A DESIGN PROGRAM FOR THE ESTIMATION AND ABATEMENT OF SOIL LOSSES FROM HIGHWAY SLOPES

by

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PREFACE

Acting upon a request by the Environmental Quality Division of the Virginia Department of Highways, the Research Council conducted an overview evaluation of the Department's erosion and siltation control program. Much of the evaluation deals with the maintenance of the environment during highway construction. A most important consideration appears to be the accurate prediction of soil loss from highway slopes during construction and the design of the siltation controls to abate this loss on the construction site.

To this end, this design manual was prepared in an attempt to estimate the soil loss and to design a set of adequate abatement structures along the ditch line of the roadway. These tasks are accomplished by a computer program which is intended to be used on the IBM Model 370 computer of the Central Office of the Virginia Highway Department.

The manual is intended to be used by the personnel of the Location and Design Division and Environmental Quality Division as part of the initial phases of planning and design and by environmental personnel at the district level for updating of control structures as construction progresses or maintenance of the structures is required.

The manual consists of a general introduction to the problem and this is followed by a brief description of the information which must be input into the computer as well as a description of the calculated results. A simple example is used to show typical input and output. Greater detail on various aspects of the computer program are given in the Appendices. These include a description of the general mathematical procedure used in the calculation of the soil-loss prediction, description and arrangement of input cards and a complete listing of the computer program.

The manual is open-ended in that as future research into the design of siltation controls is accomplished by the Research Council, the computer program will be updated.

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INTRODUCTION

This manual describes an easy to use computerized design program which estimates the soil loss from a highway slope or median strip. Input into the program consists of a basic description of the slope (location, soil erodibility, slope length and gradient) and duration of construction. The output consists of an estimated annual soil loss and a peak loss assuming a 10-year storm event over the construction period. The preventive measures required to control this peak soil loss from getting into streams are in terms of the number of straw barriers needed per 100 feet of roadway. An equivalency table is also output for alternate siltation controls and procedures in terms of straw barriers.

Several studies suggest that soil loss from highway construction can be estimated by use of the Universal Soil Loss Equation.[1,2,3,4,5] This soil loss prediction equation was developed by the U. S. Soil Conservation Service for soil losses from agricultural areas of low and uniform steepness. Two difficulties arise in its application to highway construction. These are that the typical highway slope is commonly irregularly shaped in cross section and that at least part of the slope is usually very steep. Recently, a modification of the equation by Foster and Wischmeier allows for the prediction of soil loss from irregular slopes.[6]

The program described here is intended to be used for new construction and scheduled erosion control maintenance of existing projects. It is designed for the IBM Model 370 of the Central Office of the Virginia Department of Highways so that during the initial phases of planning, personnel of the Location and Design Division and Environmental Quality Division will have access to its use. Environmental personnel at the district level can also use their remote computer terminals to maintain and redesign siltation controls as the construction proceeds. A brief description of the method of calculation is found in Appendix A.

INPUT PROCEDURE

Three basic input items are used to determine the soil loss from a highway slope using the Universal Soil Loss Equation. These are:

1. The location of the slope in terms of district and residency,

2. a description of the topographic cross section and soils of the slope, and

3. the period of construction or any selected time interval in which the soil of the slope will be disturbed.

Coded values of the district and residency are used to determine the annual regional rainfall distribution and the rainfall-energy index (see Appendix A) for the particular location of the highway construction. These values are used in the computational procedure along with the project period of construction and soil erodibility factor (see Appendix A) to produce the estimated annual soil loss as well as the soil loss occurring over selected time intervals.

The technique for describing an irregular slope such as found along a roadway undergoing construction is to divide the slope cross section into a series of straight line segments. Each segment may have a different slope length and percent gradient. The simplest number of segments would be two (as is shown in the nearly completed slope in Figure 1). The percent gradient of each segment is found from:

$$\text{Percent gradient of a segment} = \frac{\text{Vertical change in feet}}{\text{Horizontal change in feet}} \times 100$$

In Figure 1, the first slope segment would be a cut slope from which most of the soil loss would be generated and the second segment would be the drainage ditch running parallel to the roadway. This latter segment also contributes to the overall soil loss and is the location where most of the siltation abatement measures are used. The designed abatement structures are to be placed in the last segment. The program allows calculation of the soil loss for complex slopes with five segments.

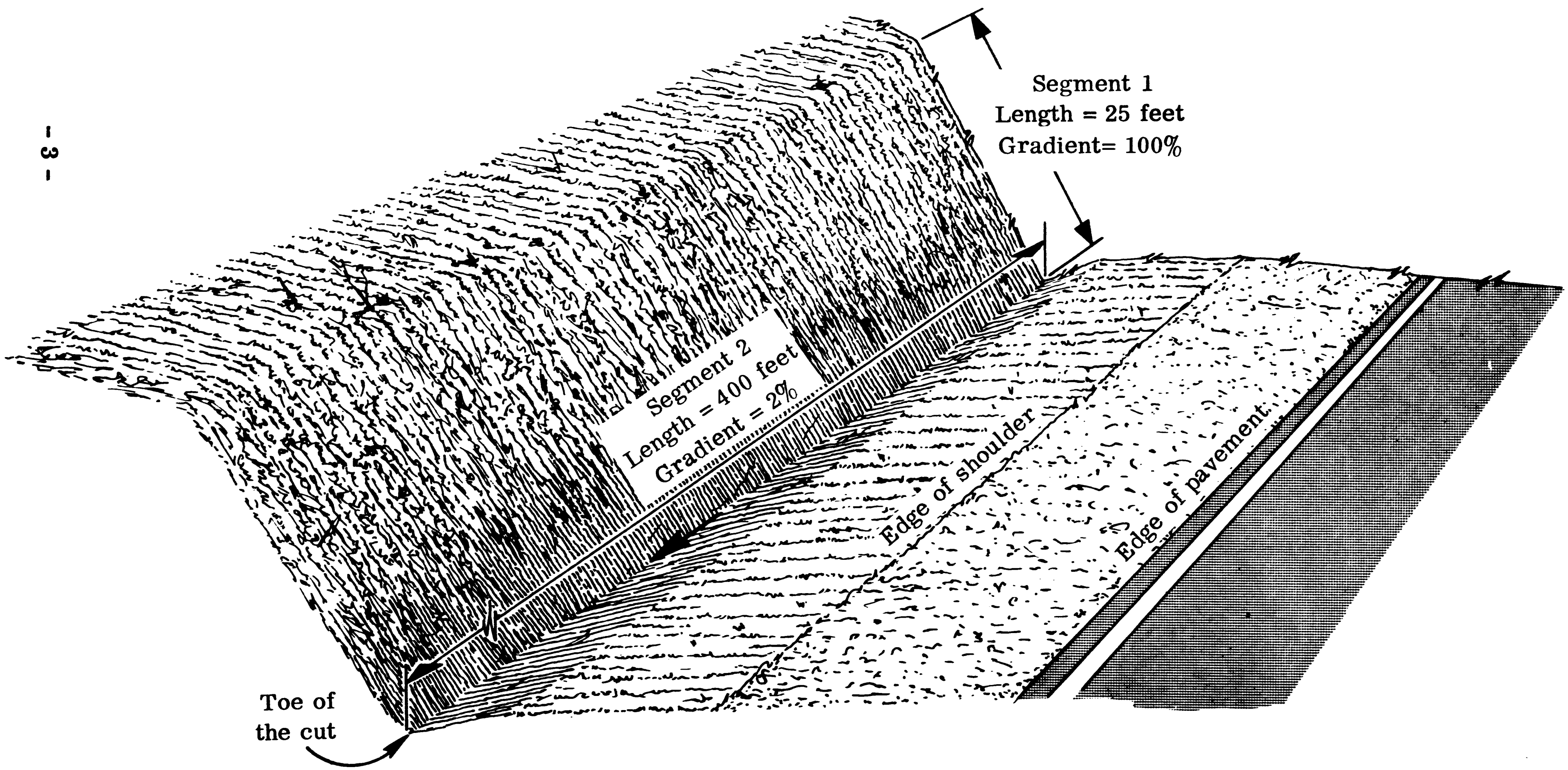

Figure 1. Typical highway slope divided into segments. (Segments are not necessarily to scale.)

OUTPUT

The basic unit of abatement utilized in this program is the two-bale straw barrier. The computer program generates the number of straw barriers which should be placed in the last segment to control the soil loss from a 10-year storm event occurring during the period of construction.

In the future, investigation by the Research Council will assess the effect of other erosion control structures and practices (rock barriers, seeding and mulching, etc.) in terms of equivalent numbers of straw barriers. For instance, control of the soil loss from a particular roadside slope may require one straw barrier every 200 feet but seeding and mulching of the same slope may reduce this to one barrier every 400 feet due to the resulting soil stabilization. As new field data are gathered, the computer program will be updated with the latest information. A small equivalence table is provided near the end of the computer output.

Given the slope shown in Figure 1, the results of the program are given in Figure 2. Columns 1-7 are intermediate calculations (see Appendix B) and should be used for checking output. The length of the segments, in this case 25 and 400 feet, respectively, are shown in column 8 of the output along with their total (425 feet). Column 9 shows that the effective length-slope (LS) factor of the slope (Appendix A) was 2.84 and column 10 shows the percent of the total sediment loss contributed by each segment of the slope.

The estimated annual soil loss from the example was 129.5 tons per acre and over the construction period (October to December) the soil loss for a simulated 10-year storm event would be 24.6 cubic yards.

The estimated number of straw barriers per 100 feet of roadway is 1.41 and the total number of barriers needed in the final section is 6.0.

The soil trapping equivalency table (Figure 2) indicates the straw barrier equivalents of certain structures or procedures. Thus if a section required a total of 17 barriers and a double-ring drop inlet were contained in the section, then only 7 barriers would be needed as abatement, since a drop inlet is equivalent to 10 straw barriers in trapping silt capacity.

The cover index C can be used to modify the designed abatement. The C index is multiplied by the abatement index to determine the number of bales needed. For example, suppose the slope shown in Figure 1 had been mulched less than 90 days. Then the abatement after mulching (see Figure 2) would be .50 times 6 barriers or 3 barriers. After 90 days of grass growth essentially no barriers would be required.

DESIGNING MAINTENANCE OF TEMPORARY SILTATION CONTROLS

DISTRICT 7 RESIDENCY 43

K VALUE 0.28 R VALUE 163.

BEGINNING MONTH 9

ENDING MONTH 12

SEGMENT	LENGTH	GRADIENT PERCENT	LENGTH-1	U2	U1	U2-U1	SEGMENT LENGTH	SEGMENT LS	PERCENT CONTRIBUTION OF TOTAL LOSS
1	25.	100.00	0.	1021.	0.	1021.	25.	40.86	84.719
2	425.	2.00	25.	187.	3.	184.	400.	0.46	15.281
						1206.	425.	2.84	100.000

ESTIMATED ANNUAL SOIL-LOSS IN TONS PER ACRE	=	129.47
ESTIMATED ANNUAL SOIL-LOSS IN CUBIC YARDS	=	112.64
ESTIMATED SOIL-LOSS IN CUBIC YARDS OVER CONSTRUCTION PERIOD	=	24.60
IN CUBIC METERS	=	18.81
ESTIMATED AREA OF INTEREST IN ACRES	=	0.23
IN HECTARES	=	0.09

ABATEMENT

NO. OF STRAW BARRIER(S) NEEDED PER 100 FEET OF ROADWAY	1.41
TOTAL NUMBER OF BARRIERS NEEDED IN FINAL SEGMENT	6.

EQUIVALENCY TABLE

1 DROP INLET(DOUBLE-RING BALED)= 10 STRAW BARRIERS

COVER INDEX C

TYPE OF COVER	C VALUE
NONE	1.00
SEEDING AND MULCHING (FIRST 90 DAYS)	.50
SEEDING AND MULCHING (AFTER 90 DAYS)	.05

Figure 2. Computed soil-loss and abatement for slope shown in Figure 1.

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2. Wischmeier, W. H., and L. D. Meyer, "Soil Erodibility on Construction Areas", Highway Research Special Report 135, Highway Research Board, pp. 20-29, 1973.

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5. Swerdon, P. M. and R. R. Koontz, "Sediment Runoff Control at Highway Construction Sites", Engineering Res. Bulletin B-108, Pennsylvania State College of Engineering, p. 70, 1973.

6. Foster, G. R., and W. H. Wischmeier, "Evaluating Irregular Slopes for Soil Loss Prediction", ASAE Paper No. 73-227, p. 16, 1973.

APPENDIX A

METHOD OF CALCULATION

Appendix A contains a very brief mathematical discourse on the method of calculation found in the computer program. For a more detailed treatment of the method used in the computer program the reader is referred to reference 6.

The basic assumptions of the Universal Soil Loss Equation are that the average soil loss per unit area (in this case, of roadside) is a product of a rainfall factor (termed R), a soil erodibility factor (K), a slope length factor (L) and a steepness factor (S). Thus,

$$A = RKLS \tag{1}$$

where A is the soil loss per unit area. For the purpose of calculation the slope length and steepness factors have been combined into a series of tables involving a length-steepness factor (LS).

As indicated by the equation, the calculation of A assumes a uniform steepness. However, Foster and Wischmeier found that in the case of irregular slopes the sediment yields are not accurately estimated by the assumption of a uniform overall average steepness. They observed that the sediment load at any location on an irregular slope must be a function of the slope's erosion characteristics, such as its local soil detachment rate and the transport capacity of the runoff. They proposed that a slope of irregular steepness be divided into a series of N segments such that the slope steepness or gradient and soil type, and thereby the soil detachment rate, within each segment could be considered to be uniform. The total soil loss from the slope is thus the sum of the losses from the N segments.

The Universal Soil Loss Equation then becomes,

$$A = RK\left\{\frac{\sum_{j=1}^{N} (S_j \lambda_j^{1.5} - S_j \lambda_{j-1})}{\lambda_e (72.6)^{0.5}}\right\} \tag{2}$$

where the bracketed expression replaces the topographic factor LS in Equation 1. The term λ_j is the distance, in feet, from the top of the slope to the lower end of any segment, j; λ_{j-1} is the slope length above segment j; and λ_e is the overall slope length. The term S_j is the value of the factor S from segment j,

where $$S = \frac{0.043\sigma^2 + 0.30\sigma + 0.43}{6.613} \tag{3}$$

and σ is the slope gradient or steepness in percent. The bracketed expression of Equation 2 may be simplified for computation purposes to

$$LS = \frac{1}{\lambda_e} \sum_{j=1}^{N} (U_{2j} - U_{1j}) \tag{4}$$

The LS value determined by this procedure is a function of all the segment lengths and slope gradients or steepnesses and of their particular sequence on the slope. The percentage of the total sediment yield that comes from each of the N slope segments is also obtained by this computational procedure. The relative sediment contribution of segment j to the total soil loss is $(U_{2j} - U_{1j}) / \sum_{j=1}^{N} (U_{2j} - U_{1j})$.

APPENDIX B

DATA INPUT FORMAT

Location Card

Code the district and residency, as indicated below.

District (card 1, column 1)

District	Code
Bristol	1
Salem	2
Lynchburg	3
Richmond	4
Suffolk	5
Fredericksburg	6
Culpeper	7
Staunton	8

Residency (card 1, columns 4-5)

District	Residency	Code
Bristol	Wise	01
	Abingdon	03
	Lebanon	04
	Tazewell	06
	Wytheville	08
	Jonesville	58
Salem	Hillsville	09
	Christiansburg	11
	Martinsville	12
	Rocky Mount	13
	Salem	14
	Bedford	16

District	Residency	Code
Lynchburg	Chatham	17
	Halifax	18
	Dillwyn	19
	Appomattox	20
	Amherst	22
Richmond	South Hill	23
	Amelia	24
	Petersburg	25
	Chesterfield	26
	Sandston	27
	Ashland	28
Suffolk	Franklin	31
	Waverly	32
	Suffolk	33
	Norfolk	34
	Williamsburg	35
	Accomac	36
Fredericksburg	Saluda	37
	Warsaw	39
	Fredericksburg	40
	Bowling Green	41
Culpeper	Louisa	42
	Charlottesville	43
	Culpeper	45
	Warrenton	46
	Fairfax	47
	Manassas	48
	Leesburg	49
Staunton	Lexington	50
	Staunton-Verona	53
	Harrisonburg	54
	Edinburg	55
	Luray	56

K value (card 1, columns 10-12)

Note: The K value will be obtained from county soil conservation maps and/or preconstruction geological survey reports. General soils of low erodibility range in K value from .10 - .23. Medium erodibility soils range from .24 to .36 and highly erodible soils have K values in the range .37 to .49.

Number of segments (card 1, column 20)

Code the number of segments of the slope in column 20 of the first card. A maximum of 5 segments is allowed.

Segment Length and Gradient Card(s)

The next data card codes the segment length and its gradient in percent. One length and gradient is required per card. If the slope is divided into 3 segments then 3 segment length and gradient cards are required.

Code the segment length and gradient as indicated:

Column 1 through 3 — Length of segment in feet. For values less than 100 feet use columns 2 and 3.

Column 9 through 13 — Slope gradient of segment in percent with decimal point in column 11.

Note: Segment cards must be ordered from upslope to downslope.

Construction Period Card

Column 1 and 2 — Code with a value from 1 to 12 the beginning month of construction of period of interest.

Column 7 and 8 — Code with a value from 1 to 12 the ending months or period of interest.

```
//SOIL      JOB (00822HWY10),17T0878,MSGLEVEL=(1,1),CLASS=G
//   EXEC FORTGCLG
//FORT.SYSIN DD *
```

} PROGRAM DECK PLACED HERE.

```
/*
//GO.SYSIN DD *
7  43     .28         2
 25     100.00
400        2.00
09     12
/*
//
```

} DATA CARDS (MULTIPLE PROBLEMS MAY BE SOLVED BY REPEATING DATA CARD SEQUENCE)

Figure B-1. Typical deck set up for problem solved in main text.

The typical program deck set up for the problem solved in the main text is shown in Figure B-1. More than one problem may be worked at a time by repeating the data input set (location card, slope length and gradient card(s), etc.) before the last card of the deck.

APPENDIX C

PROGRAM LISTING

APPENDIX C (Cont.)

```
0001            REALSLOPEL(6),SEGMEL (6),SLOPEG (6),LIST(12,3),
               $LS(6),SJ(6),QJ(6),PLS(6),SLPMN1 (6),U1(6),U2(6),RESVAL(58)
0002            REAL KVALUE,RVALUE,SUMSEL ,SUMSLG ,LS1,SUMQJ,ELS,SUMPLS
0003            INTEGER DIST,RESION ,NUMSEG,COUNT(6),MONTH1,MONTH2
          C-----------------------------------------------------------------------------C
          C
          C      DATA STATEMENT-LIST-CONTAINS 36 ELEMENTS FOR LIST-A,LIST-B,LIST-C
          C      DATA STATEMENT-RESVAL-CONTAINS 58 ELEMENTS FOR RVALUES CORRESPONDING TO
          C      RESIDENCY CODE
          C      DATA STATEMENT CONTAINS 36 ELEMENTS FOR LISTA,LISTB,AND LISTC         C
          C
          C-----------------------------------------------------------------------------C
0004            DATA LIST/0.01,0.02,0.03,0.06,0.10,0.20,0.35,0.55,0.75,0.85,0.92,
               $0.97,0.01,0.04,0.07,0.12,0.17,0.25,0.35,0.55,0.78,0.87,0.92,0.97,
               $0.01,0.02,0.03,0.06,0.10,0.20,0.40,0.65,0.82,0.91,0.95,0.96/
0005            DATA           RESVAL/150.,0.0,150.,150.,0.0,150.,0.0,150.,150.,
               $0.0,150.,163.,150.,150.,0.0,150.,175.,200.,175.,175.,0.0,163.,238.
               $,200.,250.,213.,225.,188.,0.0,0.0,250.,250.,275.,300.,300.,250.,
               $250.,0.0,250.,185.,250.,175.,163.,0.0,175.,175.,200.,175.,150.,
               $150.,0.0,0.0,138.,150.,150.,150.,0.0,150./
0006         5000 FORMAT(I1,2X,I2,4X,F3.0,7X,I1)
0007         5001 FORMAT ( F3.0,4X,F6.2)
0008         5003 FORMAT (I2,4X,I2)
0009         5004 FORMAT (F5.2)
0010         6000 FORMAT(41X,53HDESIGNING MAINTENANCE OF TEMPORARY SILTATION CONTROL
               $S,//)
0011         6001 FORMAT (48X,8HDISTRICT,7X,I1,6X,9HRESIDENCY,5X,I2/)
0012         6002 FORMAT (48X,7HK VALUE,7X,F5.2,6X,7HR VALUE,2X,F5.0/)
0013         6003 FORMAT(56X,15HBEGINNING MONTH,1X,I2/)
0014         6004 FORMAT(56X,12HENDING MONTH,4X,I2//)
0015         6005 FORMAT(9X,7HSEGMENT,6X,6HLENGTH,6X,8HGRADIENT,5X,8HLENGTH-1,6X,
               $2HU2,6X,2HU1,6X,5HU2-U1,6X,7HSEGMENT,6X,7HSEGMENT,2X,20HPERCENT CO
               $NTRIBUTION)
0016         6006 FORMAT(34X,7HPERCENT,47X,6HLENGTH,7X,2HLS,10X,13HOF TOTAL LOSS,//)
0017         6007 FORMAT(12X,I1, 9X,F5.0,7X,F6.2, 7X,F5.0,7X,F5.0,3X,F5.0,5X,F5.0,
               $7X,F5.0,9X,F5.2, 6X,F7.3)
0018         6008 FORMAT(1H0,76X,F5.0,7X,F5.0,9X,F5.2, 6X,F7.3///)
0019         6009 FORMAT(9X,46HESTIMATED ANNUAL SOIL-LOSS IN TONS PER ACRE   ,13X,
               $3H = ,F10.2/)
0020         6010 FORMAT(9X,44HESTIMATED ANNUAL SOIL-LOSS IN CUBIC YARDS   ,15X,
               $3H = ,F10.2/)
0021         6011 FORMAT(9X,62HESTIMATED SOIL-LOSS IN CUBIC YARDS OVER CONSTRUCTION
               $PERIOD = ,F10.2/)
0022         6012 FORMAT(62X,11H ABATEMENT ,//)
0023         6013 FORMAT(40X,54HNO. OF STRAW BARRIER(S) NEEDED PER 100 FEET OF ROADW
               $AY,F10.2)
0024         6014 FORMAT(9X,35HESTIMATED AREA OF INTEREST IN ACRES,24X,3H = ,F10.2/)
0025         6015 FORMAT(59X,17HEQUIVALENCY TABLE,/)
0026         6016 FORMAT(42X,50H1 DROP INLET(DOUBLE-RING BALED)= 10 STRAW BARRIERS,/
               $/)
0027         6017 FORMAT(1H1)
0028         6018 FORMAT(29X,15HIN CUBIC METERS,25X,2H= , F10.2/)
0029         6019 FORMAT(29X,11HIN HECTARES,28X,3H = ,F10.2//)
0030         6020 FORMAT(61X,13HCOVER INDEX C,//)
0031         6021 FORMAT(40X,13HTYPE OF COVER,44X,7HC VALUE,/)
0032         6022 FORMAT(40X,4HNONE,53X,7H   1.00,/)
0033         6023 FORMAT(40X,36HSEEDING AND MULCHING (FIRST 90 DAYS),21X,7H    .50/)
0034         6024 FORMAT(40X,36HSEEDING AND MULCHING (AFTER 90 DAYS),21X,7H    .05/)
```

```
      6025 FORMAT(1X,23HERROR IN RESIDENCY CODE)
      6026 FORMAT(40X,54HTOTAL NUMBER OF BARRIERS NEEDED IN FINAL SEGMENT
          $ ,F8.0/)
           SI = 0.
           LS1=0.
           SUMSLG =0.
           SUMPLS=0.
           SUMSEL =0.
           SUMQJ=0.
           ELS = 0.
           DO 1 I = 1,6
           SLOPEL(I) = 0.
           SLOPEG (I) = 0.
           SEGMEL (I) = 0.
           LS(I) = 0.
           SJ(I) = 0.
           QJ(I) = 0.
           SLPMN1  (I) = 0.
           PLS(I) = 0.
           COUNT(I) = 0
           U1(I) = 0.
           U2(I) = 0.
        1  CONTINUE
C----------------------------------------------------------------------C
C
C
C          READ DISTRICT,RESIDENCY,KVALUE AND NUMBER OF SEGMENTS
C          FORMAT(I1,2X,I2,4X,F3.0,7X,I1)
C          VARIABLE(S)-DIST,RESIDIN,KVALUE AND NUMSEG
C
C
C----------------------------------------------------------------------C
        2  READ(5,5000,END=200)DIST,RESIDN,KVALUE,NUMSEG
           DO 5 I = 1,NUMSEG
C----------------------------------------------------------------------C
C
C          READ SEGMENT LENGTHS AND SLOPE GRADIENTS
C          FORMAT(F3.0,5X,F5.2)
C          VARIABLE(S)-SEGMEL(I),SLOPEG(I)
C
C----------------------------------------------------------------------C
           READ (5,5001) SEGMEL (I),SLOPEG (I)
           COUNT(I) = 1
        5  CONTINUE
C----------------------------------------------------------------------C
C
C
C          CALCULATE SLOPE LENGTHS
C          VARIABLE(S)-SLOPEL(I)
C
C
C----------------------------------------------------------------------C
           SLOPEL(1) = SEGMEL (1)
           DO 10 I = 2,NUMSEG
           J = I - 1
           SLOPEL(I) = SLOPEL(J) + SEGMEL (I)
       10  CONTINUE
           DO 15 I = 1,NUMSEG
```

```
C-----------------------------------------------------------------------C
C
C
C      CALCULATE SLOPE LENGTH - 1
C      VARIABLE(S)-SLPMN1(I)
C
C
C-----------------------------------------------------------------------C
       SLPMN1 (I) = SLOPEL(I) - SEGMEL (I)
  15   CONTINUE
       DO 20 I = 1,NUMSEG
C-----------------------------------------------------------------------C
C
C
C      SUM THE SEGMENT LENGTHS
C      VARIABLE(S)-SUMSEL
C
C
C-----------------------------------------------------------------------C
       SUMSEL  = SUMSEL  + SEGMEL (I)
  20   CONTINUE
C-----------------------------------------------------------------------C
C
C      READ BEGINNING AND ENDING MONTH
C      FORMAT(I2,4X,I2)
C      VARIABLE(S)-MONTH1,MONTH2
C
C-----------------------------------------------------------------------C
       READ (5,5003) MONTH1,MONTH2
       IF (NUMSEG .GT. 1) GO TO 40
       GO TO 80
  40   DO 50 I = 1,NUMSEG
C-----------------------------------------------------------------------C
C
C
C      CALCULATE SJ,U2,U1,AND QJ=U2-U1
C      SUM THE QJ,S
C      VARIABLE(S)-SJ(I),U2(I),U1(I),QJ(I),SUMQJ
C
C
C-----------------------------------------------------------------------C
       SJ(I) = (0.043*SLOPEG (I)**2. + 0.30 * SLOPEG (I)+0.43)/6.613
       U2(I) = (SJ(I) * SLOPEL (I) **1.5)/(72.6)**0.5
       U1(I) = (SJ(I) * SLPMN1 (I) **1.5)/(72.6)**0.5
       QJ(I) = U2(I) - U1(I)
       SUMQJ = SUMQJ + QJ(I)
  50   CONTINUE
C-----------------------------------------------------------------------C
C
C
C      CALCULATE ELS
C      VARIABLE(S)-ELS
C
C
C-----------------------------------------------------------------------C
       ELS = SUMQJ / SUMSEL
       DO 60 I = 1,NUMSEG
C-----------------------------------------------------------------------C
```

APPENDIX C (Cont.)

```
           C
           C
           C      CALCULATE LS,PLS,SUM OF PLS,S
           C      VARIABLE(S)-LS(I),PLS(I),SUMPLS
           C
           C
           C-----------------------------------------------------------------------C
0085              LS(I) = QJ(I) / SEGMEL (I)
0086              PLS(I) =(QJ(I) / SUMQJ) * 100
0087              SUMPLS = SUMPLS + PLS(I)
0088         60   CONTINUE
0089              GO TO 110
0090         80   IF (NUMSEG .EQ. 1) GO TO 90
0091              GO TO 110
           C-----------------------------------------------------------------------C
           C
           C
           C      CALCULATE LS FOR 1 SEGMENT
           C      VARIABLE(S)-LS1
           C
           C
           C-----------------------------------------------------------------------C
0092         90   IF (SEGMEL (1) .LE. 800. .AND. SLOPEG (1) .LE. .20) GO TO 100
0093              IF (SEGMEL (1) .GT. 800. .OR. SLOPEG (1) .GT. .20) LS1=(SEGMEL (1)
                 $/75.)**0.6*(SLOPEG(1)/9.)**1.4
0094              GO TO 109
0095        100   LS1 = SEGMEL (1) **0.5*(0.0076+0.0053*SLOPEG (1)+0.0076*SLOPEG (1)
                 $**2.)
0096        109   LS(1) = LS1
0097        110   WRITE(6,6017)
0098              WRITE (6,6000)
0099              WRITE(6,6001) DIST,RESIDN
           C-----------------------------------------------------------------------C
           C
           C
           C      DETERMINE R VALUES ACCORDING TO RESIDENCY CODE
           C      VARIABLE(S)-RVALUE
           C
           C
           C-----------------------------------------------------------------------C
0100              IF (RESIDN .LE. 0 .OR. RESIDN .GT. 58) GO TO 190
0101              RVALUE = RESVAL(RESIDN)
0102              IF (RVALUE .LE. 0.0) GO TO 190
0103              WRITE (6,6002) KVALUE,RVALUE
0104              WRITE(6,6003)MONTH1
0105              WRITE (6,6004) MONTH2
0106              WRITE(6,6005)
0107              WRITE(6,6006)
0108              DO 120 I = 1,NUMSEG
0109              WRITE(6,6007)
                 $          COUNT(I),SLOPEL(I),SLOPEG (I),SLPMN1 (I),U2(I),U1(I),QJ(
                 $I),SEGMEL (I),LS(I),PLS(I)
0110        120   CONTINUE
0111              WRITE (6,6008)SUMQJ,SUMSEL ,ELS,SUMPLS
0112              IF (NUMSEG .EQ. 1) GO TO 130
           C-----------------------------------------------------------------------C
           C
           C
```

APPENDIX C (Cont.)

```
             C      CALCULATE A IN T/A (ANNUAL LOSS)
             C      VARIABLE(S)-A
             C
             C
             C-----------------------------------------------------------------------C
0113                A = RVALUE  * KVALUE * ELS
0114                GO TO 140
             C-----------------------------------------------------------------------C
             C
             C
             C      CALCULATE A IN T/A (ANNUAL LOSS) FOR 1 SEGMENT
             C      VARIABLE(S)-A
             C
             C
             C-----------------------------------------------------------------------C
0115         130    A = RVALUE * KVALUE * LS(1)
             C-----------------------------------------------------------------------C
             C
             C      CALCULATE B IN (ANNUAL LOSS) IN CUBIC YARDS
             C      VARIABLE(S)-B
             C
             C-----------------------------------------------------------------------C
0116         140    B = .87 * A
0117                WRITE (6,6009) A
0118                WRITE(6,6010) B
             C-----------------------------------------------------------------------C
             C
             C
             C      ADJUST FOR SEASON BY READING DATA FROM DATA LIST USING THE ARRAY (LIST)
             C      IF DISTRICT CODE IS-STAUNTON,SALEM OR BRISTOL
             C                            THE ELEMENTS  1-12 OF ARRAY LIST ARE USED
             C      IF DISTRICT CODE IS-CULPEPER OR LYNCHBURG
             C                            THE ELEMENTS 13-24 OF ARRAY LIST ARE USED
             C      IF DISTRICT CODE IS-RICHMOND,FREDERICKSBURG OR SUFFOLK
             C                            THE ELEMENTS 25-36 OF ARRAY LIST ARE USED
             C      VARIABLE(S)-C
             C
             C
             C-----------------------------------------------------------------------C
0119                IF(DIST .EQ. 1 .OR. DIST .EQ. 2 .OR. DIST .EQ. 8) M = 1
0120                IF (DIST .EQ. 3 .OR. DIST .EQ. 7) M = 2
0121                IF (DIST .EQ. 4 .OR. DIST .EQ. 5 .OR. DIST .EQ. 6) M = 3
0122                IF (MONTH2-MONTH1)142,143,144
0123          142   C1 = 1. - LIST(MONTH1,M)
0124                C = C1 + LIST(MONTH2,M)
0125                GO TO 160
0126          143   C = 1.
0127                GO TO 160
0128          144   C = LIST(MONTH2,M) - LIST(MONTH1,M)
             C-----------------------------------------------------------------------C
             C
             C
             C      CALCULATE ESTIMATED SOIL-LOSS IN CUBIC YARDS OVER CONSTRUCTION PERIOD
             C      VARIABLE(S)-D
             C
             C
             C-----------------------------------------------------------------------C
0129         160    D = A * C
```

```
0130          WRITE(6,6011) D
         C-------------------------------------------------------------------------C
         C
         C      CALCULATE ESTIMATED SOIL-LOSS IN CUBIC METERS OVER CONSTRUCTION PERIOD
         C      VARIABLE(S)-E
         C
         C-------------------------------------------------------------------------C
0131          E = D *  .7646
0132          WRITE(6,6018)E
0133          IF (NUMSEG .EQ. 1) GO TO 161
0134          NUM1 = NUMSEG - 1
         C-------------------------------------------------------------------------C
         C
         C
         C      SUM ALL EXCEPT LAST SEGMENT LENGTHS
         C      VARIABLE(S)-SUMSG2
         C
         C
         C-------------------------------------------------------------------------C
0135          DO 170 I = 1,NUM1
0136      170 SUMSG2 = SUMG2 + SEGMEL(I)
         C-------------------------------------------------------------------------C
         C
         C
         C      CALCULATE AREA IN FT**2
         C      VARIABLE(S)-AREA
         C
         C
         C-------------------------------------------------------------------------C
0137          AREA = SUMSG2  * SEGMEL (NUMSEG)
0138          GO TO 162
0139      161 AREA = SEGMEL (1) * 100
         C-------------------------------------------------------------------------C
         C
         C
         C      CALCULATE AREA OF INTEREST IN ACRES
         C      VARIABLE(S)-AREA1
         C
         C
         C-------------------------------------------------------------------------C
0140      162 AREA1 = AREA * (1./43560.)
0141          WRITE(6,6014) AREA1
         C-------------------------------------------------------------------------C
         C
         C
         C      CALCULATE AREA OF INTEREST IN HECTARES
         C      VARIABLE(S)-F
         C
         C
         C-------------------------------------------------------------------------C
0142          F = .4047 * AREA1
0143          WRITE(6,6019)F
0144          WRITE(6,6012)
         C-------------------------------------------------------------------------C
         C
         C
         C      CALCULATE A * AREA FOR YIELD IN YD**3
         C      VARIABLE(S)-AREA2
```

APPENDIX C (Cont.)

```
      C
      C
      C----------------------------------------------------------------------C
            AREA2 = D * AREA1
      C----------------------------------------------------------------------C
      C
      C
      C     CALCULATE NO. OF STRAW BARRIER(S) NEEDED PER 100 FT.
      C     VARIABLE(S)-Y
      C
      C
      C----------------------------------------------------------------------C
            Y = AREA2 * 100. / SEGMEL(NUMSEG)
            WRITE (6,6013) Y
      C----------------------------------------------------------------------C
      C
      C
      C     CALCULATE TOTAL NUMBER OF BARRIERS NEEDED IN FINAL SEGMENT
      C
      C
      C----------------------------------------------------------------------C
            X = (Y * SEGMEL(NUMSEG))/100.
            WRITE (6,6026) X
            WRITE (6,6015)
            WRITE(6,6016)
            WRITE(6,6020)
            WRITE(6,6021)
            WRITE(6,6022)
            WRITE(6,6023)
            WRITE(6,6024)
            GO TO 2
        190 WRITE (6,6025)
        200 STOP
            END
```