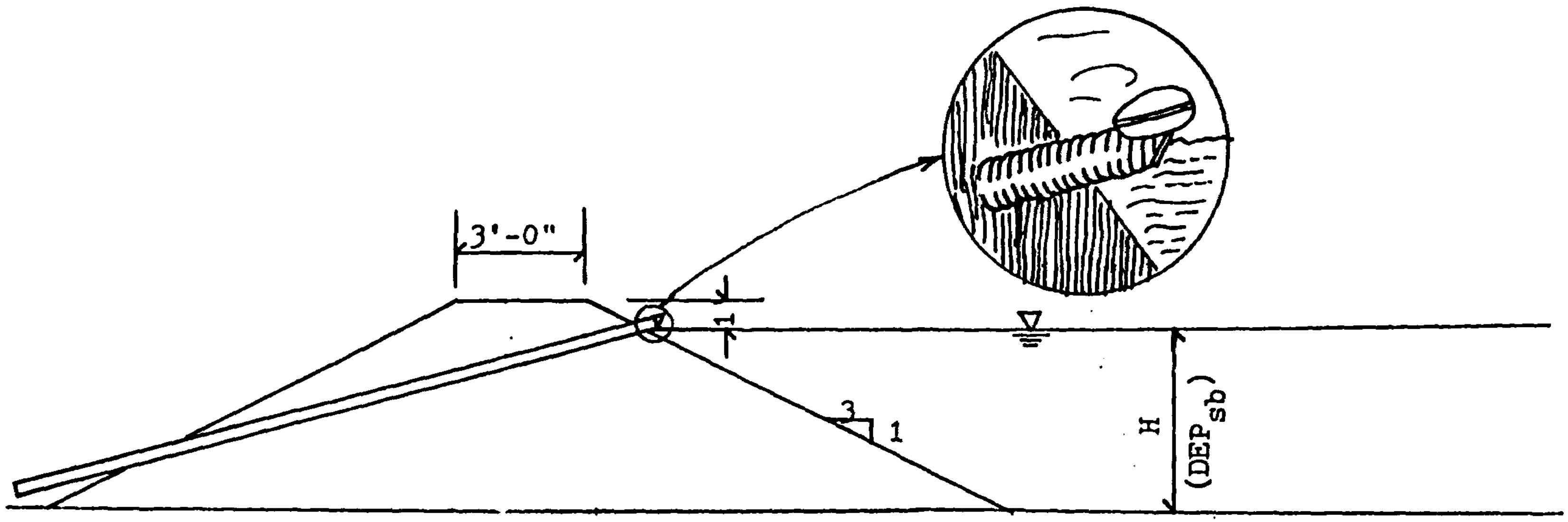


Figure 3-6 Cross Section of Sediment Basin Dike with Hood Inlet Spillway. (No Scale)

volume to obtain the construction costs. The slope and top of the dike must be mulched and vegetated to prevent soil erosion. The cost of vegetation plus the construction cost becomes the total construction cost for this alternative.

Floodwater Retarding Structure

The floodwater retarding structure is similar to a sediment basin except; (1) the height of embankment exceeds 20 feet; and (2) the drainage area exceeds 200 acres. In addition, a floodwater retarding structure may potentially result in loss of life, damage to buildings, highways, railroads, cr the interruption of service of public utilities if the structure fails.

The top width of a dike for a floodwater retarding structure is designated as 12 feet minimum to accommodate at least one lane of traffic. A perforated pipe is placed near the toe of the dike to intercept seepage water from the reservoir in order to protect the dike. The length of perforated pipe is equal to that of the dike. The total cost is the sum of excavation, hauling, filling, perforated pipe and vegetation costs.

Drop Inlet and Outlet

There are five types of inlet and outlet structures: drop, hooded inlet, pipe drop inlet, monolithic drop inlet, and chute spillway. A proper inlet and outlet structure is selected based on the head and flow rate through the sediment basin or flood water retarding structure. Figure 3-7 shows these relationships. After the selection, each inlet and outlet structure is designed based on these two factors.

Drop Spillway

The equation to compute the weir capacity is as follows (61):

$$A = \frac{3.1 L_W H_W^{3/2}}{(1.10 + 0.01H)}$$

where Q = Flow rate passing over the weir in cfs

L_W = Length of weir in ft.

H_W = Depth of weir in ft.

H = Weir overfall in ft.

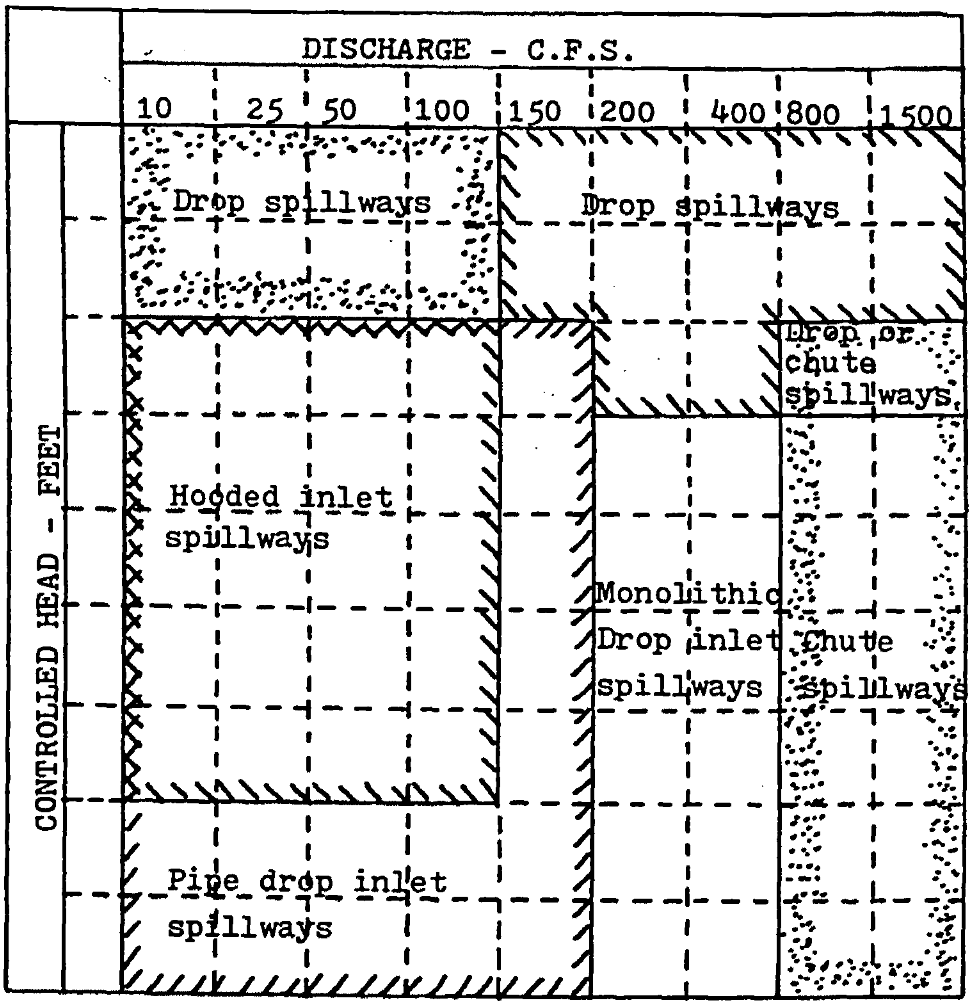
In order to simplify the equation, $L_W=5H_W$ was assumed and the equation rearranged to compute the weir depth:

$$H_W = [(1.10 + 0.01H)Q/7.75]^{0.25}$$

By referring to Figure 3-8, which shows the typical dimension of drop spillway, the volume of reinforced concrete can be computed and cost derived.

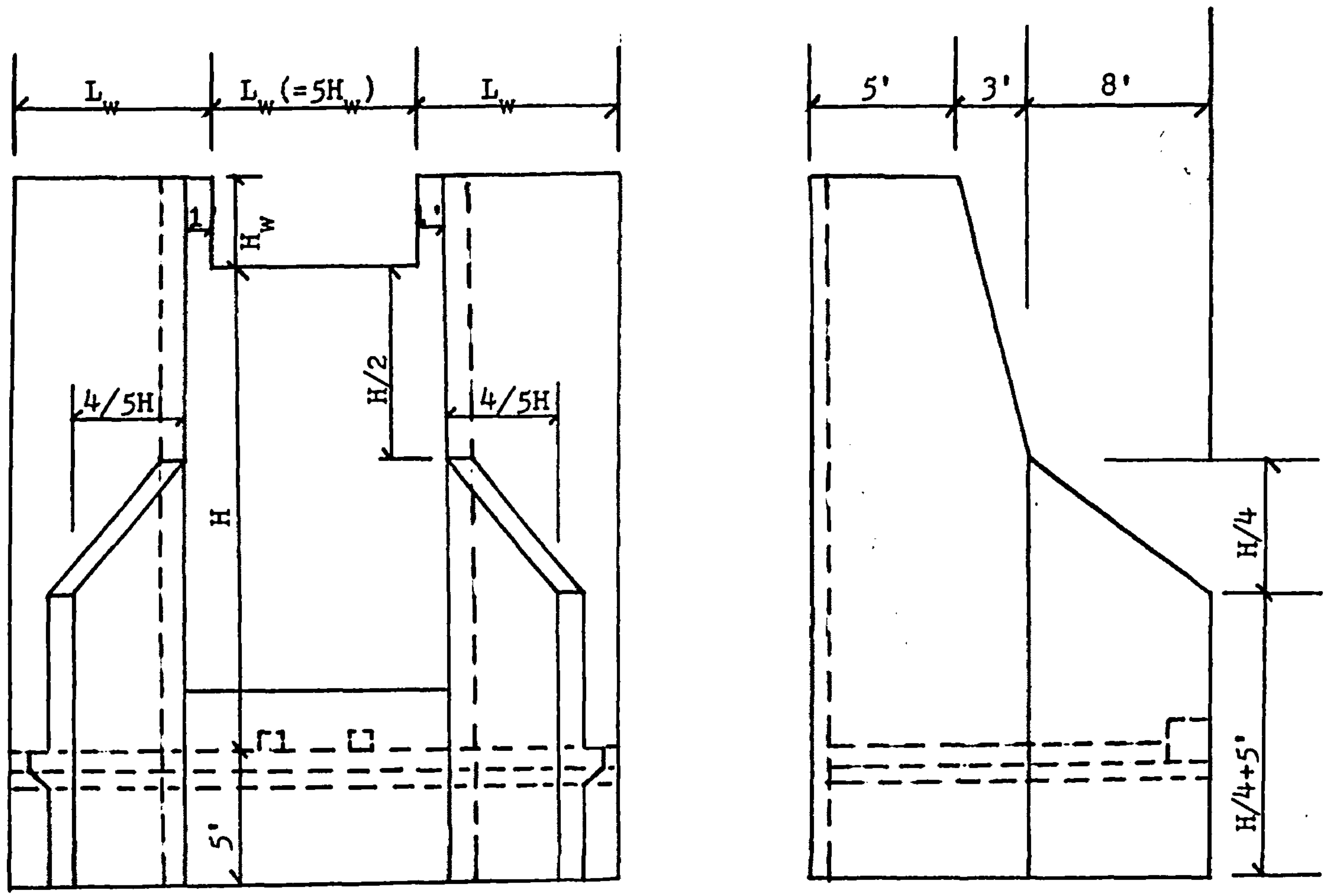
Hooded Inlet Spillway

The hooded inlet spillway consists of a pipe conduit with the inlet and formed by cutting the pipe at an



Note: Chart shows most economical structure as related to discharge and controlled head providing site conditions are adequate.

Figure 3-7 General Guide to Structure Selection (61)



Note: All concrete slab width is assumed equal to 6".

Figure 3-8 Typical Drop Spillway (No Scale) angle. The long side of the cut is placed on top which forms a hood over the entrance. By referring to Figure 3-7, the pipe length can be approximated using the following formula:

$$L = \sqrt{H^2 + (3 + 3H)^2}$$

where L = Pipe length in ft.

H = Control water head in ft.

The pipe slope can also be calculated as:

$$S_{DT} = \frac{H}{3 + 3H}$$

In this study, the corrugated metal pipe with n = 0.024 is used and "R" is equal to D/4 assuming the pipe flows full. Since

$$Q=AV= \frac{\pi D^2 V}{4} =4.\frac{\pi D^2}{16}.V=4\pi R^2V, \quad R^2=Q/4\pi V.$$

Therefore, by rearranging the Manning's equation:

$$V = \frac{1.486}{n} R^{2/3}S^{1/2} = \frac{1.486}{n} \left(\frac{Q}{4\pi V}\right)^{1/3}S^{1/2}$$

$$V = 11.726Q^{1/4}S^{3/8}$$

and the, $A = Q/V$

$$D = \sqrt{\frac{4A}{\pi}}$$

where D = Pipe diameter in inches.

The calculated pipe size is integrated into the next larger standard pipe size to estimate the pipe cost per linear foot in order to derive the total pipe cost.

Pipe Drop Inlet Spillway

A drop inlet spillway is similar to the hooded inlet spillway except the inlet end is a pipe riser which in this study is made of corrugated metal pipe. The size of pipe riser is compatible with pipe conduit size and the compatibility is tabulated as in Table 3-6. The length of pipe riser is generally calculated as:

$$Z = 4D/12$$

where D = Diameter of pipe conduit in ft.

The total cost is the sum of pipe conduit cost and pipe riser cost.

Monolithic Drop Inlet Spillway

The reinforced concrete monolithic drop inlet is generally recommended for larger spillways. Assume the side length of a square monolithic culvert is "S", the hydraulic radius "R" is then equal to $S^2/4S = S/4$ when flowing full. The cross-sectional area of the culvert is $S^2 = \frac{Q\text{(Flow rate)}}{V\text{(Flow velocity)}}$ which leads to $S = \sqrt{\frac{Q}{V}}$ and then $R = \frac{1}{4}\sqrt{\frac{Q}{V}}$.

Substitute $R = \frac{1}{4}\sqrt{\frac{Q}{V}}$ into Manning's Equation:

$$V = \frac{1.486}{n} \left(\frac{Q}{16V}\right)^{1/3} S^{1/2} = \frac{0.59}{n} \cdot \frac{Q^{1/3}}{V^{1/3}} \cdot S^{1/2}$$

Table 3-6 The Size Relationships of Pipe Riser and Pipe Conduit (61)

Diameter of Pipe Conduit, in.	Diameter of Pipe Riser, in.
8-12	18
15	21
18	24
21	30
24	30
30	36
36	48
42	54
48	60

$V = 16.54\ Q^{1/4} . S^{3/8}$ (Assume n=0.014 for concrete pipe)

After "V" become known,

A(cross-section area of culvert) = Q/V

and $S = \sqrt{A}$

The volume of reinforced concrete of the whole structure can be computed according to the dimensions shown in Figure 3-9. The cost of construction can be estimated by multiplying the volume of reinforced concrete by its unit cost.

Chute Spillway

The chute provides a satisfactory method of discharging accumulated surface runoff over fills and embankments. Typical details are presented in Figure 3-10. The discharge flow rate "Q" is given by (64):

$$Q = 3.75\ W^{0.9} H^{1.6}$$

where W = Width of flume in ft.

H = Head in ft.

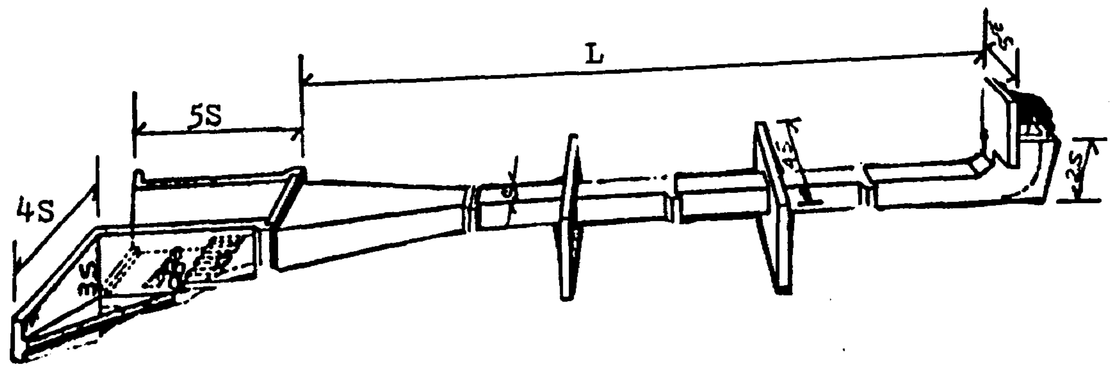
By rearranging the equation and assuming H = 5 feet, "W" can be calculated from:

$$W = \frac{Q^{1.11}}{4.34(5^{1.78})}$$

From Figure 3-10, the volume of reinforced concrete can be estimated as:

$$VOL_{RC} = [7W \cdot 5W + L(10 + W)]\ 0.5/27$$

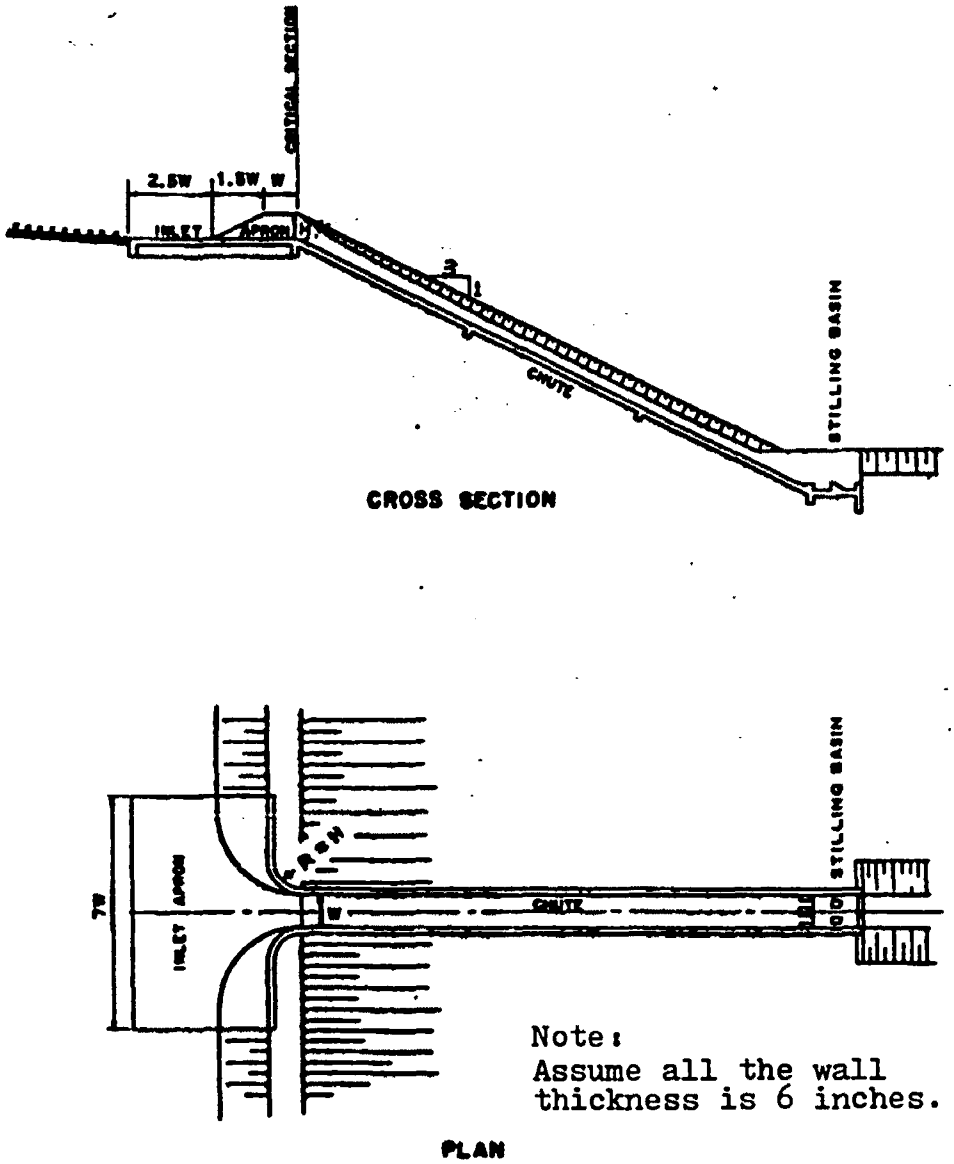
Using this volume, the construction cost can be computed.



Note: All the wall thickness is assumed to be 6".

$$V = [4S(2S+L)+2(5S\cdot 3S+4S\cdot 3S)+(3S\cdot 5S)+2\cdot 4S\cdot 4S+3S\cdot 3S]\cdot 1/2$$

Figure 3-9 Dimension of Monolithic Spillway.



Note:
Assume all the wall thickness is 6 inches.

Figure 3-10 Details of Typical Drainage Chute

3.6 Environmental Impact Assessment

Environmental impact must be considered when selecting the BMP for controlling NPSP. Because a BMP will usually change the land form, the inhabitants including wildlife, and the flora and fauna living directly above or near the land will be influenced by the BMP. For example, growing vegetation on bare land will attract more wildlife to this area simply because vegetated land is more similar to their natural living environment. However, land changed from pasture to cropland would repel the inhabitants. Aesthetics is another important factor to be considered, especially when the area under consideration is located near a recreational or inhabited area.

A matrical system is used to evaluate the impact between each alternative management practice. A weight for each parameter is assigned a value from 1 to 20 to indicate the relative importance of each parameter. These weights were obtained by averaging data from a survey of eight judges that were familiar with soil conservation and non-point source pollution control. Table 3-7 lists all the parameters and their weights. Under each parameter, a value from -10 to +10 is assigned to each alternative to assess the scale of impact from negative (harmful) to positive (beneficial). After each value has been assigned, it is then multiplied by the weight to give the individual value for every parameter under each alterna-

Table 3-7 Weights for Environmental Impacts

Impact Parameter	Weight (1 to 20)
System Reliability	14
Operation and Maintenance	11
Land Disturbance	18
Water Conservation	12
Area Affected by Noise	4
Potential for Development	5
Water Quality	18
Flora and Fauna	9
Fish and Game	6
Aesthetics	8
Historical Site	6
Archeological Site	7
Recreational	8
Pesticide and Herbicide Application	10

tive. Finally all individual values under the same alternative are summed to obtain the total value for each alternative. These total values are then compared against each other and ranked by priority for users' reference.

The environmental impacts created by using different practices for controlling NPSP problems are discussed below. For Model BMP1, the seven most common cropping management practices are compared, and each one is given a value within the range between -10 and +10. These practices are Terrace-Contour (TC), Rotation-Contour (RC), Terrace-Rotation-Contour (TRC), Terrace-No-Till-Contour (TNC), No-Till-Contour (NC), No-Till-Rotation-Contour (NRC), and Pasture (P). For Model BMP2, three construction management practices: diversion, sediment basins and floodwater retarding structures are compared and assigned a value within a range of between -10 and +10.

System Reliability

The evaluation of this parameter depends on the stability and durability over a long period of time and/or the speed of deterioration caused by local weathering, unfavorable soil conditions and unfavorable localities. Since a reliable system would better serve the purpose to control NPSP and hence improve the quality of the environment, a positive range of from 0 to 10 is given for selection with the high value representing high reliability.

For Model BMP1, two reasons are listed for ranking these seven cropping management practices from high to low positive impact as $P \geq TRC = TNC \geq TC \geq NRC \geq RC = NC$: (1) pasture offers dense cover to resist erosion better than other practices; and (2) terraces are better than rotation or no-till farming because they divert all the water above each terrace while rotation or no-till farming only decreases the water velocity and disperses the water over a sloped area. Therefore, a suggested range for each practice may be obtained by assigning 0-2 to NC or RC, 2-4 to NRC, 4-6 to TC, 6-8 to TNC or TRC, and 8-10 to P.

For Model BMP2, the ranking of floodwater retarding structure $\geq$ sediment basin $\geq$ diversion is based on: (1) the design life of a floodwater retarding structure is longer than for a sediment basin, (2) diversion is subject to greater stream erosion than a sediment basin or floodwater retarding structure, (3) the reliability of diversion depends on the lining material used in the channel. A suggested range for each practice is 0-4 for diversion, 4-7 for sediment basins and 7-10 for floodwater retarding structures. The exact value within each range would depend on the severity of weathering, soil stability and area slope.

Operation and Maintenance

A positive range of 0-10 is designated for Operation and Maintenance (O&M) because only the structure itself is concerned and no negative impacts are involved. Higher values represent less O&M.

For Model BMP1, the ranking of P = NRC = NC = RC $\geq$ TC = TRC = TNC is mainly based on the reason that terraces require more maintenance than other practices. Therefore, a range of 0 to 5 for TNC, TRC or TC and 5 to 10 for RC, NC, NRC or P is suggested.

For Model BMP2, the ranking of diversion $\geq$ floodwater retarding structure $\geq$ sediment basin is based on the fact that: (1) sediment basins require more dredging maintenance than diversion, and (2) floodwater retarding structures require more O&M such as dike maintenance than diversion. Therefore, the appropriate range for each practice is 0-3 for sediment basin, 3-7 for floodwater retarding structure and 7-10 for diversion.

Land Disturbance

The impact from -10 to +10 is given for land disturbance because the natural land configuration is changed. For Model BMP1, only terracing disturbs the land. Other practices represent different forms of cultivating and tilling methods which are indigenous to growing crops. The range is then assigned from 0 to -10 for terrace and

0 for other practices except pasture. A range from 0 to 10 is designated to pasture because pasture is assumed to restore the land to natural conditions. The impact can be measured by comparing the disturbed area with ten intervals derived from dividing a largest treatment acreage by 10. For example, within a tract of land, three management practices which disturb 100, 87 and 53 acres separately are measured. The one with 100 acre terracing has -10 impact. Since each interval is 10 (100/10), the one with 87 acre terracing has -9 impact and the one with 53 acres pasture has -5 impact. For Model BMP2, all three construction management practices are given negative impact from 0 to -10. The evaluation method is the same as for Model BMP1.

Water Conservation

Water may be stored through different management practices after runoff stops. This water may be used for irrigation or it may be directly consumed by cattle or other animals for drinking. Therefore, the beneficial impact ranges from 0 to 10 - the higher number representing more water conservation.

For Model BMP1, the ranking that $TRC \geq TC \geq TNC \geq P \geq RC \geq NRC \geq NC$ is based on the potential water storage or interception ability for each cropping management practice. Terraces have larger interception capacities than practices. Rotation, pasture and no-till farming intercept runoff by ground vegetation and residue which retain water less efficiently than terraces. In most cases, rotation and pasture retains more water than no-till due to denser vegetation coverage. The suggested range for each practice is: 0-2 for NC, 2-3 for NRC, 3-4 for RC, 4-6 for P, 6-7 for TNC, 7-8 for TC and 8-10 for TRC. The exact value within each range varies with the vegetation and crop residue density and the size of structure.

For Model BMP2, the ranking is floodwater retarding structure ≥ sediment basin ≥ diversion according to their interception or storage capability. The possible range for each practice is: 0-3 for diversion, 3-7 for sediment basin and 7-10 for floodwater retarding structure. The exact value within each range is judged by storage capacity and available sources for water use.

Area Affected by Noise

Noise is a negative impact for both human and wildlife. 0 to -10 is thus given as the total range. The degree of noise pollution depends on the noise intensity, its duration and the distance to populated areas. In most cases, noise occurs during the construction of the management practices. Therefore, the intensity of noise varies with types of construction machinery.

For Model BMP1, the ranking P≥NRC≥NC≥RC≥TC≥TNC≥TRC is based on: (1) terracing requires construction work while other practices do not, (2) rotation generally requires more cultivation than no-tilling farming, (3) terraces usually require machinery use once a year for maintenance. Therefore, the suggested range for each practice is: 0 to -2 for P, -2 to -3 for NRC, -3 to -4 for NC, -4 to -6 for RC, -6 to -7 for TC, -7 to -8 for TNC and -8 to -10 for TRC.

For Model BMP2, the ranking that diversion $\geq$ sediment basin $\geq$ floodwater retarding structure is based on their project sizes. The suggested range for each practice is 0 to -3 for diversion, -3 to -7 for sediment basin and -7 to -10 for floodwater retarding structure. For both models, the exact value within each range varies with the effective distance to receiving bodies.

Potential for Development

Land around the management practice planning area should be considered if there is a possibility for future development. This development may be the change of land use (e.g., from agricultural to residential) resulting from the prosperity of neighboring towns or industries. In most cases, the impact would be zero if the area is isolated and no development potential can be determined. Since the installation of management practices to control the NPSP would benefit nearby development, this impact is classified as beneficial and ranges from 0 to 10 with the "10" representing maximum positive impact.

For Model BMP1, each practice is given the range from 0 to 10 without ranking since no apparent difference exists among these seven practices: P, TC, TRC, TNC, NRC, NC and RC. The suggested range for diversions, sediment basins and floodwater retarding structures in Model BMP2 is from 0 to 10. It is noteworthy that in most cases, floodwater retarding structure may offer more beneficial impact for nearby development than other practices due to its flood control and recreational benefits. The exact value would depend on the distance to a potential developing area.

Water Quality

Water quality is the deciding factor for adopting a management practice depending upon its ability to meet regulatory stream water quality standards. This impact is only evaluated for practices with water qualities above the standards or when the standards do not become restrictive. For both models, the range from 0 to 10 is given for each practice with "0" representing worst water quality and "10" the best. The water quality of each practice can be represented by adding its values of three pollutant loadings: SS, BOD and COD. The numerical difference between the worst and best water quality divided by 10 gives the interval on which the ranking can be based.

Flora and Fauna

Flora and fauna are affected by the installation of management practices. The degree of disturbance depends upon the scale of project and the natural characteristics of the flora and fauna. The negative range of 0 to -10 is assigned for evaluation. For Model BMP1, a range of 0 to -10 is given to each practice since no significant difference of impact is observed among these seven practices: P, TC, TRC, TNC, NRC, NC and RC.

For BMP2, a ranking that floodwater retarding structure $\geq$ sediment basin = diversion is based on the fact that floodwater retarding structures usually have the greatest amount of construction which disturbs flora and fauna more than the rest of the practices. Therefore, a range from -5 to -10 is designated for floodwater retarding structure and 0 to -5 is for the other two practices.

For both models the exact value within each range should be further determined by the natural characters of flora and fauna.

Fish and Game

The practices may affect the neighboring habitation of birds, animals and fish which may be an appreciable resource. In most cases, the impact is negative because artificial structures are installed to interfere with animals' habitation. However, the impact may be beneficial when cropland is converted to pasture land which may attract more animals due to the fact that it is more nature-like. Therefore, a full range from -10 to 10 is assigned.

For Model BMP1, the ranking that P≥RC≥NRC=TRC≥NC=TNC =TC is based on the reason that rotation and no-till involve crop growth on ground which would not interfere with animals' habitation as much as terraces. Therefore, the range for each practice is assigned as: 0 to -3 for P, -3 to -6 for RC, NRC and TRC, -6 to -10 for NC, TNC and TC.

For Model BMP2, the ranking that floodwater retarding structure ≥ sediment basin ≥ diversion is based on: (1) diversion may cause more disturbance to animal habitat than other practices, and (2) the floodwater retarding structure may provide a good fishing resource. Therefore, the range for each practice can be approximated: 0 to 10 for floodwater retarding structure, 0 to -5 for sediment basin and -5 to -10 for diversion.

For both models, the exact value within each range varies with the planning location, the distance to fish and game area and the value of the fish and game resource.

Aesthetics

Aesthetics can be evaluated from many aspects such as topography, shape including line and curve, and the compatibility with the existing environment. An unexpected structure may harm the picture of natural integrity. However, through good design and planning, the aesthetics may be improved after the installation of the practice. For example, terrace with no erosion is more aesthetically pleasing than no terrace with extensive erosion. In most cases, a larger project will require more careful and detailed planning for aesthetics than small ones. Since the aesthetics may appear better or worse, a full range from -10 to 10 is assigned.

For Model BMP1, a ranking that P≥TRC≥RC≥TC≥NRC≥TNC≥NC is based on two reasons: (1) pasture and rotation blend into the natural environment better than other practices and pasture is better than rotation; and (2) terraces show the beauty of curve on the topography and controls erosion better than no-till farming. The range for each practice can then be assigned as: -2 to -10 for NC, -2 to 2 for TNC, 2 to 3 for NRC, 3 to 5 for TC, 5 to 7 for RC, 7 to 8 for TRC, and 8 to 10 for P.

For Model BMP2, a ranking that floodwater retarding structure ≥ diversion = sediment basin is based on the fact that floodwater retarding structures if designed properly, would raise the aesthetic quality of the environment. The suggested range of each practice can then be assigned as: 0 to -10 for diversion or sediment basin.

Historical Site

Historical site is of national historic importance and any possible impact should be avoided. In most cases, the planning site should be relocated if it is on or near the historical site. Therefore, the impact would be measured by the distance to the site, the scale of practice and the natural compatibility to the site. A range from 0 to -10 is given because the impact is negative.

For Model BMP1, the ranking that P$\geq$TC = TRC = TNC = NRC = RC = NC is based on the reason that pasture is more nature-like and more compatible to historical sites. Therefore, the suggested range for each practice is: 0 to -2 for pasture and -2 to -10 for rest practices.

For Model BMP2, the ranking that diversion $\geq$ sediment basin $\geq$ floodwater retarding structure is primarily based on project size and compatibility to historical site. The suggested range for each practice is: 0 to -3 for diversion, -3 to -7 for sediment basin and -7 to -10 for floodwater retarding structure.

For both models, the exact value within each practice is determined by its distance to the historical site and the range is the sight distance. The impact is zero if the practice is located beyond the vision of persons at historical sites.

Archeological Site

Archeological site should be investigated prior to the installation of management practices. The boundaries of archeological sites are usually designated clearly by archeologists. However, it is still possible to invade a potential archeological site outside the boundary. Therefore, the impact is inversely proportional to the distance to archeological site. From the known record that the largest archeological site covers 200 acres (35), it is assumed that a 2 mile radius is an impact effective distance to the site. For both models, a two-mile limit is then set up so that no impact would be considered beyond that distance. The range from 0 to -10 is assigned to have ten levels with 0.2 mile as a level increment. For example, 1.8 miles to archeological site represents an impact level of -1 and 1 miles represents -5.

Recreational

Recreational use may be generated from the installation of management practices. A range from 0 to 10 is suggested because it is a beneficial effect.

For Model BMP1, in most cases, the effect is zero for cropping management practices because the land is mainly used for growing crops and provides minimal recreational use. Pasture may provide a place for riding horses or other recreational activities such as hunting and hence, a range from 0 to 10 is assigned.

For Model BMP2, only floodwater retarding structures provide a place for boating or swimming. Therefore, a range that is 0 for diversion and sediment basins and 0 to 10 for floodwater retarding structure is suggested.

Pesticide and Herbicide Application

This parameter evaluates the negative impact due to the toxicity of pesticides and herbicides to the environment. The impact would depend upon application rate, spraying area and frequency of use. A range from 0 to -10 is assigned to show the degree of impact.

For Model BMP1, the ranking that $P \geq RC = NRC = TRC \geq TNC = NC = TC$ is based on: (1) pasture requires the least amount pesticide and herbicide of all practices and (2) rotation may include planting of pasture. Therefore, a suggested range is assigned that 0 to -3 for P, -3 to -6 for RC, NRC or TRC, and -6 to -10 for TNC, NC or TC.

Since no pesticide and herbicide application is involved for construction management practices in Model BMP2, zero impact is assigned for this parameter.

CHAPTER IV

APPLICATION

4.1 Application of "BMP1"

4.1.1 Location

A selected farm of 480 acres located on Section 17, R15E, T5N, Texas County, Oklahoma, as shown in Figure 4-1 is used for the application of computer program "BMP1".

The soil type is Richfield clay loam. It consists of deep, dark, clayey soils that are well drained. Locally, the soils are called hard land. They are nearly level and occupy large upland areas in all parts of the country.

Unfavorable farming conditions are low rainfall, strong winds, high temperatures in summer, and low humidity. Water is the key to successful agriculture in this semi-arid region. Crops which can be grown successfully include wheat, hay sorghum, corn and barley.

The farmer is assumed presently to employ conventional methods to raise corn, without consideration of alternative management practices. However, his farm land

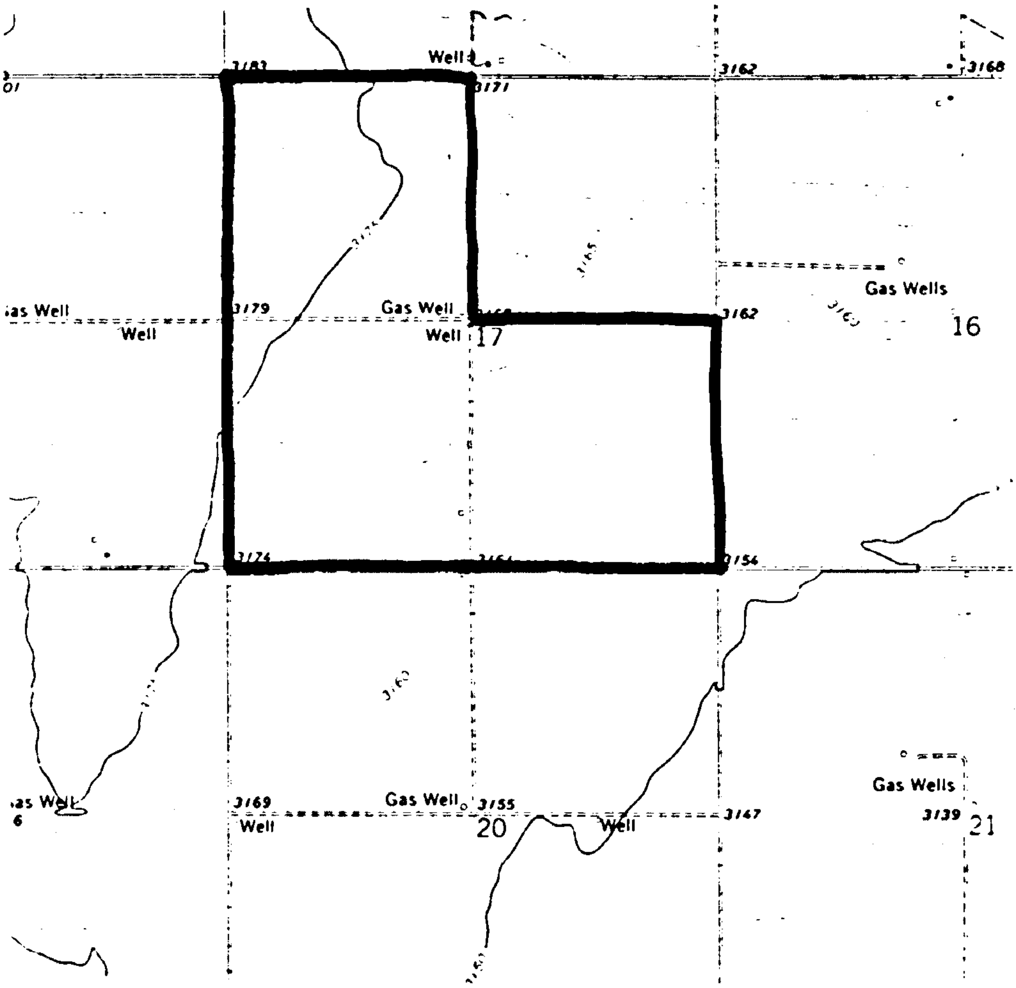


Figure 4-1 Area Used for BMP1 Application. (Section 17, R15E, T5N)

is subjected to a great deal of soil erosion, which also carries fertilizer and pesticides into receiving waters. To reduce pollution problems, seven alternatives are compared.

These alternatives are: (1) continuous corn no-till planted in 70 percent residue cover, contoured (Corn-No-Till), (2) a corn-corn-corn-wheat-meadow rotation with moldboard plowing on the first year corn and no-till planting on the second and third year corn, contoured (CCCWM-No-Till), (3) continuous corn with rotary strip tillage, terraced, (C-Strip-T), (4) continuous corn with no-till planting, terraced (C-No-Till-T), (5) a corn-soybean rotation, terraced (CB-Terr), (6) corn and hay rotation (CH), and (7) land use changed to range land.

4.1.2 Data Input and Output

All input data were carefully selected as discussed in Chapter III. The format of the input is also shown to avoid unnecessary confusion of input location. The input variable names are explained clearly within the computer program. Appendix E gives the whole list of input data.

All output data are presented in Appendix F. For each cost category, a table is formatted so that cost figures can be identified easily.

4.1.3 Discussion

Cost effectiveness is usually the most important factor to farmers. In order to better evaluate cost comparisons among eight alternatives, cost elements are ranked within alternatives and tabulated in Table 4-1 based on the results from computer cost analysis. From this table the following conclusions are suggested:

(1) Conventional corn, continuous corn with rotary strip tillage, terraced and continuous corn no-till planted have the highest gross revenue.

(2) Range land, corn-soybean rotation, terraced and corn-hay rotation have the least total planting cost.

(3) C-Strip-T, corn-soybean rotation, terraced and corn-hay rotation have the highest net return.

From computer analysis, conventional up-and-down slope corn planting is used, the annual soil loss is estimated as 10.33 tons/ac/year. Comparing this loss to the soil tolerance limit of 5 ton/ac/year designated by SCS, this loss will cause the 7 inch thick soil surface layer to be depleted in 264 years. From Table 4-2 which is also tabulated from computer analysis, only CCCWM-No-Till, C-Strip-T, CH and range land can reduce the soil loss below the soil tolerance limit. This provides the farmer with important information allowing him to select the BMP on criteria besides cost. The related water quality data is given in Table 4-3.

Since current Oklahoma State Standards do not

Table 4-1 Ranking of Cost Estimate from BMP1 Application

Item	Corn Convention	Corn No-Till	CCCWM No-Till	Corn No-Till	C-Strip-T	CB-Terr	CH	Range Land
Gross Revenue	1	2	5	1	1	3	4	6
Costs Tractor (Excl.) (Fuel)	7	3	6	5	4	2	8	1
Machine (Excl.) (Fuel)	5	3	8	4	2	6	7	1
Fuel	7	3	4	6	5	2	8	1
Seed	1	3	5	2	2	4	6	7
Fertilizer	4	4	2	4	4	3	1	1
Pesticides	3	4	2	3	3	3	1	1
Labor	7	3	4	6	5	2	8	1
Drying	4	3	2	4	4	2	2	1
Interest	6	7	2	5	4	3	1	8
Total Plan Cost	8	5	4	7	6	3	2	1
Net Return	5	6	7	4	3	1	2	8

Table 4-2 Results of Computer Analysis from Model BMP1 Application

Item	Corn Convent.	Corn No-Till	CCCWM No-Till	Corn-No-Till	C-Strip-T	CB-Terr	CH	Range Land
Cost,$ (Net Return)	44,920	44,012	34,676	47,366	48,402	50,480	49,056	4,338
Performance (Removal Efficiency, %)	0.0	40.9	63.6	50.0	54.6	45.4	70.4	63.6
Environmental Impact	-46	174	346	175	275	473	346	608

Table 4-3 Water Quality Data for BMP1 Application

	Corn Conv.	Corn No-till	CCCWM No-till	Corn-No-Till	C-Strip-T	CB-Terr	CH	Range Land
Sediment (T/AC/YR)	3.10	1.83	1.12	1.55	1.41	1.69	0.92	1.13
SS (LB/AC/YR)	124	73	45	62	56	68	37	45
BOD (LB/AC/YR)	53	32	19	27	24	29	16	19
COD (LB/AC/YR)	167	99	61	84	76	91	49	61

restrict NPSP discharge, the standards for municipal wastewater discharge not exceeding 30 mg/l BOD and 90 mg/l SS into perennial streams is used (38). By multiplying annual local runoff which is 0.35 inch from Figure 4-2 (39) over one acre land, these concentrations can be converted to loading rates. In this case, they are 2.3 lbs/ac/year for BOD and 6.9 lbs/ac/year for SS. By comparing this standard with annual loadings for all management practices, it appears that the standard is too low to meet. Therefore, four management practices with better water qualities are selected for further analysis. They are CCCWM-No-Till, C-Strip-T, CB-Terr and range land.

From the "Environmental Impact Assessment" in Table 4-4, the best management practices with the highest score or the least negative environmental impact are range land, CB-Terr, CH and CCCWM-No-Till.

Since a cost figure results from the cost analysis, a percentage figure represents treatment efficiency, and numerical value quantifies environmental impact, a BMP is easy to determine from each criterion. However, it is more difficult to select a BMP respecting all three criteria. Two methods are suggested for this purpose:

A. Ranking Method. A numerical rank is given to each practice for each criterion, "1" indicating that practice least valuable, "2" indicating the next

Figure 4-2 Average Annual Runoff in Oklahoma.
(in inches)
1931-1960

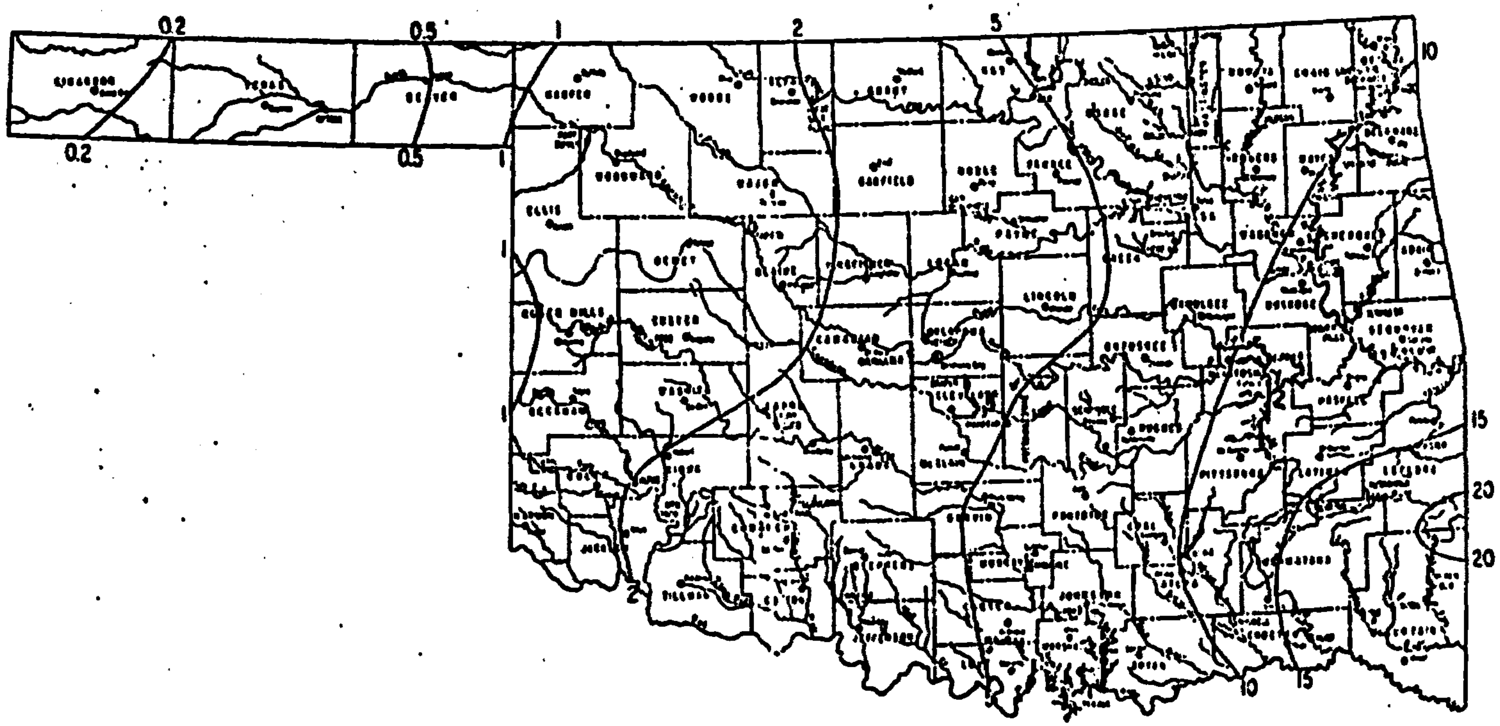


Table 4-4 Environmental Impact Value for BMP1 Application

Management Practice	S.R.	O&M	L.D.	W.C.	NOIS	P.O.	W.Q.	F&F	F&G	N.L.	H.S.	A.S.	RECR	P.A.	Total
Weight	14	11	18	12	4	5	18	9	6	8	6	7	8	10	
C Conv.	0	0	0	0	-6	0	0	0	-3	7	0	0	0	-6	
	0	0	0	0	-24	0	0	0	-18	56	0	0	0	-60	-46
C No-T	2	10	0	2	4	0	5	0	-3	-2	0	0	0	-6	
	28	110	0	24	16	0	90	0	-18	-16	0	0	0	-60	174
CCCWM No-T	4	10	0	3	3	0	9	0	-4	3	0	0	0	-3	
	56	110	0	36	12	0	162	0	-24	24	0	0	0	-30	346
C No-T-TR	2	5	-3	7	7	0	7	0	-8	2	0	0	0	-6	
	28	55	-54	84	28	0	126	0	-48	16	0	0	0	-60	175
C-Strip-T	6	5	-1	7	-6	0	9	0	-8	5	0	0	0	-6	
	84	55	-18	84	-24	0	162	0	-48	40	0	0	0	-60	275
CB-Terr	8	5	-1	8	8	0	7	0	6	8	0	0	0	-3	
	12	55	-18	96	32	0	126	0	36	64	0	0	0	-30	473
CH	2	10	3	4	-5	0	8	0	-4	7	0	0	0	-5	
	28	110	54	48	-20	0	144	0	-24	56	0	0	0	-50	346
R Land	8	10	3	4	0	0	10	0	0	10	0	0	3	0	
	112	110	54	48	0	0	180	0	0	80	0	0	24	0	608

S.R.=System Reliability, O&M=Operation and Maintenance, L.D.=Land Disturbed,
W.C.=Water Conservation, NOIS=Noise Annoyance, P.D.=Potential for Development,
W.O.=Water Quality, F&F=Flora and Fauna, F&G=Fishing and Game, AEST=Aesthetics,
H.S.=Historic Site, A.S.=Archeological Site, RECR=Recreational, P.A.=Pesticide Application

least valuable, etc. Ranks are summed for each practice. The practice with the highest value is then the recommended BMP.

B. Ranking Method with Weights. If three criteria have uneven relative importances, each criterion may be weighed from 1 to 10. The sum of the products of rank number and its weight is the weighed rank sum, the highest value being the recommended BMP.

By using Ranking Method A, a ranking value is assigned to each practice under each criterion which is tabulated as shown in Table 4-5. From this table, CH with value "10" is the highest and thus becomes the BMP. However, by using Ranking Method B, different results may be derived since different weights are assigned to emphasize certain criteria. In this case, two sets of weights are assigned. One is from the governmental point of view. The other one is from the farmer's point of view. The state government officials in charge of water quality control were consulted to obtain the average weights -- 4 for cost, 6 for performance and 3 for environmental impact -- because of their familiarity with stream water quality control requirement. The local soil conservationists were consulted to obtain the average weights -- 8 for cost, 4 for performance and 2 for environmental impact -- because of their familiarity with farmers' needs. From these two sets of weights, different BMP's may be

Table 4-5 Results of Ranking Method A in Model BMP1 Application

	CCCWM No-Till	C-Strip-T	CH	Range Land
Cost	2	3	4	1
Performance	2	1	3	2
Environmental Impact	2	1	2	3
Total	6	5	9	6

selected. As shown in Tables 4-6 and 4-7, CH is still selected as the BMP although performance is emphasized on government side and cost on farmer side. It is noteworthy that these weights are only suggested values and subject to change from various interest groups such as farmers, soil conservationists and environmental agencies.

Although CH is the BMP recommended from the ranking based on the three criteria, farmers may still have difficulty in accepting the recommendation because he will bear a loss of $4,100 when compared to Corn-Conventional. However, by referring to Table 4-2, both C-Strip-T and CH offer higher net return that Corn-Conventional when 60% of terrace cost is subsidized by the government. These two practices would therefore rank high in terms of farmers' acceptance. Unless the government is willing to compensate the loss, it will be extremely difficult for farmers to accept the CH.

In actual implementation, the above implies negotiation between farmers and government which can be complex. The results of this work are intended to identify and quantify the factors that would underlie such negotiations. For instance, two possible "algorithms" for deriving compensation follow. Where a system of fines has been established, we can consider:

$$C(\text{Compensation}) = O_1 - N_1 - F$$

Table 4-6 Results of Ranking Method B in Model BMP1 Application on Governmental Point of View

	Weight	CCCWM No-Till	C-Strip-T	CH	Range Land
Cost		2	3	4	1
X Weight	4	8	12	16	4
Performance		2	1	3	2
X Weight	6	12	6	18	12
Environmental Impact		2	1	2	3
X Weight	3	6	3	6	9
Total		26	21	40	25

Table 4-7 Results of Ranking Method B in Model BMP1 Application on Farmers' Points of View

	Weight	CCCWM No-Till	C-Strip-T	CH	Range Land
Cost	8	2	3	4	1
X Weight		16	24	32	8
Performance		2	1	3	2
X Weight	4	8	4	12	8
Environmental Impact		2	1	2	3
X Weight	2	4	2	4	6
Total		28	30	48	22

where O_1 = Net return from the original practice

N_1 = Net return from the BMP

F = Incurred fines from the violation from original practice.

Where no fine system exists, the form would be:

$$C(\text{Compensation}) = O_1 - N_1 - (P + E)$$

where P = Performance difference between the BMP and the original practice converted to a dollar value.

E = Environmental impact difference between the BMP and the original practice converted to a dollar value.

4.2 Application of "BMP2"

4.2.1 Location

A watershed of 2156 acres which includes parts of Sections 17, 18, 19, 20, 29, 30, R8W, T14N (see Figure 4-3) in Canadian County, Oklahoma was selected for the application of BMP2.

The primary soil type of this watershed is Shellabarger-Konawa Association, which is deep, well drained, and very gently sloping to strongly sloping loamy and sandy soils with loamy subsoil.

The climate is dry subhumid, which means that there is a precipitation deficiency and some irrigation is needed.

As shown in Figure 4-3, this watershed can be divided into 20 stream segments with each segment bordered

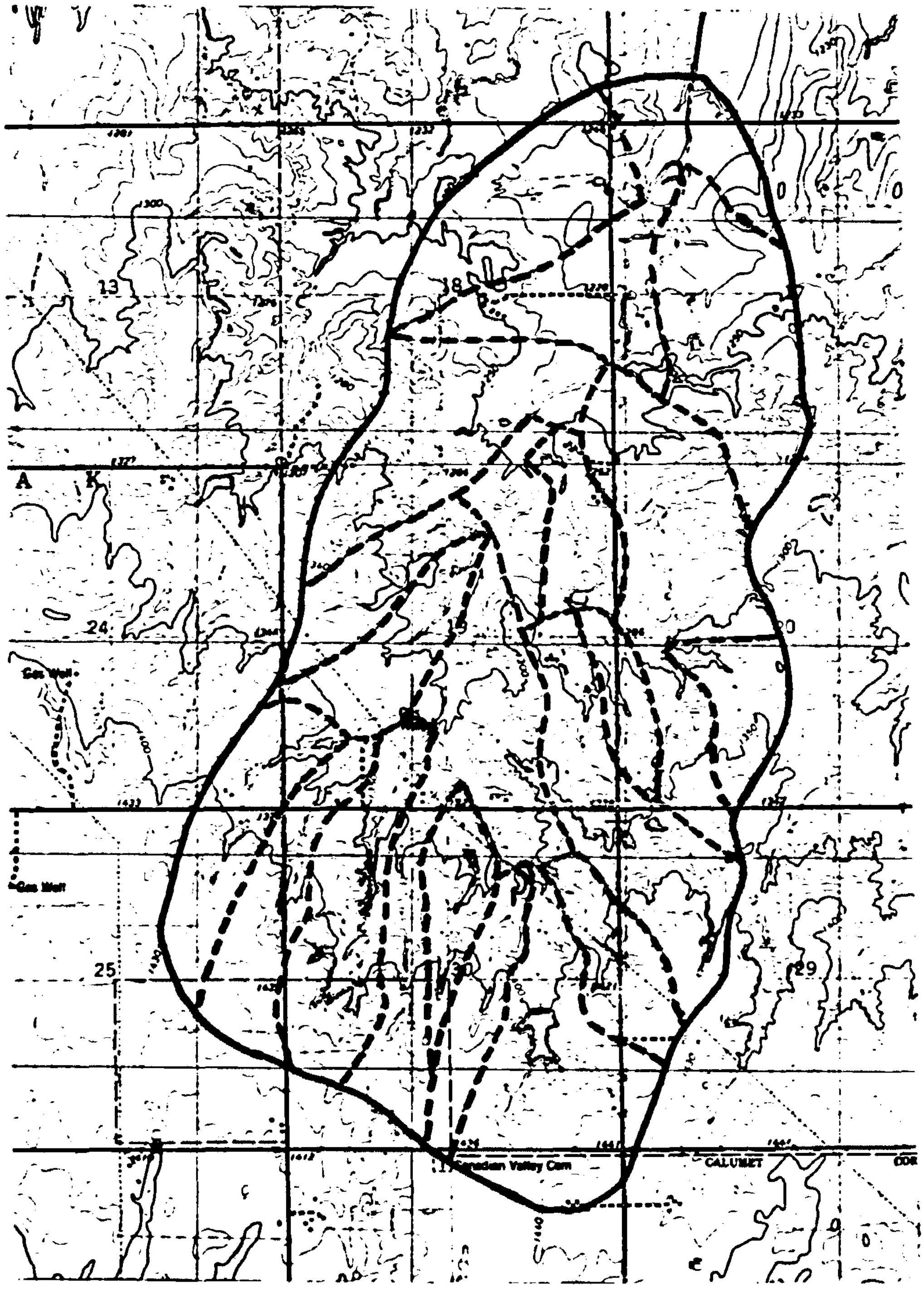


Figure 4-3 Watershed Used for Application of BMP2.
(Sections 17, 18, 19, 20, 29, 30, R8W, T14N)

along the ridge between two streams. The quantity of runoff flow rate can be estimated from these segmented areas.

After field investigation five alternative BMP's are devised to control the NPSP in this watershed. They are:

(1) the combination of C1, C2, D1, D2, D4, S2, S3, and S7.

(2) the combination of D1, D2, D3, S1, S2, S3, S4, S5, S6, S7, and S10.

(3) the combination of D3, S8, S9, S10 and F1.

(4) the combination of S10 and F2.

(5) F3.

where "C" denotes the Cropping method

"D" denotes the Diversion method

"S" denotes Sediment Basin

"F" denotes Floodwater Retarding Structure

All the locations of the above BMP's are displayed in Figure 4-4. Each BMP was analyzed separately for cost, performance and environmental impact. After analysis, the results were combined for comparison.

4.2.2 Data Input and Output

Input data are listed in Appendix G, where the data with variable names and line numbers are illustrated.

Appendix H displays output data of Model BMP2 application. The format starts with croplands followed by

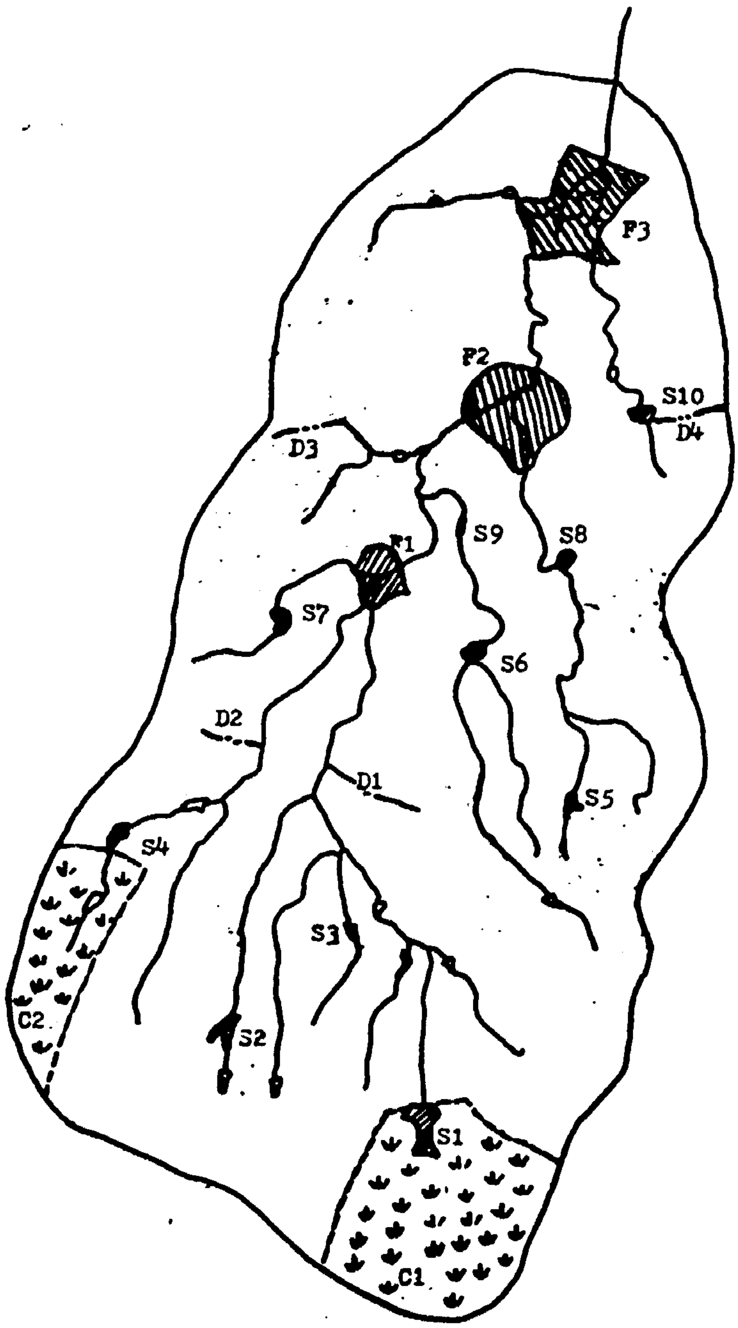


Figure 4-4 Location Map of BMP's Applied to Control NPSP of the Watershed.

diversion ditches, sediment basins and ends with floodwater retarding structures. Performance was calculated and is shown in the output of each BMP. The environmental impact assessment of each BMP is tabulated.

4.2.3 Discussion

From Appendix H, the total construction cost for each BMP is listed and tabulated in Table 4-8. Also, the removal efficiencies of all BMP's are tabulated in Table 4-9.

From Tables 4-8, 4-9 and the Environmental Impact Assessment Table in Appendix H, the combined costs, removal efficiencies and environmental impacts of all five BMP alternatives were determined and then compared. The combined cost of each alternative was determined by summing the costs of each BMP. The removal efficiency should consider the area weight of individual BMP. The following equation was used to compute Combined Removal Efficiency (CRE):

$$CRE = \frac{C_1A_a + C_2A_2 + \ldots\ldots + C_nA_n}{A_1 + A_2 + \ldots\ldots\ldots + A_n}$$

where $C_1 \ldots\ldots C_n$ = Removal efficiencies of n BMP's.

$A_1 \ldots\ldots A_n$ = Area of segment for each BMP.

The combined effect of the environmental impact for each alternative was also computed by the area weight method as that for removal efficiency. By using this

Table 4-8 Total Construction Cost for Each BMP

No.	Cropland*	Diversion	Sediment Basin	Floodwater Retarding Structure
1	$11,524	$1,672	$ 8,270	$ 50,431
2	15,061	3,581	4,513	71,281
3		2,932	5,307	380,805
4		20,644	4,362	
5			4,251	
6			9,002	
7			7,347	
8			8,823	
9			6,122	
10			18,532	

* The costs shown on this column are for the BMP's selected from several cropping management practices.

Table 4-9 Removal Efficiencies of BMP's for Model BMP2 Application

No.	Cropland %	Diversion %	Sediment Basin %	Floodwater Retarding Structure, %
1	55.5(142ac)	29.3(8ac)	89.5(142ac)	94.0(1011ac)
2	53.3(63ac)	35.6(20ac)	91.0(24ac)	93.8(1785ac)
3		29.3(16ac)	91.8(79ac)	97.4(2157ac)
4		42.2(24ac)	87.6(63ac)	
5			89.8(24ac)	
6			94.2(190ac)	
7			90.6(36ac)	
8			92.7(198ac)	
9			83.8(237ac)	
10			96.4(24ac)	

measure as the basis, the combined cost, removal efficiency and environmental impact were calculated and tabulated as shown in Table 4-10. From this table, it is found that the alternative with more but small management practices such as diversion or sediment basin is more cost effective than that with less but large management practices such as floodwater retarding structure. It is also found that the alternative with more but small management practices has lower pollutant removal efficiency and lower beneficial environmental impact than that with less but large management practice.

By using the same equation for combined removal efficiency, the combined water quality data can be acquired for SS, BOD, and COD under each alternative. The results are shown in Table 4-11. Based on 27.5 lb/ac/year BOD and 82.5 lb/ac/year SS criteria which are derived from 4 inch runoff amount (see Figure 4-2), all five alternatives can be compared.

By using Ranking Method A, Table 4-12 is formatted to show ranking values by which Alternative 4 is selected as the BMP. Using the same weights in Ranking Method B for both government personnel and farmers as those applied in the Model BMP1 application. Tables 4-13 and 4-14 are formatted by which Alternative 4 was selected from a governmental point of view and Alternative 1 was selected from farmers' points of view.

Table 4-10 Combined Cost, Removal Efficiency and Environmental Impact of BMP Alternatives

Alternative No.	Cost, $	Removal Efficiency	Environmental Impact
Alternative 1	69,649	65.4	169
Alternative 2	69,769	87.4	213
Alternative 3	86,840	91.5	285
Alternative 4	89,813	93.8	295
Alternative 5	1,380,805	97.4	225

Table 4-11 Combined Water Quality Data of Alternatives in Model BMP2 Application

	SS, LB/AC/YR	BOD, LB/AC/YR	COD,LB/AC/YR
Alternative 1	49.1	21.8	66.3
Alternative 2	28.6	12.3	38.6
Alternative 3	10.1	4.4	13.8
Alternative 4	4.6	1.9	6.2
Alternative 5	6.4	2.8	8.7

Table 4-12 Results of Ranking Method A in Model BMP2 Application

	Alt. 1	Alt.2	Alt. 3	Alt. 4	Alt. 5
Cost	5	4	3	2	1
Performance	1	2	3	4	5
Environmental Impact	1	2	4	5	3
Total	7	8	10	11	9

Table 4-13 Results of Ranking Method B in Model BMP2 Application on Governmental Point of View

	Weight	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5
Cost		5	4	3	2	1
X Weight	4	20	16	12	8	4
Performance		1	2	3	4	5
X Weight	6	6	12	18	24	30
Environmental Impact		1	2	4	5	3
X Weight	3	3	6	12	15	9
Total		29	34	42	47	43

Table 4-14 Results of Ranking Method B in Model BMP2 Application on Farmer's Point of View

	Weight	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5
Cost		5	4	3	2	1
X Weight	8	40	32	24	16	8
Performance		1	2	3	4	5
X Weight	4	4	8	12	16	20
Environmental Impact		1	2	4	5	3
X Weight	2	2	4	8	10	6
Total		46	44	44	42	34

It should be noted that construction management practices are primarily funded by the government because these practices do not create a tangible returns to the farmers. Therefore, farmers must pay only a small part of the construction cost. In order to acquire the cooperation from farmers, a governmental financial aid system should be established. The two equations mentioned in the Model BMP1 application were modified and shown as follows. Where a system of fines has been established, we can consider:

$$G = N_2 - F$$

where G = The governmental financial aid

N_2 = Total construction cost of the BMP paid by the government

Where no fine system exists, the formula would be:

$$G = N_2 - (P + E)$$

CHAPTER V

SUMMARY AND CONCLUSIONS

5.1 Summary

(1) Model BMP1 is developed to determine the optimum combination of cropping management and land treatment practices for control of NPSP. The seven most common cropping management and land treatment practices used in this dissertation are (a) terrace-contour, (b) rotation contour, (c) terrace-rotation--contour, (d) terrace-no-till-contour, (e) no-till-contour, (f) no-till-rotation-contour, and (g) pasture.

(2) Model BMP1 provides a cost figure, pollutant removal efficiency and an environmental impact value for each cropping management and land treatment practice. From the result of model application, a BMP for each criteria - cost, performance or environmental impact - can be selected.

(3) The Universal Soil Loss Equation (USLE) is used in Model BMP1 to estimate the annual soil loss for a tract of land. From the change of "CP" factor in the USLE before and after the installation of

cropping management and land treatment practice, the performance of the practice is determined.

(4) A "Sediment Delivery Ratio" is used in Model BMP1 to estimate the actual suspended soil particles flowing into downstream water bodies. This ratio varies with the sizes of watersheds from which soil erosion occurs.

(5) A "Potency factor" is used on Model BMP1 to estimate various pollutants associated with soil particles discharged into the streams. The potency factor has a short development history and few representative data. The selection of adequate potency factor should be performed with great care. Also, the water quality data derived from the potency factor should be compared with the water quality standard with great caution.

(6) The "Soil Surface Layer Depletion Time" in Model BMP1 gives the number of years in which the top soil layer would be completely lost due to erosion. However, crops will not grow when the top soil layer is depleted to zero. Therefore, the depletion time for crop growth is actually less than that predicted by the model. By knowing the minimum soil depth for growing crops, farmers can estimate the actual depletion time for growing crops by multiplying the depletion time for top soil layer by the ratio of the

difference between minimum soil depth for growing crops and the top soil layer depth over the top soil layer depth.

(7) The cost in Model BMP1 includes both construction cost of a cropping management and land treatment practice and revenue from crop yield. The most cost effective management practice is the one with the largest net income which is the difference between the construction cost and the revenue. The construction cost includes terrace, machinery, tractor, fuel, seed, fertilizer, pesticide, labor, and interest cost.

(8) Model BMP2 is developed when construction management practices are required for controlling the NPSP. These practices are diversions, sediment basins and floodwater retarding structures. Model BMP2 incorporates water quality component in Model BMP1 to obtain the water quality data. This component includes the USLE, sediment delivery ratio, potency factor, and soil tolerance limit.

(9) The "Rational Method" in Model BMP2 is used to estimate the peak runoff flow rate from a tract of land. This flow rate is used to determine the sizes and capacities of hydraulic structures. From these sizes, the construction costs can be computed for comparison.

(10) The cost in Model BMP2 includes only construction cost from which the most cost effective management practice can be determined.

(11) Performance for diversion in Model BMP2 is computed from the difference of the "LS" factor in the USLE before and after the installation of the diversion.

(12) The "Trap Efficiency" in terms of C/I (Reservoir Capacity/Annual Inflow) ratio in Model BMP2 is used to determine the performances for sediment basins and floodwater retarding structures.

(13) A numerical value is given to each management practice under each environmental parameter. These values when multiplied by the weight assigned to each environmental parameter form weighted values. The sum of these weighted values for each management practice is the environmental impact value. The objective comparison among these impact values can be achieved to determine the one with the most beneficial impact or the least negative impact.

(14) Model BMP2 can use Model BMP1 as a subroutine to simultaneously evaluate both the cropping management and land treatment and construction practices on a watershed.

(15) For a large watershed where no single BMP can control the NPSP, several alternatives, each with few management practices, must be considered. Each al-

ternative, evaluated by the combined value from its contained management practice on cost, performance and environmental impact, is compared with other alternatives to determine the best alternative BMP's. For each alternative, the combined cost is the sum of costs of its contained management practices and the combined performance or environmental impact is derived from the area weight method as mentioned in Section 4.2.3.

(16) When the output of Model BMP1 or Model BMP2 is obtained, a ranking method with or without assigned weights for cost, performance and environmental impact is used to determine the overall BMP. These weights vary when considered from different points of view i.e. government or farmers.

5.2 Conclusions

From the case studies applied in the State of Oklahoma thirteen conclusions were drawn as follows:

(1) When corn is used as the main crop planted in the panhandle area of Oklahoma, it is found that (a) terrace-contour and no-till-contour are the cropping management and land treatment practices which have the highest gross revenues, (b) pasture, rotation-terrace-contour and rotation-contour have the least total planting cost, and (c) terrace-contour, rota-

tion-terrace-contour and rotation-contour have the highest net return.

(2) With the same application, it is found that rotation-no-till-contour, terrace-contour, rotation-contour and pasture are the cropping management and land treatment practices which can reduce the soil loss below the soil tolerance limit.

(3) With the same application, it is found that pasture, rotation-terrace-contour, rotation-contour and rotation-no-till-contour are the practices which have the highest beneficial environmental impact.

(4) By using 30 mg/l BOD and 90 mg/l SS as the stream water quality data applied in the panhandle area of the State of Oklahoma, it is found that none of the seven most common cropping management and land treatment practices can meet this standard. Therefore, the BMP is selected to minimize the NPSP.

(5) By the ranking method without assigned weights, rotation-contour is selected as the BMP in Model BMP1 application. When considered from both government and farmers' points of view by adding different sets of weights, rotation-contour still appears as the BMP.

(6) From the application of Model BMP1, it is concluded that Model BMP1 has been successfully developed and satisfactorily tested. The model accompanying the

ranking method provides acceptable results which represent the most objective points of view from different interest groups.

(7) When a watershed in central Oklahoma is used as the test site for the application of Model BMP2, incorporating Model BMP1, it is found that the alternative with more but small management practices such as diversion or sediment basin is more cost effective than that with less but large management practices such as floodwater retarding structure.

(8) With the same application, it is found that the alternative with more but small management practices has lower pollutant removal efficiency than that with less but large practices.

(9) With the same application, it is found that the alternative with more but small management practices has lower beneficial environmental impact than that with less but large management practice.

(10) By using the same water quality standard as mentioned in item (4), it is found that all five alternatives in the BMP2 application can meet this standard. Therefore, the selection of BMP's will primarily depend upon the cost, performance and environmental impact.

(11) By using the ranking method without assigned weights, Alternative 4 which includes one sediment

basin and one floodwater retarding structure appears to be the BMP's.

(12) When considered from the governmental point of view by the ranking method with assigned weights, Alternative 4 still appears to be the BMP's. However, Alternative 1 becomes the BMP when considered from the farmer's points of view. This is because cost is the most important criterion from farmer's points of view on selecting BMP's.

(13) From the application of Model BMP2, it is concluded that the model has been successfully developed and satisfactorily tested. The management practices involved can be grouped into several alternatives from which a BMP can be selected to control the NPSP from a small watershed to a large basin.

CHAPTER VI

RECOMMENDATIONS

The following recommendations are made for further study of BMP modeling on controlling the NPSP:

(1) Model BMP1 and Model BMP2 can be evaluated nationwide to provide the BMP's for areas with different land uses, precipitation, topographies and soil conditions. The results could be organized to provide a reference for farmers and other interest groups.

(2) When applying both models to nationwide areas, other practices such as deferred grazing, grade stabilization, livestock exclusion, tree planting, and wildlife land habitat, management may also be considered as supplemental practices.

(3) Further analysis may be done on evaluating the sediment delivery ratio with the consideration of other factors such as soil texture, relief, type of erosion, sediment delivery routes and area of deposition.

(4) The water quality data computed from both models can be verified through the field sampling and laboratory analysis. Those field data can be used to better

verify the potency factor to calibrate the models.

(5) The required minimum soil depth for growing crops should be researched for various crops so that soil surface layer depletion time can be more accurately estimated when top soil is eroded down to the minimum soil depth.

(6) Although the models have been tested for two cases, further evaluations are advisable. Those applications will provide "fine tuning" under varying climatic, hydrologic and land use conditions, and should exhibit needs for further development and refinement.

(7) The application of BMP models can be used as tools for evaluating the impact of land use policy on NPSP control. This could be done in cooperation with local planning agencies which could assist in model application, benefit from the control of NPSP, and gain access to the BMP models for continuing use in planning processes. Such a project would demonstrate the use of BMP models in the field setting.

(8) Further research and development on BMP models should be directed to develop better methods to objectively select a BMP under the overall evaluation of cost effectiveness, treatment efficiency and environmental impact criteria.

(9) The conversion from the performance and environmen-

tal impact of BMP's to their dollar value should be further studied. The study will require extensive investigation and collection of the data regarding water quality violation and intangible cost of environmental impact. The analysis of these data may generate a feasible methodology providing tangible costs for those intangible factors.

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APPENDIX A

PARAMETER EVALUATION OF USLE

Table 1

COVER INDEX FACTOR C ON CONSTRUCTION SITES (18)

		Factor C
None (fallow ground)		1.0
Temporary Seedings (90% Stand)		
Grasses (44)		0.01
Ryegrass (perennial type)		0.05
Ryegrass (annulus)		0.1
Small grain		0.05
Millet or sudan grass		0.05
Bromegrass (44)		0.05
Permanent Seedings (90% Stand)		0.01
Sod (laid immediately)		0.01
Mulch:		
Hay(rate of application tons per acre)		
	1/2	0.25
	1	0.13
	1 1/2	0.07
	2	0.02
Small grain straw	2	0.02
Wood chips	6	0.06
Wood cellulose fiber	1 3/4	0.1
Fiberglass	1/2	0.05
Asphalt Emulsion (1250 gals/acre)		0.02

Fiber matting, excelsior, gravel and stone may be used as protective cover.

Percent soil loss reduction as compared with fallow ground.

Table 2 "C" Values for Permanent Pasture, Rangeland, and Idleland1/ (56)

Vegetal Canopy			Cover That Contacts The Surface					
Type and Height2/ of Raised Canopy	% Cover3/	Type 4/	Percent Ground Cover 0	20	40	60	80	95-100
Column No.:	2	3	4	5	6	7	8	9
No appreciable canopy		G	.45	.20	.10	.042	.013	.003
		W	.45	.24	.15	.090	.043	.011
Canopy of tall weeds or short brush (0.5m fall ht.)	25	G	.36	.17	.09	.038	.012	.003
		W	.36	.20	.13	.082	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.075	.039	.011
	75	G	.17	.10	.06	.031	.011	.003
		W	.17	.12	.09	.067	.038	.011
Appreciable brush or bushes (2m fall ht.)	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.085	.042	.011
	50	G	.34	.16	.085	.038	.012	.003
		W	.34	.19	.18	.081	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.077	.040	.011
Trees but no appreciable low brush (4m fall ht.)	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.087	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.085	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.083	.041	.011

1/ All values shown assume: (1) random distribution of mulch or vegetation, and (2) 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 or decaying, compacted duff or litter. at least 2 inches deep.

W: cover at surface is weeds (plants with little lateral-root network near the surface) or undecayed residue.

Should the need arise to use a "C" factor other than the one shown above, contact the state resource conservationist.

Table 3 "C" Factors for Woodland (56)

Stand Condition	Tree[1/] Canopy % of Area	Forest[2/] Litter % of Area	Undergrowth[3/]	"C" Factor
Well Stocked	100-75	100-90	Managed[4/] Unmanaged[4/]	.001 .003-.011
Medium Stocked	70-40	85-75	Managed Unmanaged	.002-.004 .01 -.04
Poorly Stocked	35-20	70-40	Managed Unmanaged	.003-.009[5/] .02 -.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%, the "C" values should be derived by taking 0.7 of the appropriate values in Table 19. The factor 0.7 adjusts for the much higher soil organic matter on permanent woodland.

Should the need arise to use a "C" factor other than the one shown above, contact the state resource conservationist.

Table 4 "P" Values and Slope-Length Limits for Contouring (57)

Land Slope percent	"P" Value	Maximum Length[2] Feet
1 to 2	0.60	400
3 to 5	.50	300
6 to 8	.50	200
9 to 12	.60	120
13 to 16	.70	80
17 to 20	.80	60
21 to 25	.90	50

[1] Limit may be increased by 25 percent if residue cover after crop seedings will regularly exceed 50 percent.

Table 5 "P" Values, Maximum Strip Widths, and Slope-Length Limits for Contour Stripcropping (57)

Land slope percent	"P" Values[1]			Strip width[2] feet	Maximum length feet
	A	B	C		
1 to 2	0.30	0.45	0.60	130	800
3 to 5	.25	.38	.50	100	600
6 to 8	.25	.38	.50	100	400
9 to 12	.30	.45	.60	80	240
13 to 16	.35	.52	.70	80	160
17 to 20	.40	.60	.80	60	120
21 to 25	.45	.68	.90	50	100

[1] "P" values:

A for 4-year rotation of row crop, small grain with meadow seeding, and 2 years of meadow. A second row crop can replace the small grain if meadow is established in it.

B for 4-year rotation of 2 years row crop, winter grain with meadow seeding, and 1-year meadow.

C for alternate strips of row crop and small grain.

[2] Adjust strip-width limit, generally downward, to accommodate widths of farm equipment.

Table 6 "P" Values for Contour-Farmed Terraced Fields[1] (57)

Land slope percent	Farm planning		Computing sediment yield[3]	
	Contour factor[2]	Stripcrop factor	Graded channels sod outlets	Steep backslope underground outlets
1 to 2	0.60	0.30	0.12	0.05
3 to 8	.50	.25	.10	.05
9 to 12	.60	.30	.12	.05
13 to 16	.70	.35	.14	.05
17 to 20	.80	.40	.16	.06
21 to 25	.90	.45	.18	.06

[1]Slope length is the horizontal terrace interval. The listed values are for contour farming. No additional contouring factor is used in the computation.

[2]Use these values for control of interterrace erosion within specified soil loss tolerances.

[3]These values include entrapment efficiency and are used for control of offsite sediment within limits and for estimating the field's contribution to watershed sediment yield.

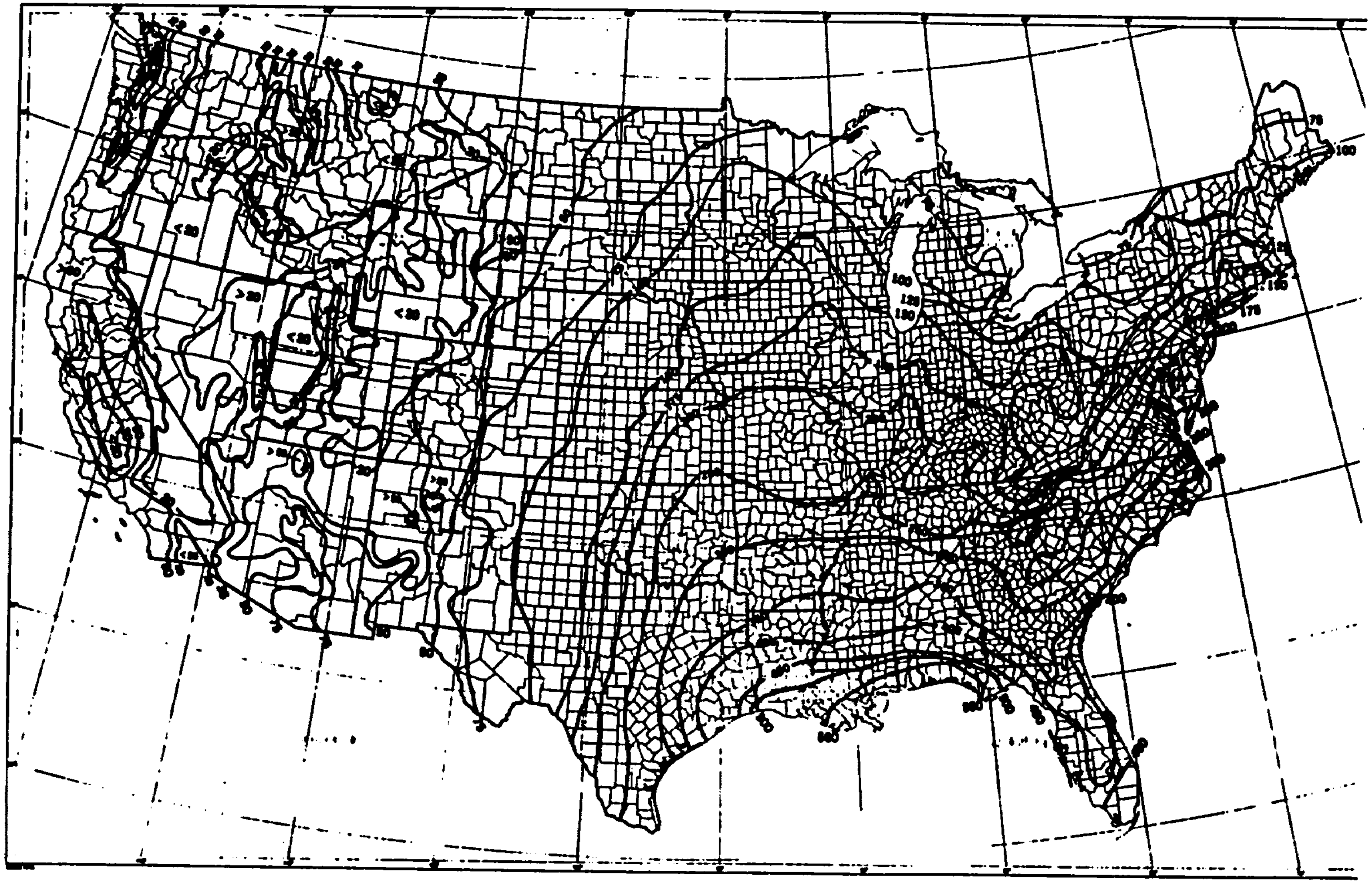


Figure 1 Average Annual Values of The Rainfall Erosion Index "R". (57)

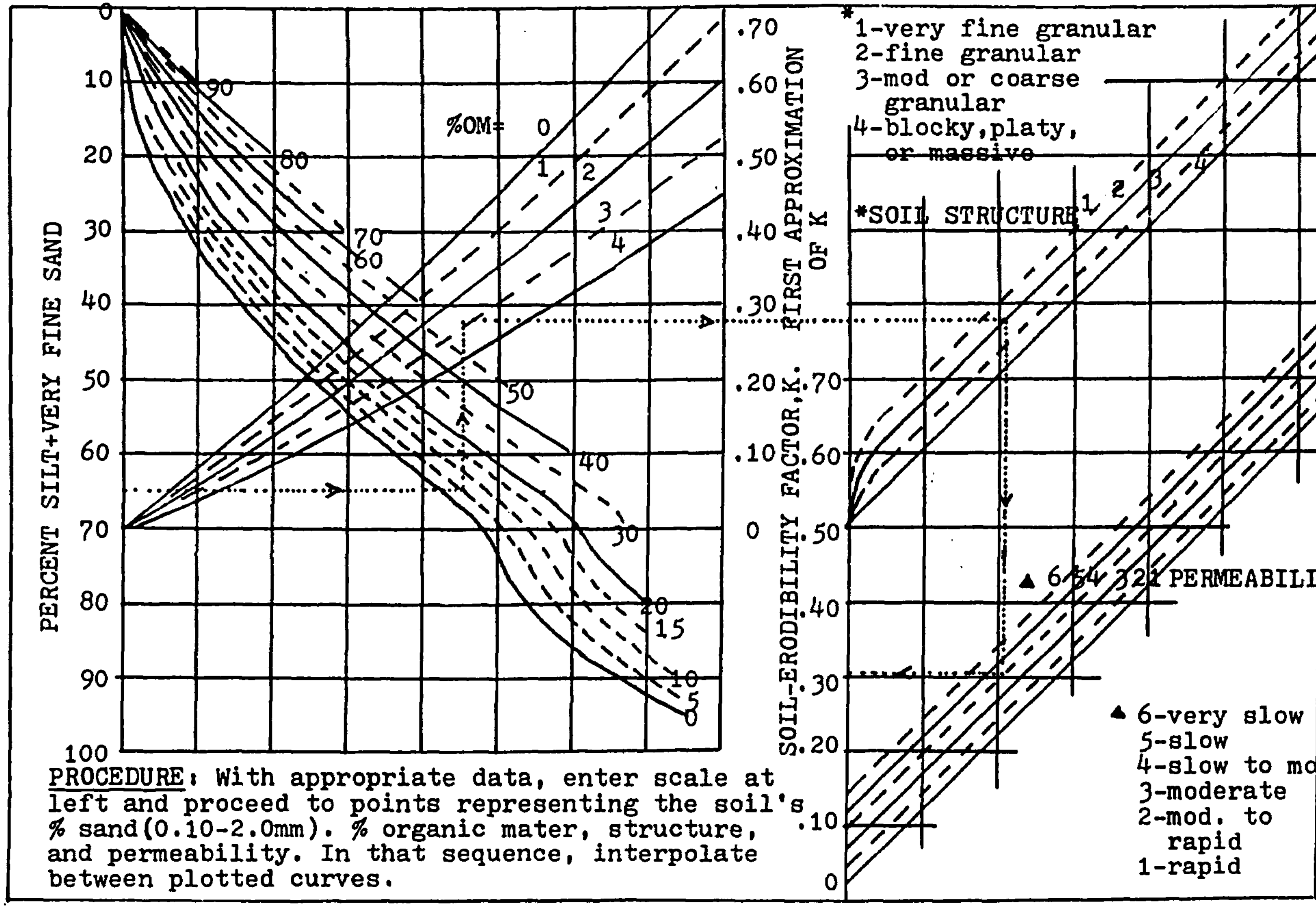
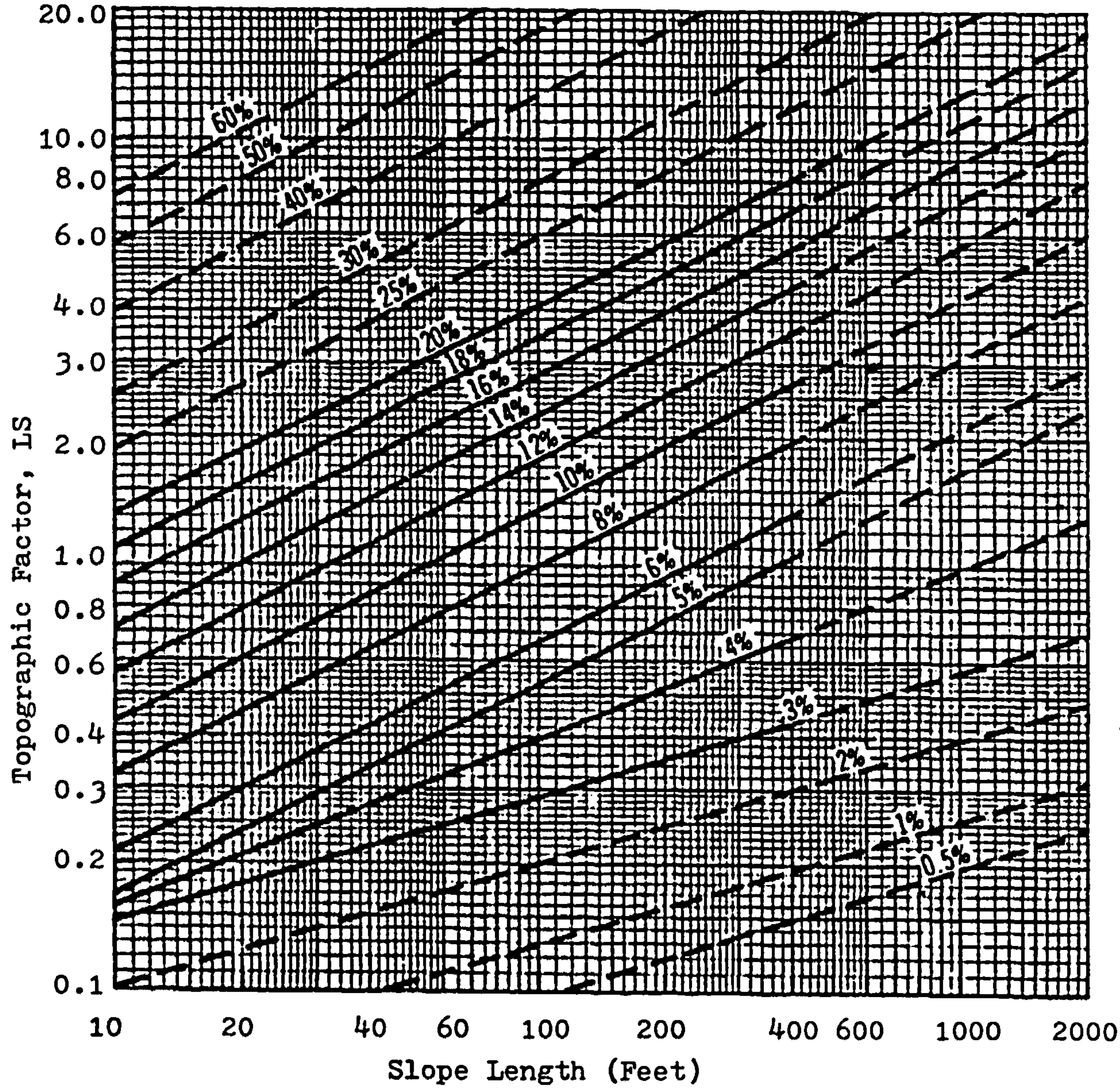


Figure 2 The Soil-Erodibility Nomograph. (56)



*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=SINΘ, Θ is the angle of slope in degrees.

Figure 3 Slope-Effect Chart (Topographic Factor, LS)* (56)

APPENDEX B

USER MANUAL OF BMP1 COST ANALYSIS

Detailed explanation concerning Model BMP1 cost analysis is provided as follows:

<u>Terrace Cost</u>

The maximum horizontal spacing (TRSP) is derived by the following formula(28):

$$TRSP = X(100) + \frac{Y(100)}{S}$$

where X = a variable with values from 0.4 to 0.8 for graded terrace (X = 0.8 for level terraces)

S = land slope in feet/per 100 feet

Y = a variable with values from 1.0 to 2.0 as influenced by soil erodibility, cropping systems, and crop management practices.

The X value in the equation is largely dependent upon the quantity and intensity of precipitation in the general area. The map in Figure 1 gives recommended values for gradient terraces in any specific location.

The value of Y is generally determined as follows:

Y = 1.0 for soils with below average intake rates and cropping systems that provide little cover during intense rainfall periods.

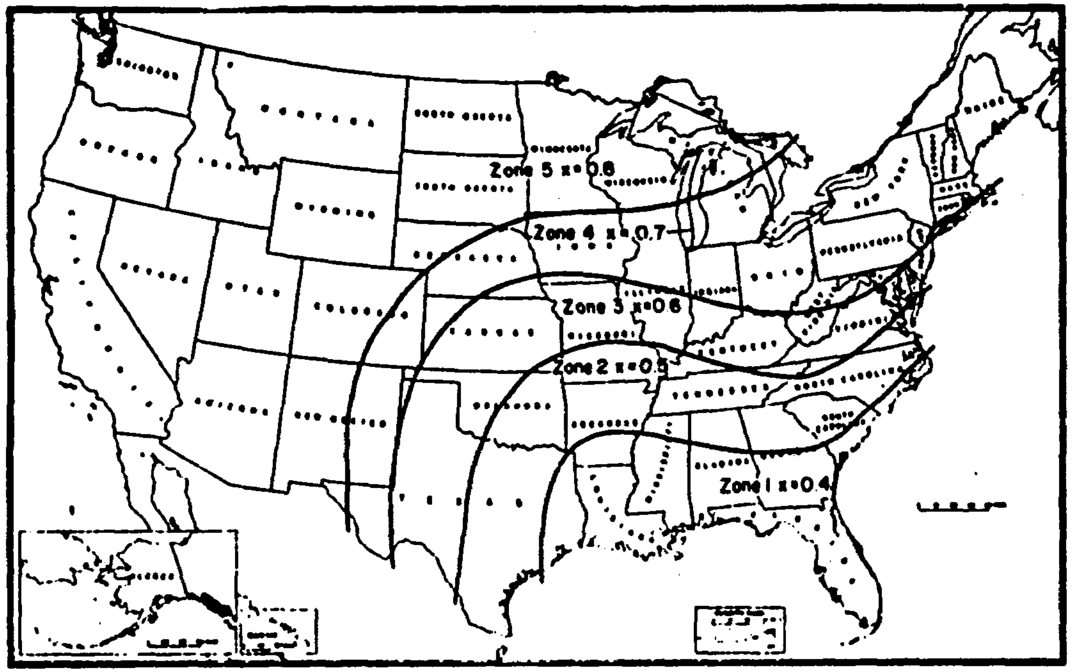


Figure 1 X Values in $HI = X + \frac{Y(100)}{S}$ (28)

Y = 2.0 for soils with average or above intake rates and cropping systems that provide good cover during periods of intense rainfall.

Y = 1.5 where one of the above factors is favorable and the other unfavorable.

After the spacing of the terrace is obtained, the number of terraces can be calculated by dividing the length of the area slope by terrace spacing. Therefore, the feet terrace per acre can be calculated as follows:

$$\text{Feet terrace/acre} = \frac{\text{1 acre}}{\text{Slope Length in ft}} \times \text{Number of terraces per slope}$$

$$= \frac{43560\ ft^2}{\text{Slope Length in ft}} \times \text{Number of terraces per slope}$$

The acquired figure is multiplied by the current estimated construction cost per foot terrace to obtain the construction cost per acre. The yearly prorated construction cost can then be calculated as follows:

Yearly prorated construction cost

$$= \text{construction cost} \times \frac{I}{1 - \left(\frac{1}{1 + I}\right)^{n}} \times (100 - GS)\%$$

where I = Interest rate, %

n = Life of terrace, year.

GS = The ratio of government subsidy to construction cost.

If the government subsidizes a percentage of the construction cost, this percentage of the cost will be deducted to leave only the portion paid by farmers in the program to process.

By the same method, the yearly maintenance cost per acre can be calculated by knowing the yearly maintenance cost per foot terrace. The sum of construction and maintenance costs is the yearly terrace charge per acre which derives the total yearly terrace charge.

Machinery Fixed Cost

The machinery initial cost, salvage value and economic life are listed separately from Tables 1 to 3. From these parameters, the yearly depreciation can be calculated as:

$$\text{Yearly depreciation} = \frac{\text{Initial Cost} - \text{Salvage value}}{\text{Economic life}}$$

It is noteworthy that the initial cost here is adjusted according to the percentage use of this crop area to the total area belonging to the same owner.

The taxes, insurance and housing can be evaluated by lumping them together as 2.8% of the average machinery investment(25) as follows:

$$\text{TIH} = 0.028 \times \frac{\text{Original cost} + \text{Salvage value}}{2}$$

After the interest rate is determined, the average interest cost can be computed as:

$$\text{Interest} = \text{Interest rate} \times \frac{\text{Original cost} + \text{Salvage value}}{2}$$

Table 1 Estimated Machinery Investment and Ownership Costs. Includes depreciation, interest (at 9%), taxes, insurance, and housing. (24)

Tractors	List Price Per Unit	Annual Ownership Costs
55 PTO Hp Gas	$11,300	$1,480
65 " " "	13,500	1,770
75 " " Diesel	16,000	2,100
85 " " "(cab, AC, duals)	21,000	2,750
105 " " " " " "	23,900	3,130
125 " " " " " "	25,600	3,350
145 " " " " " "	27,600	3,620
160 " " " " " "	30,200	3,960
180 " " " 4-wheel drive	39,200	5,130
Stalk Choppers		
6 ft. rotary	$ 1,050	$ 170
10 ft. flail	3,200	520
Discs (tandem)		
14 ft.	$ 3,810	$ 610
17 ft.	5,530	890
21 ft.	6,250	1,000
24 ft.	7,230	1,160
Discs (offset, heavy duty)		
10 ft.	$ 3,990	$ 640
13 ft.	6,300	1,010
15 ft.	7,100	1,140
18 ft.	7,400	1,190
Plows (mold board)		
3-16" mounted	$ 1,900	$ 300
4-16" "	2,650	420
5-16" semi-mounted	3,760	600
6-16" " "	4,400	710
7-16" trailing	7,120	1,140
8-16" "	7,980	1,280
Plows (chisel-2 rows spring-trip shanks)		
9 ft.	$ 1,150	$ 190
11 ft.	1,350	220
15 ft.	1,960	310
Harrows (spiketooth)		
21 ft.	$ 630	$ 100
31 ft.	940	150
Sprayers		
20 ft. tractor mounted	$ 850	$ 140
40 ft. trailing	2,530	410

Table 1 (continued). Estimated Machinery Investment and Ownership Costs

	List Price Per Unit	Annual Ownership Costs
Fertilizer Applicators		
7 knife, NH_3 applicator	$ 1,900	$ 300
Chisel plow with NH_3 applicator	2,500	400
Bulk spreader 12 ft	1,800	290
Field Cultivators		
21 ft.	$ 3,600	$ 580
34 ft.	5,750	920
Planters (plateless or air flow, no attachments)		
4-row	$ 3,600	$ 580
6-row	5,000	800
8-row	6,570	1,050
12-row	10,100	1,620
4-row minimum tillage	4,000	640
Seeders and Drills		
Endgate or broadcast	$ 240	$ 40
Packer seeder	2,260	360
Grain drill, 9 ft., 7X15	2,360	380
Grain drill, 12 ft., 7X20	2,920	470
Rotary Hoes		
4-row	$ 1,300	$ 210
6-row	1,690	270
8-row	2,210	350
12-row	3,200	510
Cultivators, Row Crop		
4-row	$ 1,500	$ 240
6-row	1,990	320
8-row	2,630	420
12-row	4,240	$ 680
Combines (self-propelled)		
Economy, gas, 70-80 hp.	$19,000	$2,570
Small, diesel, 95-110 hp.	25,800	3,490
Medium, diesel, 110-125 hp.	31,400	4,250
Large, diesel, 140-150 hp.	36,200	4,900
Corn Heads for Combine		
2-row	$ 3,350	$ 450
3-row	5,530	750
4-row	7,250	980
6-row	9,540	1,290
8-row	12,500	1,690

Table 1(continued). Estimated Machinery Investment and Ownership Costs

	List Price Per Unit	Annual Ownership Costs
Grain Heads for Combine		
10 ft.	$ 3,050	$ 410
13 ft.	3,670	500
15 ft.	3,920	530
20 ft.	4,620	620
Windrowers		
18 ft. self-propelled	$ 3,000	$ 480
12 ft. self-propelled	11,500	1,560
Picker (2 row)		
Mounted	$ 8,310	$1,120
Mounted with sheller	9,440	1,280
Wagons		
200 bu. grain	$ 1,380	$ 190
300 bu. grain	2,260	310
7 ton forage	4,170	570
Dryers		
Bin 3,000 bu.	$ 6,850	$ 930
Bin 6,000 bu.	9,100	1,240
Batch 100 bu./hr.	8,000	1,090
Batch 150 bu./hr.	12,000	1,630
Cont. flow 200 bu./hr.	14,000	1,900
Cont. flow 375 bu./hr.	18,500	2,510
Cont. flow 500 bu./hr.	23,000	3,120
Forage Harvesters		
1-row	$ 6,050	$ 980
2-row	7,750	1,250
3-row self-propelled	38,900	5,300
Haylage, 7 ft.	7,980	1,090
Self-propelled with 10' mower	31,620	4,310
Mowers and Rakes		
7 ft. mower	$ 1,230	$ 200
7 ft. mower-conditioner	3,720	600
7 ft. rake	1,100	180
Balers		
Square	$ 4,580	$ 740
Large round	6,480	1,050
3 ton stacker	11,200	1,820

Table 2 Estimated On-Farm Remaining Value of Farm Machines as a Percentage of List Price. (25)

At the end of year	Tractors	Combines, S.P.windrowers	Forage harvesters, balers, blowers	All others
1	62.6	56.6	49.6	53.1
2	57.6	50.1	43.9	53.1
3	53.0	44.4	38.8	41.6
4	48.7	39.3	34.4	36.8
5	44.8	34.7	30.4	32.6
6	41.2	30.7	26.9	28.8
7	37.9	27.2	23.8	25.5
8	34.9	24.1	21.1	22.6
9	32.1	21.3	18.6	20.0
10	29.5	18.9	16.5	17.7
11	27.2	16.7	14.6	15.7
12	25.0	14.8	12.9	13.9

Table 3 Expected Service Life for Various Farm Machines by Use Categories. (25)

Machine	Annual use	Useful life (years)
A. Powered machines		
Automobile	6,000- 8,000 mi	10
	8,000-10,000 mi	9
	10,000-12,000 mi	8
Truck		
pickup	4,000- 6,000 mi	13
	6,000- 8,000 mi	12
	8,000-10,000 mi	11
1½-2 ton	2,000- 4,000 mi	15
	4,000- 6,000 mi	13
	6,000- 8,000 mi	12
Tractor		
wheel	200-400 hrs	14
	400-600 hrs	12
	600-800 hrs	11
	800-1,000 hrs	10
crawler	400-600 hrs	14
	600-800 hrs	13
B. Seedbed preparation machines		
Plow, one-way		
3-bottom	100-150 A	12
	150-200 A	10
4-bottom	150-200 A	12
	200-300 A	10
Disk harrow	100-200 A	12
8-10 ft	200-300 A	11
	300-400 A	10
Spike harrow	...	12
Lister	...	12
Roller	...	15
Deep tillage machinery	...	12
C. Planters		
Grain drill	50-100 A	14
8-10 ft	100-150 A	12
	150-200 A	10
Corn planter		
4-row	100-200 A	12
	200-300 A	10

Machine	Annual use	Useful life (years)
D. Cultivators, weeders sprayers		
Cultivator		
4-row	100-200 A	12
	200-400 A	10
Field	...	14
Rotary hoe	...	12
Sprayer, tractor mtd.	...	10
E. Harvest machines		
Corn picker, mounted and pull		
2-row	85 A ave.	10
SP	140 A ave.	10
Combine		
pull-type	150-200 hrs	10
SP 12-ft	200-250 hrs	10
	250-300 hrs	8
Mower		
rotary	...	12
sickle bar	...	12
Side rake	...	12
Hay baler	...	8
Field chopper	...	8
Ensilage blower	...	10
F. Other farm machines		
Wagons and trailers	...	12
Commercial fertilizer spreader	...	8
Manure spreader	...	14
Post-hole digger	...	10
Tractor scoops and blades	...	12
Grinder and hammer mill	...	10

Source: Summarized from various studies conducted by agricultural experiment stations between 1960 and 1970.

Finally, the sum of yearly depreciation, taxes, insurance, housing and interest becomes the yearly machinery fixed cost.

<u>Machinery Repair Cost</u>

This cost is the sum of machinery fixed cost and machinery repair cost. The machinery fixed cost has been obtained from the previous section. The repair cost of each machine can be calculated from the following equation:

$$\text{Total Repair Cost} = \frac{\text{(hours per acre)(acre of use)(Time Over)}}{100}$$

$$\text{X (Repair cost per 100 hours).}$$

where: "Hours per acre" of each machine can be obtained from Table 4.

"acres of use" means the acreage on which the implement is used each year.

"Times over" means the number of trips through field with the implement.

"Repair cost per 100 hours" of each machine can be estimated from the curve slopes shown from Figures 2 to 5.

<u>Tractor Cost</u>

The tractor is the basic mobile equipment used in each practice along with several implements. The total machinery cost of a tractor for each practice needs to be calculated separately. The initial tractor cost, as the

Table 4 Suggested Variable Cost and Time Requirements (24)

Equipment set or operation	Size of equipment unit	Suggested fuel oil, repair, & misc. variable costs $/acre 1/	Field time & tractor time requirements Hours/acre	Acres/hour
Chop stalks	6' rotary	$1.27	.38 hrs.	2.6 A.
	10' flail	.88	.22	4.5
Disk-offset	10'	$ .72	.22 hrs.	4.6 A.
	14'	.68	.16	6.2
	18'	.68	.13	7.8
Disk-tandem	14-17'	$ .50	.12 hrs.	8.6 A.
	21'	.48	.09	11.2
	24'	.48	.08	12.8
Plow-moldboard	3 bottom	$1.85	.56 hrs.	1.8 A.
	4 bottom	1.74	.40	2.5
	5 bottom	1.72	.33	3.0
	6 bottom	1.63	.36	3.5
	7 bottom	1.59	.25	4.0
-chisel	9'	.69	.20	4.9
	11'	.72	.17	5.8
	15'	.72	.13	7.4
NH_3 Application	7 knife	$1.03	.17 hrs.	5.7 A.
	9 knife	1.03	.13	7.4
Planting-corn	4-38" rows	$ .83	.17 hrs.	5.8 A.
	6-30"	.91	.15	6.7
	8-30"	.85	.11	8.7
	12-30"	.75	.08	12.7
Sprayer	40'	$ .31	.06 hrs.	15.7 A.
	20'	.44	.13	7.9
Bulk fertilizer	12'	$ .77	.16 hrs.	10.2 A.
Grain drill	9'	$1.00	.26 hrs.	3.9 A.
	12'	.93	.18	5.5
Endgate seeder	20'	$ .27	.11 hrs.	9.1 A.
Harrow-spike tooth	21'	$ .27	.08 hrs.	12.2 A.
	31'	.25	.06	18.0
-spring tooth	14'	.47	.15	6.3
	21'	.45	.10	10.2
Rotary hoe	4-38" rows	$ .35	.10 hrs.	10.1 A.
	6-30"	.33	.09	11.7
	8-30"	.31	.07	15.3
	12-30"	.24	.05	22.4
Field cultivator	15'	$ .45	.13 hrs.	7.6 A.
	21'	.41	.10	10.2
	27'	.37	.08	13.1

1/ Add 10% to costs for gasoline power instead of diesel.

Table 4 continues.

Equipment set or operation	Size of equipment unit	Suggested fuel oil, repair, & misc. variable costs $/acre 1/	Field time & tractor time requirements Hours/Acre	Acres/hour
Cultivation	4-38" rows	$ .60	.18 hrs.	5.7 A.
	6-30"	.63	.15	6.6
	8-30"	.56	.12	8.5
	12-30"	.45	.08	12.4
Combine-corn	2-38" rows	$3.88	.67 hrs.	1.5 A.
	3-38"	3.59	.47	2.2
	3-30"	4.43	.58	1.8
	4-30"	3.67	.45	2.3
	6-30"	3.07	.32	3.2
Combine-small grain & soybean	13' platform	$2.20	.30 hrs.	3.3 A.
	15'	2.04	.27	3.7
	20'	1.84	.21	4.8
Pick-corn	2-38" rows	$2.89	.67 hrs.	1.5 A.
Picker-shell-corn	2-38"	2.98	.67	1.5
Silage-corn	1-38" rows	$6.93	1.37 hrs.	0.7 A.
	2-38"	4.07	.71	1.4
	2-30"	5.15	.90	1.1
	3-30"	5.38	.62	1.6
haylage	7'(1 cutting)	2.37	.37	2.7
Bale-hay (per cutting)	Square bales	$3.08 or 6¢/bale	.21 hr.	4.8 A.
	Large round bales	1.54 or .69/bale	.18	5.6
	3 ton stacks	1.52 or 3.41/stk.	.21	4.9
straw	Square bales	2.55 or 6¢/bale	.21	7.2
Mow	7' bar	$1.34	.30 hrs.	3.4 A.
Condition	7'	$1.06	.30 hrs.	3.4 A.
Mow-condition	7' bar	$1.74	.30 hrs.	3.6 A.
Rake	7'	$ .84	.27 hrs.	3.7 A.
SP Windrower	10'	$ .67	.16 hrs.	6.2 A.
	14'	.73	.12	8.4
		per bushel, bale or ton		
Hauling grain (to farm storage)		$0.01/bu.	Use harvest time as guide	
Hauling bales (to farm storage)		$0.01/bale	Use baling time as guide	
Hauling silage		$0.15/ton	Use chopping time as guide	
Drying corn		$0.009 per 1% moisture per bu.		

1/ Add 10% to costs for gasoline power instead of diesel.

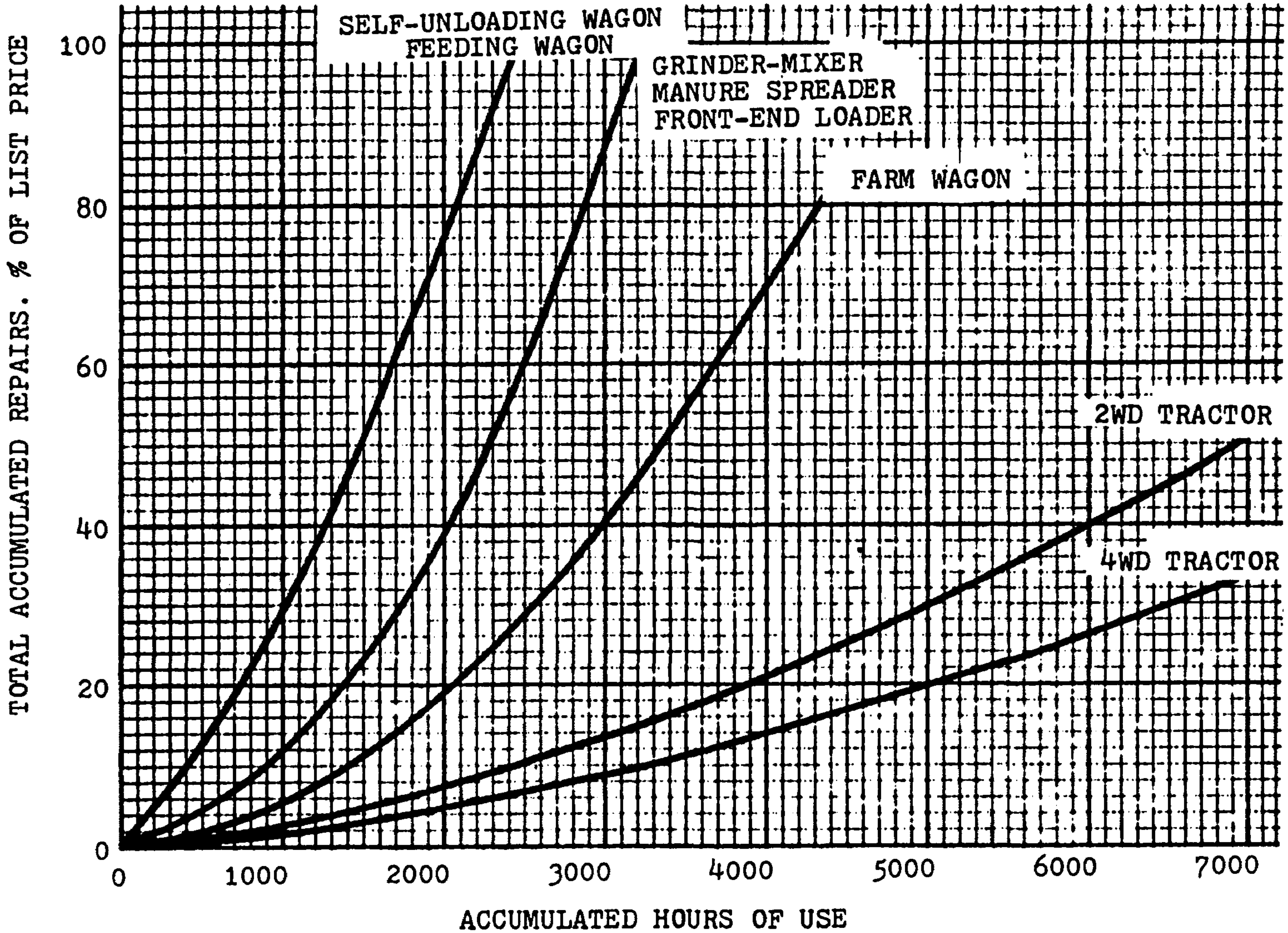


Figure 2 Accumulated Repair Costs for Tractors and Feeding Equipment. (25)

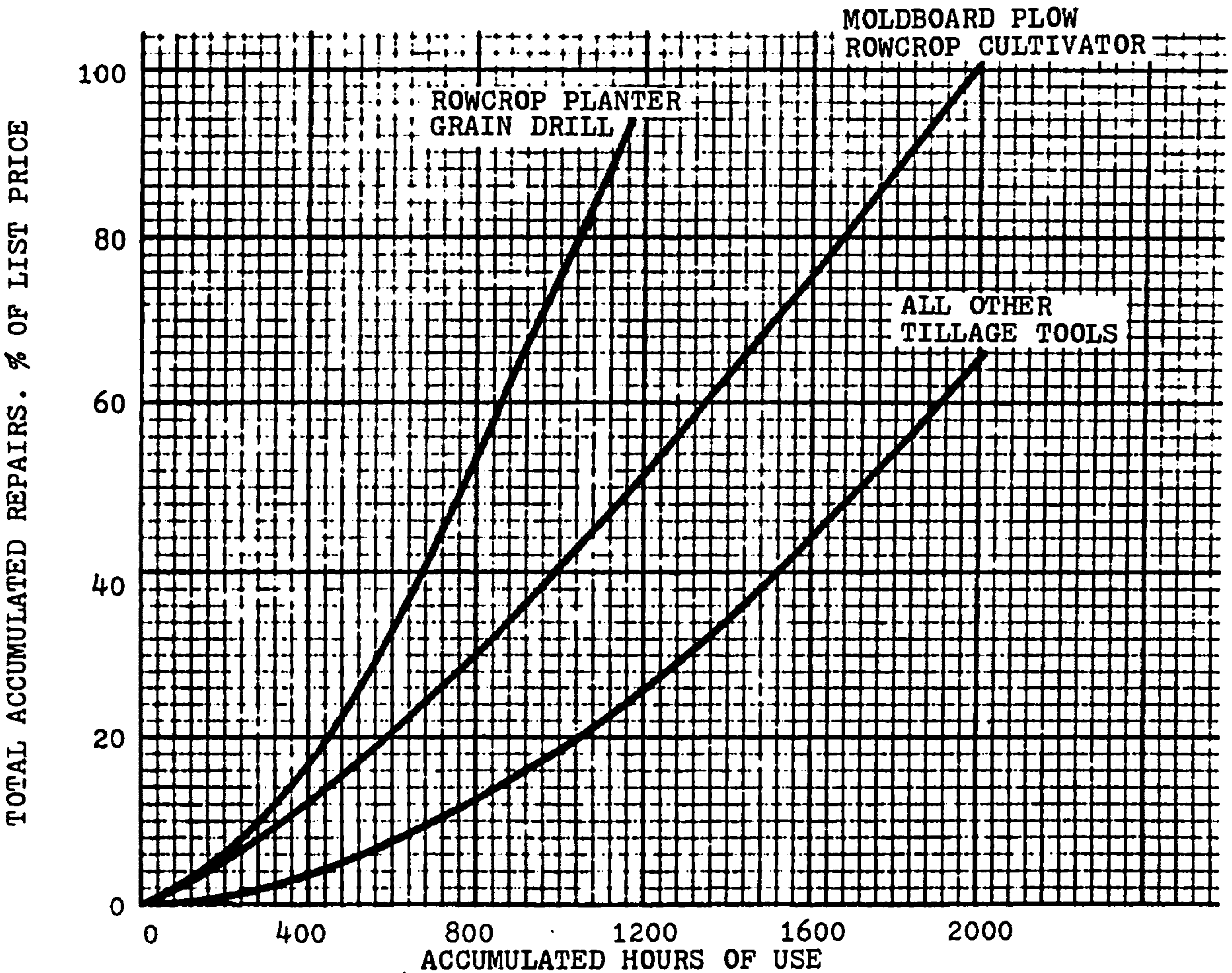


Figure 3 Accumulated Repair Costs for Tillage Tools. (25)

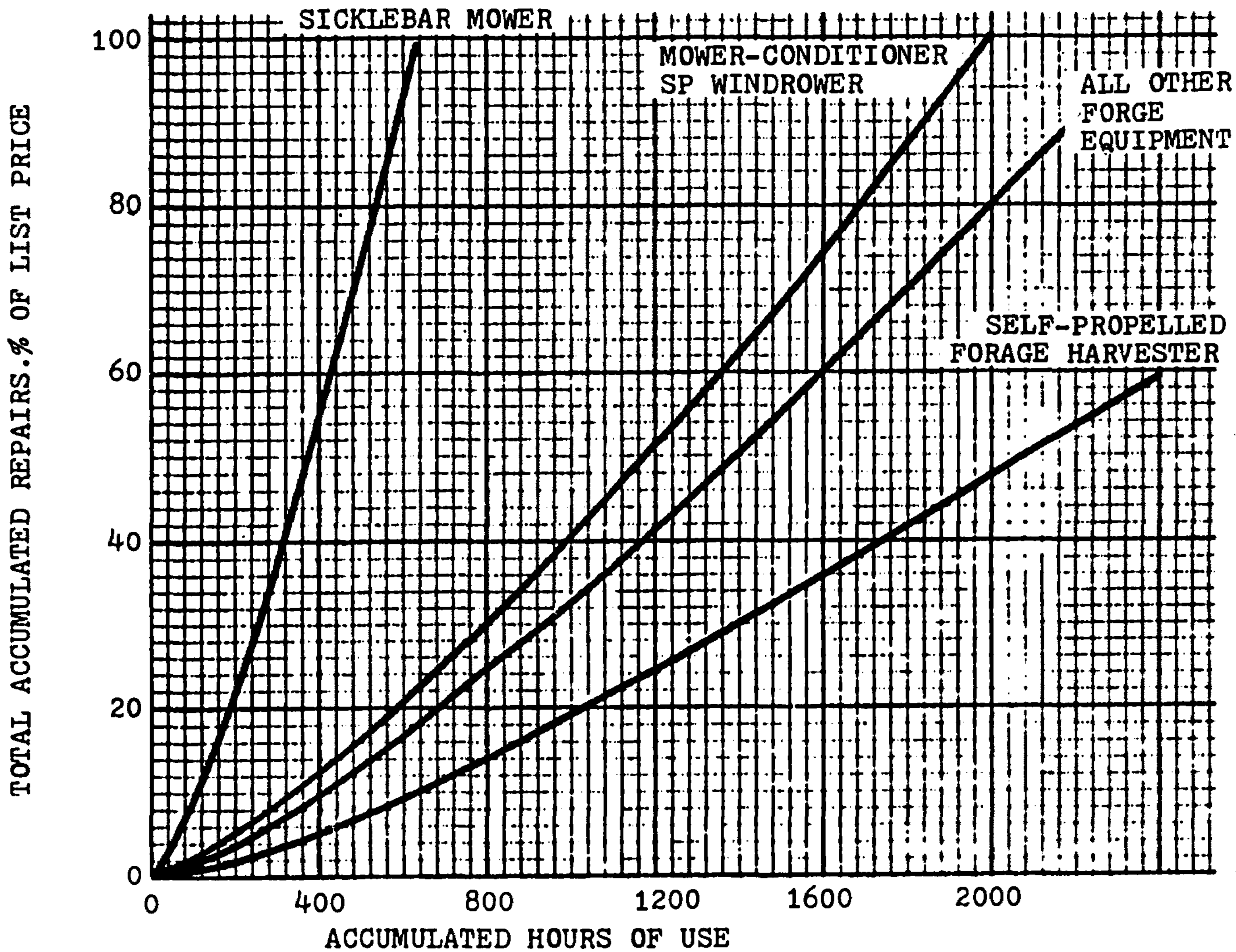


Figure 4 Accumulated Repair Costs for Forage Harvesting Equipment. (25)

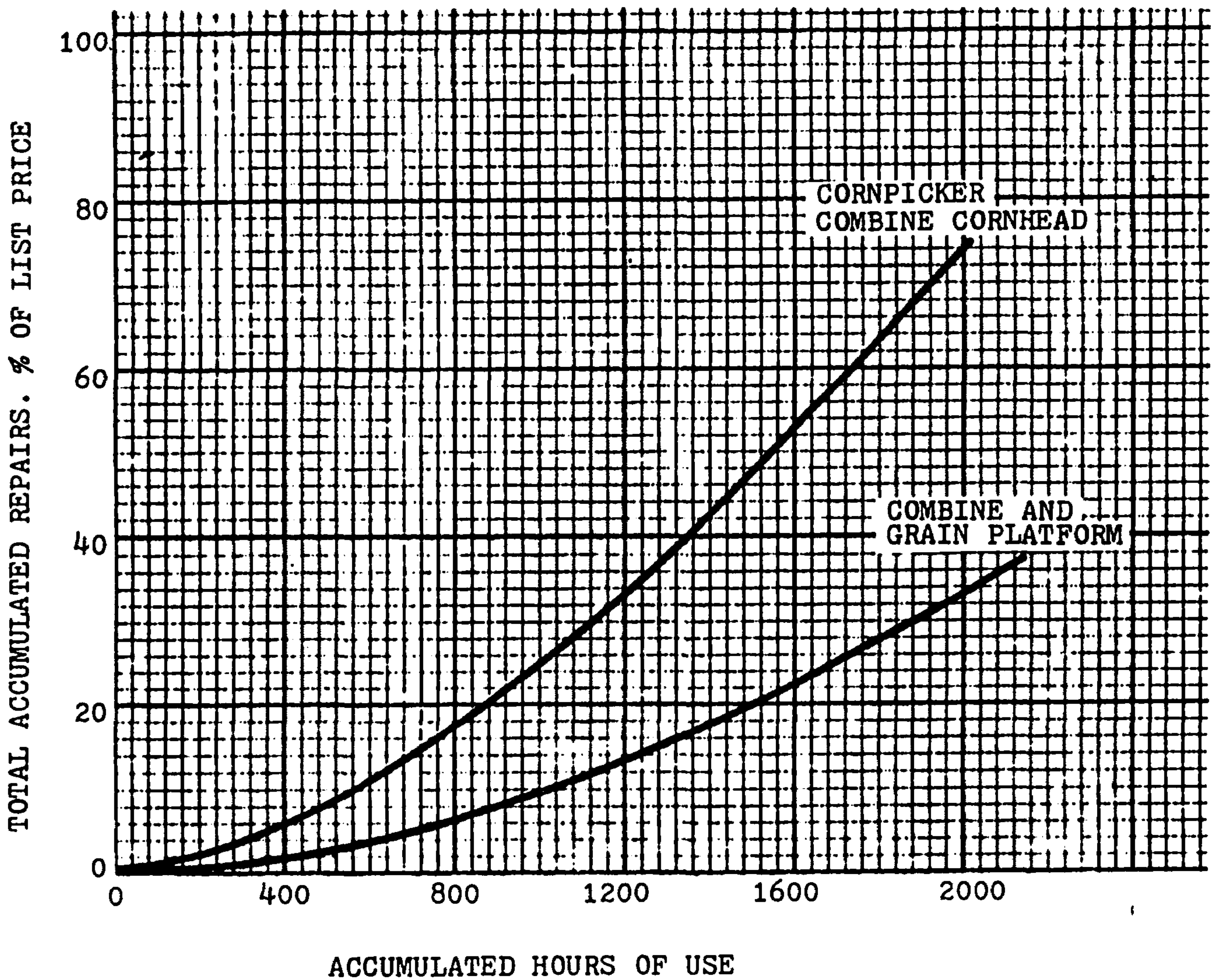


Figure 5 Accumulated Repair Costs for Grain Harvesting Equipment. (25)

other machinery initial costs, is subjected to change in accordance with the percentage of this crop area to the total area of the same owner. The calculation procedure is referenced in the previous two sections - "Machinery Fixed Cost" and "Machinery Repair Cost". It is noteworthy that the total hours of tractor has been increased by 10% to cover the time for idling, travel to field, etc.

Fuel Cost

The fuel cost is the sum of fuel costs for tractor, combine, and other fuel powered engines and vehicles. Each of these two costs can be calculated by multiplying the total hours for either tractor or combine by the fuel cost per tractor hour or combine hour.

The fuel cost per tractor hour can be computed as follows:

$$\text{Fuel Cost (\$/Tractor Hr.)} = \text{Fuel Unit Cost (\$/gal)} \times \text{Fuel Consumption} + \text{Lubrication Cost}$$

where: Fuel consumption = 0.044 x PTO hp (25)

Lubrication cost is assumed to be 15% of total fuel cost.

The fuel cost per combine hour can be computed as follows:

$$\text{Fuel Cost (\$/Combine hr)} = \text{Fuel Unit Cost (\$/gal)} \times \frac{\text{Combine or vehicle Gasoline Consumption(gal/ac)}}{\text{Combine or vehicle working Hours per Acre}} + \text{Lubrication cost.}$$

here Combine (or vehicle) Gasoline Consumption can be selected from Table 5.

Lubrication cost is assumed to be 15% of total fuel cost.

Seed Cost

The following equation is suggested for calculating the seed cost per acre:

Seed Cost per acre = Seed Amount per Acre X Seed Unit Cost

where seed amount per acre can be referred to in Table 1.20 in Reference (28) in which the seeding rate is recommended according to the soil condition.

The seed unit cost can be obtained from the Oklahoma State Department of Agriculture's annual report "Oklahoma Agricultural Statistics". The total seed cost is calculated by multiplying the unit seed cost per acre by the acreage.

Table 5 Approximate Fuel Required for Field Operations, in Gallons Per Acre. (26)

Field Operation	Fuel Type: Gasoline	Diesel
FERTILIZATION		
Spreading dry fertilizer bulk cart	0.20	0.16
Anhydrous ammonia(30-inch spacing)	0.80	0.60
TILLAGE		
Shredding cornstalks	0.70	0.50
Moldboard plow	2.70	1.90
Chisel plow	1.70	1.20
Offset disk	1.35	0.95
Powered rotary tiller	2.30	1.60
Tandem disk, plowed field	1.00	0.70
Tandem disk, tilled field	0.85	0.60
Tandem disk, cornstalks	0.70	0.50
Field cultivate, plowed field	1.15	0.80
Field cultivate, tilled field	1.00	0.70
Spring-tooth harrow, plowed field	1.00	0.70
Spring-tooth harrow, tilled field	0.85	0.60
Peg-tooth harrow, tilled field	0.45	0.30
PLANTING(30-Inch rows)		
Planter, seed only, tilled seedbed	0.65	0.45
Planter with fertilizer and pesticide attachments, tilled seedbed	0.85	0.60
Till-planter(sweep)	0.85	0.60
No-till planter(fluted coulter)	0.70	0.50
Harrow-Plant combination	1.30	0.90
Rotary strip till-plant	1.50	1.05
Grain drill	0.50	0.35
Broadcast seeder	0.20	0.15
WEED CONTROL(30-Inch rows)		
Sprayer, trailer type	0.15	0.10
Rotary hoe	0.30	0.20
Sweep cultivator	0.65	0.45
Rolling cultivator	0.60	0.40
Cultivator with disk hillers	0.65	0.45
Powered rotary cultivator	1.00	0.70

Approximate Fuel Required for Field Operations, In Gallons Per Acre (Continued)

Field Operation	Fuel Type	
	Gasoline	Diesel
HARVESTING		
Cutterbar mower	0.55	0.35
Mower-conditioner, PTO	0.85	0.60
Self-propelled windrower	0.70	0.50
Rake	0.35	0.25
Baler	0.65	0.45
Stack-forming wagon	0.70	0.50
Forage harvester		
Green forage	1.35	0.95
Haylage	1.80	1.25
Corn silage	5.20	3.60
High-moisture ground ear corn	2.75	1.90
Forage blower		
Green forage	0.50	0.35
Haylage	0.35	0.25
Corn silage	2.00	1.40
High-moisture ground ear corn	0.65	0.45
Combine, soybeans	1.70	1.10
Combine, corn	2.35	1.60
Corn picker	1.75	1.15
Grain drying, corn	10.90	7.50
Hauling, field plus 1/2 mile on graveled road		
Green forage	0.55	0.35
Haylage	0.30	0.20
Corn silage	2.00	1.40
Corn grain	0.30	0.20
Soybeans	0.12	0.08
Hauling, add following values to those above for each additional mile on gravel		
Green forage	0.20	0.14
Haylage	0.30	0.20
Corn silage	1.30	0.90
Corn grain	0.20	0.15
Soybeans	0.07	0.05

Fertilizer Cost

N, P_2O_5, and K_2O are the most common fertilizers and they are used in this program. The recommended amount for application are located in Reference (71). The average amount of each fertilizer for each practice will be calculated by dividing the total amount of each fertilizer by the number of crops. The cost of fertilizer per acre can be calculated as follows:

Cost of Fertilizer per acre

= (Unit Price of N) x (Average Amount of N)

+ (Unit Price of P_2O_5) x (Average Amount of P_2O_5)

+ (Unit Price of K_2) x (Average Amount of K_2O)

The total cost of fertilizer will be determined as the product of the cost of fertilizer per acre and the total acreage the fertilizer is being applied. NH_3 Knife and 4-ton bulk spreader are counted on the rental basis so that this cost is also included in the total fertilizer cost.

Pesticide Cost

Many interacting factors govern the effectiveness of herbicides and the potential for crop injury. Included are environmental conditions such as rainfall, temperature and relative humidity; managerial factors, such as depth of planting, time of planting, time of application, general tillage practices in seed bed preparation, weed species in the field, rate and kind of chemicals needed to provide greatest economic return from the crop. (29)

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1972 provides for the classification of all pesticides as being for restricted or general use. Pesticides classified for restricted use may only be used by certified pesticide applicators or individuals under the direct supervision of a certified pesticide applicator. (51)

From References (29) and (51), the proper amount of herbicide and insecticide can be determined and applied on the field. Those amounts multiplied by the market price determine the pesticide cost per acre which determines the total pesticide cost for the whole field. The pesticide cost for each crop can be added to get the total pesticide cost for each practice.

<u>Labor Cost</u>

The total direct labor hours is calculated as the sum of total tractor hours and total combine hours. A 30% overhead cost is also included in the total labor hours. This figure multiplied with the local current hourly labor cost becomes the total labor cost.

<u>Drying Cost</u>

The total drying cost can be calculated as the product of the grain harvested and the cost per bushel (or other proper unit). The grain harvested is computed from the later section "Revenue" and details can be sought there.

Interest Cost

Interest is calculated based on operational cost. A 10% interest rate is used to calculate operational cost based upon eight months of fertilizer, eight months of seed, six months of pesticide, three months of fuel and three months of labor. The formula used is as follows:

$$\text{Interest} = \text{Initial Cost} \times (1+I)^n - \text{Initial Cost}$$

where: I = Interest Rate

n = number of years

The total interest is the sum of interests of all operational costs.

Revenue

To determine the revenue, crop yield must be estimated accurately. Past yields should be the starting point for the estimates of future production. Where no changes in the cropping pattern are anticipated, past yield alone should form a good basis for making yield estimates. Therefore, the best reference for past crop yields in Oklahoma is "Oklahoma Agricultural Statistics" published by the Oklahoma Department of Agriculture in which the annual crop yield per harvested acre for each county in Oklahoma is reported. From the same source, the expected price for each crop can be extrapolated from the curve of the past price records. Therefore, the gross revenue can be calculated by the following equation:

Gross Revenue

= (Expected Yield, bu/ac) x (Acre Cropped, acres)

x (Expected Price, \$/bu)

If the practice is for rangeland or pasture and used for raising cattle, the crop yield is the meat production in terms of lbs/acre/year.

APPENDIX C

PROGRAM PRINTOUT OF "BMP1"

BMP1 Program

```
      $JCB
 1         DIMENSION NABMP(11),CP(11),REMEFF(11),NAMACH(11,16),SIZE(11,16),
          1          ECONLF(11,16),THOVER(11,16),INCS(11,16),SAVA(11,16),
          2          HRPAC(11,16),ACUSE(11,16),RPCS(11,16),YRDEPR(11,16),
          3          TXINHO(11,16),INSU(11,16),FXCS(11,16),TOHR(11,16),
          4          TOCSRP(11,16),TOCS(11,16),TOCSMA(11),TRHRAC(11)
 2         DIMENSION TRECLF(11),TRSAVA(11),TOHRTR(11),YRDPTR(11),TXTR(11),
          1          YRINTR(11),FXCSTR(11),RPCSTR(11),TOCSTR(11),TOHRCH(11),
          2          TRFUCS(11),CNFUCS(11),TOCSFU(11),COD(11), AMSD(11,11),
          3          USSD(11),NSD(11),CSSD(11,11),TOCSAC(11),AVCSSD(11),
          4          TOCSSD(11),NACPS(11),SDMENT(11),SS(11),BOD(11)
 3         DIMENSION AMNFR(11,11),AMPFR(11,11),AMKFR(11,11),NCROP(11),
          1          TOAMP(11),TOAMK(11),AVAMN(11),AVAMP(11),AVAMK(11),
          2          CSFRAC(11),TOCSFR(11),REEQ(11),TOFRCS(11),CSHBAC(11,11),
          3          CSINAC(11,11),TOCSHB(11),TOCSIN(11),AVCSHB(11),
          4          TOCSPS(11),TOPSCS(11),TOAMN(11),AVCSIN(11),INT(11,16)
 4         DIMENSION TODTLB(11),OVHD(11),TCLB(11),TOCSLB(11),EPYD(11,11),
          1          ACCP(11,11),UTCPYD(11),CSDY(11),CPHV(11,11),DYCS(11,11),
          2          TOCSDY(11),FRIN(11),SDIN(11),PSIN(11),FUIN(11),LBIN(11),
          3          EPPR(11),GRRN(11,11),TCHN(11),TOCOST(11),NTRN(11),
          4          IDENTR(11),TACS(11),YRPLAN(11),TOPLCS(11)
 5         DIMENSION NACPF(11),NACPP(11),NACPD(11),NACPR(11),UTSD(11)
 6         DIMENSION WGTFAC(16),ENVTAG(11,16),ENWTAG(11,16),TOENAG(11)
 7         INTEGER ECONLF,THOVER,ACUSE,TRECLF,WGTFAC,ENVTAG,ENWTAG,TOENAG
 8         REAL IN,NTRN,L2,INCSTR,K2,INT,LBIN,LS2,M2
 9         DATA TOENAG/11*0/,TOCSAC/11*0./,TOCSMA/11*0./,TOAMN/11*0./,
          1     TOAMP/11*0./,TOAMK/11*0./,TOCSHB/11*0./,TOHRTR/11*0./,
          2     TOCSIN/11*0./,TOCSDY/11*0./,TORN/11*0./
10         CHARACTER*20 NABMP,NAMACH,NACPS,SIZE,NACPF,NACPP,NACPD,NACPR
      C    R2     RAINFALL FACTOR IN EROSION INDEX UNITS PER ACRE
      C    K2     SOIL ERODIBILITY FACTOR
      C    L2     LENGTH OF SLOPE
      C    S2     GROUND SLOPE
      C    C2     CROPPING-MANAGEMENT FACTOR
      C    P2     CONSERVATION PRACTICE FACTOR
      C    DSSL   DEPLETION TIME OF SURFACE SOIL LAYER
      C    NBMP   NUMBER OF BEST MANAGEMENT PRACTICE
      C    NCPS   NUMBER OF CROPS FOR SEEDING
      C    NCPF   NUMBER OF CROPS NEED FERTILIZER
      C    NCPP   NUMBER OF CROPS NEED PESTICIDE
      C    NCPD   NUMBER OF CROPS NEED DRYING
      C    NCPR   NUMBER OF CROPS AND CATTLES FOR REVENUE
      C    TRLT   TOLERANCE LIMIT OF SOIL
      C    PTSS   POTENCY FACTOR OF SUSPENDED SOLID TO SEDIMENT
      C    PTBOD  POTENCY FACTOR OF BOD TO SEDIMENT
      C    PTCOD  POTENCY FACTOR OF COD TO SEDIMENT
      C    PERCFP PERCENT OF CROPLAND TO THE TOTAL CROPLAND OWNED
      C    DSSL   DEPTH OF SURFACE SOIL LAYER, INCH
      C    NABMP  NAME OF EACH BEST MANAGEMENT PRACTICE
      C    CP     CROPPING-MANAGEMENT AND CONSERVATION PRACTICE FACTOR
      C    X3     VARIABLE FROM 0.4 TO 0.8
      C    Y      VARIABLE FROM 1.0 TO 2.0
      C    CSCNFT CONSTRUCTION COST PER FOOT TERRACE
      C    IN     INTEREST RATE
      C    CSMNFT MAINTENANCE COST/FOOT
      C    ACR2   ACREAGE OF COVERED LAND
      C    CSLB   COST OF LABOR PER HOUR
      C    GS     PERCENT OF GOVERNMENT SUBSIDY,%
      C    NYR    NUMBER OF FINANCE YEAR
      C    NMACH  NUMBER OF MACHINE USED
```

```
C      NAMACH NAME OF MACHINE USED
C      SIZE   SIZE OF MACHINE USED
C      ECONLF ECONOMIC LIFE IN YEAR
C      TMOVER TIMES OVER OF MACHINE WORK
C      INCS   INITIAL COST OF MACHINE
C      SAVA   SALVAGE VALUE OF MACHINE IN %
C      HRPAC  HOURS PER ACRE OF MACHINE WORK
C      ACUSE  ACRES USED BY MACHINE
C      RPCS   REPAIR COST PER 100 HOURS
C      INCSTR TRACTOR INITIAL COST
C      TRECLF TRACTOR ECONOMIC LIFE IN YEAR
C      TRSAVA TRACTOR SALVAGE VALUE IN %
C      FUCSHR FUEL COST PER TRACTOR HOUR
C      FUCSCM FUEL COST PER COMBINE HOUR
C      TOHRCM TOTAL COMBINE HOURS
C      NACPS  NAME OF CROPS FOR SEEDING INVOLVED
C      AMSD   AMOUNT OF SEED USED FOR EACH BMP
C      USSD   UNIT COST OF SEED FOR EACH BMP
C      NSD    NUMBER OF SEEDS USED FOR EACH BMP
C      NACPF  NAMES OF CROPS NEED FERTILIZER
C      AMNFR  AMOUNT OF NITROGEN APPLIED, IN LBS/AC
C      AMPFR  AMOUNT OF P2O5 APPLIED, IN LBS/AC
C      AMKFR  AMOUNT OF K2O APPLIED, IN LBS/AC
C      CSFRN  COST OF NITROGEN PER ACRE
C      CSFRP  COST OF P2O5 PER ACRE
C      CSFRK  COST OF K2O PER ACRE
C      RNNFN  RENTAL FOR NH3 KNIFE
C      RNSP   RENTAL FOR 4-TON BULK SPREADER
C      NCROP  NUMBER OF CROPS FOR EACH PRACTICE
C      NACPP  NAMES OF CROPS NEED PESTICIDE
C      CSHBAC COST OF HERBICIDE PER ACRE
C      CSINAC COST OF INSECTICIDE PER ACRE
C      NACPD  NAMES OF CROPS NEED DRYING
C      NACPR  NAMES OF CROPS AND CATTLES FOR REVENUE
C      EPYD   EXPECTED CROP YIELD PER ACRE
C      ACCP   ACRES FOR EACH CROP
C      UTCPYD UNIT FOR EACH CROP YIELD
C      CSDY   DRYING COST FOR EACH CROP
C      EPPR   EXPECTED PRICE PER UNIT OF CROP
C      IDENTR : IDENTIFING IF TERRACE COST INCLUDED, 0 = NOT NEEDED;
C               1 = NEEDED.
C      YRPLAN PLANNING YEARS FOR EACH PRACTICE
C      WGTFAT : WEIGHTING FACTOR FOR EIA
C      ENVTAG : EIA EVALUATION FOR BMPS
C
C
C      SOIL LOSS
C
       READ (5,401) R2,K2,L2,S2,C2,P2,DSSL
       THETA=ATAN(S2)
       X2=SIN(THETA)
       IF (S2.GE.0.05) GO TO 136
       IF (S2.LE.0.03) GO TO 137
       M2=0.4
       GO TO 138
   136 M2=0.5
       GO TO 138
   137 M2=0.3
   138 LS2=((L2/72.6)**M2)*(((430.*X2*X2)+(30.*X2)+0.43)/6.57*15)
       SLLS2=R2*K2*LS2*C2*P2
```

```
      READ (5,403) NBMP,NMACH,NCPS,NCPF,NCPP,NCPD,NCPR
      READ (5,401) TRLT,ACR2,PTSS,PTBOD,PTCOD,PERCRP
      READ (5,405) (NABMP(I),I=1,NBMP)
      READ (5,401) (CP(I),I=1,NBMP)
      IF (SLLS2.LE.TRLT) GO TO 155
      SDY=DSSL/((SLLS2-TRLT)/201.)
C
C     CALCULATE REMOVAL EFFICIENCY
C
  155 DO 101 I=1,NBMP
      CTP=C2*P2
  101 REMEFF(I)=(CTP-CP(I))/CTP*100.
      WRITE(6,701) R2,K2,L2,S2,C2,P2,LS2,SLLS2,TRLT,DSSL,SDY
      WRITE (6,702) (NABMP(I),I=1,NBMP)
      WRITE (6,799) (CP(I),I=1,NBMP)
      WRITE (6,800) (REMEFF(I),I=1,NBMP)
      WRITE (6,792)
C
C     WATER QUALITY
C
      IF (ACR2.LE.320.) GO TO 139
      IF (ACR2.LE.640.) GO TO 140
      IF (ACR2.LE.3200.) GO TO 141
      IF (ACR2.LE.6400.) GO TO 142
      IF (ACR2.LE.32000.) GO TO 143
      IF (ACR2.LE.64000.) GO TO 144
      GO TO 145
  139 SDDER2=0.33
      GO TO 146
  140 SDDER2=0.3
      GO TO 146
  141 SDDER2=0.22
      GO TO 146
  142 SDDER2=0.18
      GO TO 146
  143 SDDER2=0.12
      GO TO 146
  144 SDDER2=0.1
      GO TO 146
  145 SDDER2=0.08
  146 WRITE (6,797) SDDER2,PTSS,PTBOD,PTCOD
      DO 147 I=1,NBMP
      SDMENT(I)=SLLS2*CP(I)/CTP*SDDER2
      SS(I)=PTSS*SDMENT(I)*2000.
      BOD(I)=PTBOD*SDMENT(I)*2000.
  147 COD(I)=PTCOD*SDMENT(I)*2000.
      WRITE (6,798) (NABMP(I),I=1,NBMP)
      WRITE (6,801) (SDMENT(I),I=1,NBMP)
      WRITE (6,802) (SS(I),I=1,NBMP)
      WRITE (6,803) (BOD(I),I=1,NBMP)
      WRITE (6,804) (COD(I),I=1,NBMP)
C
C
C     TERRACE COSTS
C
      READ (5,408) X3,Y,CSCNFT,IN,CSMNFT,CSLB,GS
      READ (5,403) NYR
      TRSP=X3*100.+(Y/S2)
      NOTR=L2/TRSP
      FTTRAC=43560.*NOTR/L2
```

```
      CSCNAC=CSCNFT*FTTRAC
      PRCSCN=CSCNAC*IN/(1.-(1./((1.+IN)**NYR)))
      CSMNAC=CSMNFT*ACR2
      CSTRYR=PRCSCN+CSMNAC
      TACSTR=CSTRYR*ACR2
      FRSR=((100.-GS)/100.)*TACSTR
      WRITE(6,703) TRSP,L2,NOTR,FTTRAC,CSCNFT,CSCNAC,PRCSCN,CSMNFT,
     1CSMNAC,CSTRYR,TACSTR,GS,FRSR
C
C
C     MACHINERY FIXED COSTS
C
      DO 102 I=1,NBMP
      READ (5,404) (NAMACH(I,J),J=1,NMACH)
      READ (5,404) (SIZE(I,J),J=1,NMACH)
      READ (5,403) (ECONLF(I,J),J=1,NMACH)
      READ (5,403) (TMOVER(I,J),J=1,NMACH)
      READ (5,403) (INCS(I,J),J=1,NMACH)
      READ (5,402) (SAVA(I,J),J=1,NMACH)
      READ (5,402) (HRPAC(I,J),J=1,NMACH)
      READ (5,403) (ACUSE(I,J),J=1,NMACH)
      READ (5,402) (RPCS(I,J),J=1,NMACH)
      DO 103 J=1,NMACH
      IF (ECONLF(I,J) .EQ. 0) GO TO 102
      YRDEPR(I,J)=INCS(I,J)*(100.-SAVA(I,J))/ECONLF(I,J)/100.
      TXINHO(I,J)=0.028*(INCS(I,J)*(100.+SAVA(I,J))/100.)/2.
      INT(I,J)=INCS(I,J)*(100.+SAVA(I,J))/2.*IN/100.
      FXCS(I,J)=(YRDEPR(I,J)+TXINHO(I,J)+INT(I,J))*PERCRP/100.
      TOHR(I,J)=HRPAC(I,J)*ACUSE(I,J)*TMOVER(I,J)
      TOHRTR(I)=TOHRTR(I)+TOHR(I,J)
      TOCSRP(I,J)=RPCS(I,J)*TOHR(I,J)/100.
      TOCS(I,J)=FXCS(I,J)+TOCSRP(I,J)
  103 TOCSMA(I)=TOCSMA(I)+TOCS(I,J)
  102 CONTINUE
      WRITE (6,704) PERCRP
      DO 104 I=1,NBMP
      WRITE (6,705) NABMP(I)
      DO 105 J=1,NMACH
      IF (ECONLF(I,J) .EQ. 0) GO TO 105
      WRITE (6,706) NAMACH(I,J),SIZE(I,J),INCS(I,J),SAVA(I,J),ECONLF(I,J
     1),YRDEPR(I,J),TXINHO(I,J),INT(I,J),FXCS(I,J)
  105 CONTINUE
  104 CONTINUE
C
C
C     MACHINERY COST
C
      WRITE(6,707)
      DO 106 I=1,NBMP
      WRITE (6,705) NABMP(I)
      DO 107 J=1,NMACH
      IF (HRPAC(I,J) .EQ. 0.) GO TO 107
      WRITE (6,708) NAMACH(I,J),HRPAC(I,J),ACUSE(I,J),TMOVER(I,J),TOHR(I
     1,J),RPCS(I,J),TOCSRP(I,J),FXCS(I,J),TOCS(I,J)
  107 CONTINUE
  106 WRITE (6,709) TOCSMA(I)
C
C
C     TRACTOR COST
C
```

```
      READ (5,402) INCSTR
      READ (5,403) (TRECLF(I),I=1,NBMP)
      READ (5,402) (TRSAVA(I),I=1,NBMP)
      PRCSTR=INCSTR*PERCRP/100.
      DO 108 I=1,NBMP
      TRHRAC(I)=TOHRTR(I)/ACR2+0.2
      TOHRTR(I)=1.1*TRHRAC(I)*ACR2
      YRDPTR(I)=PRCSTR*(1.-TRSAVA(I)/100.)/TRECLF(I)
      TXTR(I)=.05*PRCSTR
      YRINTR(I)=PRCSTR*(1.+TRSAVA(I)/100.)/2.*IN
      FXCSTR(I)=YRDPTR(I)+TXTR(I)+YRINTR(I)
      RPCSTR(I)=PRCSTR*.008/100.*TOHRTR(I)
  108 TOCSTR(I)=FXCSTR(I)+RPCSTR(I)
      WRITE (6,710) (NABMP(I),I=1,NBMP)
      WRITE (6,711) (TRHRAC(I),I=1,NBMP)
      WRITE (6,712) (TOHRTR(I),I=1,NBMP)
      WRITE (6,713) PRCSTR,PERCRP,(TRECLF(I),I=1,NBMP)
      WRITE (6,714) (TRSAVA(I),I=1,NBMP)
      WRITE (6,715) (YRDPTR(I),I=1,NBMP)
      WRITE (6,716) (TXTR(I),I=1,NBMP)
      WRITE (6,717) (YRINTR(I),I=1,NBMP)
      WRITE (6,718) (FXCSTR(I),I=1,NBMP)
      WRITE (6,719) (RPCSTR(I),I=1,NBMP)
      WRITE (6,720) (TOCSTR(I),I=1,NBMP)
C
C
C     FUEL COSTS
C
      READ (5,401) FUCSHR,FUCSCM
      READ (5,402) (TOHRCM(I),I=1,NBMP)
      DO 109 I=1,NBMP
      TRFUCS(I)=TOHRTR(I)*FUCSHR
      CMFUCS(I)=FUCSCM*TOHRCM(I)
  109 TOCSFU(I)=TRFUCS(I)+CMFUCS(I)
      WRITE (6,721) (NABMP(I),I=1,NBMP)
      WRITE (6,722) (TOHRTR(I),I=1,NBMP)
      WRITE (6,723) FUCSHR,(TRFUCS(I),I=1,NBMP)
      WRITE (6,724) (TOHRCM(I),I=1,NBMP)
      WRITE (6,725) FUCSCM,(CMFUCS(I),I=1,NBMP)
      WRITE (6,726) (TOCSFU(I),I=1,NBMP)
C
C
C     SEED COST
C
      READ (5,404) (NACPS(J),J=1,NCPS)
      READ (5,407) (UTSD(J),J=1,NCPS)
      DO 110 J=1,NCPS
  110 READ (5,402) (AMSD(I,J),I=1,NBMP)
      READ (5,402) (USSD(J),J=1,NCPS)
      READ (5,403) (NSD(I),I=1,NBMP)
      DO 111 I=1,NBMP
      DO 112 J=1,NCPS
      CSSD(I,J)=USSD(J)*AMSD(I,J)
  112 TOCSAC(I)=TOCSAC(I)+CSSD(I,J)
      AVCSSD(I)=TOCSAC(I)/NSD(I)
  111 TOCSSD(I)=AVCSSD(I)*ACR2
      AVCSSD(3)=(CSSD(3,1)*NSD(3)+CSSD(3,2)+CSSD(3,3))/5.
      TOCSSD(3)=AVCSSD(3)*ACR2
      WRITE (6,727) (NABMP(I),I=1,NBMP)
      DO 113 J=1,NCPS
```

```
      WRITE (6,728) NACPS(J)
      WRITE (6,791) UTSD(J),(AMSD(I,J),I=1,NBMP)
      WRITE (6,729) USSD(J)
  113 WRITE (6,730) (CSSD(I,J),I=1,NBMP)
      WRITE (6,731) (AVCSSD(I),I=1,NBMP)
      WRITE (6,732) (TOCSSD(I),I=1,NBMP)
C
C     FERTILIZER COST
C
C
      READ (5,404) (NACPF(J),J=1,NCPF)
      DO 114 J=1,NCPF
      READ (5,402) (AMNFR(I,J),I=1,NBMP)
      READ (5,402) (AMPFR(I,J),I=1,NBMP)
  114 READ (5,402) (AMKFR(I,J),I=1,NBMP)
      READ (5,402) CSFRN,CSFRP,CSFRK,RNNFN,RNSP
      READ (5,403) (NCROP(I),I=1,NBMP)
      DO 115 I=1,NBMP
      DO 116 J=1,NCPF
      TOAMN(I)=TOAMN(I)+AMNFR(I,J)
      TOAMP(I)=TOAMP(I)+AMPFR(I,J)
  116 TOAMK(I)=TOAMK(I)+AMKFR(I,J)
      AVAMN(I)=TOAMN(I)/NCROP(I)
      AVAMP(I)=TOAMP(I)/NCROP(I)
      AVAMK(I)=TOAMK(I)/NCROP(I)
      CSFRAC(I)=(AVAMN(I)*CSFRN)+(AVAMP(I)*CSFRP)+(AVAMK(I)*CSFRK)
      TOCSFR(I)=CSFRAC(I)*ACR2
      IF (TOCSFR(I).EQ.0.) GO TO 150
      REEQ(I)=(RNNFN+RNSP)*ACR2
      GO TO 115
  150 REEQ(I)=0.
  115 TOFRCS(I)=TOCSFR(I)+REEQ(I)
      AVAMN(3)=(AMNFR(3,1)*NCROP(3)+AMNFR(3,2))/5.
      AVAMP(3)=(AMPFR(3,1)*NCROP(3)+AMPFR(3,2))/5.
      AVAMK(3)=(AMKFR(3,1)*NCROP(3)+AMKFR(3,2))/5.
      CSFRAC(3)=(AVAMN(3)*CSFRN)+(AVAMP(3)*CSFRP)+(AVAMK(3)*CSFRK)
      TOCSFR(3)=CSFRAC(3)*ACR2
      WRITE (6,733) (NABMP(I),I=1,NBMP)
      DO 117 J=1,NCPF
      WRITE (6,728) NACPF(J)
      WRITE (6,735) (AMNFR(I,J),I=1,NBMP)
      WRITE (6,736) (AMPFR(I,J),I=1,NBMP)
  117 WRITE (6,737) (AMKFR(I,J),I=1,NBMP)
      WRITE (6,738) (AVAMN(I),I=1,NBMP)
      WRITE (6,739) (AVAMP(I),I=1,NBMP)
      WRITE (6,740) (AVAMK(I),I=1,NBMP)
      WRITE (6,741) (CSFRAC(I),I=1,NBMP)
      WRITE (6,742) (TOCSFR(I),I=1,NBMP)
      WRITE (6,743) (REEQ(I),I=1,NBMP)
      WRITE (6,744) (TOFRCS(I),I=1,NBMP)
C
C     PESTICIDE COST
C
C
      READ (5,404) (NACPP(J),J=1,NCPP)
      DO 118 J=1,NCPP
      READ (5,402) (CSHBAC(I,J),I=1,NBMP)
  118 READ (5,402) (CSINAC(I,J),I=1,NBMP)
      DO 152 I=1,11
      TOCSHB(I)=0.0
```

```
      TOCSIN(I)=0.0
  152 CONTINUE
      DO 119 I=1,NBMP
      DO 120 J=1,NCPP
      TOCSHB(I)=TOCSHB(I)+CSHBAC(I,J)
  120 TOCSIN(I)=TOCSIN(I)+CSINAC(I,J)
      AVCSHB(I)=TOCSHB(I)/NCRUP(I)
      AVCSIN(I)=TOCSIN(I)/NCRCP(I)
      TOCSPS(I)=AVCSHB(I)+AVCSIN(I)
  119 TOPSCS(I)=TOCSPS(I)*ACR2
      AVCSHB(3)=(CSHBAC(3,1)*NCRCP(3))/5.
      AVCSIN(3)=(CSINAC(3,1)*NCROP(3))/5.
      TOCSPS(3)=AVCSHB(3)+AVCSIN(3)
      TOPSCS(3)=TOCSPS(3)*ACR2
      WRITE (6,745) (NABMP(I),I=1,NBMP)
      DO 121 J=1,NCPP
      WRITE (6,728) NACPP(J)
      WRITE (6,746) (CSHBAC(I,J),I=1,NBMP)
  121 WRITE (6,747) (CSINAC(I,J),I=1,NBMP)
      WRITE (6,748) (AVCSHB(I),I=1,NBMP)
      WRITE (6,749) (AVCSIN(I),I=1,NBMP)
      WRITE (6,750) (TOCSPS(I),I=1,NBMP)
      WRITE (6,751) ACR2,(TOPSCS(I),I=1,NBMP)
C
C     LABOR COST
C
C
      DO 122 I=1,NBMP
      TODTLB(I)=TOHRTR(I)+TOHRCM(I)
      OVHD(I)=TODTLB(I)*0.3
      TOLB(I)=TODTLB(I)+OVHD(I)
  122 TOCSLB(I)=TOLB(I)*CSLB
      WRITE (6,752) (NABMP(I),I=1,NBMP)
      WRITE (6,753) (TODTLB(I),I=1,NBMP)
      WRITE (6,754) (OVHD(I),I=1,NBMP)
      WRITE (6,755) (TOLB(I),I=1,NBMP)
      WRITE (6,756) CSLB
      WRITE (6,757) (TOCSLB(I),I=1,NBMP)
C
C     DRYING COST
C
C
      IF (NCPD.EQ.0) GO TO 149
      READ (5,404) (NACPD(J),J=1,NCPD)
  149 DO 123 J=1,NCPR
      READ (5,402) (EPYD(I,J),I=1,NBMP)
  123 READ (5,402) (ACCP(I,J),I=1,NBMP)
      READ (5,407) (UTCPYD(J),J=1,NCPR)
      IF (NCPD.EQ.0) GO TO 151
      READ (5,402) (CSDY(J),J=1,NCPD)
      DO 124 I=1,NBMP
      DO 125 J=1,NCPD
      CPHV(I,J)=EPYD(I,J)*ACCP(I,J)
      DYCS(I,J)=CPHV(I,J)*CSDY(J)
  125 TOCSDY(I)=TOCSDY(I)+DYCS(I,J)
  124 CONTINUE
      WRITE (6,758) (NABMP(I),I=1,NBMP)
      DO 133 J=1,NCPD
      WRITE (6,759) NACPD(J),UTCPYD(J),(CPHV(I,J),I=1,NBMP)
      WRITE (6,760) CSDY(J)
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  133 WRITE (6,761) (DYCS(I,J),I=1,NBMP)
      WRITE (6,762) (TOCSDY(I),I=1,NBMP)
C
C     INTEREST COST
C
C
  151 DO 126 I=1,NBMP
      FRIN(I)=TOFRCS(I)*IN*.667
      SDIN(I)=TOCSSD(I)*IN*.667
      PSIN(I)=TOPSCS(I)*IN*.5
      FUIN(I)=TOCSFU(I)*IN*.25
      LBIN(I)=TOCSLB(I)*IN*.25
  126 TOCSIN(I)=FRIN(I)+SDIN(I)+PSIN(I)+FUIN(I)+LBIN(I)
      WRITE (6,763) (NABMP(I),I=1,NBMP)
      WRITE (6,764) (FRIN(I),I=1,NBMP)
      WRITE (6,765) (SDIN(I),I=1,NBMP)
      WRITE (6,766) (PSIN(I),I=1,NBMP)
      WRITE (6,767) (FUIN(I),I=1,NBMP)
      WRITE (6,768) (LBIN(I),I=1,NBMP)
      WRITE (6,769) (TOCSIN(I),I=1,NBMP)
C
C     REVENUE
C
C
      READ (5,404) (NACPR(J),J=1,NCPR)
      READ (5,402) (EPPR(J),J=1,NCPR)
      DO 153 I=1,11
  153 TORN(I)=0.0
      DO 127 I=1,NBMP
      DO 128 J=1,NCPR
      CPHV(I,J)=EPYD(I,J)*ACCP(I,J)
      GRRN(I,J)=EPPR(J)*CPHV(I,J)
  128 TORN(I)=TORN(I)+GRRN(I,J)
  127 CONTINUE
      WRITE (6,770) (NABMP(I),I=1,NBMP)
      DO 129 J=1,NCPR
      WRITE (6,771) NACPR(J),UTCPYD(J),(EPYD(I,J),I=1,NBMP)
      WRITE (6,772) (ACCP(I,J),I=1,NBMP)
      WRITE (6,773) UTCPYD(J),(CPHV(I,J),I=1,NBMP)
      WRITE (6,774) UTCPYD(J),EPPR(J)
  129 WRITE (6,775) (GRRN(I,J),I=1,NBMP)
      WRITE (6,776) (TORN(I),I=1,NBMP)
C
C     SUMMARY
C
C
      READ (5,406) (IDENTR(I),I=1,NBMP)
      READ (5,402) (YRPLAN(I),I=1,NBMP)
      DO 130 I=1,NBMP
      IF (IDENTR(I).EQ.1) GO TO 135
      TACS(I)=FRSR
      GO TO 148
  135 TACS(I)=0.
  148 TOCOST(I)=TOCSTR(I)+TOCSMA(I)+TOCSFU(I)+TOCSSD(I)+TOFRCS(I)+TOPSCS
     1(I)+TOCSLB(I)+TOCSDY(I)+TOCSIN(I)+TACS(I)
      TOPLCS(I)=TOCOST(I)/YRPLAN(I)
  130 NTRN(I)=TORN(I)-TOPLCS(I)
      WRITE (6,777) (NABMP(I),I=1,NBMP)
      WRITE (6,778) (TORN(I),I=1,NBMP)
      WRITE (6,779) (TOCSTR(I),I=1,NBMP)
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      WRITE (6,780) (TOCSMA(I),I=1,NBMP)
      WRITE (6,781) (TOCSFU(I),I=1,NBMP)
      WRITE (6,782) (TOCSSD(I),I=1,NBMP)
      WRITE (6,783) (TOFRCS(I),I=1,NBMP)
      WRITE (6,784) (TOPSCS(I),I=1,NBMP)
      WRITE (6,785) (TOCSLB(I),I=1,NBMP)
      WRITE (6,786) (TOCSDY(I),I=1,NBMP)
      WRITE (6,787) (TOCSIN(I),I=1,NBMP)
      WRITE (6,788) (TACS(I),I=1,NBMP)
      WRITE (6,789) (TOCOST(I),I=1,NBMP)
      WRITE (6,805)(YRPLAN(I),I=1,NBMP)
      WRITE (6,806)  (TOPLCS(I),I=1,NBMP)
      WRITE (6,790) (NTRN(I),I=1,NBMP)
C
C     ENVIRONMENTAL IMPACT STATEMENT
C
      READ (5,406) (WGTFAC(IW),IW=1,14)
      DO 154 I=1,11
  154 TOENAG(I)=0
      DO 131 I=1,NBMP
      READ (5,406) (ENVTAG(I,IW),IW=1,14)
      DO 132 IW=1,14
      ENWTAG(I,IW)=ENVTAG(I,IW)*WGTFAC(IW)
  132 TOENAG(I)=TOENAG(I)+ENWTAG(I,IW)
  131 CONTINUE
      WRITE (6,793)
      WRITE (6,794) (WGTFAC(IW),IW=1,14)
      DO 134 I=1,NBMP
  134 WRITE (6,795) NABMP(I),(ENVTAG(I,IW),IW=1,14),(ENWTAG(I,IW),IW=1,1
     14),TOENAG(I)
      WRITE (6,796)
C
  401 FORMAT(8F10.4)
  402 FORMAT(8F10.2)
  403 FORMAT(8I10)
  404 FORMAT(4(A20))
  405 FORMAT(8(A10))
  406 FORMAT(14I3)
  407 FORMAT(8(A3,7X))
  408 FORMAT(8F10.5)
  701 FORMAT(1H1,50X,'ANNUAL SOIL LOSS ESTIMATE',///,35X,'R',9X,'K',9X,
     1'L',9X,'S',9X,'C',9X,'P',9X,'LS',//,31X,7(1X,F8.3,1X),///,50X,
     2'ANNUAL SOIL LOSS = ',F10.2,' T/AC/YR',///,50X,'TOLERANCE LIMIT= '
     3,F10.2,' T/AC/YR',///,30X,'DEPTH OF SURFACE SOIL LAYER=',
     4F4.1,' INCH',4X,'SOIL DEPLETION YEAR= ',F6.1,' YR')
  702 FORMAT(5(/),55X,'REMOVAL EFFICIENCY',///,20X,8(A10))
  703 FORMAT(1H1,45X,'TERRACE CONSTRUCTION AND MAINTENANCE COSTS',///,
     158X,'ITEM',25X,'AMOUNT',//,35X,'TERRACE SPACING, FT',31X,F10.2,//,
     235X,'SLOPE LENGTH, FT',34X,F10.2,//,35X,'NUMBER OF TERRACES PER SL
     3OPE',22X, I10,//,35X,'FEET TERRACE/ACRE',33X,F10.2,//,35X,'CONSTR
     4UCTION COST/FOOT TERRACE, $',17X,F10.2,//,35X,'CONSTRUCTION COST/A
     5CRE, $',25X,F10.2,//,35X,'PRORATED CONSTRUCTION COST, $',21X,F10.2
     6,//,35X,'MAINTENANCE COST, FT, $',26X,F10.5,//,35X,'MAINTENANCE CO
     7ST, ACRE, $',25X,F10.2,//,35X,'YEARLY TERRACE CHARGE/ACRE, $',21X,
     8F10.2,//,35X,'TOTAL YEARLY TERRACE CHARGE, $',20X,F10.2,
     9//,35X,'GOVERNMENT SUBSIDY, X',29X,F10.2,//,35X,'FARMER SHARE, $',
     135X,F10.2)
  704 FORMAT(1H1,50X,'MACHINERY FIXED COST',//, 6X,'MACHINE',15X,'SIZE',
     113X,'INIT COST',1X,'SAL VALUE',1X,'ECON LIFE',2X,'YR DEPR',2X,'TX
     2INS HOU',1X,'INTEREST',1X,'YR FIX CS',/,105X,'(X',F5.1,'X)',/,
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     344X,'$',10X,'%',10X,'YR',9X,4('$',10X))
 705 FORMAT(//,55X,A10)
 706 FORMAT(/,1X,2(A20),1X,  I8,2X,F8.1,2X,I8,4(2X,F8.2))
 707 FORMAT(1H1,55X,'MACHINERY COSTS',///,15X,'IMPLEMENT', 9X,'HR/AC',3
    1X,'AC OF USE',1X,'TIMES OVER',2X,'TOTAL',2X,'REPAIR COST',2X,'TOTA
    2L',5X,'YEARLY',4X,'TOTAL',/,64X,'HR',3X,'PER 100 HR',1X,'REPAIR CO
    3ST',1X,'FIXED COST',2X,'COST',/,74X,'$',3(10X,'$'))
 708 FORMAT(/,10X,A20,1X,F8.2,2X,  I8,2X,I8,2X,F8.1,4(2X,F8.2))
 709 FORMAT(/,10X,'TOTAL',95X,F8.2)
 710 FORMAT(1H1,60X,'TRACTOR COSTS',///,8X,'ITEM',10X,11(A10))
 711 FORMAT(//,1X,'TRACTOR HRS/ACRE',3X,11(1X,F8.2,1X))
 712 FORMAT(/,1X,'TOTAL TRACTOR HRS',2X,11(1X,F8.2,1X))
 713 FORMAT(/,1X,'TR INITIAL COST, $',23X,'- ',F8.2,' -',/,1X,'(X',
    1F5.1,'%)',//,1X,'ECONOMIC LIFE, YR',2X,11(1X,I8,1X))
 714 FORMAT(/,1X,'SALVAGE VALUE, %',3X,11(1X,F8.1,1X))
 715 FORMAT(/,1X,'YR DEPRECIATION, $',1X,11(1X,F8.2,1X))
 716 FORMAT(/,1X,'TX, INSR & HOUSE, $',11(1X,F8.2,1X))
 717 FORMAT(/,1X,'AVG YR INTEREST, $',1X,11(1X,F8.2,1X))
 718 FORMAT(/,1X,'TOT FIXED COST, $',2X,11(1X,F8.2,1X))
 719 FORMAT(/,1X,'REPAIR COST, $',5X,11(1X,F8.2,1X))
 720 FORMAT(/,1X,'TOT TRACTOR COST, $',11(1X,F8.2,1X))
 721 FORMAT(1H1,60X,'FUEL COSTS',///,10X,'ITEM',8X,11(A10))
 722 FORMAT(//,1X,'TOT TRACTOR HRS',4X,11(1X,F8.2,1X))
 723 FORMAT(/,1X,'FUEL COST/TRAC. HR, $',23X,'- ',F8.3,' -',/,1X,'TRAC.
    1 FUEL COST, $',1X,11(1X,F8.2,1X))
 724 FORMAT(/,1X,'TOT COMBINE HRS',4X,11(1X,F8.3,1X))
 725 FORMAT(/,1X,'FUEL CS/COMB HR, $',25X,'- ',F8.3,' -',/,1X,'COMBINE
    1FUEL CS, $',1X,11(1X,F8.2,1X))
 726 FORMAT(/,1X,'TOT FUEL COST, $',3X,11(1X,F8.2,1X))
 727 FORMAT(1H1,60X,'SEED COSTS',///,8X,'ITEM',12X,11(A10))
 728 FORMAT(//,1X,A20)
 729 FORMAT(/,1X,'SEED UNIT COST, $',21X,'- ',F8.2,' -')
 730 FORMAT(/,1X,'SEED COST, $/AC',4X,11(1X,F8.2,1X))
 731 FORMAT(//,1X,'AVE SD COST, $/AC',2X,11(1X,F8.2,1X))
 732 FORMAT(/,1X,'TOT SD COST, $',5X,11(1X,F8.1,1X))
 733 FORMAT(1H1,58X,'FERTILIZER COSTS',//,8X,'ITEM',11X,11(A10))
 735 FORMAT(//,2X,'N,LB/AC',11X,11(1X,F8.1,1X))
 736 FORMAT(/,2X,'P2O5,LB/AC',8X,11(1X,F8.1,1X))
 737 FORMAT(/,2X,'K2O,LB/AC',9X,11(1X,F8.1,1X))
 738 FORMAT(//,1X,'AVERAGE AMOUNT',//,2X,'N,LB/AC',11X,11(1X,F8.1,1X))
 739 FORMAT(/,2X,'P2O5,LB/AC',9X,11(1X,F8.1,1X))
 740 FORMAT(/,2X,'K2O,LB/AC',9X,11(1X,F8.1,1X))
 741 FORMAT(//,1X,'COST OF FERT./AC,$',2X,11(1X,F8.1,1X))
 742 FORMAT(/,1X,'TOT. COST OF FERT.,$',11(1X,F8.2,1X))
 743 FORMAT(/,1X,'RENTAL OF EQUIP.,$',2X,11(1X,F8.2,1X))
 744 FORMAT(/,1X,'TOTAL FERT. COST,$',2X,11(1X,F8.2,1X))
 745 FORMAT(1H1,//,58X,'PESTICIDES COSTS',//,8X,'ITEM',11X,11(A10))
 746 FORMAT(//,4X,'HERBICIDE,$',5X,11(1X,F8.2,1X))
 747 FORMAT(/,3X,'INSECTICIDE,$',4X,11(1X,F8.2,1X))
 748 FORMAT(//,1X,'AVERAGE AMOUNT',//,2X,'HERBICIDE,$',9X,11(1X,F8.2,1X
    1))
 749 FORMAT(/,2X,'INSECTICIDE,$',7X,11(1X,F8.2,1X))
 750 FORMAT(//,1X,'TOT. PEST. COST, $/AC',11(1X,F8.2,1X))
 751 FORMAT(/,1X,'TOT. PEST. COST, $',/,1X,'(X ',F4.0,' AC)',9X,11(1X,F
    18.2,1X))
 752 FORMAT(1H1,//,60X,'LABOR COSTS',//,8X,'ITEM',11X,11(A10))
 753 FORMAT(//,1X,'TOT. DIRECT LABOR,HR',11(1X,F8.2,1X))
 754 FORMAT(/,1X,'OVERHEAD(30%), HR',3X,11(1X,F8.2,1X))
 755 FORMAT(/,1X,'TOTAL LABOR, HR',5X,11(1X,F8.2,1X))
 756 FORMAT(/,1X,'COST PER HOUR, $',37X,'-',F4.2,'-')
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757 FORMAT(/,1X,'TOTAL LABOR COST, $',1X,11(1X,F8.2,1X))
758 FORMAT(1H1,//,34X,'DRYING COSTS',//,8X,'ITEM',10X,11(A10))
759 FORMAT(//,1X,A20,/,2X,'GRAN HARV., ',A3,2X,11(1X,F8.2,1X))
760 FORMAT(/,2X,'COST PER UNIT, $',29X,'-',F4.2,'-')
761 FORMAT(/,2X,'TOTAL COST, $',5X,11(1X,F8.2,1X))
762 FORMAT(//,1X,'TOT. DRY. COST. $',3X,11(1X,F8.2,1X))
763 FORMAT(1H1,//,50X,'INTEREST ON OPERATING CAPITAL',//,8X,'ITEM',8X,
   111(A10))
764 FORMAT(/,2X,'FERTILIZER(8 MO)',2X,11(1X,F8.2,1X))
765 FORMAT(/,2X,'SEED(8 MO)',8X,11(1X,F8.2,1X))
766 FORMAT(/,2X,'PESTICIDE(6 MC)',3X,11(1X,F8.2,1X))
767 FORMAT(/,2X,'FUEL(3 MO)',8X,11(1X,F8.2,1X))
768 FORMAT(/,2X,'LABOR(3 MO)',7X,11(1X,F8.2,1X))
769 FORMAT(/,1X,'TOTAL INTEREST',6X,11(1X,F8.2,1X))
770 FORMAT(1H1,//,55X,'REVENUE',//,8X,'ITEM',12X,11(A10))
771 FORMAT(//,1X,A20,/,2X,'EXPECT YIELC,',A3,'/AC',2X,11(1X,F8.2,1X))
772 FORMAT(/,2X,'AREA CROPPED,ACRES',2X,11(1X,F8.2,1X))
773 FCRMAT(/,2X,'TCTAL CUTPUT',A3,5X,11(1X,F8.2,1X))
774 FCRMAT(/,2X,'EXPECTED PRICE,$/',A3,27X,'-',F4.1,'-')
775 FORMAT(/,2X,'GROSS REVENUE,$',5X,11(1X,F8.1,1X))
776 FORMAT(/,1X,'TOTAL GROSS REV,$',3X,11(1X,F8.1,1X))
777 FORMAT(1H1,//,60X,'SUMMARY',//,8X,'ITEM',10X,11(A10))
778 FORMAT(//,1X,'GROSS REVENUE,$',4X,11(1X,F8.1,1X))
779 FORMAT(//,1X, 'COSTS,$',/,2X,'TRACTCR(EXCL. FUEL)',11(F8.1,2X))
780 FORMAT(/,2X,'MACHINE(EXCL FUEL)',11(1X,F8.1,1X))
781 FORMAT(/,2X,'FUEL',14X,11(1X,F8.1,1X))
782 FORMAT(/,2X,'SEED',14X,11(1X,F8.1,1X))
783 FORMAT(/,2X,'FERTILIZER',8X,11(1X,F8.1,1X))
784 FORMAT(/,2X,'PESTICIDES',8X,11(1X,F8.1,1X))
785 FORMAT(/,2X,'LABOR',13X,11(1X,F8.1,1X))
786 FCRMAT(/,2X,'DRYING',12X,11(1X,F8.1,1X))
787 FORMAT(/,2X,'INTEREST',10X,11(1X,F8.1,1X))
788 FORMAT(/,2X,'TERRACING',10X,11(1X,F8.1,1X))
789 FCRMAT(/,2X,'TOTAL COST',8X,11(1X,F8.0,1X))
790 FORMAT(/,1X,'NET RETURN', 9X,11(1X,F8.0,1X))
791 FORMAT(/,1X,'SEED AMOUNT,',A3,'/AC',1X,11(1X,F8.2,1X))
792 FORMAT(///,7X,'C CCNV= CCRN, RESIDUE LEFT, SPRING TURN-PLOW, CONVE
   1NTIONAL',/,7X,'C NO-T=CORN, FALL SHRED, NO-TILL PLANT, 50-70% RESI
   3DUE COVER',/,7X,'CCCWM NO-T= CORN-CORN-CORN-WHEAT-MEADOW, RESIDUE
   4LEFT, NO-TILL PLANT 2ND AND 3RD CORN',/,7X,'CORN NO-T TR=CORN, FAL
   5L SHRED STALKS, NO-TILL PLANT, 30-40% RESIDUE COVER, TERRACED',
   6/,7X,'C STP TR= CORN, STRIP-TILL RCW ZCNES',/,7X,'CB TR= CORN-SOYB
   7EANS, TERRACED',/,7X,'CH= CORN-HAY ROTATION, CONTOUR',/,7X,
   8'R LAND= RANGE LAND')
793 FORMAT(1H1,51X,'ENVIRONMENTAL IMPACT ASSESMENT',///,1X,8X,'BMP',8X
   1,'S.R. O&M  L.D. W.C. NOIS P.D. W.Q. F&F  F&G  N.L. H.S. A.S. RECR
   2  P.A. ',11X,'TOTAL')
794 FORMAT(//,3X,'WEIGHING FACTOR',2X,14(1X,I3,1X),11X,I5)
795 FORMAT(//,5X,A10,5X,14(1X,I3,1X),/,20X,14(1X,I4),11X,I5)
796 FORMAT(//,1X,'S.R.=SYSTEM RELIABILITY; O&M=OPERATION AND MAINTENAN
   1CE; L.D.=LAND DISTURBED; W.C.=WATER CONSERVATION; NOIS=NOISE ANNOY
   2ANCE;',//,1X,'P.D.=POTENTIAL FOR DEVELOPMENT; W.Q.=WATER QUALITY;
   3F&F=FLORA AND FAUNA; F&G=FISHING AND GAME; AEST=AESTHETICS;',//,
   41X,'H.S.=HISTORIC SITE; A.S.=ARCHEOLOGICAL SITE; RECR=RECREATIONAL
   5; P.A.=PESTICIDE APPLICATION')
797 FORMAT(////,40X,'SEDIMENT DELIVERY RATIO = ',F10.3,//,40X,
   1'POTENCY FACTOR : SS= ',F10.3,  ' OF SEDIMENT',/,57X,'OOD= ',F10.3
   2,  ' OF SEDIMENT',/,57X,'CCD= ',F10.3,  ' OF SEDIMENT')
798 FORMAT(///,55X,'WATER QUALITY',///,22X,8(A10))
799 FORMAT(//,9X,'CP',8X,8(1X,F8.3,1X))
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      800 FORMAT(//,7X,'R.E. %',6X,8(1X,F8.2,1X))
      801 FORMAT(//,1X,' SEDIMENT(T/AC/YR)',2X,8(F8.3,2X))
      802 FORMAT(//,4X,'SS(LB/AC/YR)',4X,8(F8.2,2X))
      803 FORMAT(//,3X,'BOD(LB/AC/YR)',4X,8(F8.2,2X))
      804 FORMAT(//,3X,'COD(LB/AC/YR)',4X,8(F8.2,2X))
      805 FORMAT(/,2X,'PLAN YR',11X,11(1X,F8.1,1X))
      806 FORMAT(/,2X,'TOTAL PLAN COST,$',1X,11(1X,F8.0,1X))
          STOP
          END

$EXEC
```

APPENDIX D

PROGRAM PRINTOUT OF "BMP2"

BMP2 Program

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      $JOB
1           DIMENSION NALNDV(10),REEFDV(10),SLLS(10),  NNDV(10),MPDV(10),
           1          NDV(10),OGLEDV(10),CHSPDV(10),BBDV(10),VELDV(10),
           2          LENGDV(10),ZDV(10),UCLNDV(10),LLDV(10),OVTDV(10),
           3          CHTDV(10),TCDV(10),I25DV(10),QDV(10),LS(10), ADV(10),
           4          YDV(10),BDV(10),TDV(10),LNADV(10),TOEXDV(10),CSEXDV(10)
2           DIMENSION CSHADV(10),CSLNDV(10),TOCSDV(10),ENWTDV(10,16),
           1          TOENDV(10),UCHADV(10),CFAADV(10),PCDDDV(10),HRDV(10),
           2               KDV(10),DVLEDV(10),DVSPDV(10),CFABDV(10),RDV(10),
           3           PDV(10),ACREDV(10),TOLTDV(10),PSSDV(10),PBDDDV(10)
3           DIMENSION CAPASB(10),SOLSSB(10),NNSB(10),LLSB(10),OVTSB(10),
           1          CHTSB(10),TCSB(10),YDDKSB(10),LENGSB(10),BBSB(10),
           2          CHSPSB(10),I25SB(10),NSB(10),CSDKSB(10),       LSSB(10),
           3          TOCSSB(10),QSB(10),SVSB(10),VOLSB(10),LFSB(10)
4           DIMENSION LEDKSB(10),ANINSB(10),UCHASB(10),UCFLSB(10),AREASB(10),
           1          DEPSB(10),VLDKSB(10),CISB(10),TESB(10),CSEXSB(10),
           2          CSHASB(10),CSFLSB(10)
5           DIMENSION      KSB(10),DVLESB(10),DVSPSB(10),CFABSB(10),RSB(10),
           1           PSB(10),ACRESB(10),TOLTSB(10),PSSSB(10),PBDDSB(10),
           2          CFAASB(10),PCDDSB(10)
6           DIMENSION SOLSRT(10),NAPPRT(10),NNRT(10),LLRT(10),OVTRT(10),
           1          CHTRT(10),TCRT(10),YDDKRT(10),LENGRT(10),BBRT(10),
           2          CHSPRT(10),I25RT(10),QRT(10),CSDKRT(10),       LSRT(10),
           3          SVRT(10),VOLRT(10),LFRT(10),LEDKRT(10),ANINRT(10),
           4          NRT(10)
7           DIMENSION UCHART(10),UCFLRT(10),UCPPRT(10),AREART(10),DEPRT(10)
8           DIMENSION CAPART(10),VLDKRT(10),CIRT(10),TERT(10),CSEXRT(10),
           1          CSHART(10),CSFLRT(10),CSPPRT(10),TOCSRT(10)
9           DIMENSION      KRT(10),DVLERT(10),DVSPRT(10),CFABRT(10),RRT(10),
           1           PRT(10),ACRERT(10),TOLTRT(10),PSSRT(10),PBDDRT(10),
           2          CFAART(10),PCDDRT(10)
10          DIMENSION QDT(20),HDT(20),KMDT(20),KPDT(20),SLPPDT(20),
           1          LDT(20),WDT(20), HWDT(20),LWDT(20),VRCDT(20),CSRCDT(20),
           2          VDT(20),ADT(20),DDT(20),UCCMDT(20),CSCMDT(20),DPHDT(20),
           3          UCPRDT(20),ZDT(20),CSPRDT(20),TOCSDT(20),SDT(20)
11          COMMON    NABMP(11),CP(11),REMEFF(11),NAMACH(11,16),SIZE(11,16),
           1          ECONLF(11,16),TMOVER(11,16),INCS(11,16),SAVA(11,16),
           2          HRPAC(11,16),ACUSE(11,16),RPCS(11,16),YRDEPR(11,16),
           3          TXINHO(11,16),INSU(11,16),FXCS(11,16),TOHR(11,16),
           4          TOCSRP(11,16),TOCS(11,16),TOCSMA(11),TRHRAC(11)
12          COMMON    TRECLF(11),TRSAVA(11),TOHRTR(11),YRDPTR(11),TXTR(11),
           1          YRINTR(11),FXCSTR(11),RPCSTR(11),TOCSTR(11),TOHRCM(11),
           2          TRFUCS(11),CMFUCS(11),TOCSFU(11),COD(11), AMSD(11,11),
           3          USSD(11),NSD(11),CSSD(11,11),TOCSAC(11),AVCSSD(11),
           4          TOCSSD(11),NACPS(11),SDMENT(11),SS(11),BOD(11)
13          COMMON    AMNFR(11,11),AMPFR(11,11),AMKFR(11,11),NCROP(11),
           1          TOAMP(11),TOAMK(11),AVAMN(11),AVAMP(11),AVAMK(11),
           2          CSFRAC(11),TOCSFR(11),REEQ(11),TOFRCS(11),CSHBAC(11,11),
           3          CSINAC(11,11),TOCSHB(11),TOCSIN(11),AVCSHB(11),
           4          TOCSPS(11),TOPSCS(11),TOAMN(11),AVCSIN(11),INT(11,16)
14          COMMON    TODTLB(11),OVHD(11),TOLB(11),TOCSLB(11),EPYD(11,11),
           1          ACCP(11,11),UTCPYD(11),CSDY(11),CPHV(11,11),DYCS(11,11),
           2          TOCSDY(11),FRIN(11),SDIN(11),PSIN(11),FUIN(11),LBIN(11),
           3          EPPR(11),GRRN(11,11),TORN(11),TOCOST(11),NTRN(11),
           4          IDENTR(11),TACS(11),YRPLAN(11),TOPLCS(11)
15          COMMON    NACPF(11),NACPP(11),NACPD(11),NACPR(11),UTSD(11)
16          COMMON    WGTFAC(16),ENVTAG(11,16),ENWTAG(11,16),TOENAG(11)
17          INTEGER ENVTDV(10,17),ENWTDV,TOENDV,TOENRT(10),WGTFAT(16),
           1ENVTSB(10,17),ENWTSB(10,17),TOENSB(10),ENVTRT(10,17),ENWTRT(10,17)
18          DATA TOENDV/10*0/,TOENSB/10*0/,TOENRT/10*0/
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      CHARACTER*20 NALNDV,NAPPRT
      REAL KDV
      REAL NDV,LENGDV,LLDV,I25DV,NNDV,LNADV
      REAL NSB,LENGSB,LLSB,I25SB,NNSB,KSB,LSSB,LFSB,LEDKSB
      REAL NRT,LENGRT,LLRT,I25RT,NNRT,KRT,LSRT,LFRT,LEDKRT,
     1LDT,KMDT,KPDT,LHDT,LWDT
C     JJ     : NUMBER OF DIVERSION
C     LL     : NUMBER OF SEDMENT BASIN
C     MM     : NUMBER OF FLOOD WATER RETARDING STRUCTURE
C     NN     : NUMBER OF CROPLAND
C     WGTFAT : WEIGHTING FACTOR FOR EIA
C     UCEXC  : UNIT COST OF EXCAVATION
C     UCPC   : UNIT COST OF PLAIN CONCRETE
C     UCRC   : UNIT COST OF REINFORCED CONCRETE
C     UCLB   : UNIT COST OF LABOR
C     UCSDP  : UNIT COST OF SEED BED PREPARATION
C     UCSP   : COST OF SPRIGGING PER SQ YD
C     NALNDV : NAME OF THE LINING MATERIAL OF DIVERSION
C     QDV    : FLOW RATE IN DIVERSION, IN CFS
C     NDV    : MANNING'S COEFFICIENT FOR THE DIVERSION
C     VELDV  : FLOW VELOCITY IN DIVERSION IN FPS
C     SCV    : SLOP OF DIVERSION
C     LENGDV : LENGTH OF DIVERSION IN FT
C     ZDV    : HORIZONTAL DISTANCE VS ONE UNIT OF VERTICAL DISTANCE ON
C     RDV    : RAINFALL FACTOR (DIVERSION)
C     KDV    : EROSION FACTOR (DIVERSION)
C     CFABDV : GROUND COVER FACTOR BEFORE BMP (DIVERSION)
C     CFAADV : GROUND COVER FACTOR AFTER BMP (DIVERSION)
C     PDV    : MANAGEMENT PRACTICE FACTOR (DIVERSION)
C     TOLTDV : TOLERANCE LIMIT (DIVERSION)
C     PSSDV  : POTENCY FACTOR OF SS TO SEDIMENT (DIVERSION)
C     PBODDV : POTENCY FACTOR OF BOD TO SEDIMENT (DIVERSION)
C     PCODDV : POTENCY FACTOR OF COD TO SEDIMENT (DIVERSION)
C     UCLNDV : UNIT COST OF DIVERSION LINING MATERIAL, IN $/SQ FT
C     ENVTDV : EIA EVALUATION FOR DIVERSION
C     UCHADV : UNIT COST OF HAULING DIRT FOR DIVERSION
C     BDV    : BOTTOM WIDTH OF DIVERSION IN FOOT
C     OVLEDV : THE FURTHEREST RUNOFF OVERLAND LENGTH TO DIVERSION
C     NNDV   : MANNING,S CIEFFICIENT OF OVERLAND SURFACE
C     OGLEDV : ORIGINAL SLOPE LENGTH WITHOUT DIVERSION IN FOOT
C     OVSPDV : SLOPE OF OVERLAND SURFACE
C     BBDV   : FACTOR OF DIVERSION CHARACTERISTICS
C     CHSPDV : SLOPE OF DIVERSION
C     QSB    : FLOW RATE IN SEDIMENT BASIN IN CFS
C     SVSB   : SETTLING VELOCITY IN SEDIMENT BASIN, IN FPS
C     VOLSB  : ANNUAL SEDIMENT INFLUW VOLUME, IN CF/YR
C     LFSB   : EXPECTED LIFE OF SEDIMENT BASIN, IN YR
C     LEDKSB : LENGTH OF DIKE OF SEDIMENT BASIN, IN FT
C     ANINSB : ANNUAL RUNOFF INFLOW VOLUME INTO SEDIMENT BASIN, IN CY
C     UCHASB : UNIT COST OF HAULING DIRT FOR SEDIMENT BASIN
C     UCFLSB : UNIT COST OF FILLING AND COMPACTING DIRT FOR SEDIMENT
C              BASIN
C     ENVTSB : EIA EVALUATION FOR SEDIMENT BASIN
C     OVLESB : THE FURTHEREST RUNOFF OVERLAND LENGTH TO CHANNEL
C     NNSB   : MANNING,S COEFFICIENT OF OVERLAND SURFACE
C     OVSPSB : SLOPE OF OVERLAND SURFACE
C     BBSB   : FACTOR OF CHANNEL CHARACTERISTICS
C     CHSPSB : SLOPE OF CHANNEL
C     RSB    : RAINFALL FACTOR OF USLE
C     KSB    : SOIL ERODIBILITY FACTOR OF USLE
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C       LSSB   : SLOPE LENGTH & STEEPNESS FACTOR OF USLE
C       CFABSB : CROPPING & CONSERVATION FACTOR OF USLE
C       CFAASB : GROUND COVER FACTOR AFTER BMP (SEDIMENT BASIN)
C       PSB    : MANAGEMENT PRACTICE FACTOR (SEDIMENT BASIN)
C       TOLTSB : TOLERANCE LIMIT (SEDIMENT BASIN)
C       PSSSB  : POTENCY FACTOR OF SS TO SEDIMENT (SEDIMENT BASIN)
C       PBODSB : POTENCY FACTOR OF BOD TO SEDIMENT (SEDIMENT BASIN)
C       PCODSB : POTENCY FACTOR OF COD TO SEDIMENT (SEDIMENT BASIN)
C       SOLSSB : SOIL LOSS IN TONS/AC/YR
C       NAPPRT : SIZE AND MATERIAL OF PERFORATED PIPE IN DIKE
C       QRT    : FLOW RATE INTO FLOODWATER RETARDING STRUCTURE
C       SVRT   : SETTLING VELOCITY IN RESERVOIR
C       VOLRT  : ANNUAL SEDIMENT INFLOW VOLUME, IN CF/YR
C       LFRT   : EXPECTED LIFE FOR FLOODWATER RETARDING STRUCTURE, IN YR
C       LEDKRT : LENGTH OF DIKE OF FLOODWATER RETARDING STRUCTURE, IN FT
C       ANINRT : ANNUL RUNOFF INFLOW VOLUME INTO RESERVOIR, IN CY
C       UCHART : UNIT COST OF HAULING DIRT FOR FLOODWATER RETARDING
C                STRUCTURE
C       UCFLRT : UNIT COST OF FILLING AND COMPACTING DIRT FOR FLOODWATER
C                RETARDING STRUCTURE
C       ENVTRT : EIA EVALUATION FOR FLOOD WATER RETARDING STRUCTURE
C       UCPPRT : UNIT COST OF PERFORATED PIPE
C       OVLERT : THE FURTHEREST RUNOFF OVERLAND LENGTH TO DIVERSION
C       NNRT   : MANNING'S COEFFICIENT OF OVERLAND SURFACE
C       OVSPRT : SLOPE OF OVERLAND SURFACE
C       BBRT   : FACTOR OF CHANNEL CHARACTERISTICS
C       CHSPRT : SLOPE OF CHANNEL
C       RRT    : RAINFALL FACTOR OF USLE
C       KRT    : SOIL ERODIBILITY FACTOR OF USLE
C       CFABRT : CROPPING & CONSERVATION FACTOR OF USLE
C       CFAART : GROUND COVER FACTOR AFTER BMP (FLOOD STRUCTURE)
C       PRT    : MANAGEMENT PRACTICE FACTOR (FLOOD STRUCTURE)
C       TOLTRT : TOLERANCE LIMIT (FLOOD STRUCTURE)
C       PSSRT  : POTENCY FACTOR OF SS TO SEDIMENT (FLOOD STRUCTURE)
C       PBODRT : POTENCY FACTOR OF BOD TO SEDIMENT (FLOOD STRUCTURE)
C       PCODRT : POTENCY FACTOR OF COD TO SEDIMENT (FLOOD STRUCTURE)
C       SOLSRT : SOIL LOSS IN TONS/AC/YR
C       UCCM08 : UNIT COST OF 8 INCH CORRUGATED METAL PIPE
C       UCCM12 : UNIT COST OF 12 INCH CORRUGATED METAL PIPE
C       UCCM15 : UNIT COST OF 15 INCH CORRUGATED METAL PIPE
C       UCCM18 : UNIT COST OF 18 INCH CORRUGATED METAL PIPE
C       UCCM21 : UNIT COST OF 21 INCH CORRUGATED METAL PIPE
C       UCCM24 : UNIT COST OF 24 INCH CORRUGATED METAL PIPE
C       UCCM30 : UNIT COST OF 30 INCH CORRUGATED METAL PIPE
C       UCCM36 : UNIT COST OF 36 INCH CORRUGATED METAL PIPE
C       UCCM42 : UNIT COST OF 42 INCH CORRUGATED METAL PIPE
C       UCCM48 : UNIT COST OF 48 INCH CORRUGATED METAL PIPE
C       UCCM54 : UNIT COST OF 54 INCH CORRUGATED METAL PIPE
C       UCCM60 : UNIT COST OF 60 INCH CORRUGATED METAL PIPE
C       QDT    : FLOW RATE THROUGH ST UCTURE, IN CFS
C       HDT    : ELEVATION DROP HEAD BETWEEN INLET AND OUTLET, IN FT
C       KMDT   : COEFFICIENT OF MINOR LOSSES
C       KPDT   : PIPE FRICTION COEFFICIENT
C       LDT    : LENGTH OF STRUCTURE, IN FT
C
C
C       GENERAL
C
        READ (5,501) JJ,LL,MM,NN
        READ (5,502) UCEXC,UCPC,UCRC,UCLB,UCSOP
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         READ (5,502) UCCM08,UCCM12,UCCM15,UCCM18,UCCM21,UCCM24,UCCM30,
        1UCCM36,UCCM42,UCCM48,UCCM54,UCCM60,UCSP
         READ (5,506) (WGTFAT(IW),IW=1,14)
C
C        CROP LAND
C
         DO 58 N=1,NN
         CALL BMP1
      58 CONTINUE
C
C
C        DIVERSION
C
      42 IF (JJ.EQ.0) GO TO 44
         WRITE (6,606) JJ
         DO 2 J=1,JJ
         READ (5,507) NALNDV(J),ACREDV(J),OVLEDV(J),LENGDV(J)
         READ (5,508) NNDV(J),NDV(J),OVSPDV(J),CHSPDV(J),BBDV(J)
         READ (5,502) RDV(J),KDV(J),CFABDV(J),CFAADV(J),PDV(J)
         READ (5,513) TOLTDV(J),PSSDV(J),PBCDDV(J),PCDDDV(J),OGLEDV(J)
         READ(5,502) VELDV(J),ZDV(J),UCLNDV(J),UCHADV(J),BDV(J)
         READ (5,506) (ENVTDV(J,IW),IW=1,14)
C
C       CALCULATE FLOWRATE
C
         LLDV(J)=0.25*NNDV(J)*OVLEDV(J)*(OVSPDV(J)**(-.5))
         OVTDV(J)=1.4*(LLDV(J)**.5)
         CHTDV(J)=BBDV(J)*(LENGDV(J)**0.77)*(CHSPDV(J)**(-.385))
         TCDV(J)=OVTDV(J)+CHTDV(J)
         IF (TCDV(J).GE.20.) GO TO 50
         TCDV(J)=20.
      50 I25DV(J)=134.*((TCDV(J)+18.5)**(-.843))
         QDV(J)=ACREDV(J)*.5*I25DV(J)
C
C        CALCULATE REMOVAL EFFICIENCY
C
         IF (OVSPDV(J).GE.0.05) GO TO 59
         IF (OVSPDV(J).LE.0.03) GO TO 60
         DVM=0.4
         GO TO 61
      59 DVM=0.5
         GO TO 61
      60 DVM=0.3
      61 REEFDV(J)=(OGLEDV(J)**DVM-OVLEDV(J)**DVM)/(OGLEDV(J)**DVM)*100.
C
C        CALCULATE HYDRAULIC RADIUS, CROSS SECTION AND SIZING
C
         HRDV(J)=(VELDV(J)*NDV(J)/1.486)**1.5/(CHSPDV(J)**0.75)
         ADV(J)=QDV(J)/VELDV(J)
         WPDV(J)=ADV(J)/HRDV(J)
         YDV(J)=(WPDV(J)-BDV(J))/(2.*((1.+ZDV(J)**2.)**0.5))
         TDV(J)=BDV(J)+(ZDV(J)*1.25*YDV(J)*2.)
         LNADV(J)=((1.+ZDV(J)**2.)**.5*2.*YDV(J)+BDV(J))*LENGDV(J)/9.
         TOEXDV(J)=LENGDV(J)*ADV(J)/27.
C
C        COST ESTIMATE
C
         CSEXDV(J)=TOEXDV(J)*UCEXC
         CSHADV(J)=UCHADV(J)*TOEXDV(J)
         CSLNDV(J)=UCLNDV(J)*LNADV(J)
```

```
      TOCSDV(J)=CSEXDV(J)+CSHADV(J)+CSLNDV(J)
      DO 33 IW=1,14
      ENWTDV(J,IW)=ENVTDV(J,IW)*WGTFAT(IW)
   33 TOENDV(J)=TOENDV(J)+ENWTDV(J,IW)
      WRITE (6,607) J,NALNDV(J),QDV(J),NDV(J),VELDV(J),CHSPDV(J),
     1LENGDV(J),HRDV(J)
      WRITE (6,608) ADV(J),ZDV(J),YDV(J),BDV(J),TDV(J)
      CALL SOLWTQ(RDV,KDV,OVLEDV,OVSPDV,CFABDV,REEFDV,PDV,ACREDV,TLLTDV,
     1PSSDV,PBODDV,PCODDV,J)
      WRITE (6,609) TOEXDV(J),TGEXDV(J),LNADV(J),UCEXC,UCHADV(J),
     1UCLNDV(J),CSEXDV(J),CSHADV(J),CSLNDV(J),TOCSDV(J)
    2 CONTINUE
C
C
C     SEDIMENT BASIN
C
   44 IF (LL.EQ.0) GO TO 45
      WRITE (6,615) LL
      DO 4 L=1,LL
      READ (5,512) ACRESB(L),OVLESB(L),LENGSB(L),SVSB(L),LFSB(L)
      READ (5,508) NNSB(L),NSB(L),OVSPSB(L),CHSPSB(L),BBSB(L)
      READ (5,508) RSB(L),KSB(L),CFABSB(L),PSB(L)
      READ (5,502) TOLTSB(L),PSSSB(L),PBODSB(L),PCODSB(L)
      READ (5,508) LEDKSB(L),ANINSB(L),UCHASB(L),UCFLSB(L)
      READ (5,506) (ENVTSB(L,IW),IW=1,14)
C
C     CALCULATE FLOWRATE
C
      LLSB(L)=.25*NNSB(L)*OVLESB(L)*(OVSPSB(L)**(-.5))
      OVTSB(L)=1.4*(LLSB(L)**.5)
      CHTSB(L)=BBSB(L)*(LENGSB(L)**.77)*(CHSPSB(L)**(-.385))
      TCSB(L)=OVTSB(L)+CHTSB(L)
      IF (TCSB(L).GE.20.) GO TO 51
      TCSB(L)=20.
   51 I25SB(L)=134.*((TCSB(L)+16.5)**(-.843))
      QSB(L)=ACRESB(L)*.5*I25SB(L)
C
C     SIZING OF BASIN
C
      AREASB(L)=QSB(L)/SVSB(L)
      THETA=ATAN(OVSPSB(L))
      X=SIN(THETA)
      IF(OVSPSB(L).GE.0.05) GO TO 52
      IF(OVSPSB(L).LE.0.03) GO TO 53
      F=0.4
      GO TO 54
   52 F=0.5
      GO TO 54
   53 F=0.3
   54 LSSB(L)=((OVLESB(L)/72.6)**F)*(((430.*X*X)+(30.*X)+0.43)/6.57415)
      SOLSSB(L)=RSB(L)*KSB(L)*LSSB(L)*CFABSB(L)*PSB(L)
      DEPSB(L)=LFSB(L)*SOLSSB(L)*ACRESB(L)*2000./85./AREASB(L)
      CAPASB(L)=AREASB(L)*DEPSB(L)/27.
      VLDKSB(L)=(3.+(DEPSB(L)+1.)*6.)*(DEPSB(L)+1. )/2.*LEDKSB(L)/27.
      YDDKSB(L)=LEDKSB(L)*(DEPSB(L)*3.+6.)/9.
C
C     TRAP EFFICIENCY
C
      CISB(L)=DEPSB(L)*AREASB(L)*.67/ANINSB(L)/3.
      TESB(L)=100.*(.97**(.19**ALOG10(CISB(L))))
```

```
        DO 35 IW=1,14
        ENWTSB(L,IW)=ENVTSB(L,IW)*WGTFAT(IW)
     35 TOENSB(L)=TOENSB(L)+ENWTSB(L,IW)
C
C       COST ESTIMATE
C
        CSEXSB(L)=UCEXC*VLDKSB(L)
        CSHASB(L)=UCHASB(L)*VLDKSB(L)
        CSFLSB(L)=UCFLSB(L)*VLDKSB(L)
        CSDKSB(L)=UCSP*YDDKSB(L)
        TOCSSB(L)=CSEXSB(L)+CSHASB(L)+CSFLSB(L)+CSDKSB(L)
        WRITE (6,616) L,SVSB(L),LFSB(L),SOLSSB(L),QSB(L),AREASB(L),
       1DEPSB(L),LEDKSB(L)
        WRITE (6,617) CAPASB(L),ANINSB(L),CISB(L),TESB(L)
        CALL SOLWTQ(RSB,KSB,OVLESB,OVSPSB,CFABSB,  TESB,PSB,ACRESB,
       1TOLTSB,PSSSB,PBODSB,PCODSB,L)
        WRITE (6,618) VLDKSB(L),YDDKSB(L),UCEXC,UCHASB(L),UCFLSB(L),
       1UCSP,CSEXSB(L),CSHASB(L),CSFLSB(L),CSDKSB(L),TOCSSB(L)
        N=L
        QDT(N)=QSB(L)
        HDT(N)=DEPSB(L)
        CALL DPLET(QDT,HDT,UCCM08,UCCM12,UCCM15,UCCM18,UCCM21,UCCM24,
       1UCCM30,UCCM36,UCCM42,UCCM48,UCCM54,UCCM60,N,UCRC)
      4 CONTINUE
C
C
C       FLOODWATER RETARDING STRUCTURE
C
     45 IF(MM.EQ.0) GO TO 47
        WRITE (6,619) MM
        DO 5 M=1,MM
        READ (5,511) NAPPRT(M),UCPPRT(M)
        READ (5,512) ACRERT(M),OVLERT(M),LENGRT(M),SVRT(M),LFRT(M)
        READ (5,508) NNRT(M),NRT(M),OVSPRT(M),CHSPRT(M),BBRT(M)
        READ (5,508) RRT(M),KRT(M),CFABRT(M),PRT(M)
        READ (5,502) TOLTRT(M),PSSRT(M),PBODRT(M),PCODRT(M)
        READ (5,510) LEDKRT(M),ANINRT(M),UCHART(M),UCFLRT(M)
        READ (5,506) (ENVTRT(M,IW),IW=1,14)
C
C      CALCULATE FLOWRATE
C
        LLRT(M)=.25*NNRT(M)*OVLERT(M)*(OVSPRT(M)**(-.5))
        OVTRT(M)=1.4*(LLRT(M)**.3)
        CHTRT(M)=BBRT(M)*(LENGRT(M)**.77)*(CHSPRT(M)**(-.385))
        TCRT(M)=OVTRT(M)+CHTRT(M)
        IF (TCRT(M).GE.20.) GO TO 48
        TCRT(M)=20.
     48 I25RT(M)=134.*((TCRT(M)+18.5)**(-.843))
        QRT(M)=ACRERT(M)*.5*I25RT(M)
C
C       SIZE OF RESERVOIR
C
        AREART(M)=QRT(M)/SVRT(M)
        THETA=ATAN(OVSPRT(M))
        X=SIN(THETA)
        IF(OVSPRT(M).GE.0.05) GO TO 55
        IF (OVSPRT(M).LE.0.03) GO TO 56
        F=0.4
        GO TO 57
     55 F=0.5
```

```
      GC TC 57
   56 F=0.3
   57 LSRT(M)=((OVLERT(M)/72.6)**F)*(((430.*X*X)+(30.*X)+0.43)/6.57415)
      SOLSRT(M)=RRT(M)*KRT(M)*LSRT(M)*CFABRT(M)*PRT(M)
      DEPRT(M)=LFRT(M)*SOLSRT(M)*ACRERT(M)*2000./85./AREART(M)
      CAPART(M)=AREART(M)*DEPRT(M)/27.
      VLDKRT(M)=(12.+(DEPRT(M)+2.)*6.)*(DEPRT(M)+2.)/2.*LEDKRT(M)/27.
      YDDKRT(M)=LEDKRT(M)*(DEPRT(M)*3.+6.)/9.
C
C     TRAP EFFICIENCY
C
      CIRT(M)=DEPRT(M)*AREART(M)*.67/(ANINRT(M)*3.)
      TERT(M)=100.*(.97**(.19**ALOG10(CIRT(M))))
      DO 36  IW=1,14
      ENWTRT(M,IW)=ENVTRT(M,IW)*WGTFAT(IW)
   36 TOENRT(M)=TOENRT(M)+ENWTRT(M,IW)
C
C     COST ESTIMATE
C
      CSEXRT(M)=UCEXC*VLDKRT(M)
      CSHART(M)=UCHART(M)*VLDKRT(M)
      CSFLRT(M)=UCFLRT(M)*VLDKRT(M)
      CSPPRT(M)=UCPPRT(M)*LEDKRT(M)
      CSDKRT(M)=UCSP*YDDKRT(M)
      TOCSRT(M)=CSEXRT(M)+CSHART(M)+CSFLRT(M)+CSPPRT(M)+CSDKRT(M)
      WRITE (6,620) M,SVRT(M),LFRT(M),SOLSRT(M),ORT(M),AREART(M),
     1DEPRT(M),LEDKRT(M)
      WRITE (6,617) CAPART(M),ANINRT(M),CIRT(M),TERT(M)
      CALL SOLWTJ(RRT,KRT,OVLERT,OVSPRT,CFABRT,  TERT,PRT,ACRERT,
     1TOLTRT,PSSRT,PBODRT,PCUDRT,M)
      WRITE (6,621) NAPPRT(M),VLDKRT(M),YDDKRT(M),LEDKRT(M),UCEXC,
     1UCHART(M),UCFLRT(M),UCPPRT(M),UCSP,CSEXRT(M),CSHART(M),CSFLRT(M),
     2CSPPRT(M),CSDKRT(M),TOCSRT(M)
      N=LL+M
      QDT(N)=QRT(M)
      HDT(N)=DEPRT(M)
      CALL OPLET(QDT,HDT,UCCM08,UCCM12,UCCM15,UCCM18,UCCM21,UCCM24,
     1UCCM30,UCCM36,UCCM42,UCCM48,UCCM54,UCCM60,N,UCRC)
    5 CONTINUE
C
C     ENVIRONMENTAL IMPACT ASSESMENT
C
   47 WRITE (6,632)
      WRITE (6,633) (WGTFAT(IW),IW=1,14)
      DO 38 J=1,JJ
   38 WRITE (6,635) J,(ENVTDV(J,IW),IW=1,14),(ENWTDV(J,IW),IW=1,14),
     1TOENDV(J)
      DO 40 L=1,LL
   40 WRITE (6,637) L,(ENVTSB(L,IW),IW=1,14),(ENWTSB(L,IW),IW=1,14),
     1TOENSB(L)
      DO 41 M=1,MM
   41 WRITE (6,638) M,(ENVTRT(M,IW),IW=1,14),(ENWTRT(M,IW),IW=1,14),
     1TOENRT(M)
      WRITE (6,639)
C
  501 FORMAT(6(3X,I7))
  502 FORMAT(5(7X,F8.2))
  506 FORMAT( 7X,16I3)
  507 FORMAT(7X, A8,4(7X,F8.2))
  512 FORMAT(3(7X,F8.2),7X,F8.5,7X,F8.2)
```

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195       508 FORMAT(5(7X,F8.5))
196       510 FORMAT(7X,F8.2,7X,F8.0,2(7X,F8.2))
197       511 FORMAT(7X,A20,20X,F8.2)
198       513 FORMAT(4(7X,F8.4),7X,F8.2)
199       606 FORMAT (1H1,55X,'DIVERSION - ',I2,' DITCHES')
200       607 FORMAT (4(/),20X,'DIVERSION ',I2,///,30X,'NAME OF THE LINING MATER
             1IAL : ', A20,//,30X,'GENERAL CHARACTERS',//,42X,'Q,CFS',7X,'N',7X,
             2'V,FPS',5X,'SLOPE',4X,'LENG,FT',1X,'HY RAD,FT',//,39X,F8.2,2X,
             3F8.4,2X,F8.2,2X,F8.4,2X,F8.2,2X,F8.5)
201       608 FORMAT (4(/),30X,'CROSS-SECTION DIMENSION',//,40X,'AREA,SQ FT',4X,
             1'Z',8X,'Y,FT',6X,'B,FT',6X,'T,FT',//,39X,F8.2,2X,F8.1,2X,F8.2,2X,
             2F8.2,2X,F8.2)
202       609 FORMAT (4(/),30X,'COST ESTIMATE',//,56X,'EXC. CY',3X,'HAUL. CY',
             12X,'LIN. SY',//,46X,'QUANTITY',2X,F8.2,2X,F8.2,2X,F8.2,//,47X,
             2'$/UNIT',3X,F8.2,2X,F8.2,2X,F8.2,//,48X,'COST,$',4X,F8.2,2X,F8.2,
             32X,F8.2,//,30X,'TOTAL COST,$ = ',F8.2)
203       615 FORMAT (1H1,50X,'SEDIMENT BASIN - ',I2,' BASINS')
204       616 FORMAT (4(/),20X,'BASIN ',I2,///,30X,'GENERAL CHARACTER',//,11X,
             1'SETTLING VEL. CFS',4X,'EXPECT. LIFE. YR',3X,'YR SEDT. T/AC/YR',
             23X,'Q IN. CFS',2X,'AREA.  SF',2X,'DEPT. FT',4X,'DIKE LENG. FT',
             3//,16X,F8.5,12X,F8.2,12X,F8.2,7X,4(F8.1,2X))
205       617 FORMAT (///,30X,'TRAP EFFICIENCY',//,31X,'BASIN VOL. CY (C)',3X,
             1'YR INFLOW. CY (I)',5X,'C/I',6X,'TRAP EFF. %',//,36X,F8.0,12X,F8.0
             2,7X,F8.2,4X,F8.2)
206       618 FORMAT (///,30X,'COST ESTIMATE',//,56X,'EXC. CY',3X,'HAUL. CY',2X,
             1'FILL. CY',2X,'SPRIG. CY',//,46X,'QUANTITY',10X,'---',F10.0,'---',
             26X,F10.2,//,47X,'$/UNIT',3X,4(F8.2,2X),//,48X,'COST,$',4(F10.0),
             3//,30X,'TOTAL COST,$ = ',F10.0)
207       619 FORMAT (1H1,40X,'FLOODWATER RETARDING STRUCTURE - ',I2,' RESERVOIR
             1S')
208       620 FORMAT (4(/),20X,'RESERVOIR ',I2,///,30X,'GENERAL CHARACTER',//,
             111X,'SETTLING VEL. FPS',4X,'EXPECT. LIFE. YR',5X,'YR SEDT. T/YR',
             2 4X,'Q IN. CFS',2X,'AREA. SF',2X,'DEPT. FT',4X,'DIKE LENG. FT',//,
             316X,F8.5,12X,F8.2,12X,F8.2,7X,F8.2,2X,F8.0,2X,       2(F8.2,2X))
209       621 FORMAT (///,30X,'COST ESTIMATE',//,46X,'EXC. CY',3X,'HAUL. CY',2X,
             1'FILL. CY',1X,A20,1X,'SPRIG CY',//,36X,'QUANTITY',10X,'---',F8.1,
             2'---',12X,F8.2,10X,F10.2,//,37X,'$/UNIT',3X,3(F8.2,2X),6X,F8.2,7X,
             3F8.2,//,38X,'COST,$',3(F10.0),6X,F10.0,6X,F10.0,//,30X,
             4'TOTAL COST,$ = ',F10.0)
210       632 FORMAT(1H1,51X,'ENVIRONMENTAL IMPACT ASSESMENT',///,1X,8X,'BMP',8X
             1,'S.R. O&M  L.D. W.C. NOIS P.D. W.Q. F&F  F&G  AEST H.S. A.S. RECR
             2 P.A. ',11X,'TOTAL')
211       633 FORMAT(//,3X,'WEIGHING FACTOR',2X,14(1X,I3,1X),11X,I5)
212       635 FORMAT(//,4X,'DIVERSION',1X,I3,3X,14(1X,I3,1X),/,20X,14(1X,I4),
             111X,I5)
213       637 FORMAT(//,6X,'BASIN',1X,I3,5X,14(1X,I3,1X),/,20X,14(1X,I4),11X,I5)
214       638 FORMAT(//,4X,'RESERVOIR',1X,I3,3X,14(1X,I3,1X),/,20X,14(1X,I4),
             111X,I5)
215       639 FORMAT(//,1X,'S.R.=SYSTEM RELIABILITY; O&M=OPERATION AND MAINTENAN
             1CE; L.D.=LAND DISTURBED; W.C.=WATER CONSERVATION; NOIS=NOISE ANNOY
             2ANCE;',//,1X,'P.D.=POTENTIAL FOR DEVELOPMENT; W.Q.=WATER QUALITY;
             3F&F=FLORA AND FAUNA; F&G=FISHING AND GAME; AEST=AESTHETICS;',
             4//,1X,'H.S.=HISTORICAL SITE; A.S.=ARCHEOLOGICAL SITE; RECR=RECREAT
             5IONAL; P.A.=PESTICIDE APPLICATION')
216           STOP
217           END
        C
        C
        C     DROP INLET AND OUTLET
        C
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      SUBROUTINE DPLET(QDT.HDT.UCCM08.UCCM12.UCCM15.UCCM18.UCCM21.
     1UCCM24.UCCM30.UCCM36.UCCM42.UCCM48.UCCM54.UCCM60.N.UCRC)
      DIMENSION QDT(20).HDT(20).KMDT(20).KPDT(20).SLPPDT(20).
     1          LDT(20).WDT(20). HWDT(20).LWDT(20).VRCDT(20).CSRCDT(20).
     2          VDT(20).ADT(20).DDT(20).UCCMDT(20).CSCMDT(20).DPHDT(20).
     3          UCPRDT(20).ZDT(20).CSPRDT(20).TOCSDT(20).SDT(20)
      REAL LDT.KMDT.KPDT.LHDT.LWDT
      IF (HDT(N).LE.8.) GO TO 7
      IF ((HDT(N).LE.00.).AND.(QDT(N).LE.150.)) GO TO 8
      IF ((HDT(N).LE.12).AND.(QDT(N).GT.150.)) GO TO 7
      IF ((HDT(N).GT.12.).AND.(QDT(N).LE.400.)) GO TO 8
      IF ((HDT(N).GT.12.).AND.(QDT(N).GT.400.)) GO TO 31
C
C     DROP SPILLWAY
C
    7 HWDT(N)=((1.10+0.01*HDT(N))*QDT(N)/7.75)**0.25
      LWDT(N)=5.*HWDT(N)
      VRCDT(N)=0.5* (3.*LWDT(N)*(5.+HDT(N)+HWDT(N))-(LWDT(N)*HWDT(N))
     1+5.*(5.+HDT(N)+HWDT(N))+3.*(5.+HDT(N)+HWDT(N)+0.5*HDT(N)+5.)
     2+8.*(0.5*HDT(N)+5.+0.25*HDT(N)+5.)+8.*(2.+LWDT(N))+4.*(2.
     3+LWDT(N)+2.+LWDT(N)+1.6*HDT(N)))/27.
      CSRCDT(N)=UCRC*VRCDT(N)
      WRITE (6.623)    QDT(N).HDT(N)
      WRITE (6.624) LWDT(N).HWDT(N).VRCDT(N).UCRC.CSRCDT(N)
      GO TO 6
C
C     HOODED INLET SPILLWAY
C
    8 LDT(N)=(HDT(N)**2.+(3.+3.*HDT(N))**2.)**0.5
      SLPPDT(N)=HDT(N)/(3.*HDT(N)+3.)
      IF((HDT(N).GT.12.).AND.(QDT(N).GT.150.)) GO TO 29
      VDT(N)=11.726*(QDT(N)**.25)*(SLPPDT(N)**.375)
      ADT(N)=QDT(N)/VDT(N)
      DDT(N)=(4.*ADT(N)/3.1416)**.5*12.
      IF (DDT(N).GT.8.) GO TO 9
      DDT(N)=8.
      UCCMDT(N)=UCCM08
      GO TO 18
    9 IF (DDT(N).GT.12.) GO TO 10
      DDT(N)=12.
      UCCMDT(N)=UCCM12
      GO TO 18
   10 IF (DDT(N).GT.15.) GO TO 11
      DDT(N)=15.
      UCCMDT(N)=UCCM15
      GO TO 18
   11 IF (DDT(N).GT.18.) GO TO 12
      DDT(N)=18.
      UCCMDT(N)=UCCM18
      GO TO 18
   12 IF (DDT(N).GT.21.) GO TO 13
      DDT(N)=21.
      UCCMDT(N)=UCCM21
      GO TO 18
   13 IF (DDT(N).GT.24) GO TO 14
      DDT(N)=24.
      UCCMDT(N)=UCCM24
      GO TO 18
   14 IF (DDT(N).GT.30) GO TO 15
      DDT(N)=30.
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      UCCMDT(N)=UCCM30
      GO TO 18
   15 IF (DDT(N).GT.36.) GO TO 16
      DDT(N)=36.
      UCCMDT(N)=UCCM36
      GO TO 18
   16 IF (DDT(N).GT.42.) GO TO 17
      DDT(N)=42.
      UCCMDT(N)=UCCM42
      GO TO 18
   17 DDT(N)=48.
      UCCMDT(N)=UCCM48
   18 IF ((HDT(N).GT.30.) .OR.(QDT(N).GT.100.)) GO TO 19
      CSCMDT(N)=UCCMDT(N)*LDT(N)
      WRITE (6,625) QDT(N),HDT(N),SLPPDT(N),VDT(N)
      WRITE (6,626) DDT(N),LDT(N),UCCMDT(N),CSCMDT(N)
      GO TO 6
C
C     PIPE DROP INLET SPILLWAY
C
   19 IF (DDT(N).GT.12.) GO TO 20
      DPRDT(N)=18.
      UCPRDT(N)=UCCM18
      ZDT(N)=4.*18./12.
      GO TO 28
   20 IF (DDT(N).GT.15.) GO TO 21
      DPRDT(N)=21.
      UCPRDT(N)=UCCM21
      ZDT(N)=4.*21./12.
      GO TO 28
   21 IF (DDT(N).GT.18.) GO TO 22
      DPRDT(N)=24.
      UCPRDT(N)=UCCM24
      ZDT(N)=4.*24./12.
      GO TO 28
   22 IF (DDT(N).GT.21.) GO TO 23
      DPRDT(N)=30.
      UCPRDT(N)=UCCM30
      ZDT(N)=4.*30./12.
      GO TO 28
   23 IF (DDT(N).GT.24.) GO TO 24
      DPRDT(N)=30.
      UCPRDT(N)=UCCM30
      ZDT(N)=4.*30./12.
      GO TO 28
   24 IF (DDT(N).GT.30.) GO TO 25
      DPRDT(N)=36.
      UCPRDT(N)=UCCM36
      ZDT(N)=4.*36./12.
      GO TO 28
   25 IF (DDT(N).GT.36.) GO TO 26
      DPRDT(N)=48.
      UCPRDT(N)=UCCM48
      ZDT(N)=4.*48./12.
      GO TO 28
   26 IF (DDT(N).GT.42.) GO TO 27
      DPRDT(N)=54.
      UCPRDT(N)=UCCM54
      ZDT(N)=4.*54./12.
      GO TO 28
```

```
   27 DPRDT(N)=60.
      UCPRDT(N)=UCCM60
      ZDT(N)=4.*60./12.
   28 CSPRDT(N)=UCPRDT(N)*ZDT(N)
      CSCMDT(N)=UCCMDT(N)*LDT(N)
      TOCSDT(N)=CSPRDT(N)+CSCMDT(N)
      WRITE (6,627) QDT(N),HDT(N),SLPPDT(N),VDT(N)
      WRITE (6,628) DPRDT(N),DDT(N),ZDT(N),LDT(N),UCPRDT(N),UCCMDT(N),
     1CSPRDT(N),CSCMDT(N),TOCSDT(N)
      GO TO 6
C
C     MONOLITHIC DROP INLET SPILLWAY
C
   29 VDT(N)=16.5*(QDT(N)**.25)*(SLPPDT(N)**.375)
      ADT(N)=QDT(N)/VDT(N)
      SDT(N)=ADT(N)**.5
      IF (SDT(N).GT.3.) GO TO 30
      SDT(N)=3.
   30 VRCDT(N)=(4.*SDT(N)*(2.*SDT(N)+LDT(N))+2.*((5.*SDT(N)*3.*SDT(N))
     1+(4.*SDT(N)*3.*SDT(N)))+(3.*SDT(N)*5.*SDT(N))+2.*4.*SDT(N)*4.
     2*SDT(N)+3.*SDT(N)*3.*SDT(N))*0.5/27.
      CSRCDT(N)=UCRC*VRCDT(N)
      WRITE (6,629) QDT(N),HDT(N),LDT(N),SLPPDT(N),VDT(N)
      WRITE (6,630) SDT(N),VRCDT(N),UCRC,CSRCDT(N)
      GO TO 6
C
C     CHUTE SPILLWAY
C
   31 WDT(N)=(QDT(N)**1.11)/(4.34*(5.**1.78))
      LDT(N)=HDT(N)*3.
      VRCDT(N)=(7.*WDT(N)*5.*WDT(N)+LDT(N)*(10.+WDT(N)))*0.5/27.
      CSRCDT(N)=UCRC*VRCDT(N)
      WRITE (6,631)   QDT(N),LDT(N),WDT(N),VRCDT(N),UCRC,CSRCDT(N)
  623 FORMAT (4(/),25X,            'DROP SPILLWAY',///,30X,'FLOW RATE =
     1',F8.2,' CFS',//,30X,'HEAD DROP = ',F8.2,' FT')
  624 FORMAT (///,30X,'SIZE AND COST',//,33X,'L, FT',5X,'H, FT',3X,'V OF
     1 REIN CONC, CY',2X,'$/CY RC',3X,'$ OF RC',//,31X,F8.2,2X,F8.2,7X,F
     28.2,7X,F8.2,2X,F8.2)
  625 FORMAT (4(/),25X,            'HOODED INLET SPILLWAY',///,35X,'Q CF
     1S',6X,'HEAD DROP, FT',6X,'PIPE SLOPE',9X,'V, FPS',//,33X,F8.2,7X,
     2F8.2,7X,F8.4,7X,F8.4)
  626 FORMAT (///,30X,'SIZE AND COST - ',F3.0,' INCH CORRUGATED METAL PI
     1PE',//,51X,'PIPE, FT',1X,'$/FT PIPE',1X,'$ OF PIPE',//,51X,F8.2,2X
     2,F8.2,2X,F8.2)
  627 FORMAT (4(/),25X,            'PIPE DROP INLET SPILLWAY',///,35X,'Q
     1 CFS',6X,'HEAD DROP, FT',4X,'PIPE SLOPE',7X,'V, FPS',//,33X,F8.2,
     27X,F8.2,7X,F8.3,7X,          F8.2)
  628 FORMAT (///,30X,'COST ESTIMATE',//,47X,F3.0,' CMP RISER, FT',2X,F3
     1.0,' CMP, FT',//,37X,'LENGTH',8X,F8.2,7X,F8.2,//,38X,'$/FT',9X,F8.
     22,7X,F8.2,//,37X,'COST,$',8X,F8.2,7X,F8.2,//,30X,'TOTAL COST,$ = '
     3,F8.2)
  629 FORMAT (4(/),25X,            'MONOLITHIC DROP INLET SPILLWAY',///,
     135X,'Q CFS',6X,'HEAD DROP, FT',1X,'PIPE LENGTH,FT',3X,'PIPE SLOPE'
     2,4X,'FLOW VEL,FPS',//,30X,2(3X,F9.2,3X),3X,F9.4,3X,2(3X,F9.2,3X))
  630 FORMAT (///,30X,'COST ESTIMATE',//,41X,'SIZE,FT',2X,'V OF REIN CON
     1C, CY',2X,'$/CY RC',3X,'$ OF RC',//,41X,F8.2,7X,F8.2,7X,F8.2,2X,F8
     2.0)
  631 FORMAT (4(/),25X,          'CHUTE SPILLWAY',///,32X,'Q CFS',4X,'L
     1ENG, FT',1X,'WIDTH, FT',2X,'VOL OF RC, CY',2X,'$/CY RC',2X,'COST O
     2F RC',//,31X,F8.2,2X,F8.2,2X,F8.2,4X,F8.2,5X,F8.2,2X,F8.0)
```

```
      6 RETURN
        END
C
C
C
        SUBROUTINE SOLWTQ(R,K1,L1,S,CFAB,REEF,P,ACRE,TOLT,PSS,PBOD,PCOD,N)
        DIMENSION SDYS(10),      S(10),CFAB(10),REEF(10),P(10),ACRE(10),
       1TOLT(10),PSS(10),PBOD(10),PCOD(10),         SLLS(10),R(10)
        REAL K1(10),L1(10),LS(10)
        THETA=ATAN(S(N))
        X=SIN(THETA)
        IF (S(N).GE.0.05) GO TO 9
        IF (S(N).LE.0.03) GO TO 10
        F=0.4
        GO TO 11
      9 F=0.5
        GO TO 11
     10 F=0.3
     11 LS(N)=((L1(N)/72.6)**F)*(((430.*X*X)+(30.*X)+0.43)/6.57415)
        SLLS(N)=R(N)*K1(N)*LS(N)*CFAB(N)*P(N)
        WRITE (6,642) R(N),K1(N),L1(N),S(N),CFAB(N),P(N),LS(N),SLLS(N),
       1TOLT(N),REEF(N)
        IF (ACRE(N).LE.320.) GO TO 1
        IF (ACRE(N).LE.640.) GO TO 2
        IF (ACRE(N).LE.3200.) GO TO 3
        IF (ACRE(N).LE.6400.) GO TO 4
        IF (ACRE(N).LE.32000.) GO TO 5
        IF (ACRE(N).LE.64000.) GO TO 6
        GO TO 7
      1 SDDERT=0.33
        GO TO 8
      2 SDDERT=0.3
        GO TO 8
      3 SDDERT=0.22
        GO TO 8
      4 SDDERT=0.18
        GO TO 8
      5 SDDERT=0.12
        GO TO 8
      6 SDDERT=0.1
        GO TO 8
      7 SDDERT=0.08
      8 WRITE (6,640) SDDERT,PSS(N),PBOD(N),PCOD(N)
        SDMTB=SLLS(N)*SDDERT
        SDMTA=REEF(N)/100.
        SSB=PSS(N)*SDMTB*2000.
        BODB=PBOD(N)*SDMTB*2000.
        CODB=PCOD(N)*SDMTB*2000.
        SSA=PSS(N)*SDMTA*2000.
        BODA=PBOD(N)*SDMTA*2000.
        CODA=PCOD(N)*SDMTA*2000.
        WRITE(6,641) SDMTB,SSB,BODB,CODB,SDMTA,SSA,BODA,CODA
    640 FORMAT(////,40X,'SEDIMENT DELIVERY RATIO = ',F10.3,//,40X,
       1'POTENCY FACTOR : SS= ',F10.3,  ' OF SEDIMENT',/,57X,'BOD= ',
       2F10.3,  ' OF SEDIMENT',/,57X,'COD= ',F10.3,  ' OF SEDIMENT')
    641 FORMAT(////,55X,'WATER QUALITY',///,51X,'SEDIMENT',5X,'SS',7X,
       1'BOD',7X,'COD',/,50X,'(T/AC/YR)',1X,'(LB/AC/Y)',1X,'(LB/AC/Y)',
       21X,'(LB/AC/Y)',//,38X,'BEFORE BMP',2X,4(1X,F8.3,1X),//,39X,
       3'AFTER BMP',2X,4(1X,F8.3,1X))
```

```
      642 FORMAT(////,50X,'ANNUAL SOIL LOSS ESTIMATE',///,35X,'R',9X,'K',
         19X,'L',9X,'S',9X,'C',9X,'P',9X,'LS',//,31X,7(1X,F8.3,1X),///,
         2///,50X,'ANNUAL SOIL LOSS = ',F10.2,' T/AC/YR',//,50X,
         3'TOLERANCE LIMIT = ',F10.2,' T/AC/YR',//,50X,'REMOVAL EFFICIENCY =
         4 ',F10.2,' %')
          RETURN
          END
C
C
C
          SUBROUTINE BMP1
          COMMON    NABMP(11),CP(11),REMEFF(11),NAMACH(11,16),SIZE(11,16),
         1          ECONLF(11,16),TMOVER(11,16),INCS(11,16),SAVA(11,16),
         2          HRPAC(11,16),ACUSE(11,16),RPCS(11,16),YHDEPR(11,16),
         3          TXINHO(11,16),INSU(11,16),FXCS(11,16),TOHR(11,16),
         4          TOCSRP(11,16),TOCS(11,16),TOCSHA(11),TRHRAC(11)
          COMMON    TRECLF(11),TRSAVA(11),TOHRTR(11),YRDPTR(11),TXTR(11),
         1          YRINTR(11),FXCSTR(11),RPCSTR(11),TOCSTR(11),TOMRCM(11),
         2          TRFUCS(11),CMFUCS(11),TOCSFU(11),CUD(11), AMSD(11,11),
         3          USSD(11),NSD(11),CSSD(11,11),TOCSAC(11),AVCSSD(11),
         4          TOCSSD(11),NACPS(11),SDMENT(11),SS(11),BOD(11)
          COMMON    AMNFR(11,11),AMPFR(11,11),AMKFR(11,11),NCROP(11),
         1          TOAMP(11),TOAMK(11),AVAMN(11),AVAMP(11),AVAMK(11),
         2          CSFRAC(11),TOCSFR(11),REEQ(11),TOFRCS(11),CSMBAC(11,11),
         3          CSINAC(11,11),TOCSMB(11),TOCSIN(11),AVCSMB(11),
         4          TOCSPS(11),TOPSCS(11),TOAMN(11),AVCSIN(11),INT(11,16)
          COMMON    TODTLB(11),UVHD(11),TOLB(11),TOCSLB(11),EPYD(11,11),
         1          ACCP(11,11),UTCPYD(11),CSDY(11),CPHV(11,11),DYCS(11,11),
         2          TOCSDY(11),FRIN(11),SDIN(11),PSIN(11),FUIN(11),LBIN(11),
         3          EPPR(11),GRRN(11,11),TCRN(11),TOCOST(11),NTRN(11),
         4          IDENTR(11),TACS(11),YRPLAN(11),TUPLCS(11)
          COMMON    NACPF(11),NACPP(11),NACPD(11),NACPR(11),UTSD(11)
          COMMON    WGTFAC(16),ENVTAG(11,16),ENWTAG(11,16),TOENAG(11)
```

(The same as per Appendix F)

APPENDIX E

INPUT DATA OF "BMP1" APPLICATION

(Each input data name is described in the computer program as per PP. C-1 and C-2 in Appendix C. The position of input data can be located from the scale at the top of each page.)

```
0|      10|       20 |        30|       40|        50|        60|        70|        80|
   220.(R2)   .32(K2) 7000.(L2) 0.004(S2)   .44(C2)    1.(P2)    7.(DSSL)
     6(NBMP)  10(NMACH)  6(NCPS)   3(NCPF)   2(NCPP)   1(NCPD)   5(NCPR)
S.      480.(ACR2) 0.02(PTSS) 0.0006(   ) 0.027(PTCOD)   100.(PERCRP)
C CONV.   C NO-T.   CCCUM NO-T C NO-T TR C STP TR CB TR   CH        R LAND   ——— (NABMP)
      .44        .26       .16       .22       .2        .24       .13      .16 ——— (CP)
     6.6(X3)    1.6(Y)    0.02(CSCMPT) 0.1(IN) 0.00023(     ) 8.0(CSL3)  60.(GS)
      20(NYR)
STALK SHREDDER     MOLDBOARD PLOW     SPRAYER           DISK   ┐
HARROW             PLANTER            CULTIVATOR        COMBINE┘——— (NAMACH) ┐
CORN HEAD                                                                     │
                                                                              │
12" FLAIR          5-16"              TRACTOR MOUNTED   21'    ┐              │
21'                4-38"              4-38"             SMALL 70-80 HP ┘——— (SIZE)
2-38"                                                                         │
                                                                              │
      12       10       10       10       12       10       10       10 ——— (ECONLF)
      10                                                                      │
       1        1        1        1        1        1        2        1 ——— (IMOVER) ├── (1)
       1                                                                      │
    2350     3760      850     6250      630     3600     1500    19000 ——— (INCS)
    3350                                                                      │
    13.7     17.7     17.7     17.7     17.7     17.7     17.7     18.9 ——— (SAVA)
    18.9                                                                      │
     .10      .33      .21      .09       .1      .17      .16      .67 ——— (HRPAC)
     .63                                                                      │
     400      400      460      460      480      460      400      480 ——— (ACUSE)
     460                                                                      │
   94.00   120.50    34.00   219.25    10.20   114.40    73.50   322.00 ——— (RPCS) ┘
   56.00
STALK SHREDDER     SPRAYER            NO-TILL PLANTER   DUSTER ——————————————┐
COMBINE            CORN HEAD                                                  │
                                                                              │
12" FLAIL          TRACTOR MOUNTED    4-38"             4-ROW                 │
SMALL 70-80 HP     2-38"                                                      │
                                                                              │
      12       10       10       12       10       10                         │
                                                                              ├── (2)
       1        1        1        1        1        1                         │
                                                                              │
    2350      850     6250      400    19000     3350                         │
                                                                              │
    13.7     17.7     17.7     13.7     18.9     18.9                         │
                                                                              │
     .16      .21      .17      .21      .67      .63                         │
                                                                              │
     480      460      480      480      480      480                         │
                                                                              │
   94.00    34.00    350.0       8.     322.      56. ————————————————————————┘
STALK SHREDDER     MOLDBOARD PLOW     SPRAYER           DISK ————————————————┐
HARROW             NO-TILL PLANTER    WHEAT DRILL       DUSTER                │
COMBINE CORN       COMBINE WHEAT      CORN HEAD         PLATFORM              │
HAY MOWER          HAY CONDITIONER    HAY RAKE          HAY BALER             │
```

0	10	20	30	40	50	60	70	80
7'		7'		SIDE DELIVERY		SQUARE		
	12	10	10	10	12	10	14	12
	10	10	10	10	12	12	12	8
	1	1	1	1	1	1	1	1
	1	1	1	1	3	3	3	3
	2350	3760	850	6250	630	4375	2920	400
	19000	19000	3350	2500	1230	1300	1100	4580
	13.7	17.7	17.7	17.7	17.7	17.7	9.7	13.7
	18.9	18.9	18.6	18.9	12.5	12.5	12.5	21.1
	.18	.33	.21	.09	.1	.17	.18	.21
	.67	.3	.63	.3	.3	.3	.27	.21
	300	100	300	200	100	300	100	300
	300	100	300	100	100	100	100	180
	94.	129.5	34.	219.25	18.2	350.	219.2	8.
	161.	161.	56.	80.	96.	52.	58.8	210.0

STALK SHREDDER　　SPRAYER　　HARROW　　NO-TILL PLANTER
CULTIVATOR　　COMBINE　　CORNHEAD

12" FLAIL　　TRACTOR MOUNTED　　21'　　4-30"
4-30"　　SMALL 70-80 HP　　2-30"

12	10	12	10	10	10	10
1	1	1	1	2	1	1
2350	850	630	4375	1800	19000	3350
13.7	17.7	17.7	17.7	17.7	18.9	18.9
.18	.21	.18	.17	.18	.67	.63
480	480	480	480	480	480	480
94.	34.	18.8	380.	73.5	322.	56.

(4)

STALK SHREDDER　　SPRAYER　　ROTARY STRIP PLATR　　CULTIVATOR
COMBINE　　CORN HEAD

12" FLAIL　　TRACTOR MOUNTED　　4-30"　　4-30"
SMALL 70-80 HP　　2-30"

12	10	10	10	10	10
1	1	1	2	1	1
2350	850	3875	1800	18000	3350
13.7	17.7	17.7	17.7	18.9	18.9
.18	.21	.17	.18	.67	.63
480	480	480	480	480	480
94.	34.	294.	73.5	322.	56.

(5)

STALK SHREDDER　　SPRAYER　　PLANTER　　DUSTER

```
0         10        20        30        40        50        60        70        80
         12        10        10        12        10        10        10        10
          1         1         1         1         1         1         1         1
       2350       850      3600       400     19000     19000      3350      2600
       13.7      17.7      17.7      13.7      10.8      10.8      10.8      10.8
        .18       .21       .17       .21       .67        .3       .63        .3
        240       400       480       240       240       240       240       240
        94.       34.      350.        0.      322.      322.       56.            --- (6)
STALK SHREDDER       SPRAYER              PLANTER              COMBINE
HAY MOWER            HAY CONDITIONER      HAY RAKE             HAY BALER
DISK                 HARROW               CULTIVATOR           CCRNHEAD

12" FLAIR            TRACTOR MOUNTED      4-38"                SMALL 70-80 HP
7'                   7'                   SIDE DELIVERY        SQUARE
21'                  21'                  4-38"                2-38"

         12        10        10        10        12        12        12         8
         10        12        10        10
          1         1         1         1         3         3         3         3
          1         1         2         1
       2350       850      3600     19000      1230      1300      1100      4580
       4280       630      1800      3380
       13.7      17.7      17.7      10.8      12.8      12.5      12.5      21.1
       17.7      17.7      17.7      10.9
       0.18      0.21      0.17      0.67      0.30      0.30      0.27      0.21
       0.09      0.10      0.10      0.63
        400       400       400       480       240       240       240       240
        240       240       240       240
        94.       34.       88.      322.       90.       82.      50.8      210.   --- (7)
     210.25     10.20     73.88       56,
STALK SHREDDER       SPRAYER              PLANTER


12" FLAIR            TRACTOR MOUNTED      4-38"



         12        10        10
          1         1         1
       2530       850      3600
       13.7      17.7      17.7                                                      --- (8)
       0.18      0.18      0.17
        480       480       480
        94.       34.       55.
    23900 (INCSTR)
         11        13        11        12        13        14        14        14  --- (TRECLP)
```

```
0|       10|      20 |      30|      40|      50|      60|      70|      80|
BU        BU       LB        BU       LB       --------------------------- (UTSD)
     .274      .31      .31      .246     .266     .31      0.       0.  -+
                        1.0                                               |
                        15.                                 15.           +- (AMSD)
                                                   1.                     |
                                                                   20.  -+
     2.15      6.6      1.7      9.5      0.       ------------------------- (USSD)
       1         1        3        1        1        2        2        1 ---- (NSD)
CORN              WHEAT                 SOYBEANS   ------------------------- (NACPP)
     170.      170.     113.     170.     170.     150.   ---+
      30.       30.      30.      30.      30.      30.      +-------------- (AMNFR)
      20.       20.      20.      20.      20.      20.   ---+
                         60.                            -----+
                         20.                                 +-------------- (AMPFR)
                         30.                            -----+
                                                    0.  -----+
                                                   30.       +-------------- (AMKFR)
                                                   30.  -----+
  .14 (CSFRN).21 (CSFRP).08 (CSFRK) 1. (MMNFN) .5 (RVSP)
       1         1        3        1        1        2        8        1 ---- (NCROP)
CORN            SOYBEANS                           ------------------------- (NACPP)
      11.       10.      10.      11.      11.      10.   ---+
       7.        7.       9.       7.       7.       7.   ---+-------------- (CSHMAC)
                                                    11.   ---+
                                                     0.   ---+-------------- (CSINAC)
CORN                                               ------------------------- (NACPD)
     110.      105.     105.     110.     110.     105.     105. ---+
     460.      480.     300.     460.     460.     300.     300. ---+------- (KPYD)
                         45.                       ----------------------+
                         90.                                             |
                          4.                                4.           |
                         90.                              180.           +-- (ACCP)
                                                   40.                   |
                                                  180.                   |
                                                                   50.   |
                                                                  460. --+
BU        BU        TON        BU        LB        ------------------------- (UTCPYD)
     .15                                           ------------------------- (CSDY)
CORN                WHEAT               HAY          SOYBEANS --------+
CATTLE                                             -------------------+----- (NACPR)
     2.15       2.3        45.      0.25      .33  ------------------------- (KPPR)
  1 1 1 0 0 0 1 1                                  ------------------------- (IDENTR)
       1.        1.       1.       1.       1.       1.       1.      20. -- (YRPLAN)
14 11 10 12  4  5 10  9  4  8  4  2  0 00          ------------------------- (MOTPAC)
 0  0  0  0 -6  0  6  0 -3  7  0  0  0 -6          ----------------------+
 2 10  0  2  4  0  5  0 -3 -2  0  0  0 -6                                |
 4 10  0  3  3  0  9  0 -4  3  0  0  0 -3                                |
 2  0 -3  7  7  0  7  0 -8  2  0  0  0 -6                                +-- (ENVTAG)
 6  5 -1  7 -6  0  9  0 -8  9  0  0  0 -6                                |
 0  5 -1  8  0  0  7  0  6  6  0  0  0 -3                                |
 2 10  3  6 -5  0  0  0 -4  7  0  0  0 -5                                |
 8 10  3  4  0  0 10  0  0 10  0  0  3  0          ----------------------+
$STOP
//

------ JES2 JOB STATISTICS ------

      249 CARDS READ
```

APPENDIX F

PRINTOUT OF "BMP1" APPLICATION

ANNUAL SOIL LOSS ESTIMATE

R	K	L	S	C	P	LS
220.000	0.320	7000.000	0.004	0.440	1.000	0.334

ANNUAL SOIL LOSS = 10.33 T/AC/YR

TOLERANCE LIMIT= 5.00 T/AC/YR

DEPTH OF SURFACE SOIL LAYER= 7.0 INCH   SOIL DEPLETION YEAR= 263.9 YR

REMOVAL EFFICIENCY

	C CONV.	C NO-T.	CCCWM NO-T	C NO-T TR	C STP TR	CB TR	CH	R LAND
CP	0.440	0.260	0.160	0.220	0.200	0.240	0.130	0.160
R.E. %	0.00	40.91	63.64	50.00	54.55	45.45	70.45	63.64

C CONV= CORN, RESIDUE LEFT, SPRING TURN-PLOW, CONVENTIONAL
C NO-T=CORN, FALL SHRED, NO-TILL PLANT, 50-70% RESIDUE COVER
CCCWM NO-T= CORN-CORN-CORN-WHEAT-MEADOW, RESIDUE LEFT, NO-TILL PLANT 2ND AND 3RD CORN
CORN NO-T TR=CORN, FALL SHRED STALKS, NO-TILL PLANT, 30-40% RESIDUE COVER, TERRACED
C STP TR= CORN, STRIP-TILL ROW ZONES
CB TR= CORN-SOYBEANS, TERRACED
CH= CORN-HAY ROTATION, CONTOUR
R LAND= RANGE LAND

SEDIMENT DELIVERY RATIO = 0.300

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

	C CONV.	C NO-T.	CCCWM NO-T	C NO-T TR	C STP TR	CB TR	CH	R LAND
SEDIMENT(T/AC/YR)	3.100	1.832	1.127	1.550	1.409	1.691	0.916	1.127

SS(LB/AC/YR)	123.99	73.26	45.09	61.99	56.36	67.63	36.63	45.09
BOD(LB/AC/YR)	53.31	31.50	19.39	26.06	24.23	29.08	15.75	19.39
COD(LB/AC/YR)	167.38	98.91	60.87	83.69	76.08	91.30	49.45	60.87

TERRACE CONSTRUCTION AND MAINTENANCE COSTS

ITEM	AMOUNT
TERRACE SPACING, FT	435.00
SLOPE LENGTH, FT	7000.00
NUMBER OF TERRACES PER SLOPE	16
FEET TERRACE/ACRE	99.57
CONSTRUCTION COST/FOOT TERRACE, $	0.92
CONSTRUCTION COST/ACRE, $	91.60
PRORATED CONSTRUCTION COST, $	10.76
MAINTENANCE COST, FT, $	0.00023
MAINTENANCE COST, ACRE, $	0.11
YEARLY TERRACE CHARGE/ACRE, $	10.87
TOTAL YEARLY TERRACE CHARGE, $	5217.49
GOVERNMENT SUBSIDY, %	60.00
FARMER SHARE, $	2087.00

MACHINERY FIXED COST

MACHINE	SIZE	INIT COST $	SAL VALUE %	ECON LIFE YR	YR DEPR $	TX INS HOU $	INTEREST $	YR FIX CS (X100.0%) $
				C CONV.				
STALK SHREDDER	12" FLAIL	2350	13.7	12	169.00	37.41	133.60	340.01
MOLDBOARD PLOW	5-16"	3760	17.7	10	309.45	61.96	221.28	592.68
SPRAYER	TRACTOR MOUNTED	850	17.7	10	69.95	14.01	50.02	133.98
DISK	21'	6250	17.7	10	514.38	102.99	367.81	985.17
HARROW	21'	630	17.7	12	43.21	10.38	37.08	90.66
PLANTER	4-38"	3600	17.7	10	296.28	59.32	211.86	567.46
CULTIVATOR	4-38"	1500	17.7	10	123.45	24.72	88.27	236.44
COMBINE	SMALL 70-80 HP	19000	18.9	10	1540.90	316.27	1129.55	2986.72
CORN HEAD	2-38"	3350	18.9	10	271.68	55.76	199.16	526.61
				C NO-T.				
STALK SHREDDER	12" FLAIL	2350	13.7	12	169.00	37.41	133.60	340.01
SPRAYER	TRACTOR MOUNTED	850	17.7	10	69.95	14.01	50.02	133.98
NO-TILL PLANTER	4-38"	6250	17.7	10	514.38	102.99	367.81	985.17
DUSTER	4-ROW	400	13.7	12	28.77	6.37	22.74	57.87
COMBINE	SMALL 70-80 HP	19000	18.9	10	1540.90	316.27	1129.55	2986.72
CORN HEAD	2-38"	3350	18.9	10	271.68	55.76	199.16	526.61
				CCCWW NO-T				
STALK SHREDDER	12" FLAIL	2350	13.7	12	169.00	37.41	133.60	340.01
MOLDBOARD PLOW	5-16"	3760	17.7	10	309.45	61.96	221.28	592.68
SPRAYER	TRACTOR MOUNTED	850	17.7	10	69.95	14.01	50.02	133.98
DISK	TANDEM	6250	17.7	10	514.38	102.99	367.81	985.17
HARROW	21'	630	17.7	12	43.21	10.38	37.08	90.66
NO-TILL PLANTER	FLUTED COULTERS	4375	17.7	10	360.06	72.03	257.47	689.62
WHEAT DRILL	W/ GRASS SEEDG. ATT	2920	9.7	14	188.34	44.83	160.16	393.35
DUSTER	4-ROW	400	13.7	12	28.77	6.37	22.74	57.87

COMBINE CORN	SMALL 70-80 HP	19000	16.9	10	1540.90	316.27	1129.55	2986.72
COMBINE WHEAT	SMALL 70-80 HP	19000	16.9	10	1540.90	316.27	1129.55	2986.72
CORN HEAD	2-38"	3350	16.8	10	272.02	55.72	198.99	526.73
PLATFORM	13'	2500	16.9	10	202.75	41.61	148.62	392.99
HAY MOWER	7'	1230	12.5	12	89.69	19.37	69.19	178.25
HAY CONDITIONER	7'	1300	12.5	12	94.79	20.47	73.13	188.39
HAY RAKE	SIDE DELIVERY	1100	12.5	12	80.21	17.32	61.88	159.41
HAY BALER	SQUARE	4560	21.1	8	451.70	77.65	277.32	806.67
			C NO-T TR					
STALK SHREDDER	12" FLAIL	2350	13.7	12	169.00	37.41	133.60	340.01
SPRAYER	TRACTOR MOUNTED	850	17.7	10	69.95	14.01	50.02	133.98
HARROW	21'	630	17.7	12	43.21	10.38	37.08	90.66
NO-TILL PLANTER	4-36"	4375	17.7	10	360.06	72.09	257.47	689.62
CULTIVATOR	4-38"	1500	17.7	10	123.45	24.72	88.27	236.44
COMBINE	SMALL 70-80 HP	19000	16.9	10	1540.90	316.27	1129.55	2986.72
CORNHEAD	2-38"	3350	16.9	10	271.68	55.76	199.16	526.61
			C STP TR					
STALK SHREDDER	12" FLAIL	2350	13.7	12	169.00	37.41	133.60	340.01
SPRAYER	TRACTOR MOUNTED	850	17.7	10	69.95	14.01	50.02	133.98
ROTARY STRIP PLATR	4-38"	3675	17.7	10	302.45	60.56	216.27	579.28
CULTIVATOR	4-38"	1500	17.7	10	123.45	24.72	88.27	236.44
COMBINE	SMALL 70-80 HP	19000	16.9	10	1540.90	316.27	1129.55	2986.72
CORN HEAD	2-38"	3350	16.9	10	271.68	55.76	199.16	526.61
			CB TR					
STALK SHREDDER	12" FLAIL	2350	13.7	12	169.00	37.41	133.60	340.01
SPRAYER	TRACTOR MOUNTED	850	17.7	10	69.95	14.01	50.02	133.98
PLANTER	4-38"	3600	17.7	10	296.28	59.32	211.86	567.46
DUSTER	4-ROW	400	13.7	12	28.77	6.37	22.74	57.87

COMBINE CORN	SMALL 70-80 HP	19000	18.8	10	1542.80	316.01	1128.60	2987.41
COMBINE SOYBEANS	SMALL 70-80 HP	19000	18.8	10	1542.80	316.01	1128.60	2987.41
CORN HEAD	2-38"	3350	18.8	10	272.02	55.72	198.99	526.73
PLATFORM	13'	2500	18.8	10	203.00	41.58	148.50	393.08
			CH					
STALK SHREDDER	12" FLAIR	2350	13.7	12	169.00	37.41	133.60	340.01
SPRAYER	TRACTOR MOUNTED	850	17.7	10	69.95	14.01	50.02	133.98
PLANTER	4-38"	3600	17.7	10	296.28	59.32	211.86	567.46
COMBINE	SMALL 70-80 HP	19000	18.9	10	1540.90	316.27	1129.55	2986.72
HAY MOWER	7'	1230	12.5	12	89.69	19.37	69.19	178.25
HAY CONDITIONER	7'	1300	12.5	12	94.79	20.47	73.13	188.39
HAY RAKE	SIDE DELIVERY	1100	12.5	12	80.21	17.32	61.88	159.41
HAY BALER	SQUARE	4580	21.1	8	451.70	77.65	277.32	806.67
DISK	21'	6250	17.7	10	514.38	102.99	367.81	985.17
HARROW	21'	630	17.7	12	43.21	10.38	37.08	90.66
CULTIVATOR	4-38"	1500	17.7	10	123.45	24.72	88.27	236.44
CORNHEAD	2-38"	3350	18.9	10	271.60	55.76	199.16	526.51
			R LAND					
STALK SHREDDER	12" FLAIR	2530	13.7	12	181.95	40.27	143.83	366.05
SPRAYER	TRACTOR MOUNTED	850	17.7	10	69.95	14.01	50.02	133.98
PLANTER	4-38"	3600	17.7	10	296.28	59.32	211.86	567.46

MACHINERY COSTS

IMPLEMENT	HR/AC	AC OF USE	TIMES OVER	TOTAL HR	REPAIR COST PER 100 HR $	TOTAL REPAIR COST $	YEARLY FIXED COST $	TOTAL COST $	
			C CONV.						
STALK SHREDDER	0.18	480	1	86.4	94.00	81.22	340.01	421.22	
MOLDBOARD PLOW	0.33	480	1	158.4	129.50	205.13	592.68	797.81	
SPRAYER	0.21	480	1	100.8	34.00	34.27	133.98	168.26	
DISK	0.09	480	1	43.2	219.25	94.72	985.17	1079.89	
HARROW	0.10	480	1	48.0	10.20	4.90	90.66	95.56	
PLANTER	0.17	480	1	81.6	114.40	93.35	567.46	660.81	
CULTIVATOR	0.18	480	2	172.8	73.50	127.01	236.44	363.45	
COMBINE	0.67	480	1	321.6	322.00	1035.55	2986.72	4022.27	
CORN HEAD	0.63	480	1	302.4	56.00	169.34	526.61	695.95	
TOTAL									8305.22
			C NO-T.						
STALK SHREDDER	0.18	480	1	86.4	94.00	81.22	340.01	421.22	
SPRAYER	0.21	480	1	100.8	34.00	34.27	133.98	168.26	
NO-TILL PLANTER	0.17	480	1	81.6	350.00	285.60	985.17	1270.77	
DUSTER	0.21	480	1	100.8	8.00	8.06	57.87	65.94	
COMBINE	0.67	480	1	321.6	322.00	1035.55	2986.72	4022.27	
CORN HEAD	0.63	480	1	302.4	56.00	169.34	526.61	695.95	
TOTAL									6644.41
			CCCWM NO-T						
STALK SHREDDER	0.18	300	1	54.0	94.00	50.76	340.01	390.77	
MOLDBOARD PLOW	0.33	100	1	33.0	129.50	42.73	592.68	635.42	
SPRAYER	0.21	300	1	63.0	34.00	21.42	133.98	155.40	
DISK	0.09	200	1	18.0	219.25	39.46	985.17	1024.64	
HARROW	0.10	100	1	10.0	10.20	1.02	90.66	91.68	

NO-TILL PLANTER	0.17	300	1	51.0	350.00	178.50	689.62	868.12	
WHEAT DRILL	0.18	100	1	18.0	219.20	39.46	393.35	432.80	
DUSTER	0.21	300	1	63.0	8.00	5.04	57.87	62.91	
COMBINE CORN	0.67	300	1	201.0	161.00	323.61	2986.72	3310.33	
COMBINE WHEAT	0.30	100	1	30.0	161.00	48.30	2986.72	3035.02	
CORN HEAD	0.63	300	1	189.0	56.00	105.84	526.73	632.57	
PLATFORM	0.30	100	1	30.0	50.00	15.00	392.99	407.99	
HAY MOWER	0.30	100	3	90.0	96.00	86.40	178.25	264.65	
HAY CONDITIONER	0.30	100	3	90.0	52.00	46.80	188.39	235.19	
HAY RAKE	0.27	100	3	81.0	58.80	47.63	159.41	207.04	
HAY BALER	0.21	100	3	63.0	210.00	132.30	806.67	938.97	
TOTAL									12693,49

C NO-T TR

STALK SHREDDER	0.18	480	1	86.4	94.00	81.22	340.01	421.22	
SPRAYER	0.21	480	1	100.8	34.00	34.27	133.98	168.26	
HARROW	0.10	480	1	48.0	10.20	4.90	90.66	95.56	
NO-TILL PLANTER	0.17	480	1	81.6	350.00	285.60	689.62	975.22	
CULTIVATOR	0.18	480	2	172.8	73.50	127.01	236.44	363.45	
COMBINE	0.67	480	1	321.6	322.00	1035.55	2986.72	4022.27	
CORNHEAD	0.63	480	1	302.4	56.00	169.34	526.61	695.95	
TOTAL									6741.93

C STP TR

STALK SHREDDER	0.18	480	1	86.4	94.00	81.22	340.01	421.22	
SPRAYER	0.21	48C	1	100.8	34.00	34.27	133.98	168.26	
ROTARY STRIP PLATR	0.17	480	1	81.6	294.00	239.90	579.28	819.19	
CULTIVATOR	0.18	480	2	172.8	73.50	127.01	236.44	363.45	
COMBINE	0.67	480	1	321.6	322.00	1035.55	2986.72	4022.27	
CORN HEAD	0.63	480	1	302.4	56.00	169.34	526.61	695.95	
TCTAL									6490.34

CB TR

STALK SHREDDER	0.18	240	1	43.2	94.00	40.61	340.01	380.62	
SPRAYER	0.21	480	1	100.8	34.00	34.27	133.98	168.26	
PLANTER	0.17	480	1	81.6	350.00	285.60	567.46	853.06	
DUSTER	0.21	240	1	50.4	8.00	4.03	57.87	61.91	
COMBINE CORN	0.67	240	1	160.8	322.00	517.78	2987.41	3505.18	
COMBINE SOYBEANS	0.30	240	1	72.0	322.00	231.84	2987.41	3219.25	
CORN HEAD	0.63	240	1	151.2	56.00	84.67	526.73	611.40	
PLATFORM	0.30	240	1	72.0	0.00	0.00	393.08	393.08	
TOTAL									9192.74

CH

STALK SHREDDER	0.18	480	1	86.4	94.00	81.22	340.01	421.22	
SPRAYER	0.21	480	1	100.8	34.00	34.27	133.98	168.26	
PLANTER	0.17	480	1	81.6	55.00	44.88	567.46	612.34	
COMBINE	0.67	480	1	321.6	322.00	1035.55	2986.72	4022.27	
HAY MOWER	0.30	240	3	216.0	96.00	207.36	178.28	385.61	
HAY CONDITIONER	0.30	240	3	216.0	52.00	112.32	188.39	300.71	
HAY RAKE	0.27	240	3	194.4	58.80	114.31	159.41	273.72	
HAY BALER	0.21	240	3	151.2	210.00	317.52	806.67	1124.19	
DISK	0.09	240	1	21.6	219.25	47.36	985.17	1032.53	
HARROW	0.10	240	1	24.0	10.20	2.45	90.66	93.11	
CULTIVATOR	0.18	240	2	86.4	73.50	63.50	236.44	299.95	
CORNHEAD	0.63	240	1	151.2	56.00	84.67	526.61	611.28	
TOTAL									9345.17

R LAND

STALK SHREDDER	0.18	480	1	86.4	94.00	81.22	366.05	447.27	
SPRAYER	0.18	480	1	86.4	34.00	29.38	133.98	163.36	
PLANTER	0.17	480	1	81.6	55.00	44.88	567.46	612.34	
TOTAL									1222.97

TRACTOR COSTS

ITEM	C CONV.	C NO-T.	CCCWM NO-T	C NO-T TR	C STP TR	CB TR	CH	R LAND
TRACTOR HRS/ACRE	2.94	2.27	2.46	2.52	2.42	1.72	3.64	0.73
TOTAL TRACTOR HRS	1852.32	1198.56	1298.00	1330.56	1277.76	910.80	1921.92	385.44
TR INITIAL COST, $ (X100.0%)			- 23900.C0 -					
ECONOMIC LIFE, YR	11	13	11	12	13	14	14	14
SALVAGE VALUE, %	27.5	23.5	27.5	25.5	23.5	21.5	21.5	21.5
YR DEPRECIATION, $	1575.23	1406.42	1575.23	1483.79	1406.42	1340.11	1340.11	1340.11
TX, INSR & HOUSE, $	1195.00	1195.00	1195.00	1195.00	1195.00	1195.00	1195.00	1195.00
AVG YR INTEREST, $	1523.62	1475.82	1523.62	1499.72	1475.82	1451.92	1451.92	1451.92
TOT FIXED COST, $	4293.85	4077.25	4293.85	4178.52	4077.25	3987.03	3987.03	3987.03
REPAIR COST, $	2968.03	2291.64	2481.77	2544.03	2443.08	1741.45	3674.71	736.96
TOT TRACTOR COST, $	7261.88	6368.89	6775.62	6722.54	6520.32	5728.48	7661.74	4723.99

FUEL COSTS

ITEM	C CONV.	C NO-T.	CCCWM NO-T	C NO-T TR	C STP TR	CB TR	CH	R LAND
TOT TRACTOR HRS	1552.32	1198.56	1298.00	1330.56	1277.76	910.80	1921.92	388.44
FUEL COST/TRAC. HR. $			-	4.250 -				
TRAC. FUEL COST. $	6597.36	5093.88	5516.49	5654.87	5430.48	3870.90	8168.15	1638.12
TOT COMBINE HRS	157.500	157.500	109.500	157.500	157.500	116.250	157.500	0.000
FUEL CS/COMB HR. $			-	3.630 -				
COMBINE FUEL CS. $	571.72	571.72	397.48	571.72	571.72	421.99	571.72	0.00
TOT FUEL COST. $	7169.08	5665.60	5913.98	6226.59	6002.20	4292.88	8739.88	1638.12

SEED COSTS

ITEM	C CCNV.	C NO-T.	CCCWN NO-T	C NO-T TR	C STP TR	CB TR	CH	R LAND
CORN								
SEED AMOUNT,BU /AC	0.27	0.31	0.31	0.29	0.29	0.31	0.00	0.00
SEED UNIT COST, $		-	2.15 -					
SEED COST, $/AC	0.59	0.67	0.67	0.61	0.61	0.67	0.00	0.00
WHEAT								
SEED AMOUNT,BU /AC	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00
SEED UNIT COST, $		-	6.50 -					
SEED COST, $/AC	0.00	0.00	9.75	0.00	0.00	0.00	0.00	0.00
HAY								
SEED AMOUNT,LB /AC	0.00	0.00	15.00	0.00	0.00	0.00	15.00	0.00
SEED UNIT COST, $		-	1.70 -					
SEED COST, $/AC	0.00	0.00	25.50	0.00	0.00	0.00	25.50	0.00
SOYBEANS								
SEED AMOUNT,BU /AC	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
SEED UNIT COST, $		-	9.50 -					
SEED COST, $/AC	0.00	0.00	0.00	0.00	0.00	9.50	0.00	0.00
BLUESTEM								
SEED AMOUNT,LB /AC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00
SEED UNIT COST, $		-	6.00 -					
SEED COST, $/AC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	120.00
AVE SD COST, $/AC	0.59	0.67	7.45	0.61	0.61	5.08	12.75	120.00
TOT SD COST, $	282.8	319.9	3575.9	295.2	295.2	2440.0	6120.0	57600.0

FERTILIZER COSTS

ITEM	C CONV.	C NO-T.	CCCWM NO-T	C NO-T TR	C STP TR	CB TR	CH	R LAND
CORN								
N.LB/AC	170.0	170.0	113.0	170.0	170.0	150.0	0.0	0.0
P2O5.LB/AC	30.0	30.0	30.0	30.0	30.0	30.0	0.0	0.0
K2O.LB/AC	20.0	20.0	20.0	20.0	20.0	20.0	0.0	0.0
WHEAT								
N.LB/AC	0.0	0.0	60.0	0.0	0.0	0.0	0.0	0.0
P2O5.LB/AC	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0
K2O.LB/AC	0.0	0.0	30.0	0.0	0.0	0.0	0.0	0.0
SOYBEANS								
N.LB/AC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P2O5.LB/AC	0.0	0.0	0.0	0.0	0.0	30.0	0.0	0.0
K2O.LB/AC	0.0	0.0	0.0	0.0	0.0	30.0	0.0	0.0
AVERAGE AMOUNT								
N.LB/AC	170.0	170.0	79.8	170.0	170.0	75.0	0.0	0.0
P2O5.LB/AC	30.0	30.0	23.0	30.0	30.0	30.0	0.0	0.0
K2O.LB/AC	20.0	20.0	18.0	20.0	20.0	25.0	0.0	0.0
COST OF FERT./AC.$	31.7	31.7	17.4	31.7	31.7	18.8	0.0	0.0
TOT. COST OF FERT..$	15215.98	15215.98	8372.14	15215.98	15215.98	9023.98	0.00	0.00
RENTAL OF EQUIP..$	720.00	720.00	720.00	720.00	720.00	720.00	0.00	0.00
TOTAL FERT. COST.$	15935.98	15935.98	7083.20	15935.98	15935.98	9743.98	0.00	0.00

PESTICIDES COSTS

ITEM	C CONV.	C NO-T.	CCCWM NO-T	C NO-T TH	C STP TR	CB TR	CH	R LAND
CORN								
HERBICIDE,$	11.00	16.00	16.00	11.00	11.00	18.00	0.00	0.00
INSECTICIDE,$	7.00	7.00	9.00	7.00	7.00	7.00	0.00	0.00
SOYBEANS								
HERBICIDE,$	0.00	0.00	0.00	0.00	0.00	11.00	0.00	0.00
INSECTICIDE,$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AVERAGE AMOUNT								
HERBICIDE,$	11.00	16.00	9.60	11.00	11.00	14.50	0.00	0.00
INSECTICIDE,$	7.00	7.00	5.40	7.00	7.00	3.50	0.00	0.00
TOT. PEST. COST. $/AC	18.00	23.00	15.00	18.00	18.00	18.00	0.00	0.00
TOT. PEST. COST. $ (X 480. AC)	8640.00	11040.00	7200.00	8640.00	8640.00	8640.00	0.00	0.00

LABOR COSTS

ITEM	C CONV.	C NO-T.	CCCWM NO-T	C NO-T TR	C STP TR	CB TR	CH	R LAND
TOT. DIRECT LABOR,HR	1709.82	1356.06	1407.50	1488.06	1435.26	1027.05	2079.42	385.44
OVERHEAD(30%), HR	512.95	406.82	422.25	446.42	430.58	308.11	623.83	115.63
TOTAL LABOR, HR	2222.76	1762.88	1829.75	1934.48	1865.84	1335.16	2703.24	501.07
COST PER HOUR, $				-5.00-				
TOTAL LABOR COST, $	11113.82	8814.38	9148.74	9672.38	9329.18	6675.82	13516.22	2505.36

DRYING COSTS

ITEM	C CONV.	C NO-T.	CCCWM NO-T	C NO-T TR	C STP TR	CW TR	CH	R LAND
CORN								
GRAN HARV., BU	52800.00	50400.00	31500.00	52800.00	52800.00	31500.00	31500.00	0.00
COST PER UNIT, $			-0.15-					
TOTAL COST, $	7920.00	7560.00	4725.00	7920.00	7920.00	4725.00	4725.00	0.00
TOT. DRY. COST, $	7920.00	7560.00	4725.00	7920.00	7920.00	4725.00	4725.00	0.00

INTEREST ON OPERATING CAPITAL

ITEM	C CCNV.	C NO-T.	CCCWN NO-T	C NO-T TR	C STP TR	CB TR	CH	R LAND
FERTILIZER(6 MO)	1062.93	1062.93	472.45	1062.93	1062.93	649.92	0.00	0.00
SEED(8 MO)	18.86	21.34	238.52	19.69	19.69	162.75	408.20	3841.92
PESTICIDE(6 MO)	432.00	552.00	360.00	432.00	432.00	432.00	0.00	0.00
FUEL(3 MO)	179.23	141.64	147.85	155.66	150.05	107.32	218.50	40.98
LABOR(3 MO)	277.85	220.36	228.72	241.81	233.23	166.90	337.91	62.63
TOTAL INTEREST	1970.86	1998.27	1447.53	1912.09	1897.90	1518.89	964.61	3945.81

REVENUE

ITEM	C CONV.	C NO-T.	CCCWW NO-T	C NO-T TR	C STP TR	CB TR	CH	R LAND
CORN								
EXPECT YIELD.BU /AC	110.00	105.00	105.00	110.00	110.00	105.00	105.00	0.00
AREA CROPPED.ACRES	480.00	480.00	300.00	480.00	480.00	300.00	300.00	0.00
TOTAL OUTPUTBU	52800.00	50400.00	31500.00	52800.00	52800.00	31500.00	31500.00	0.00
EXPECTED PRICE.$/BU			- 2.1-					
GROSS REVENUE.$	113519.9	108359.9	67724.9	113519.9	113519.9	67724.9	67724.9	0.0
WHEAT								
EXPECT YIELD.BU /AC	0.00	0.00	45.00	0.00	0.00	0.00	0.00	0.00
AREA CROPPED.ACRES	0.00	0.00	90.00	0.00	0.00	0.00	0.00	0.00
TOTAL OUTPUTBU	0.00	0.00	4050.00	0.00	0.00	0.00	0.00	0.00
EXPECTED PRICE.$/BU			- 2.3-					
GROSS REVENUE.$	0.0	0.0	9315.0	0.0	0.0	0.0	0.0	0.0
HAY								
EXPECT YIELD.TON/AC	0.00	0.00	4.00	0.00	0.00	0.00	4.00	0.00
AREA CROPPED.ACRES	0.00	0.00	90.00	0.00	0.00	0.00	180.00	0.00
TOTAL OUTPUTTON	0.00	0.00	360.00	0.00	0.00	0.00	720.00	0.00
EXPECTED PRICE.$/TON			-45.0-					
GROSS REVENUE.$	0.0	0.0	16200.0	0.0	0.0	0.0	32400.0	0.0
SOYBEANS								
EXPECT YIELD.BU /AC	0.00	0.00	0.00	0.00	0.00	40.00	0.00	0.00
AREA CROPPED.ACRES	0.00	0.00	0.00	0.00	0.00	180.00	0.00	0.00
TOTAL OUTPUTBU	0.00	0.00	0.00	0.00	0.00	7200.00	0.00	0.00
EXPECTED PRICE.$/BU			- 5.3-					
GROSS REVENUE.$	0.0	0.0	0.0	0.0	0.0	37800.0	0.0	0.0
CATTLE								
EXPECT YIELD.LB /AC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00
AREA CROPPED.ACRES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	480.00

TOTAL OUTPUTLB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24000.00
EXPECTED PRICE.$/LB			- 0.3-					
GROSS REVENUE.$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7920.0
TOTAL GROSS REV.$	113519.9	108359.9	93239.9	113519.9	113519.9	105524.9	100124.9	7920.0

SUMMARY

ITEM	C CONV.	C NO-T.	CCC*M NO-T	C NO-T TR	C STP TR	CH TH	CH	R LAND
GROSS REVENUE,$	113519.9	108359.9	93239.9	113519.9	113519.9	105524.9	100124.9	7920.0
COSTS,$								
TRACTOR(EXCL. FUEL)	7261.9	6368.9	6775.6	6722.5	6520.3	5728.5	7661.7	4724.0
MACHINE(EXCL FUEL)	8305.2	6644.4	12693.5	6741.9	6490.3	9192.7	9345.2	1223.0
FUEL	7169.1	5665.6	5914.0	6226.6	6002.2	4292.9	6739.9	1638.1
SEED	282.8	319.9	3575.9	295.2	295.2	2440.0	6120.0	57600.0
FERTILIZER	15936.0	15936.0	7083.2	15936.0	15936.0	9744.0	0.0	0.0
PESTICIDES	8640.0	11040.0	7200.0	8640.0	8640.0	8640.0	0.0	0.0
LABOR	11113.8	6814.4	9148.7	9672.4	9329.2	6675.8	13516.2	2808.4
DRYING	7920.0	7560.0	4725.0	7920.0	7920.0	4725.0	4725.0	0.0
INTEREST	1970.9	1998.3	1447.5	1912.1	1897.9	1818.9	964.6	3948.5
TERRACING	0.0	0.0	0.0	2087.0	2087.0	2087.0	0.0	0.0
TOTAL COST	68600.	64347.	58563.	66154.	65118.	55045.	51073.	71636.
PLAN YR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	20.0
TOTAL PLAN COST,$	68600.	64347.	58563.	66154.	65118.	55045.	51073.	3582.
NET RETURN	44920.	44012.	34676.	47366.	48402.	50480.	49052.	4338.

F-21

ENVIRONMENTAL IMPACT ASSESMENT

BMP	S.R.	O&M	L.D.	W.C.	NOIS	P.D.	W.Q.	F&F	F&G	N.L.	H.S.	A.S.	RECR	P.A.	TOTAL
WEIGHING FACTOR	14	11	18	12	4	5	18	9	6	8	6	7	8	10	
C CONV.	0	0	0	0	-6	0	0	0	-3	7	0	0	0	-6	
	0	0	0	0	-24	0	0	0	-18	56	0	0	0	-60	-46
C NO-T.	2	10	0	2	4	0	5	0	-3	-2	0	0	0	-6	
	28	110	0	24	16	0	90	0	-18	-16	0	0	0	-60	174
CCCWN NO-T	4	10	0	3	3	0	9	0	-4	3	0	0	0	-3	
	56	110	0	36	12	0	162	0	-24	24	0	0	0	-30	346
C NO-T TR	2	5	-3	7	7	0	7	0	-8	2	0	0	0	-6	
	28	55	-54	84	28	0	126	0	-48	16	0	0	0	-60	175
C STP TR	6	5	-1	7	-6	0	9	0	-8	5	0	0	0	-6	
	84	55	-18	84	-24	0	162	0	-48	40	0	0	0	-60	278
CB TR	8	5	-1	8	8	0	7	0	6	8	0	0	0	-3	
	112	55	-18	96	32	0	126	0	36	64	0	0	0	-30	473
CH	2	10	3	4	-5	0	8	0	-4	7	0	0	0	-5	
	28	110	54	48	-20	0	144	0	-24	56	0	0	0	-50	346
R LAND	8	10	3	4	0	0	10	0	0	10	0	0	3	0	
	112	110	54	48	0	0	180	0	0	80	0	0	24	0	608

S.R.=SYSTEM RELIABILITY; O&M=OPERATION AND MAINTENANCE; L.D.=LAND DISTURBED; W.C.=WATER CONSERVATION; NOIS=NOISE ANNOYANCE;

P.D.=POTENTIAL FOR DEVELOPMENT; W.Q.=WATER QUALITY; F&F=FLORA AND FAUNA; F&G=FISHING AND GAME; AEST=AESTHETICS;

H.S.=HISTORIC SITE; A.S.=ARCHEOLOGICAL SITE; RECR=RECREATIONAL; P.A.=PESTICIDE APPLICATION

STATEMENTS EXECUTED= 2802

CORE USAGE OBJECT CODE= 36632 BYTES,ARRAY AREA= 29060 BYTES,TOTAL AREA AVAILABLE= 366592 BYTES

DIAGNOSTICS NUMBER OF ERRORS= 0, NUMBER OF WARNINGS= 0, NUMBER OF EXTENSIONS= 0

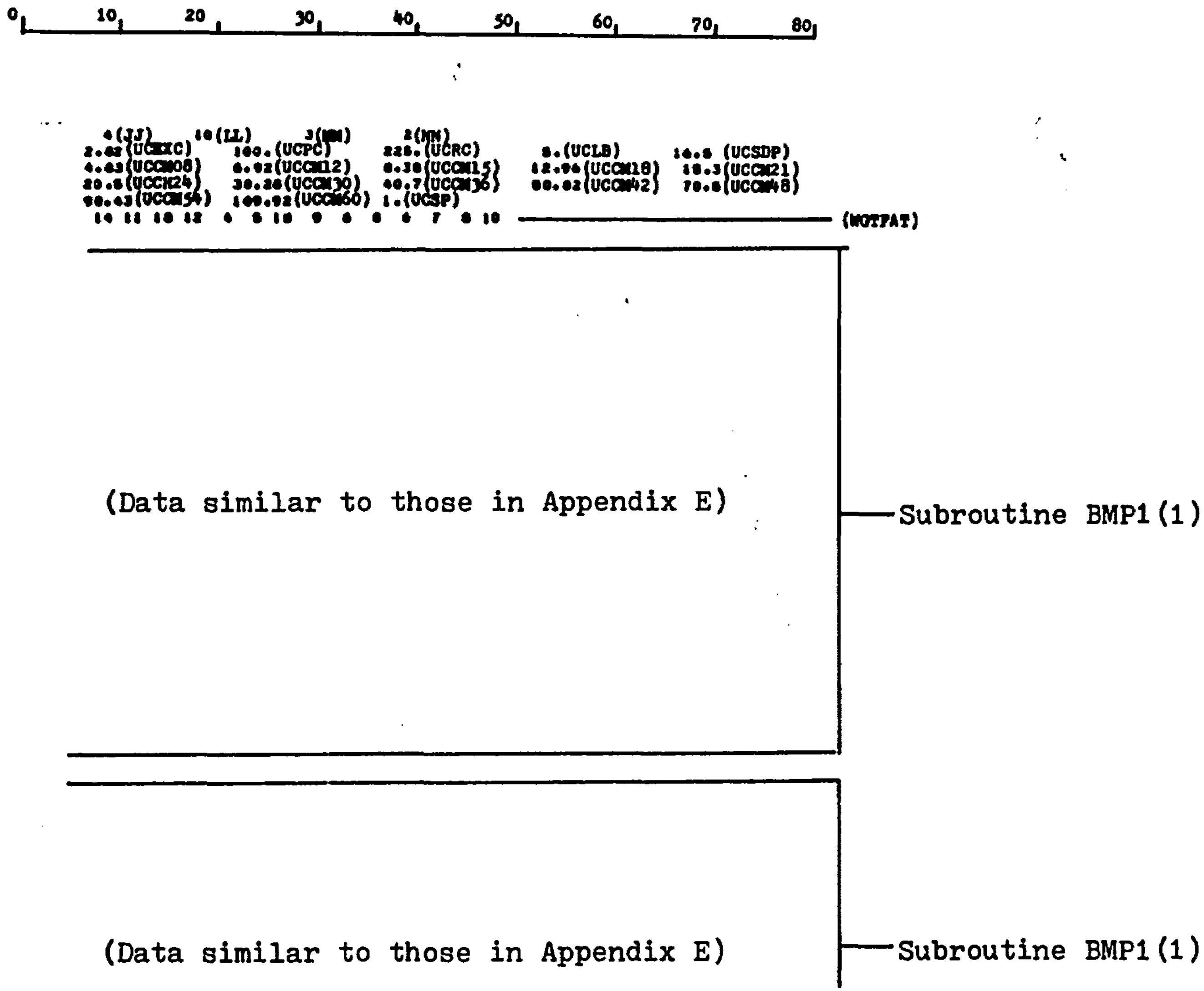
COMPILE TIME= 0.27 SEC,EXECUTION TIME= 0.24 SEC, 17.50.40 FRIDAY 18 NOV 83 WATFIV - JUN 1977 V1L6

C$BTCHEND

APPENDIX G

INPUT DATA OF "BMP2" APPLICATION

(Each input data name is described in the computer program as per PP. D-1, D-2 and D-3 in Appendix D. The position of input data can be located from the scale at the top of each page.)


0 10 20 30 40 50 60 70 80
(UCPC)
(UCRC)
(UCLB)
(UCSDP)
(UCCM12)
(UCCM15)
(UCCM18)
(UCCM21)
(UCCM24)
(UCCM30)
(UCCM42)
(UCSP)
(Data similar to those in Appendix E)
Subroutine BMP1(1)
(Data similar to those in Appendix E)
Subroutine BMP1(1)

```
0         10        20        30        40        50        60        70        80

GRASS (NALNDV)  0.(ACREDV)      2000.(OVLEDV)    1000.(LENGDV)
0.25(NNDV)      0.07 (NDV)      0.006(OVSPDV)    0.002(CHSPDV)    0.00838(BBDV)
220.(RDV)       0.37 (KDV)      0.16(CPABDV)     0.16(CPAADV)     1.(PDV)               -- Diversion (1)
2.(TOLTDV)      0.02 (PSSDV)    0.0086(PBODDV)   0.027(PCODDV)    4000. (OGLEDV)
4.(VELDV)       3. (ZDV)        16. (UCINDV)     2.9 (UCHADV)     .1(BDV)
  0  7 -3  0  0  0 10  0 -5 -3  0  0  0  0                          (ENVTDV)
BARESOIL        20.             1000.            1000.
0.25            0.02            0.004            0.001            0.00838
220.            0.37            0.36             0.36             1.                    -- Diversion (2)
4.              0.02            0.0086           0.027            3000.
2.              3.              0.               3.4              1.
  2  7 -3  0  0  0  0  0 -5 -3  0  0  0  0
GRASS           10.             1000.            1000.
0.25            0.07            0.005            0.002            0.00838
220.            0.37            0.27             0.27             1.                    -- Diversion (3)
8.              0.02            0.0086           0.027            2000.
4.              4.              15.              3.7              .1
  2  7 -2  0  0  0 40  0 -0 -3  0  0  0  0
CONCRETE        24.             1000.            1100.
0.25            0.02            0.005            0.003            0.00838
220.            0.37            0.18             0.10             1.                    -- Diversion (4)
2.              0.08            0.0086           0.027            3000.
6.              4.              40.              4.               1.
  2  7 -3  0  0  0  0  0 -6 -4  0  0  0  0
142. (ACRESB)   3000.(OVLESB)   600. (LENGSB)    0.012(SVSB)      3. (LFSB)
0.25 (NNSB)     0.1 (NSB)       0.013 (OVSPSB)   0.02 (CHSPSB)    0.00838 (BBSB)
220. (RSB)      0.24 (KSB)      0.28 (CPABSB)    1. (PSB)                               -- Sediment Basin (1)
5.  (TOLTSB)    0.02 (PSSSB)    0.0086 (PBODSB)  0.027 (PCODSB)
300.(LEDKSB)    02100. (ANINSB) 2.1 (UCHASB)     2. (UCFLSB)
  7  3 -2  7 -3  0  0  0 -1 -2  0  0  0  0                        (ENVTSB)
24.             1800.           600.             0.012            4.
0.25            0.1             0.02             0.07             0.00838
220.            0.37            0.18             1.                                     -- Sediment Basin (2)
5.              0.02            0.0086           0.027
100.            18100.          2.3              2.
  7  3 -2  7 -3  0  4  0 -1 -2  0  0  0  0
79.             1000.           1400.            0.012            4.
0.25            0.1             0.05             0.03             0.00838
220.            0.37            0.055            1.                                     -- Sediment Basin (3)
5.              0.02            0.0086           0.027
100.            53100.          2.5              2.
  7  3 -2  7 -3  0  4  0 -1 -2  0  0  0  0
63.             1500.           1500.            0.012            3.
0.25            0.1             0.01             0.04             0.00835
220.            0.24            0.36             1.                                     -- Sediment Basin (4)
5.              0.02            0.0086           0.027
120.            42350.          2.6              2.
  7  3 -2  7 -3  0  0  0 -1 -2  0  0  0  0
```

```
0|        10|        20 |        30|        40|        50|        60|        70|        80|
          7  3 -2  7 -3  0  5  0 -1 -2  0  0  0  0
        190.           2000.          4000.          0.012          6.
        0.25           0.1            0.04           0.03           0.00035
        220.           0.37           0.075          1.
        2.             0.02           0.0086         0.027
        60.            122000.        2.9            2.
          7  3 -2  7 -3  0  3  0 -1 -2  0  0  0  0
        36.            300.           1000.          0.012          5.
        0.25           0.1            0.03           0.03           0.00036
        220.           0.37           0.2            1.
        4.             0.02           0.0086         0.027
        250.           31400.         3.1            2.
          7  3 -2  7 -4  0  4  0 -1 -2  0  0  0  0
        190.           1000.          3000.          0.012          5.
        0.25           0.1            0.06           0.02           0.00035
        220.           0.37           0.04           1.
        2.             0.02           0.0086         0.027
        130.           130000.        3.3            2.
          7  3 -2  7 -4  0  4  0 -1 -2  0  0  0  0
        237.           1000.          0000.          0.012          5.
        0.25           0.1            0.03           0.02           0.00035
        220.           0.37           0.055          1.
        2.             0.02           0.0086         0.027
        180.           257000.        3.0            2.
          7  3 -2  7 -3  0  6  0 -1 -1  0  0  0  0
        20.            1000.          0000.          0.012          5.
        0.20           0.1            0.06           0.02           0.00035
        220.           0.37           0.08           1.
        2.             0.02           0.0086         0.027
        110.           11300.         3.8            2.
          7  3 -2  7 -4  0  2  0 -1 -2  0  0  0  0
        8" ASPHALT COATED (NAPPRT)                 10.(UCPPRT)
        1011.(ACHERT)  3000.(OVLERT   6000.(LENGRT)  0.012(SVRT)    20. (LPRT)
        0.25 (NNRT)    0.1 (NRT)      0.01 (OVSPRT)  0.02 (CHSPRT)  0.00035 (BBRT)
        220. (RRT)     0.24 (KRT)     0.12 (CPABRT)  1. (PRT)
        2. (TOLTRT)    0.02 (PSSRT)   0.0086 (PBODRT) 0.027 (PCODRT)
        360.(LEDKRT)   652000. (ANINRT)2.1 (UCHART)  2. (UCPLRT)
         10  7 -6 10 -7  0  3  0  1  1  0  0  5  0                     (ENVTRT)
        8" ASPHALT COATED                          10.
        1785.          3000.          9000.          0.012          20.
        0.25           0.1            0.01           0.02           0.00035
        220.           0.37           0.075          1.
        2.             0.02           0.0086         0.027
        400.           1192000.       2.1            2.
         10  7 -7 10 -7  0  3  0  2  1  0  0  5  0
        8" ASPHALT COATED                          10.
        2157.          3000.          11000.         0.012          20.
        0.25           0.1            0.01           0.02           0.00035
        220.           0.37           0.25           1.
        0.             0.02           0.0086         0.027
        400.           1392000.       2.5            2.
         10  7-10 10 -7  0  2  0  2  1  0  0  5  0
0STOP
//
```

Sediment Basin (6)

Sediment Basin (7)

Sediment Basin (8)

Sediment Basin (9)

Sediment Basin (10)

Floodwater Retarding Structure (1)

Floodwater Retarding Structure (2)

Floodwater Retarding Structure (3)

------ JES2 JOB STATISTICS ------

513 CARDS READ

APPENDIX H

PRINTOUT OF "BMP2" APPLICATION

(The output of Croplands C1 and C2 have the same forms as per Appendix F and therefore, are not shown here.)

DIVERSION - 4 DITCHES

DIVERSION 1

NAME OF THE LINING MATERIAL : GRASS

GENERAL CHARACTERS

Q.CFS	N	V.FPS	SLOPE	LENG.FT	HY RAD.FT
11.02	0.0700	4.00	0.0020	1500.00	8.64841

CROSS-SECTION DIMENSION

AREA.SQ FT	Z	Y.FT	B.FT	T.FT
2.76	3.0	0.03	0.10	0.36

ANNUAL SOIL LOSS ESTIMATE

R	K	L	S	C	P	LS
220.000	0.370	2000.000	0.006	0.160	1.000	0.257

ANNUAL SOIL LOSS = 3.35 T/AC/YR

TOLERANCE LIMIT = 2.00 T/AC/YR

REMOVAL EFFICIENCY = 18.77 %

SEDIMENT DELIVERY RATIO = 0.330

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

	SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)
BEFORE BMP	1.106	44.230	19.019	59.710
AFTER BMP	0.188	7.510	3.229	10.138

COST ESTIMATE

	EXC. CY	HAUL. CY	LIN. SY
QUANTITY	153.10	153.10	53.11
$/UNIT	2.82	2.90	15.00
COST,$	431.76	444.00	796.65

TOTAL COST,$ = 1672.41

DIVERSION 2

NAME OF THE LINING MATERIAL : BARESOIL

GENERAL CHARACTERS

Q,CFS	N	V,FPS	SLOPE	LENG,FT	HY RAD,FT
31.09	0.0300	2.00	0.0010	1000.00	1.44277

CROSS-SECTION DIMENSION

AREA,SQ FT	Z	Y,FT	B,FT	T,FT
15.55	3.0	1.55	1.00	12.59

ANNUAL SOIL LOSS ESTIMATE

R	K	L	S	C	P	LS
220.000	0.370	1000.000	0.004	0.360	1.000	0.186

ANNUAL SOIL LOSS = 5.45 T/AC/YR

TOLERANCE LIMIT = 4.00 T/AC/YR

REMOVAL EFFICIENCY = 28.08 %

SEDIMENT DELIVERY RATIO = 0.330

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

	SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)
BEFORE BMP	1.799	71.968	30.946	97.157
AFTER BMP	0.281	11.231	4.829	15.162

COST ESTIMATE

	EXC. CY	HAUL. CY	LIN. SY
QUANTITY	575.76	575.76	1197.19
$/UNIT	2.82	3.40	0.00
COST.$	1623.64	1957.58	0.00

TOTAL COST.$ = 3581.22

DIVERSION 3

NAME OF THE LINING MATERIAL : GRASS

GENERAL CHARACTERS

Q.CFS	N	V.FPS	SLOPE	LENG.FT	HY RAD.FT
27.01	0.0730	4.00	0.0020	1000.00	8.64841

CROSS-SECTION DIMENSION

AREA,SQ FT	Z	Y,FT	B,FT	T,FT
0.75	4.0	0.08	0.10	0.93

ANNUAL SOIL LOSS ESTIMATE :

R	K	L	S	C	P	LS
220.000	0.370	1000.000	0.005	0.270	1.000	0.197

ANNUAL SOIL LOSS = 4.34 T/AC/YR

TOLERANCE LIMIT = 2.00 T/AC/YR

REMOVAL EFFICIENCY = 18.77 %

SEDIMENT DELIVERY RATIO = 0.330

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

	SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)
BEFORE BMP	1.431	57.259	24.621	77.299
AFTER BMP	0.188	7.510	3.229	10.138

COST ESTIMATE

	EXC. CY	HAUL. CY	LIN. SY
QUANTITY	250.10	250.10	86.75
$/UNIT	2.82	3.70	15.00
COST,$	705.27	925.35	1301.31

TOTAL COST,$ = 2931.94

DIVERSION 4

NAME OF THE LINING MATERIAL : CONCRETE

GENERAL CHARACTERS

Q,CFS	N	V,FPS	SLOPE	LENG,FT	HY RAD,FT
41.17	0.0200	6.00	0.0030	1100.00	1.79020

CROSS-SECTION DIMENSION

AREA,SQ FT	Z	Y,FT	B,FT	T,FT
6.86	4.0	0.34	1.00	4.44

ANNUAL SOIL LOSS ESTIMATE

R	K	L	S	C	P	LS
220.000	0.370	1000.000	0.005	0.180	1.000	0.197

ANNUAL SOIL LOSS = 2.89 T/AC/YR

TOLERANCE LIMIT = 2.00 T/AC/YR

REMOVAL EFFICIENCY = 28.08 %

SEDIMENT DELIVERY RATIO = 0.330

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

	SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)
BEFORE BMP	0.954	38.173	16.414	51.533
AFTER BMP	0.281	11.231	4.829	15.162

COST ESTIMATE

	EXC. CY	HAUL. CY	LIN. SY
QUANTITY	279.54	279.54	468.45
$/UNIT	2.82	4.00	40.00
COST,$	788.31	1118.17	18738.11

TOTAL COST,$ = 20644.58

SEDIMENT BASIN - 10 BASINS

BASIN 1

GENERAL CHARACTER

SETTLING VEL. CFS	EXPECT. LIFE. YR	YR SEDT. T/AC/YR	Q IN. CFS	AREA. SF	DEPT. FT	DIKE LENG. FT
0.01200	3.00	6.13	235.5	19623.4	3.1	300.0

TRAP EFFICIENCY

BASIN VOL. CY (C)	YR INFLOW. CY (I)	C/I	TRAP EFF. %
2276.	82100.	0.17	89.52

ANNUAL SOIL LOSS ESTIMATE

R	K	L	S	C	P	LS
220.000	0.240	3000.000	0.013	0.260	1.000	0.415

ANNUAL SOIL LOSS = 6.13 T/AC/YR

TOLERANCE LIMIT = 5.00 T/AC/YR

REMOVAL EFFICIENCY = 89.52 %

SEDIMENT DELIVERY RATIO = 0.330

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)

232

BEFORE BMP	2.023	80.919	34.795	109.240
AFTER BMP	0.895	35.809	15.398	48.342

COST ESTIMATE

	EXC. CY	HAUL. CY	FILL. CY	SPRIG. CY
QUANTITY	--	638.--		513.13
$/UNIT	2.82	2.10	2.00	1.00
COST.$	1799.	1339.	1276.	513.

TOTAL COST.$ = 4926.

DROP SPILLWAY

FLOW RATE = 238.48 CFS

HEAD DROP = 3.13 FT

SIZE AND COST

L. FT	H. FT	V OF REIN CONC. CY	$/CY RC	$ OF RC
12.11	2.42	14.86	225.00	3344.23

BASIN 2

GENERAL CHARACTER

SETTLING VEL. CFS	EXPECT. LIFE. YR	YR SEDT. T/AC/YR	Q IN. CFS	AREA. SF	DEPT. FT	DIKE LENG. FT
0.01200	4.00	6.64	52.6	4386.6	3.4	100.0

TRAP EFFICIENCY

BASIN VOL. CY (C)	YR INFLOW. CY (I)	C/I	TRAP EFF. %
556.	16100.	0.21	90.99

ANNUAL SOIL LOSS ESTIMATE

R	K	L	S	C	P	LS
220.000	0.370	1500.000	0.020	0.180	1.000	0.453

ANNUAL SOIL LOSS = 6.64 T/AC/YR

TOLERANCE LIMIT = 5.00 T/AC/YR

REMOVAL EFFICIENCY = 90.99 %

SEDIMENT DELIVERY RATIO = 0.330

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

	SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)
BEFORE BMP	2.193	87.703	37.712	118.399
AFTER BMP	0.910	36.394	15.650	49.132

COST ESTIMATE

	EXC. CY	HAUL. CY	FILL. CY	SPRIG. CY
QUANTITY	--	242.--		180.71
$/UNIT	2.82	2.30	2.00	1.00
COST,$	682.	556.	484.	181.

TOTAL COST,$ = 19C2.

DROP SPILLWAY

FLOW RATE = 52.64 CFS

HEAD DROP = 3.42 FT

SIZE AND COST

L, FT	H, FT	V OF REIN CONC, CY	$/CY RC	$ OF RC
8.33	1.67	11.61	225.00	2611.41

BASIN 3

GENERAL CHARACTER

SETTLING VEL, CFS	EXPECT, LIFE, YR	YR SEDT, T/AC/YR	Q IN, CFS	AREA, SF	DEPT, FT	DIKE LENG, FT
0.01200	4.00	7.58	194.2	16187.3	3.5	100.0

TRAP EFFICIENCY

BASIN VOL, CY (C)	YR INFLOW, CY (I)	C/I	TRAP EFF, %
2088.	53100.	0.24	91.76

ANNUAL SOIL LOSS ESTIMATE

R	K	L	S	C	P	LS
220.000	0.370	1000.000	0.050	0.055	1.000	1.694

ANNUAL SOIL LOSS = 7.58 T/AC/YR

TOLERANCE LIMIT = 5.00 T/AC/YR

REMOVAL EFFICIENCY = 91.76 %

SEDIMENT DELIVERY RATIO = 0.330

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

	SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)
BEFORE BMP	2.503	100.101	43.043	135.136
AFTER BMP	0.918	36.704	15.783	49.580

COST ESTIMATE

	EXC. CY	HAUL. CY	FILL. CY	SPRIG. CY
QUANTITY	--	248.--		182.78
$/UNIT	2.82	2.50	2.00	1.00
COST.$	700.	621.	496.	183.

TOTAL COST.$ = 2000.

DROP SPILLWAY

FLOW RATE = 194.25 CFS

HEAD DROP = 3.48 FT

SIZE AND COST

L. FT	H. FT	V OF REIN CONC. CY	$/CY RC	$ OF RC
11.55	2.31	14.70	225.00	3307.12

BASIN 4

GENERAL CHARACTER

SETTLING VEL. CFS	EXPECT. LIFE. YR	YR SEDT. T/AC/YR	Q IN. CFS	AREA. SF	DEPT. FT	DIKE LENG. FT
0.01200	3.00	5.54	118.3	9860.8	2.5	120.0

TRAP EFFICIENCY

BASIN VOL. CY (C)	YR INFLOW. CY (I)	C/I	TRAP EFF. %
913.	42350.	0.13	87.58

ANNUAL SOIL LOSS ESTIMATE

R	K	L	S	C	P	LS
220.000	0.240	1500.000	0.010	0.360	1.000	0.292

ANNUAL SOIL LOSS = 5.54 T/AC/YR

TOLERANCE LIMIT = 5.00 T/AC/YR

REMOVAL EFFICIENCY = 87.58 %

SEDIMENT DELIVERY RATIO = 0.330

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

	SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)
BEFORE BMP	1.629	73.179	31.467	98.791
AFTER BMP	0.876	35.030	15.063	47.291

COST ESTIMATE

	EXC. CY	HAUL. CY	FILL. CY	SPRIG. CY
QUANTITY	--	187.--		160.01
$/UNIT	2.82	2.60	2.00	1.00
COST.$	526.	485.	373.	160.

TOTAL COST.$ = 1565.

DROP SPILLWAY

FLOW RATE = 118.33 CFS

HEAD DROP = 2.50 FT

SIZE AND COST

L, FT	H, FT	V OF REIN CONC, CY	$/CY RC	$ OF RC
10.18	2.04	12.43	225.00	2797.43

BASIN 5

GENERAL CHARACTER

SETTLING VEL. CFS	EXPECT. LIFE. YR	YR SEDT. T/AC/YR	Q IN. CFS	AREA. SF	DEPT. FT	DIKE LENG. FT
0.01200	5.00	4.89	58.8	4900.9	2.8	110.0

TRAP EFFICIENCY

BASIN VOL. CY (C)	YR INFLOW. CY (I)	C/I	TRAP EFF. %
512.	17700.	0.17	89.82

ANNUAL SOIL LOSS ESTIMATE

R	K	L	S	C	P	LS
220.000	0.370	1400.000	0.050	0.030	1.000	2.004

ANNUAL SOIL LOSS = 4.89 T/AC/YR

TOLERANCE LIMIT = 2.00 T/AC/YR

REMOVAL EFFICIENCY = 89.82 %

SEDIMENT DELIVERY RATIO = 0.330

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

	SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)
BEFORE BMP	1.615	64.604	27.780	87.216
AFTER BMP	0.898	35.928	15.449	48.503

COST ESTIMATE

	EXC. CY	HAUL. CY	FILL. CY	SPRIG. CY
QUANTITY	--	202.--		176.72
$/UNIT	2.82	2.80	2.00	1.00
COST,$	569.	565.	403.	177.

TOTAL COST,$ = 1713.

DROP SPILLWAY

FLOW RATE = 58.61 CFS

HEAD DROP = 2.82 FT

SIZE AND COST

L, FT	H, FT	V OF REIN CONC, CY	$/CY RC	$ OF RC
8.55	1.71	11.28	225.00	2538.24

BASIN 6

GENERAL CHARACTER

239

SETTLING VEL. CFS	EXPECT. LIFE. YR	YR SEDT. T/AC/YR	Q IN. CFS	AREA. SF	DEPT. FT	DIKE LENG. FT
0.01200	6.00	8.10	343.5	28625.7	7.6	60.0

TRAP EFFICIENCY

BASIN VOL. CY (C)	YR INFLOW. CY (I)	C/I	TRAP EFF. %
8049.	122600.	0.40	94.23

ANNUAL SOIL LOSS ESTIMATE

R	K	L	S	C	P	LS
220.000	0.370	2000.000	0.040	0.075	1.000	1.327

ANNUAL SOIL LOSS = 8.10 T/AC/YR

TOLERANCE LIMIT = 2.00 T/AC/YR

REMOVAL EFFICIENCY = 94.23 %

SEDIMENT DELIVERY RATIO = 0.330

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

	SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)
BEFORE BMP	2.674	106.951	45.989	144.384
AFTER BMP	0.942	37.692	16.208	50.885

COST ESTIMATE

EXC. CY	HAUL. CY	FILL. CY	SPRIG. CY

QUANTITY	--	521.--		191.84
$/UNIT	2.82	2.90	2.00	1.00
COST,$	1469.	1510.	1042.	192.

TOTAL COST,$ = 4213.

DROP SPILLWAY

FLOW RATE = 343.51 CFS

HEAD DROP = 7.59 FT

SIZE AND COST

L, FT	H, FT	V OF REIN CONC, CY	$/CY RC	$ OF RC
13.43	2.65	21.29	225.00	4789.27

BASIN 7

GENERAL CHARACTER

SETTLING VEL. CFS	EXPECT. LIFE, YR	YR SEDT. T/AC/YR	Q IN, CFS	AREA, SF	DEPT. FT	DIKE LENG, FT
0.01200	5.00	6.51	108.4	9035.3	3.0	280.0

TRAP EFFICIENCY

BASIN VOL. CY (C)	YR INFLOW, CY (I)	C/I	TRAP EFF. %
1020.	31460.	0.20	90.59

ANNUAL SOIL LOSS ESTIMATE

R	K	L	S	C	P	LS
220.000	0.370	300.000	0.030	0.200	1.000	0.400

ANNUAL SOIL LOSS = 6.51 T/AC/YR

TOLERANCE LIMIT = 4.00 T/AC/YR

REMOVAL EFFICIENCY = 90.59 %

SEDIMENT DELIVERY RATIO = 0.330

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

	SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)
BEFORE BMP	2.147	85.866	36.923	115.920
AFTER BMP	0.906	36.236	15.582	48.919

COST ESTIMATE

	EXC. CY	HAUL. CY	FILL. CY	SPRIG. CY
QUANTITY	--	512.--		420.77
$/UNIT	2.82	3.10	2.00	1.00
COST.$	1443.	1586.	1023.	421.

TOTAL COST.$ = 4473.

DROP SPILLWAY

FLOW RATE = 108.42 CFS

HEAD DROP = 3.05 FT

SIZE AND COST

L. FT	H. FT	V OF REIN CONC. CY	$/CY RC	$ OF RC
9.97	1.99	12.77	225.00	2874.23

BASIN 8

GENERAL CHARACTER

SETTLING VEL. CFS	EXPECT. LIFE. YR	YR SEDT. T/AC/YR	Q IN. CFS	AREA. SF	DEPT. FT	DIKE LENG. FT
0.01200	5.00	6.93	381.2	31765.1	5.1	120.0

TRAP EFFICIENCY

BASIN VOL. CY (C)	YR INFLOW. CY (I)	C/I	TRAP EFF. %
5977.	128000.	0.28	92.68

ANNUAL SOIL LOSS ESTIMATE

R	K	L	S	C	P	LS
220.000	0.370	1000.000	0.060	0.040	1.000	2.128

ANNUAL SOIL LOSS = 6.93 T/AC/YR

TOLERANCE LIMIT = 2.00 T/AC/YR

REMOVAL EFFICIENCY = 92.68 %

SEDIMENT DELIVERY RATIO = 0.330

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

	SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)
BEFORE BMP	2.286	91.454	39.325	123.462

AFTER BMP	0.927	37.073	15.942	50.049

COST ESTIMATE

	EXC. CY	HAUL. CY	FILL. CY	SPRIG. CY
QUANTITY	--	534.--		283.23
$/UNIT	2.82	3.30	2.00	1.00
COST.$	1505.	1761.	1067.	283.

TOTAL COST.$ = 4616.

DROP SPILLWAY

FLOW RATE = 381.18 CFS

HEAD DROP = 5.08 FT

SIZE AND COST

L. FT	H. FT	V OF REIN CONC. CY	$/CY RC	$ OF RC
13.71	2.74	18.70	225.00	4206.78

BASIN 9

GENERAL CHARACTER

SETTLING VEL. CFS	EXPECT. LIFE. YR	YR SEDT. T/AC/YR	Q IN. CFS	AREA. SF	DEPT. FT	DIKE LENG. FT
0.01200	5.00	2.90	388.3	32354.8	2.5	180.0

TRAP EFFICIENCY

BASIN VOL. CY (C)	YR INFLOW. CY (I)	C/I	TRAP EFF. %
2994.	207000.	0.09	63.78

ANNUAL SOIL LOSS ESTIMATE

244

R	K	L	S	C	P	LS
220.000	0.370	1500.000	0.030	0.055	1.000	0.648

ANNUAL SOIL LOSS = 2.90 T/AC/YR

TOLERANCE LIMIT = 2.00 T/AC/YR

REMOVAL EFFICIENCY = 83.78 %

SEDIMENT DELIVERY RATIO = 0.330

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

	SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)
BEFORE BMP	0.957	38.269	16.456	51.663
AFTER BMP	0.838	33.513	14.411	45.243

COST ESTIMATE

	EXC. CY	HAUL. CY	FILL. CY	SPHIG. CY
QUANTITY	--	280.--		269.88
$/UNIT	2.82	3.50	2.00	1.00
COST,$	789.	979.	559.	270.

TOTAL COST,$ = 2597.

DROP SPILLWAY

FLOW RATE = 388.32 CFS

HEAD DROP = 2.50 FT

SIZE AND COST

L, FT	H, FT	V OF REIN CONC, CY	$/CY RC	$ OF RC
13.70	2.74	15.67	225.00	3525.34

BASIN 10

GENERAL CHARACTER

SETTLING VEL, CFS	EXPECT. LIFE, YR	YR SEDT. T/AC/YR	Q IN, CFS	AREA, SF	DEPT, FT	DIKE LENG, FT
0.01200	5.00	13.86	40.4	3368.8	11.6	110.0

TRAP EFFICIENCY

BASIN VOL, CY (C)	YR INFLOW, CY (I)	C/I	TRAP EFF, %
1449.	11300.	0.77	96.40

ANNUAL SOIL LOSS ESTIMATE

R	K	L	S	C	P	LS
220.000	0.370	1000.000	0.060	0.080	1.000	2.128

ANNUAL SOIL LOSS = 13.86 T/AC/YR

TOLERANCE LIMIT = 2.00 T/AC/YR

REMOVAL EFFICIENCY = 96.40 %

SEDIMENT DELIVERY RATIO = 0.330

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

	SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)
BEFORE BMP	4.573	182.907	78.650	246.925
AFTER BMP	0.964	38.560	16.581	52.056

COST ESTIMATE

	EXC. CY	HAUL. CY	FILL. CY	SPRIG. CY
QUANTITY	--	2022.--		499.17
$/UNIT	2.82	3.80	2.00	1.00
COST.$	5701.	7683.	4043.	499.

TOTAL COST.$ = 17926.

HOODED INLET SPILLWAY

Q CFS	HEAD DROP. FT	PIPE SLOPE	V. FPS
40.43	11.61	0.3069	18.9864

SIZE AND COST - 21. INCH CORRUGATED METAL PIPE

PIPE. FT	$/FT PIPE	$ OF PIPE
39.58	15.30	605.62

FLOODWATER RETARDING STRUCTURE - 3 RESERVOIRS

RESERVOIR 1

GENERAL CHARACTER

SETTLING VEL. FPS	EXPECT. LIFE. YR	YR SEDT. T/YR	Q IN. CFS	AREA. SF	DEPT. FT	DIKE LENG. FT
0.01200	20.00	2.28	1291.33	107611.	10.06	300.00

TRAP EFFICIENCY

BASIN VOL. CY (C)	YR INFLOW. CY (I)	C/I	TRAP EFF. %
40089.	652000.	0.37	93.96

ANNUAL SOIL LOSS ESTIMATE

R	K	L	S	C	P	LS
220.000	0.240	3000.000	0.010	0.120	1.000	0.359

ANNUAL SOIL LOSS = 2.28 T/AC/YR

TOLERANCE LIMIT = 2.00 T/AC/YR

REMOVAL EFFICIENCY = 93.96 %

SEDIMENT DELIVERY RATIO = 0.220

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)

BEFORE BMP	0.501	20.021	6.609	27.028
AFTER BMP	0.940	37.584	16.161	50.738

COST ESTIMATE

	EXC. CY	HAUL. CY	FILL. CY	8" ASPHALT COATED	SPRIG CY
QUANTITY	--	5650.9	--	1205.86	300.00
$/UNIT	2.82	2.10	2.00	10.00	1.00
COST.$	15935.	11867.	11302.	3000.	1206.

TOTAL COST.$ = 43310.

DROP SPILLWAY

FLOW RATE = 1291.33 CFS

HEAD DROP = 10.06 FT

SIZE AND COST

L. FT	H. FT	V OF REIN CONC. CY	$/CY RC	$ OF RC
18.80	3.76	31.65	225.00	7121.48

RESERVOIR 2

GENERAL CHARACTER

SETTLING VEL. FPS	EXPECT. LIFE. YR	YR SEDT. T/YR	Q IN. CFS	AREA. SF	DEPT. FT	DIKE LENG. FT
0.01200	20.00	2.19	2100.60	175050.	10.52	400.00

TRAP EFFICIENCY

BASIN VOL. CY (C)	YR INFLOW. CY (I)	C/I	TRAP EFF. %
68200.	1152000.	0.36	93.80

ANNUAL SOIL LOSS ESTIMATE

R	K	L	S	C	P	LS
220.000	0.370	3000.000	0.010	0.075	1.000	0.359

ANNUAL SOIL LOSS = 2.19 T/AC/YR

TOLERANCE LIMIT = 2.00 T/AC/YR

REMOVAL EFFICIENCY = 93.80 %

SEDIMENT DELIVERY RATIO = 0.220

POTENCY FACTOR : SS= 0.020 OF SEDIMENT
BOD= 0.009 OF SEDIMENT
COD= 0.027 OF SEDIMENT

WATER QUALITY

	SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)
BEFORE BMP	0.482	19.291	8.295	26.043
AFTER BMP	0.938	37.519	16.133	50.651

COST ESTIMATE

	EXC. CY	HAUL. CY	FILL. CY	8" ASPHALT COATED	SPRIG CY
QUANTITY	--	8078.7--		1669.24	400.00
$/UNIT	2.82	2.30	2.00	10.00	1.00
COST.$	22782.	18581.	16157.	4000.	1669.

TOTAL COST.$ = 63190.

DROP SPILLWAY

FLOW RATE = 2100.60 CFS

HEAD DROP =   10.52 FT

SIZE AND COST

L, FT	H, FT	V OF REIN CONC, CY	$/CY RC	$ OF RC
21.26	4.25	35.96	225.00	8091.20

RESERVOIR 3

GENERAL CHARACTER

SETTLING VEL. FPS	EXPECT. LIFE, YR	YR SEDT. T/YR	Q IN, CFS	AREA, SF	DEPT. FT	DIKE LENG. FT
0.01200	20.00	7.31	2421.11	201759.	36.76	400.00

TRAP EFFICIENCY

BASIN VOL. CY (C)	YR INFLOW, CY (I)	C/I	TRAP EFF. %
274711.	1392000.	1.19	97.35

ANNUAL SOIL LOSS ESTIMATE

R	K	L	S	C	P	LS
220.000	0.370	3000.000	0.010	0.250	1.000	0.359

ANNUAL SOIL LOSS =   7.31 T/AC/YR

TOLERANCE LIMIT =   5.00 T/AC/YR

REMOVAL EFFICIENCY =   97.35 %

SEDIMENT DELIVERY RATIO =   0.220

POTENCY FACTOR : SS=   0.020 OF SEDIMENT
BOD=   0.009 OF SEDIMENT
COD=   0.027 OF SEDIMENT

WATER QUALITY

	SEDIMENT (T/AC/YR)	SS (LB/AC/Y)	BOD (LB/AC/Y)	COD (LB/AC/Y)
BEFORE BMP	1.608	64.303	27.650	86.809
AFTER BMP	C.973	38.940	16.744	52.568

COST ESTIMATE

	EXC. CY	HAUL. CY	FILL. CY	8" ASPHALT COATED	SPRIG CY
QUANTITY	-- 70225.0--			5168.34	400.00
$/UNIT	2.82	2.50	2.00	10.00	1.00
COST,$	198034.	175563.	140450.	4000.	5168.

TOTAL COST,$ = 523215.

CHUTE SPILLWAY

Q CFS	LENG. FT	WIDTH. FT	VOL OF RC. CY	$/CY RC	COST OF RC
2421.11	110.25	74.92	3811.51	225.00	857590.

ENVIRONMENTAL IMPACT ASSESMENT

BMP	S.R.	O&M	L.D.	W.C.	NOIS	P.D.	W.Q.	F&F	F&G	AEST	H.S.	A.S.	RECH	P.A.	TOTAL
WEIGHING FACTOR	14	11	18	12	4	5	18	9	6	8	6	7	8	10	
DIVERSION 1	2	7	-3	0	0	0	10	0	-5	-3	0	0	0	0	
	28	77	-54	0	0	0	180	0	-30	-24	0	0	0	0	177
DIVERSION 2	2	7	-3	0	0	0	9	0	-5	-3	0	0	0	0	
	28	77	-54	0	0	0	162	0	-30	-24	0	0	0	0	159
DIVERSION 3	2	7	-2	0	0	0	10	0	-5	-3	0	0	0	0	
	28	77	-36	0	0	0	180	0	-30	-24	0	0	0	0	195
DIVERSION 4	2	7	-3	0	0	0	9	0	-5	-4	0	0	0	0	
	28	77	-54	0	0	0	162	0	-30	-32	0	0	0	0	151
BASIN 1	7	3	-2	7	-3	0	5	0	-1	-2	0	0	0	0	
	98	33	-36	84	-12	0	90	0	-6	-16	0	0	0	0	235
BASIN 2	7	3	-2	7	-3	0	4	0	-1	-2	0	0	0	0	
	98	33	-36	84	-12	0	72	0	-6	-16	0	0	0	0	217
BASIN 3	7	3	-2	7	-3	0	4	0	-1	-2	0	0	0	0	
	98	33	-36	84	-12	0	72	0	-6	-16	0	0	0	0	217
BASIN 4	7	3	-2	7	-3	0	5	0	-1	-2	0	0	0	0	
	98	33	-36	84	-12	0	90	0	-6	-16	0	0	0	0	235
BASIN 5	7	3	-2	7	-3	0	5	0	-1	-2	0	0	0	0	
	98	33	-36	84	-12	0	90	0	-6	-16	0	0	0	0	235
BASIN 6	7	3	-2	7	-3	0	3	0	-1	-2	0	0	0	0	
	98	33	-36	84	-12	0	54	0	-6	-16	0	0	0	0	199
BASIN 7	7	3	-2	7	-4	0	4	0	-1	-2	0	0	0	0	
	98	33	-36	84	-16	0	72	0	-6	-16	0	0	0	0	213
BASIN 8	7	3	-2	7	-4	0	4	0	-1	-2	0	0	0	0	
	98	33	-36	84	-16	0	72	0	-6	-16	0	0	0	0	213
BASIN 9	7	3	-2	7	-3	0	6	0	-1	-1	0	0	0	0	
	98	33	-36	84	-12	0	108	0	-6	-8	0	0	0	0	261

BASIN 10	7	3	-2	7	-4	0	2	0	-1	-2	0	0	0	0	
	98	33	-36	84	-16	0	36	0	-6	-16	0	0	0	0	177
RESERVOIR 1	10	7	-6	10	-7	0	3	0	1	1	0	0	5	0	
	140	77	-108	120	-28	0	54	0	6	8	0	0	40	0	309
RESERVOIR 2	10	7	-7	10	-7	0	3	0	2	1	0	0	5	0	
	140	77	-126	120	-28	0	54	0	12	8	0	0	40	0	287
RESERVOIR 3	10	7	-10	10	-7	0	2	0	2	1	0	0	5	0	
	140	77	-180	120	-28	0	36	0	12	8	0	0	40	0	228

S.R.=SYSTEM RELIABILITY; O&M=OPERATION AND MAINTENANCE; L.D.=LAND DISTURBED; W.C.=WATER CONSERVATION; NOIS=NOISE ANNOYANCE;

P.D.=POTENTIAL FOR DEVELOPMENT; W.Q.=WATER QUALITY; F&F=FLORA AND FAUNA; F&G=FISHING AND GAME; AEST=AESTHETICS;

H.S.=HISTORICAL SITE; A.S.=ARCHEOLOGICAL SITE; RECR=RECREATIONAL; P.A.=PESTICIDE APPLICATION

STATEMENTS EXECUTED= 1720

CORE USAGE OBJECT CODE= 30952 BYTES,ARRAY AREA= 13424 BYTES,TOTAL AREA AVAILABLE= 366592 BYTES

DIAGNOSTICS NUMBER OF ERRORS= 0, NUMBER OF WARNINGS= 0, NUMBER OF EXTENSIONS= 0

COMPILE TIME= 0.25 SEC,EXECUTION TIME= 0.21 SEC, 14.45.21 WEDNESDAY 4 JAN 84 WATFIV - JUN 1977 V1L6

C$STOPEND