RESPONSE 35

APPENDIX III-2E

FINAL COVER EROSION SOIL LOSS CALCULATION

FINAL COVER EROSION SOIL LOSS CALCULATION

Made By: VJE/HPR
Checked by: MX
Reviewed by: CGD

1.0 OBJECTIVE:

Estimate add-on berm spacing required under final closure conditions for the Temple Recycling and Disposal Facility to limit the average annual erosion to 2.0-3.0 ton/acre/year.

Estimate flow velocity and compare to the permissible non-erodible velocity.

2.0 METHOD:

Add-on berm spacing was determined using the Revised Universal Soil Loss Equation (RUSLE), (UDSA,1997).

I) Use revised universal soil loss equation.

A = R K L S C P Variables described below

Rainfall and erosivity index (R)

From Fig. 1, Reference1(Page 5), the average annual rainfall erosion index for the site is approx. **300**

Soil Erodibility Factor (K)

Assume a clay loam with an organic matter content of 4% and use Table 1, Reference 1 (Page 6), to determine the K factor.

Use K = 0.21

Cover and Management Factor [C]

Assume 90% ground cover and interpolate C from values shown on Table 2, Reference 1 (Page 7)

C = 0.006

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Support Practice Factor (P)

Surface tracked with dozer -- rough surface

Use P = 1

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Length Slope Factor (LS) (Reference 2)

For regular slopes > 15 ft long, the **Slope Steepness Factor, S** =

$S = 10.8 \sin \Theta + 0.03$; $\sin \Theta < 0.09$ Eqn. 8.39

or $16.8 \sin \Theta - 0.50$; $\sin \Theta \geq 0.09$ Eqn. 8.40

Where: Θ = slope angle

Length Factor, L

$L = [\lambda/72.6]^m$ Eqn. 8.43

λ = slope length (measured as the horizontal projection of plot length)

m is an exponent dependent upon slope given by

$$m = \frac{\beta}{1+\beta} \quad \text{Eqn. 8.44}$$

β for soils moderately susceptible to erosion is given by (Reference 3):

$$\beta_{mod} = \frac{11.16 \sin\Theta}{3.0(\sin\Theta)^{0.8} + 0.56} \quad \text{Eqn. 8.45}$$

β is modified as follows for soils of low and high susceptibility to erosion:

$\beta_{low} = (1/2)\beta_{mod}$

$\beta_{high} = 2\beta_{mod}$

3.0 ASSUMPTIONS:

Soil series is primarily Austin silty clay (USDA, Soil Conservation Service, Soil Survey of Bell County, Texas, 1977),

Facility slopes are 4H:1V on the sides, 4% on top,

R was taken from Figure 1, Average Annual Values of the Rainfall Erosion Index,

K was taken from the USDA Soil Interpretation Records, Soil Conservation Services,

S = slope steepness factor (Haan, 1994),

There are three equations available to determine S. If the length of the applicable slope is less than 15 feet, then you would use equation 8.41 which is $S = 3.0 (\sin \Theta)^{0.8}+0.56$. If the applicable slope is greater than 15 feet then the equation 8.39 or 8.40 would apply depending on the angle of the slope. These two equations are:

If $\sin \Theta < 0.09$, then $S = 10.8 \sin \Theta + 0.03$

If $\sin \Theta \geq 0.09$, then $S = 16.8 \sin \Theta - 0.50$

In our specific calculation, our slope angles are as follows:

For the 4 (H): 1(V) slope, $\Theta = 14.04°$

$\sin 14.04° = 0.24 \geq 0.09$, Use eq. 8.40

For the 4% slope, $\Theta = 2.86°$

$\sin 2.86° = 0.05 < 0.09$, Use eq. 8.39

L = slope length factor

$$L = \frac{\lambda}{72.6}^{m}$$

where λ = horizontal projection of plot length

$$m = \frac{\beta}{1+\beta}$$

$$\beta = rill\ erosion$$

$$\beta_{mod} = \frac{11.16 \sin \Theta}{3.0(sin\Theta)^{0.8} + 0.56}$$

The equation for rill erosion applies to moderate erosion.

C represents 90% ground cover without appreciable canopy - Table 2, USDA-SCS TR 52,

P was assumed to be 1.0 for long-range prediction & no maintenance.

4.0 CALCULATIONS

RUSLE calculations were performed for the longest final cover side slope between add-on berms. The 4:1 (H:V) side slopes are more critical than the 4% top dome in terms of erosion.

The existing final cover areas at 3H:1V slopes are also analyzed for soil erosion.

Summaries of the RUSLE calculation is presented in Table 1.

5.0 FLOW VELOCITY

The storm water flow velocity on the slope is calculated following the methods provided in the USDA TR-55, the same as those as discussed in Appendix III-2C-1. The final cover slope consists of the following:

1) 4% top dome surface at maximum length of 500 ft. The flow on this slope is shallow concentrated flow. The flow velocity is 3.2 ft/sec (same as Section 3.1 of Appendix III-2C-1).

2) 4H:1V sideslope with a maximum length of 160 ft between add-on berms. The flow on this slope is sheet flow. Flow velocity on the 4H: 1V slope is 1.82 ft/sec (same as Section 3.1 of Appendix III-2C-1).

3) 3H:1V sideslope on the existing final cover areas with a maximum length of 50 feet. The flow on this slope is sheet flow. The flow velocity on the 3H:1V slope is 1.96 ft/sec (using the equation in Section 3.1.1 between add-on berms of Appendix III-2C-1).

6.0 CONCLUSION/RESULTS

RUSLE calculation for a simple 4H:1V slope is found in Table 1. Recommended horizontal add-on berm spacing for closure is 160 feet (or 40 vertical feet).

RUSLE calculation for a simple 3H: 1V slope is found in Table 2. Soil erosion on the existing final cover areas at 3H:1V slopes is 1.5 tons/acre/yr, meeting the soil erosion requirements.

Results showed that the flow velocities for all final cover slope gradients are below the permissible non-erodible velocity of 5 ft/sec.

7.0 REFERENCES:

1) Use of the Universal Soil Loss Equation in Final Cover/Configuration Design, Procedural Handbook," TNRCC, Permits Section, October 1993.

2) Haan C.T., B. J. Barfield, and J.C. Hayes. 1994. Design hydrology and sedimentology for small catchments. San Diego CA : Academic Press Inc.

3) TCEQ Regulatory Guidance, "Guidelines for Preparing a Surface Water Drainage Report for a Municipal Solid Waste Facility.", August 2006

4) City of Temple, "Drainage Criteria and Design Manual."

TABLE 1. TEMPLE RECYCLING AND DISPOSAL FACILITY - ESTIMATED AVERAGE ANNUAL EROSION MAXIMUM ALLOWABLE LENGTH WITH 4:1 SLOPE

R	K	Slope (ft/ft)	Length (1) (ft)	rill susceptability low, mod, high	LS	C	P	A_i ton/ac/yr	Vertical Bench/ Terrace Spacing (ft)
Final Cover - (90% cover)									
300	0.21	0.25	160	mod	5.925	0.006	1.0	2.4	40
								2.4	

NOTES: **R** was taken from Figure 1, Average Annual Values of the Rainfall Index
M was calculated from Eq. 8.37 (p. 256) - *Design Hydrology and Sedimentology for Small Catchments*
K was based on soil survey descriptions of Austin silty clay soils and obtained from the USDA, Soil Interpretation Records, Soil Conservation Services
LS was calculated from Eqs. 8.39-41 and 43 (p. 261) - *Design Hydrology and Sedimentology for Small Catchments*
C represents 90% ground cover without appreciable canopy - *USDA-SCS TR 51*
P was assumed to be 1.0 for long-range prediction & no maintenance

A = R * K * LS * C * P

where:

A = soil loss, tons/(acre - year)
R = rainfall erosion index
K = soil erodibility factor
LS = slope length and steepness factor
C = vegetative cover factor
P = erosion control practice factor

TABLE 2. TEMPLE RECYCLING AND DISPOSAL FACILITY - ESTIMATED AVERAGE ANNUAL EROSION MAXIMUM ALLOWABLE LENGTH WITH 3:1 SLOPE

R	K	Slope (ft/ft)	Length (l) (ft)	rill susceptability low, mod, high	LS	C	P	A_i ton/ac/yr	Vertical Bench/ Terrace Spacing (ft)
Final Cover - (90% cover)									
300	0.21	0.33	50	mod	3.715	0.006	1.0	1.5	
								1.5	17

NOTES: **R** was taken from Figure 1, Average Annual Values of the Rainfall Index

M was calculated from Eq. 8.37 (p. 256) - *Design Hydrology and Sedimentology for Small Catchments*

K was based on soil survey descriptions of Austin silty clay soils and obtained from the USDA, Soil Interpretation Records, Soil Conservation Services

LS was calculated from Eqs. 8.39-41 and 43 (p. 261) - *Design Hydrology and Sedimentology for Small Catchments*

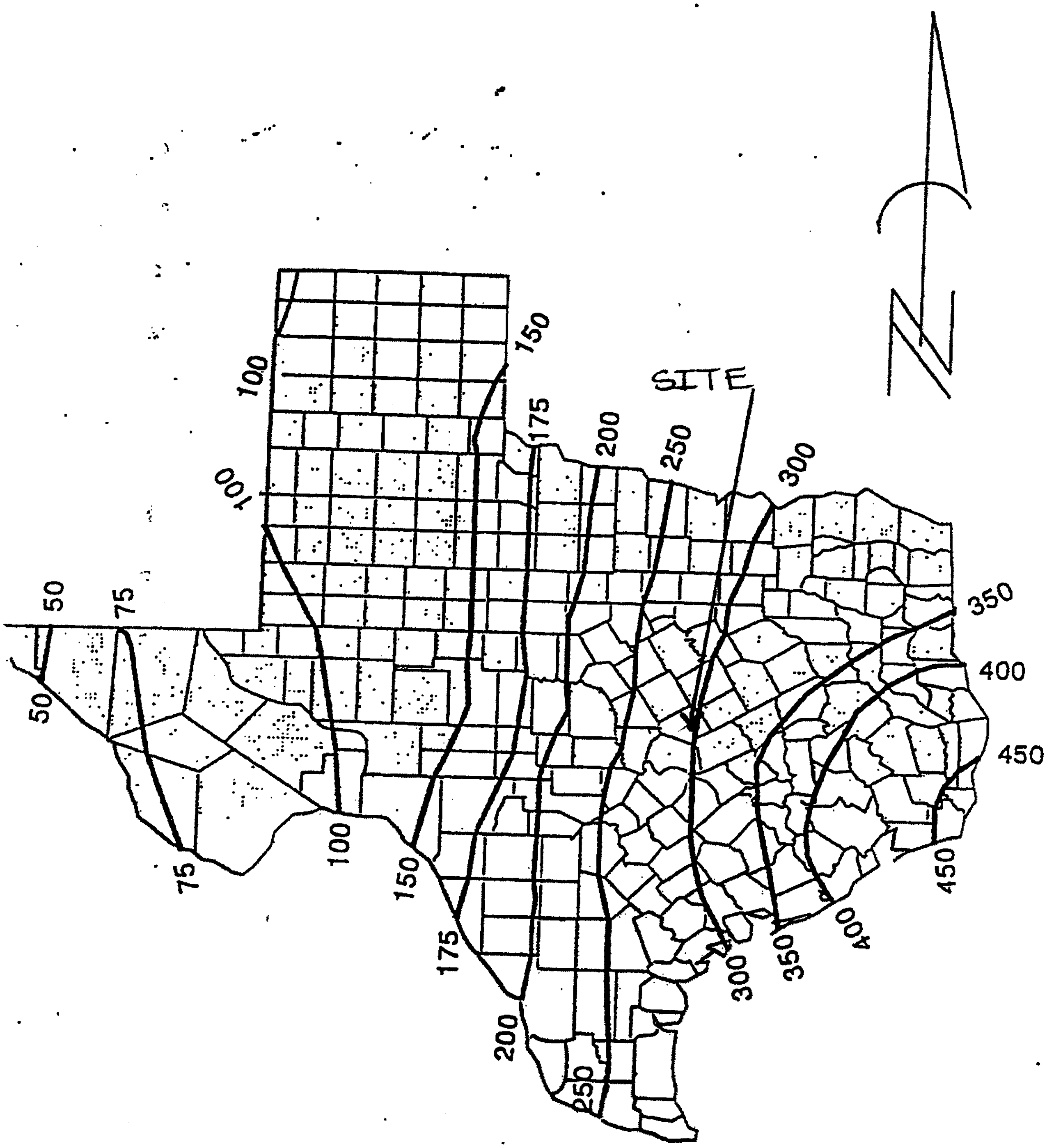
C represents 90% ground cover without appreciable canopy - *USDA-SCS TR 51*

P was assumed to be 1.0 for long-range prediction & no maintenance

A = R * K * LS * C * P

where:

A = soil loss, tons/(acre - year)
R = rainfall erosion index
K = soil erodibility factor
LS = slope length and steepness factor
C = vegetative cover factor
P = erosion control practice factor



URE 1: - AVERAGE ANNUAL VALUES OF THE RAINFALL EROSION INDEX

Table 1 Approximate Values of Factor K for USDA Textural Classes

TABLE 1

Texture Class	Organic Matter Content		
	<0.5%	2%	4%
	K	K	K
Sand	0.05	0.03	0.02
Fine Sand	0.16	0.14	0.10
Very Fine Sand	0.42	0.36	0.28
Loamy Sand	0.12	0.10	0.08
Loamy Fine Sand	0.24	0.20	0.16
Loamy Very Fine Sand	0.44	0.38	0.30
Sandy Loam	0.27	0.24	0.19
Fine Sandy Loam	0.35	0.30	0.24
Very Fine Sandy Loam	0.47	0.41	0.33
Loam	0.38	0.32	0.29
Silt Loam	0.48	0.42	0.33
Silt	0.60	0.52	0.42
Sandy Clay Loam	0.27	0.25	0.21
Clay Loam	0.28	0.25	0.21
Silty Clay Loam	0.37	0.32	0.26
Sandy Clay	0.14	0.13	0.12
Silty Clay	0.25	0.23	0.19
Clay	0.13 - 0.29		

The values shown are estimated averages of broad ranges of specific-soil values. When a texture is near the borderline of two texture classes, use the average of the two K values.

Table 2 Factor C for permanent pasture, range, and idle land[1]

Vegetative Canopy		Cover that contacts the soil surface						
Type and height[2]	Percent cover[3]	Percent ground cover						
		0	20	40	60	70	80	90
No Appreciable Canopy		0.45	0.20	0.10	0.042	.028	0.013	0.006
Tall weeds or short brush with average drop fall height of 20 in.								
	50	0.26	0.13	0.07	0.035	.023	0.012	0.006
	75	0.17	0.10	0.06	0.032	.022	0.011	0.005

Extracted from:
United States Department of Agriculture, AGRICULTURE HANDBOOK NUMBER 537

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1 The listed C values assume that the vegetation and mulch are randomly distributed over the entire area.

2 Canopy height is measured as the average fall height of water drops falling from the canopy to the ground. Canopy effect is inversely proportional to drop fall height and is negligible if fall height exceeds 33 ft.

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

The impact of changes in saturated hydraulic conductivity on the K factor must be accounted for by the nomograph in Fig. 8.9. To accomplish this correction using Eq. (8.38), relationships between hydraulic conductivity and permeability classes used in Fig. 8.9 must be known. Rawls *et al.* (1982) proposed the relationship shown in Table 8.3.

Example Problem 8.4. Effects of rock fragments on K

A silty clay loam soil is classified as permeability class 5. Based on textural information, soil structure, and a permeability class of 5, K is estimated as 0.21 in English units. What would be the value for K as corrected for rock fragments if the percentage of rock fragments greater than 2 mm occupies 40% of the soil mass by weight?

Solution:

1. *Impact of rock fragment on hydraulic conductivity.* From Table 8.3, k_f for a silty clay loam soil is between 0.04 and 0.08 in./hr. Assume a value of 0.06 in./hr. From Eq. (8.38)

$$k_b = k_f(1 - R_w) = 0.06(1 - 0.40) = 0.036 \text{ in./hr.}$$

2. *Estimating the revised permeability class.* From Table 8.3, the permeability class for $k_b = 0.036$ in./hr is 6.
3. *Estimating the new-erodibility.* Entering Fig. 8.9 with an estimated K of 0.21 for a permeability class of 5, the K value for a class 6 permeability is estimated as 0.22 (English units).

It is again important to note that this procedure corrects only for the effects of rock fragments on infiltration. Impacts on the C factor must be based on percentage ground cover, as discussed in a subsequent section.

Rough Estimates of K from Textural Information and Experimental Values for Construction and Mined Sites

The USDA–SCS has developed estimates of K based on textural classification for topsoil, subsoil, and residual materials as shown in Table 8.4. These values are first estimates only and do not include the influence of soil structure or infiltration characteristics.

A limited number of data sets have been developed for drastically disturbed lands and for reconstructed soils. A summary of the data is given in Table 8.5 along with a comparison to values from the Wischmeier *et al.* (1971) nomograph shown in Fig. 8.9. The comparison is sufficiently favorable to warrant the use of the nomograph for a first estimate of K on disturbed topsoil or A-horizon material. The comparison is not favorable for subsoil materials.

Length and Slope Factors L and S

The effects of topography on soil erosion are determined by dimensionless L and S factors, which account for both rill and interrill erosion impacts.

Slope Steepness Factor S

The slope steepness factor S is used to predict the effect of slope gradient on soil loss. For slope lengths

Table 8.3 Soil Water Data for the Major USDA Soil Textural Classes (after Rawls *et al.*, 1982)

Texture	Permeability class[a]	Saturated hydraulic conductivity in./hr	Saturated hydraulic conductivity mm/hr	Hydrologic soil group[b]
Silty clay, clay	6	< 0.04	<1	D
Silty clay loam, sandy clay	5	0.04–0.08	1–2	C–D
Sandy clay loam, clay loam	4	0.08–0.20	2–5	C
Loam, silt loam	3	0.20–0.80	5–20	B
Loamy sand, sandy loam	2	0.80–2.40	20–60	A
Sand	1	> 2.40	>60	A+

[a]See Soil Conservation Service National Soils Handbook (SCS, 1983).
[b]See Soil Conservation Service National Engineering Handbook (SCS, 1972, 1984).
[c]Note: Although the silt texture is missing from the NEH because of inadequate data, it undoubtedly should be in permeability class 3.

greater than 15 ft, the S factor from the USLE was modified significantly by McCool *et al.* (1987, 1993) after extensive evaluation of the original USLE data base. The modified version is

$$S = 10.8 \sin\theta + 0.03; \quad \sin\theta < 0.09 \quad (8.39)$$

$$S = 16.8 \sin\theta - 0.50; \quad \sin\theta \geq 0.09, \quad (8.40)$$

where θ is the slope angle. Based on an evaluation of data from disturbed lands with slopes up to 84%, McIssac *et al.* (1987) developed an equation similar to (8.39) and (8.40) with exponents in the same range; thus McCool *et al.* (1993) recommend that Eqs. (8.39) and (8.40) also be used for disturbed lands.

For slope lengths less than 15 ft, the S factor is not as strongly related to slope (slope exponent less than 1.0) since rilling would not have been initiated. The recommended factor is

$$S = 3.0(\sin\theta)^{0.8} + 0.56. \quad (8.41)$$

Under conditions where thawing of recently tilled soils is occurring and surface runoff is the primary factor causing erosion (typical of the Pacific Northwest in the spring), the S factor should be (McCool *et al.*, 1987, 1993)

$$S = 4.25(\sin\theta)^{0.6}, \quad \sin\theta \geq 0.09. \quad (8.42)$$

For thawing soils with slopes less than 9%, Eq. (8.39) should be used.

The S factor in the RUSLE is significantly modified from the original USLE as a result of an extensive reevaluation of the original data base, addition of the factors for short slope lengths, and new values for thawing soils (McCool *et al.*, 1987). The original data base did not include values beyond 20%. When using the quadratic form of the equation for S developed for the original USLE, projections beyond 20% yielded unreasonably high values for erosion. The RUSLE equation with the linear function corrects this problem.

Table 8.4 K Value Estimates based on Textural Information (English Units) (Soil Conservation Service, 1978)

Texture	Estimated K value[a]
Topsoil	
Clay, clay loam, loam, silty clay	0.32[b]
Fine sandy loam, loamy very fine sand, sandy loam	0.24
Loamy fine sand, loamy sand	0.17
Sand	0.15
Silt loam, silty clay loam, very fine sandy loam	0.37
Subsoil and Residual Material	
Outwash Soils	
Sand	0.17
Loamy sand	0.24
Sandy loam	0.43
Gravel, fine to moderate fine	0.24
Gravel, medium to moderate coarse	0.49
Lacrustrine Soils	
Silt loam and very fine sandy loam	0.37
Silty clay loam	0.28
Clay and silty clay	0.28
Glacial Till	
Loam, fine to moderate fine subsoil	0.32
Loam, medium subsoil	0.37
Clay loam	0.32
Clay and silty clay	0.28
Loess	0.37
Residual	
Sandstone	0.49
Siltstone, nonchannery	0.43
Siltstone, channery	0.32
Acid clay shale	0.28
Calcareous clay shale or limestone residuum	0.24

[a]These values are typical based only on textural information. Values for an actual soil can be considerably different due to different structure and infiltration.

[b]Units on K in this table are English units (tons•acre•hr/hundreds•acre•ft•tonsf•in.). To convert to metric units (t•ha•h/ha•MJ•mm), multiply K values by 0.1317.

Slope Length Factor

The slope length factor was developed by McCool *et al.* (1989, 1993) from the original USLE data base augmented with theoretical considerations. The L factor retains its original form

$$L = \left[\frac{\lambda}{72.6}\right]^m, \quad (8.43)$$

where λ is the slope length in feet, 72.6 ft is the length of a standard erosion plot, and m is a variable slope length exponent. Slope length, λ, is the horizontal projection of plot length, not the length measured along the slope. The difference in horizontal projections and slope lengths becomes important on steeper slopes.

The slope length exponent is related to the ratio of rill to interrill erosion, β (Foster *et al.*, 1977b; McCool *et al.*, 1989, 1993), by

$$m = \frac{\beta}{1+\beta}. \quad (8.44)$$

Table 8.5 Experimental K Value Estimates for Disturbed Lands (English Units)

Reclaimed soil or residual material	Location of experimental site	K Exp[a]/Nomo[b]	Reference
Hosmer silt loam	Indiana	0.387/0.485[c]	Stein *et al.* (1983)
Alfred silt loam	Southern Indiana	0.812/0.485	
Ava silt loam	Southern Indiana	0.842/0.478	
Graded overburden	Southern Indiana	0.197–0.835/ 0.250–0.478	
Clinton silt loam[d]	Western Illinois	0.370/0.360	Mitchell *et al.* (1983)
Tama silty clay loam[d]	Western Illinois	0.210/0.310	
Hosmer silt loam[d]	Southern Indiana	0.450–0.650/ 0.470	
Sadler silt loam (A horizon)	Western Kentucky	0.415/0.385	Barfield *et al.* (1988)
Sadler silt loam (B horizon)	Western Kentucky	0.380/0.640	
Shale spoil material	Western Kentucky	0.140/0.180	

[a]Values measured experimentally with rainfall simulators.
[b]Values calculated from Wischmeier *et al.* (1971) nomograph shown in Fig. 8.9.
[c]Values in English units of tons•acre•hr/hundreds•acre•ft•tonsf•in. To convert to metric units of t•a•h/ha•MJ•mm, multiply by 0.1317.
[d]The dominant soil series. Some mixing occurred with other series.

For soils that are classed as being moderately susceptible to erosion, McCool *et al.* (1989) proposed that

$$\beta_{\text{mod}} = \frac{11.16 \sin \theta}{3.0(\sin \theta)^{0.8} + 0.56}, \tag{8.45}$$

where θ is the slope angle. Thus, the slope exponent is a function of the slope angle θ.

Soils in the RUSLE are classed as having low, moderate, or high susceptibility to rill erosion. Equation (8.45) is for soils that are moderately susceptible to erosion. Conversions for soils that have low or high susceptibility to erosion are given in Table 8.6. Values in Table 8.6 are based on the assumption that moderately erodible soils have a β defined by Eq. (8.45), soils highly susceptible to rilling have a β that is twice that given by Eq. (8.45), and soils with low susceptibility to rilling have a β that is defined by half that given by Eq. (8.45).

For soils in the Pacific Northwest, or other soils that are exposed to runoff during thawing without sufficient rainfall energy to cause interrill erosion, the values in Table 8.6 should not be used. Instead, McCool *et al.* (1989) recommend that a slope length exponent of 0.5 be used for all slopes. When runoff on thawing soils is exposed to rainfall sufficient to cause significant interrill erosion, the slope length exponent for the low rill to interrill erosion ratio should be used (column 1 in Table 8.6). For rangeland soils, the use of a low rill to interrill erosion ratio is proposed. Selection of the appropriate column to use in Table 8.6 requires professional judgement. The assistance of a soil scientist may be helpful.

Combined Length and Slope Factors

Combined slope length and slope steepness factors were calculated using the factors from Eqs. (8.39) to (8.43). These combination factors are given in Fig. 8.13 for all susceptibilities and for thawing soils.

Irregular and Segmented Slopes

Soil loss is strongly impacted by slope shape (Foster and Huggins, 1979). A convex shape will have greater erosion than a uniform slope by as much as 30%. A concave slope will have less erosion than a uniform slope. Foster and Wischmeier (1974) developed a procedure for evaluating the impact of irregular slopes by dividing the slope into segments. The soil loss per unit area from the ith segment is

$$A_i = RK_iC_iP_iS_i\left[\frac{\lambda_i^{m+1} - \lambda_{i-1}^{m+1}}{(\lambda_i - \lambda_{i-1})72.6^m}\right], \tag{8.46}$$

where λ_i and λ_{i-1} are the slope lengths at the start and end of segment i, and K_i, C_i, P_i, and S_i are USLE factors for segment i. Equation (8.46) can be used for each segment i. The total erosion from each segment

Table 8.6 Slope Length Exponent m in Eq. (8.43) (after McCool *et al.*, 1993)[a]

Percentage slope	Rill/interrill ratio		
	Low[b]	Moderate[c]	High[d]
0.2	0.02	0.04	0.07
0.5	0.04	0.08	0.16
1.0	0.08	0.15	0.26
2.0	0.14	0.24	0.39
3.0	0.18	0.31	0.47
4.0	0.22	0.36	0.53
5.0	0.25	0.40	0.57
6.0	0.28	0.43	0.60
8.0	0.32	0.48	0.65
10.0	0.35	0.52	0.68
12.0	0.37	0.55	0.71
14.0	0.40	0.57	0.72
16.0	0.41	0.59	0.74
20.0	0.44	0.61	0.76
25.0	0.47	0.64	0.78
30.0	0.49	0.66	0.79
40.0	0.52	0.68	0.81
50.0	0.54	0.70	0.82
60.0	0.55	0.71	0.83

[a]Values in table are not applicable to thawing soils. See text for explanation.
[b]$\beta = 1/2$ value from Eq. (8.45) in Eq. (8.44).
[c]$\beta = 1 \times$ value from Eq. (8.45) in Eq. (8.44).
[d]$\beta = 2 \times$ value from Eq. (8.45) in Eq. (8.44).

would be $A_i(\lambda_i - \lambda_{i-1})$, and the average erosion per unit area over the entire slope length would be

$$A = R \sum_{i=1}^{n} K_i C_i P_i S_i \frac{\left[\lambda_i^{m+1} - \lambda_{i-1}^{m+1}\right]}{\lambda_e 72.6^m}, \qquad (8.47)$$

where λ_e is the total slope length. Equation (8.47) can also be used to evaluate the effects of variation in K, C, and P over the slope length.

An alternate method for evaluating irregular slopes is the use of a slope length adjustment factor (SAF). If the slope is divided into n increments of equal length ΔX, then

$$A = R \sum_{i=1}^{n} K_i C_i P_i S_i \frac{\left[(i\,\Delta X)^{m+1} - ([i-1]\,\Delta X)^{m+1}\right]}{n\,\Delta X 72.6^m}. \qquad (8.48)$$

Dividing by n times the soil loss from a uniform slope of equal length and assuming constant values of K_i C_i P_i along the slope, a slope adjustment factor can be developed for each segment, or

$$\mathrm{SAF}_i = \frac{A_i}{A} = \frac{i^{m+1} - (i-1)^{m+1}}{n^m}, \qquad (8.49)$$

where n is the number of segments and SAF is the slope adjustment factor. The sum of the SAF_i for a given slope is equal to the number of segments n; thus the average erosion over the slope is

$$A = \frac{R}{n} \sum_{i=1}^{n} K_i C_i P_i S_i L_i (\mathrm{SAF})_i. \qquad (8.50a)$$

where L_i is the slope length factor calculated from Eq. (8.43) using the m value corresponding to the segment steepness. In the development of a SAF relationship, R, K, C, and P remain constant over all segments; thus Eq. (8.50a) can be solved for an equivalent LS factor

$$LS = \frac{1}{n} \sum_{i=1}^{n} S_i L_i (\mathrm{SAF})_i. \qquad (8.50b)$$

Factors calculated from Eq. (8.50b) are given in Table 8.7. An example of its use is given in Example Problem 8.5.

Example Problem 8.5. Estimating *LS* factors

A soil that is very susceptible to rilling has a slope length of 210 ft and an average slope of 15%. Estimate the LS factor if:

(1) the slope is uniform
(2) the slope is convex with slopes of 10, 15, and 20% on segments 1, 2, and 3
(3) the slope is concave with slopes of 20, 15, and 10% on segments 1, 2, and 3.

Assume that the soil is not freezing and thawing.

Solution:

1. Uniform slope. The slope angle is

$$\theta = \tan^{-1} 0.15 = 8.53°.$$

From Eq. (8.45) for soils moderately susceptible to rilling,

$$\beta = \frac{11.16 \sin 8.53}{3.0(\sin 8.53)^{0.8} + 0.56} = 1.37.$$