yards. These figures indicate that there is a 20% chance that soil losses will be 1482 cubic yards in any one year (a probability of one year in five) based on long-term averages. In any one year there is a 5% chance (a probability of one year in 20) that soil losses from this site will be 2056 cubic yards.

<u>Problem 4.</u> Compute the estimated soil loss from a single storm with a magnitude which would be exceeded only once in five years.

An adjustment of the annual (R) value of 150 is necessary. Refer to the fourth column of Table 3 and note that the EI value of a single storm, the magnitude of which is exceeded once in five years is 52. Since we are determining the soil loss for only one storm, the (R) (or EI) value will be less than the annual (R). Therefore, 52 ÷ 150 = 0.34 and 0.34 X the average annual loss of 1335 cubic yards gives us a loss of 454 cubic yards from the 15 acres for this one storm. The losses from single storms with magnitudes exceeding once in 10 and 20 years are calculated in the same manner. The EI values from Table 3 are 68 and 83 and the adjusted values become 0.45 and 0.55 (0.45 ÷ 150 and 0.55 ÷ 150), respectively. The estimated soil losses are 600 and 734 cubic yards (0.45 X 1335 and 0.55 X 1335).

These figures indicate that we could expect soil losses from this 15-acre site as high as 454, 600 and 734 cubic yards from single storms so damaging they are likely to occur only once in 5, 10, or 20 years, respectively.

Table 5

SLOPE-EFFECT TABLE (TOPOGRAPHIC FACTOR, LS)

Slope Length in Feet (L)	LS Value % Slope (s)															
	2	4	6	8	10	12	14	16	18	20	25	30	35	40	50	100
10	.1	.1	.2	.3	.4	.6	.7	.9	1.1	1.3	2.0	2.7	3.6	4.6	6.9	25.7
15	.1	.2	.3	.4	.5	.7	.9	1.1	1.4	1.6	2.4	3.3	4.4	5.6	8.4	31.5
20	.1	.2	.3	.4	.6	.8	1.5	1.3	1.6	1.9	2.8	3.8	5.0	6.4	9.7	36.4
25	.1	.2	.3	.5	.7	.9	1.2	1.4	1.7	2.1	3.1	4.3	5.6	7.2	10.9	40.7
30	.1	.2	.4	.5	.8	1.0	1.3	1.6	1.9	2.3	3.4	4.7	6.1	7.9	11.9	44.6
35	.1	.2	.4	.6	.8	1.1	1.4	1.7	2.1	2.5	3.7	5.1	6.7	8.5	12.9	
40	.2	.3	.4	.6	.9	1.2	1.5	1.8	2.2	2.7	3.9	5.4	7.1	9.1	13.8	
50	.2	.3	.5	.7	1.0	1.3	1.7	2.0	2.4	3.0	4.4	6.0	8.0	10.2	15.4	
60	.2	.3	.5	.8	1.1	1.4	1.8	2.2	2.7	3.3	4.8	6.6	8.7	11.2	16.9	
100	.2	.4	.7	1.0	1.4	1.8	2.3	2.8	3.5	4.2	6.2	8.5	11.3	14.4	21.8	
200	.3	.6	1.0	1.4	2.0	2.6	3.3	4.0	5.0	5.9	8.7	12.1	15.9	20.4		
300	.4	.7	1.2	1.7	2.4	3.2	4.0	5.0	5.9	7.3	10.7	14.8	19.5	24.9		
400	.4	.8	1.4	2.0	2.8	3.6	4.7	5.0	6.0	8.4	12.4	17.1	22.6			
500	.5	.9	1.5	2.2	3.1	4.1	5.2	6.4	7.6	9.4	13.8	19.1	25.2			
600	.5	1.0	1.7	2.4	3.4	4.5	5.7	7.0	8.3	10.3	15.1	20.9				
800	.6	1.2	1.9	2.8	3.9	5.1	6.7	8.1	9.6	11.9	17.5	24.1				
1000	.7	1.3	2.1	3.14	4.4	5.8	7.4	9.1	10.8	13.3	19.5					

$$(LS) = \frac{\sqrt{L}}{100} \text{ X } (.76 + .53s + .076s^2)$$

Section A REVIEW OF THE UNIVERSAL SOIL LOSS EQUATION AND FACTORS

The method described here is based on modification of the Universal Soil Loss Equation (USLE) and is used to predict soil loss from sheet and rill erosion. The rate of this erosion depends on several factors, as follows:

1. rainfall energy and intensity
2. soil erodibility
3. land slope steepness and length of slope
4. soil surface conditions such as grass, woodland, crops, pavement, or no cover,
5. condition of the soil surface and land management practice used.

These factors may be assigned quantitative values to be used in estimating soil loss. However, the method does not account for soil loss by gully erosion.

The equation is: A = RK(LS)CP

A = the computed annual soil loss expressed in tons per unit of area. For volume estimates, Table 7-8 may be used to convert tons to cubic yards based on soil textures.

R = the rainfall factor is the number of erosion index units in a normal year's rain. The erosion index is a measure of the erosion force of specific rainfall. The average annual erosive rainfall factor (R value) for Rhode Island is 150.

K = the soil erodibility factor as shown in Table 7-1, is the erosion rate per unit of erosion index for a specific soil as measured on a unit plot of 72.6 feet in length on a uniform nine percent slope continuously in a clean-tilled fallow condition.

L = the slope length factor is the ratio of soil loss from a specific slope length to the 72.6 foot slope of the same soil and gradient.

S = the slope steepness factor is the ratio of soil loss from the field gradient to that from a nine percent slope. The slope length and slope steepness are combined into a single topographic factor (LS) and computed from Table 7-4.

C = the soil cover and management factor as shown in Table 7-5 is the ratio of soil loss from a field with specified cropping management to that from the fallow condition on which the factor is evaluated. This factor is also called the cover index and can be used to represent the effect of land cover or treatment that may be used to protect construction sites.

P = the erosion control practice factor as shown in Table 7-6 is the ratio of soil loss with certain conservation practices to that of no practice.

The value A may be modified by a factor M shown in Table 7-7. The M factor may be used to estimate the soil loss from rainfall for a portion of a year or longer periods. The rainfall factor does not account for snow melt, freezing, thawing, and snow cover.

Table 7-1 contains erodibility (K) values and textures of the A, B and C soil layers for the Rhode Island soil series. Values for B or C layers are generally used in determining soil loss on construction sites because these layers are left exposed when the site is disturbed. The values for the A layers are used when the soil is in a more natural state.

The soil layers, or horizons, are defined as follows:

1. *Subsurface Soil* The horizon is generally dark in color and is 0-10 inches thick.

2. *Subsoil* It is below the surface horizon and is 10-26 inches thick.

3. *Substratum* It is below the subsoil horizon and is 26-60 inches thick.

Table 7-2 lists soil textures and abbreviations used in Tables 7-1 and 7-8.

Section B EXAMPLES OF HOW THE UNIVERSAL SOIL LOSS EQUATION IS USED

Given: A disturbed site of 15 acres near Charlestown, Rhode Island. The soil is Charlton fine sandy loam and the B horizon is completely exposed. The average slope is eight percent and the length of slope is 200 feet.

EXAMPLE 1

Determine the estimated soil loss from this site if it was scraped up and down slope with a bulldozer and remains unprotected for one year.

Solution: Refer to Table 7-1 and determine that the K value for the B horizon of Charlton fine sandy loam is 0.24. Note that the K values are not always the same for the B and C horizons of some soils. Table 7-2 provides textures and modifiers for abbreviations given in Table 7-1.

Refer to Table 7-4 to determine the topographic adjustment factor (LS) for length and percent of slope. The length and percent slope data are not multiplied together in the formula, but are developed mathematically from a complex equation. They may be obtained directly from Table 7-4. Find eight percent under the left hand column and move horizontally to read 1.40 under slope length of 200 feet. To find quantities not included in Table 7-4, interpret between gradients and slope lengths to estimate the required (LS).

Table 7-5 provides the cover index factor (C) for planning conditions. Note that the C-factor for exposed soil is 1.0. Increasing the cover or soil protection decreases the C-factor accordingly.

Refer to Table 7-6 for the practice factor (P). The P-factor for a compact and smooth, bulldozer scraped surface is 1.3.

To determine the average annual soil movement on this site enter the data into the USLE and compute for these conditions.

$A = RK(LS)CP$

$A = 150 \times 0.24 \times 1.40 \times 1.0 \times 1.3$

A = 65.5 tons per acre per year

Total soil loss in one year
= 65.5 tons/acre/year x 15 acres x 1 year
= 983 tons

To convert to volume use Table 7-8. Note that for fine sandy loams, one cubic foot of material weighs 100 pounds. Each ton of soil equals 0.74 cubic yards. Thus, 983 tons x 0.74 cubic yards per ton = 727 cubic yards total soil loss in one year within the site.

EXAMPLE 2

Determine the soil loss from this site during the period from June 1 to September 1.

Solution: Refer to Table 7-7 to obtain the adjustment factor M for the period. During this three month period M = 12 + 13 + 18 = 43 percent of the average annual soil loss will occur. Therefore, in Example 1, we determined the total average annual soil loss to be 983 tons or 727 cubic yards. Forty-three percent of 983 tons is 423 tons for the amount of soil moved between June 1 and September 1. Forty-three percent of 727 cubic yards is 313 cubic yards.

EXAMPLE 3

Determine the soil loss from this site during the period November 1 to March 1, when hay mulch at the rate of 2 tons per acre has been applied.

Solution: Refer to Table 7-5 for the C-factor for hay mulch at 2 tons per acre (C=0.02), and Table 7-7 to obtain the adjustment factor M for the period (M = 8 + 7 + 3 + 3 = 21 percent). Use the USLE to compute the soil loss for the conditions.

$A = RK(LS)CP$

$A = 150 \times 0.24 \times 1.40 \times 0.02 \times 1.3$

A = 1.3 tons per acre per year. Twenty-one percent of 1.3 tons equals 0.3 tons per acre for the period from November 1 to March 1 with hay mulch protection.

Using Table 7-8 for conversions; 0.3 tons/acre x 15 acres = 4.5 tons total, 4.5 tons x 0.74 cubic yards/ton = 3.3 cubic yards for the entire site, a dramatic decrease from an unprotected site.

TABLE 7-1

Soil Erodibility Factors (K) and Textures of the A, B, and C Horizons (page 1)

SOIL SERIES	HORIZONS	USDA TEXTURES	"K" FACTORS
ADRAIN	(ORGANIC SOIL)		
AGAWAM	A	FSL,VFSL,L	.28
	B	FSL	.28
	C	FS, LFS, LS	.17
BEACHES	(TOO VARIABLE TO RATE)		
BIRCHWOOD	A	FSL, SL, LS	.24
	B	LS, LFS, S	.17
	C	FSL,GR-FSL,GR-L	.24
BRIDGE-HAMPTON	A	SIL, VFSL	.49
	B	SIL, VFSL, SI	.64
	C	GR-S,GR-LS,GRV-S	.10
BRIDGE-HAMPTON, TILL SUBSTM	A	SIL, VFSL	.49
	A	STONY PHASES	.37
	B	SIL, VFSL, SI	.64
	C	GR-SL, SL, GR-LS	.20
BROADBROOK	A	SIL, VFSL, L	.28
	A	STONY PHASES	.20
	B	SIL, VFSL, L	.43
	C	SL, FSL, GR-SL	.24
CANTON	A	FSL, L, VFSL	.24
	A	STONY PHASES	.20
	B	FSL, VFSL, GR-L	.28
	C	GR-LS,LFS,GR-LCOS	.17
CARLISLE	(ORGANIC SOIL)		
CHARLTON	A	FSL, SL, L	.24
	A	STONY PHASES	.20
	B	FSL, GR-FSL,GR-L	.24
	C	GR-SL, GR-FSL, L	.24

SOIL SERIES	HORIZONS	USDA TEXTURES	"K" FACTORS
DEERFIELD	A	LS, S, LFS	.17
	B	LS, S, COS	.17
	C	S, FS, COS	.17
DUMPS	(TOO VARIABLE TO RATE)		
ENFIELD	A	SIL, VFSL	.49
	B	SIL, VFSL	.64
	C	GRV-S, GR-S	.10
GLOUCESTER	A	SL, COSL, FSL	.24
	A	STONY PHASES	.17
	B	GR-SL, SL, FSL	.17
	C	GRV-LCOS, GR-LS, GR-SL	.17
HINCKLEY	A	GR-LS, GR-SL, GR-LCOS	.17
	B	GR-LS, LFS, GR-LCOS	.17
	C	SR-GRV-LFS,CB-COS	.10
IPSWICH	(ORGANIC SOIL)		
LEICESTER	A	FSL, L, VFSL	.28
	A	STONY PHASES	.20
	B	FSL, L, GR-SL	.32
	C	FSL, SL, GR-SL	.24
LIPPITT	A	GR-FSL, GR-SL	.20
	B	GRV-SL, GRV-LS	.10
	C	WETH'D BEDROCK	
MANSFIELD	A	SIL, L, CN-SIL	.28
	A	STONY PHASES	.20
	B	SIL, L, CN-SIL	.37
	C	SIL,CN-SIL,CN-FSL	.24

Source: U.S. Department of Agriculture, Soil Conservation Service, West Warwick, Rhode Island

TABLE 7-1

Soil Erodibility Factors (K) and Textures of the A, B, and C Horizons (page 2)

SOIL SERIES	HORIZONS	USDA TEXTURES	"K" FACTORS
MATUNUCK	O	ORGANIC LAYER	
	B	S, LS, FSL	.17
	C	S, LS	.17
MERRIMAC	A	SL	.24
	B	SL, GR-SL	.17
	C	SR-S-GRV-COS	.10
NARRAGANSETT	A	SIL, VFSL	.28
	A	STONY PHASES	.24
	B	SIL, VFSL, L	.43
	C	GR-COSL, GR-FSL	.24
NEWPORT	A	SIL, L, VFSL	.28
	A	STONY PHASES	.20
	B	SIL, CN-L, VFSL	.37
	C	SIL, CN-FSL, CN-VFSL	.24
NINIGRET	A	FSL, VFSL	.28
	B	FSL, SL, VFSL	.32
	C	LS, S, GR-S	.10
PAXTON	A	FSL, SL, L	.24
	A	STONY PHASES	.20
	B	FSL, L, GR-SL	.32
	C	FSL, L, GR-SL	.24
PITS	(TOO VARIABLE TO RATE)		
PITTSTOWN	A	SIL, L, VFSL	.28
	A	STONY PHASES	.20
	B	SIL, CN-L, VFSL	.37
	C	CN-SIL, CN-L, VFSL	.28
PODUNK		(USE POOTATUCK DATA)	
POOTATUCK	A	SL, FSL	.20
	B	SL, FSL	.20
	C	S, LS, GR-S	.17
POQUONOCK	A	LFS, LS	.20
	A	STONY PHASES	.17
	B	LFS, LS, S	.17
	C	GR-L, GR-SL, FSL	.24
QUONSET	A	GR-SL, GR-FSL	.17
	B	CN-LS, GR-LS	.17
	C	SR-CNV-COS,CNV-S	.10
RAINBOW	A	SIL, VFSL, L	.28
	A	STONY PHASES	.24
	B	SIL, VFSL, L	.43
	C	FSL, GR-SL, L	.24
RAYPOL	A	SIL, VFSL, L	.49
	B	SIL, VFSL, L	.49
	C	GR-S, S, GRV-S	.10
RIDGEBURY	A	SL, L, FSL	.24
	A	STONY PHASES	.20
	B	SL, GR-L	.32
	C	SL, GR-L	.24
RIPPOWAM	A	FSL, SL	.20
	B	FSL, SL	.20
	C	LS, COS, GR-S	.17
ROCK OUTCROP	(BEDROCK)		
RUMNEY	(USE RIPPOWAM DATA)		

Source: U.S. Department of Agriculture, Soil Conservation Service, West Warwick, Rhode Island