APPENDIX B
PERFORMANCE EVALUATION FOR TEMPORARY EROSION AND SEDIMENT CONTROL PRACTICES

Background

Standard details and drawings for temporary erosion and sediment control practices have been used since the early 1970's. Many of these details were developed by the United States Department of Agriculture (USDA) Soil Conservation Service (SCS), now known as the Natural Resources Conservation Service (NRCS). These details were incorporated into many state design manuals. These practices included the following:

- Earth Dike
- Temporary Swale
- Perimeter Dike/Swale
- Level Spreader
- Pipe Slope Drain
- Straw Bale Dike
- Silt Fence

What made the use of these details attractive was that they were sized based upon the drainage area, and no extensive engineering calculations were needed for design. For example, if we needed to design a temporary swale to control the runoff from 8 acres above a disturbed construction area by sloping the swale at 3 percent, we would look at page 7A.3 and select Swale B, with a channel treatment of seed and straw mulch. The Swale B cross section is a 6-foot bottom width, 1-foot design depth, and 2:1 side slopes.

This selection process is independent of location in New York State as well as the design rainfall amount. As a result, individuals have often wondered what level of protection is actually being provided.

Site specific practice design depends on a number of variables. These include drainage area, hydrologic soil group, cover, topography, rainfall amount, and intensity or distribution. The following evaluation procedure can be used to incorporate these variables into the practice design. The procedure can also be used to design temporary practices for site specific storm events.

Conveyance Evaluation Procedure

This method of evaluating the performance of a practice is applicable to most of the temporary practices. The first example evaluates the effectiveness of the temporary swale.

CASE 1—Swale A, Average Conditions

Given:

Drainage Area = 4.9 acres

Hydrologic Soil Group = C

Runoff Curve Number = 91
(C soil disturbed for construction)

Slope of Swale = 3%

Rainfall (P) = 2.5 inches
(This represents NY state's average 1-year, 24-hour storm)

Runoff (Q) = 1.6 inches

Time of Concentration for Runoff (T_c) = 6 minutes
(assumed 0.1 hour, the shortest allowed with TR-55)

From Section 4, TR-55 Graphical Method, where:

I_a = Initial Abstraction = 0.198"
Q_{in} = Runoff in inches
q_u = Unit peak discharge in cubic feet per second per square mile
A_m = Drainage area in square miles
F_p = Pond and swamp factor

Drainage Area = 4.9/640 = 0.00766 sq. mi.

if P = 2.5 inches, then I_a/P = 0.00, use 0.1

Q_{in} = 1.6

Then, from Figure 4.15 (Type 2), q_u = 1,000 csmlin

from Equation 4.8 $q_p = (q_u)(A_m)(Q)(F_p)$

Therefore, $q_p = (1{,}000)(.00766)(1.6)$

q_p = 12.2 cfs

For Swale A, the design cross-section shows a bottom width of 4 feet., design depth of 1 foot, and 2:1 side slopes.

Therefore, swale area = 6 ft^2 for design depth

Compute velocity, $V = \frac{1.486}{n}\left(\frac{A}{Wp}\right)^{2/3} S^{1/2}$

Where

n = .040 for vegetated channels

A = 6 sq. ft.
Wp = 8.2 ft. (wetted perimeter)
S = .03 ft/ft (slope)

Therefore, $V = \frac{1.486}{.04} \left(\frac{6}{8.2}\right)^{2/3} (.03)^{1/2}$

= 5 feet per second

Since Q = AV, the swale capacity is

$Q = (6\ ft^2)(5\ ft/sec) = 30$ cfs or more than twice required

CASE 2—Swale B, Average Conditions

Given:

Drainage Area = 10 acres

Hydrologic Soil Group = C

Runoff Curve Number = 91, therefore $I_a = 0.198"$

Slope of Swale = 3%

Rainfall (P) = 2.5 inches

Runoff (Q) = 1.6 inches

Time of Concentration for Runoff (T_c) = 0.1

Similarly to Case 1, q_u = 1,000 CSM

$A_m = 10/640 = 0.01563$

$q_p = (1{,}000)(.01563)(1.6) = 25$ cfs

For Swale B, the design cross-section has a 6-foot bottom width, 1-foot depth, and 2:1 side slopes.

Therefore, the area = 8 ft^2

Computing velocity for a swale slope of 3%,

$V = \frac{1.486}{.04} \left(\frac{8}{10.47}\right)^{2/3} (.03)^{1/2}$

V = (37.15)(.836)(.173) = 5.37 ft/sec

Since Q = AV, the swale capacity is

$Q = (8\ ft^2)(5.37\ ft/sec) = 43$ cfs

CASE 3—This site is adjacent to a significant water body in Westchester County. We want to protect the site for the 2-year, 24-hour storm.

Given:

Drainage Area = 10 acres

Hydrologic Soil Group = D soils

Runoff Curve Number = 94, ("D" under construction)

Slope of Swale = 3%

Rainfall (P) = 3.5 inches; Ia = 0.128"

Runoff (Q) = 2.8 inches; Type 3 rainfall

Assume Time of Concentration for Runoff (T_c) = 0.1 hour (most conservative value)

$A_m = 10/640 = 0.01563$ sq. mi.

$I_a/P = 0.128/3.5 = 0.04$, therefore use 0.1

From Figure 4.16 (Type 3), q_u = 655 CSM

Therefore, qp = (655)(0.01563)(2.8)

= 28.7 cfs

From CASE 2, Swale B, we know that the maximum capacity is 43 cfs with a velocity of 5.37 feet per second.

Our conclusions would indicate that Swale B is adequate for capacity. The velocity is higher and thus a mulch lining should be used to protect the swale from erosion.

Storage Evaluation Procedure

Practices such as silt fence, straw bale dikes, and earthen berms are often used on slopes or near the toes of fill slopes to capture sediment laden runoff. These have failed many times in the field due to poor siting, improper installation, lack of maintenance, and little consideration of the proper use of the practice.

As an example of how careful we need to be in using these practices, look at the use of silt fence in the following typical situations.

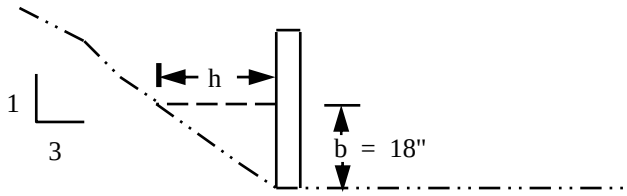
CASE 1—At the toe of a 3:1 earthfill

Given: 30' high earthfill
Hydrologic Soil Group—C
Therefore, Runoff Curve Number = 91

Typically, the installed height of the silt fence is 30-36". The maximum design sediment depth behind the silt fence is 50% of its height, or 18" maximum.

For this case, the design sediment area is equal to:

A = 1/2bh



A = 1/2 (1.5')(4-5') = 3.375 sq. ft. per linear foot

This equals 337.5 cubic feet per 100 feet of fence.

The actual slope surface is approximately 95 feet. For a rainfall of 1 inch on this site, the runoff equals 0.4 inches. The total volume of runoff would equal

$$\frac{0.4 \text{ inches}}{12 \text{ inches/ft}} \times 9500 \text{ sq. ft.} = 317 \text{ cu. ft.}$$

This example shows that the volume required for a 1-inch storm is barely provided, but the location of the fence provides no buffer for material that rolls down the slope nor room for maintenance. The fence should be located at least 10 feet from the toe of the slope.

CASE 2—Determine level of protection for CASE 1 when fence is moved 10 feet from the toe of slope.

When the silt fence is moved 10' away from the 3:1 slope, the design area of storage equals,

337.5 sq. ft. + 1,500 sq. ft. = 1,837.5 cu.ft. per 100 feet of fence

Since this is the maximum runoff volume that can be controlled, the runoff depth is,

$$\frac{1{,}837.5 \text{ ft}^3}{9{,}500 \text{ ft}^2} = 0.193 \text{ feet} = 2.3 \text{ inches}$$

From Section 4, Figure 4.1 for a Q = 2.3 inches, and a Curve Number at 91, P is interpreted at 3.2 inches.

Thus, this design configuration can manage to store the runoff from a 3.2 inch rainfall event.

This method can be used to evaluate the positioning of these sediment control practices on the contour to hold sediment close to its source. It allows a designer to evaluate an existing condition, or to select a specific level of protection higher than that which may be provided by the standard details.

APPENDIX C
COST ANALYSIS OF
EROSION AND SEDIMENT CONTROL PRACTICES

CONTENTS

Page

List of Tables

Analyzing Benefits and Costs……. C.1

Ascribing Effects to Treatment Measures…… C.1

Pricing Treatment Measures and Benefits……..……. C.1

Period of Analysis and Evaluation……...…… C.1

Appraisal of Damages and Treatment Costs…… C.1

Treatment Measures……..……...…… C.1

Benefit-Cost Analysis……..…… C.2

Example……..……...…… C.2

Cost Estimate—SITE EXAMPLE…… C.5

References

Section prepared by:

Donald W. Lake Jr., P.E., CPESC, CPSWQ
Engineering Specialist
New York State Soil & Water Conservation Committee

List of Tables

Table	Title	Page
C.1	Cost Table…….…….	C.3
C.2	Annual Maintenance Cost As Percentage of Installation Cost……..	C.4
C.3	Cost Estimate—SITE EXAMPLE…….	C.5

COST ANALYSIS OF EROSION AND SEDIMENT CONTROL PRACTICES

Analyzing Benefits and Costs

Benefit-Cost analysis is a technique used to determine whether a measure will result in more benefits than it will cost.

For the purposes of making a benefit-cost analysis for erosion and sediment control, the time period associated with erosion and sedimentation is considered to extend from the first disturbance of the land to the time of establishing effective erosion control.

Ascribing Effects to Treatment Measures

The generally accepted basis for attributing effects of treatment measures on a comparable basis is the "with" and "without" approach. This approach compares the expected difference in damages between what is expected if no control is used and what is expected if a measure is installed. The total difference in expected damage is the estimated benefit of the measure.

Sediment damages may be related to (1) deposition of eroded materials on flood plains, in channels, reservoirs, residences, utilities, and other properties that require the removal and disposition of materials, and the repairing of damaged facilities and (2) swamping damage which adversely affects existing features or limits potential improvement of land caused by a rise in the ground water table or by impairing surface drainage.

Sediment resulting from construction sites can be deposited along a stream and cause individual landowners to pay for its removal. Sediment can also destroy aesthetic values of a stream (clean water vs. turbid water) and adversely impact stream fisheries and micro-organisms.

In municipal and industrial uses where water is pumped directly from a river or reservoir, slugs of sediment associated with excessive rainfall may pose sever water quality problems. Turbidity may be increased, necessitating increased treatment, which raises the cost of operations. Sediment may also be deposited in storm drains, reducing their ability to control flooding. This increases flood damage and requires the cleanout of sediment from the storm drain systems.

Pricing Treatment Measures and Benefits

Prices applied should reflect values expected to prevail at the time of occurrence. Current prices are used for installation costs of treatment measures. Projected normalized prices (based on past prices and trends) should be used for estimating future values (benefits, operations and maintenance costs and replacement costs) for permanent type measures only.

Period of Analysis and Evaluation

The period of analysis in years should equal the economic life (need for a measure) or the physical life of treatment measures, whichever is less. The benefits considered over the evaluation period include those accruing over the period.

The annual costs of permanent measures chargeable to the evaluation period include the amortized installation cost and the future annual operation, maintenance, and replacement cost necessary to provide the benefits over the evaluation period. The amortization rate should be based on prevailing local interest rates at the time of installation.

Appraisal of Damages and Treatment Costs

Many people are affected by the damages resulting from erosion and sedimentation. Also, communities and individuals benefit from its prevention, reduction, or mitigation.

Costs will be incurred to: (1) install remedial treatment measures; or (2) correct damages; or (3) a combination of the two.

Treatment Measures

Treatment measures on developing sites are frequently temporary—generally lasting only one or two construction seasons. Benefits and cost for temporary measures can be compared directly using current prices.

Permanent measures are planned to trap sediment and control erosion and runoff during and beyond the construction period. The prevention of sediment damages can be accomplished by either, or both of, two methods:

1. Stabilizing sediment source areas by applying conservation erosion control measures.

2. Trapping sediment before it leaves the construction area (sediment control)

(Erosion control is often more effective than sediment control at preventing sediment damage. It is highly recommended to use both methods to maximize benefits.)

Some of the potential benefits from preventing downstream sediment transport and deposition include:

1. Prevention or reduction in cost of removal and disposition of sediment from properties.
2. Prevention or reduction in damage to property.
3. Prevention of water quality impairment.

Some permanent measures may be retained to provide long-term benefits.

For example, a sediment basin may be cleaned out after construction is finished and utilized for aesthetics, recreation, fish, or stormwater management.

Benefits and costs for permanent measures need to be converted by discounting and amortizing to average annual figures for comparison.

Benefit-Cost Analysis

A simple equation for determining the benefits of controlling sediment is:

B = (SxY) - [C + (SxY)(1.00-P)]

Where: B = Benefits in dollars.

S = Cubic yards of sediment expected to move off the site if no control measures are applied. (See Section 3).

Y = Cost in dollars per yard to recover and dispose of sediment that has moved off the site.

C = Estimated cost of temporary measures to be installed. (See Cost Tables).

P = Estimated effectiveness of proposed measures expressed as a decimal.

Example

This example illustrates the methodology of a benefit-cost analysis:

Given: A construction site of 78 acres, which without erosion or sediment control measures will yield about 5 acre feet or 8,000 cubic yards of sediment (S) to the lower end of the site. There is a channel with several culverts located below the site and it is assumed all the sediment would be deposited in it. It would be necessary to remove all the additional sediment in order to maintain the capacity of the channel and avoid increased hazard to flooding. The cost of removing and disposing the sediment is estimated at $2.00 per cubic yard (Y).
With temporary erosion and sediment control measures, including a sediment basin, in place during the one year construction period, sediment delivered to the channel will be reduced 90 percent (P). The cost of the measures would be as follows, (no amortization is required since costs and benefits are incurred in a similar one year period):

1. Land grading measures…….$2,000
2. Temporary sediment basin……$3,000
   a. Construction……$1,500
   b. Maintenance……$1,000
   c. Restoration……..$500

Total Cost (C)……...…….$5,000

The "without treatment" condition reveals damages in the form of costs to remove sediment. Benefit (costs saved) are derived by subtracting the sediment removal costs under the "with treatment" condition.

1. Without treatment condition

   8,000 cu.yd. (S) x $2.00/cu.yd. (Y) = $16,000 (SxY)

2. With treatment condition

   a. Costs (C) described above = ……...$5,000

   b. Removal costs for the 10% of sediment that passes through the control measure (measure is 90% effective)

   (SxY)(1.00-P) = (16,000)(1.00 - .90) …$1,600

   c. Total Cost = $5,000 + $1,600 =……. .$6,600

3. Benefits

   $16,000—$6,600 = ……..$9,400 (B)
($9,400 is money saved by installing sediment treatment)

Using the formula directly, the computations show the same results:

B = (SxY)-[c + (SxY)(1.00-P)]

B = ($8,000 x 2.00)-[($5,000 + (8,000 x 2.00)(1.00-0.90)]

B = ($16,000)-($5,000 + 1,600)

B = ($16,000)-($6,600)

B = $9,400

In this example, the more economical approach would be to install treatment measures rather than correct damages at a later date. A third alternative would be "do nothing" which would result in a higher flood damage hazard that would need evaluation under a more sophisticated analytical model. **Also, in this simple example, water quality issues (such as habitat loss) were not included even though society, in general, does place a value on such issues.**

Table C.1—Cost Table

The cost of implementing erosion and sediment control practices is highly variable and dependent upon many factors including availability and proximity of materials, time of year, prevailing wage rates, and regional cost trends to name a few. It is therefore difficult to develop cost estimates that are applicable statewide and year-round. The cost data contained in this chapter is based on actual bid prices from county and state highway construction projects, and suppliers for the year 2000. The following cost figures are provided to aid project planners in estimating erosion and sediment cost for feasibility studies. The actual dollar amounts are not recommended for use in estimating and bidding construction contracts. It is advisable to check with local suppliers and contractors for this purpose.

Erosion and Sediment Control Measures	$ Low	$ High	$ Median
VEGETATIVE MEASURES			
Temporary Seeding	400/ac.	1,020/ac.	550/ac.
Permanent Seeding	1,500/ac.	2,690/ac.	2,000/ac.
Straw Mulch	660/ac.	1,000/ac.	750/ac.
Wood Mulch		23,000/ac.	23,000/ac.
Topsoil Stripping			1.60 cu.yd.
Topsoil Spreading			20/cu.yd.
Sodding			12/sq.yd.
RECP Netting	4.00/sq.yd.	4.53/sq.yd.	4.50 sq.yd.
Tree Protection			5/ln.ft.
BIOTECHNICAL MEASURES			
Willow Wattles			10/ln.ft.
Live Stakes			1.50/ln.ft.
Brush Layering			8/ln.ft.
RUNOFF CONTROL MEASURES			
Temporary Swale	2.00/ln.ft.	3.00/ln.ft.	2.50/ln.ft.
Rock Check Dam	130/ea.	450/ea.	200/ea.
Diversion or Grass Channel	6/ln.ft.	12/ln.ft.	10/ln.ft.
Riprap Channel	36.40/cu.yd.	55.00/cu.yd.	45.00/cu.yd.
Level Lip Spreader			25/ln.ft.
Rock Outlet Structure			1,000/ea.

Table C.1 (cont'd)
Cost Table

Erosion and Sediment Control Measures	$ Low	$ High	$ Median
SEDIMENT CONTROL MEASURES			
Silt Fence	2.00/ln.ft.	2.68/ln.ft.	2.50/ln.ft.
Straw Bale Berm	3.25/ln.ft.	5.00/ln.ft.	4.00/ln.ft.
Stabilized Construction Entrance			30/cu.yd.
Temporary Sediment Basin			50/cu.yd.
Temporary Sediment Trap	600/ea.	2,000/ea.	1,500/ea.
Temporary Silt Dike			12/ln.ft.
Turbidity Curtain	4/sq.yd.	55/sq.yd.	20/sq.yd.
Filter Fabric Inlet Protection			100/ea.
Excavated Drop Inlet Protection			500/ea.
Temporary Sediment Tank			2,600/ea.
Block & Gravel Inlet Protection			500/ea.

Table C.2
Annual Maintenance Cost As Percentage of Installation Cost

Item	Percentage (%)
Seeding	20
Mulch	2
Silt Fence	100
Sediment Trap	20
Sediment Basin	25
Inlet Protection	60
Stabilized Construction Entrance	100
Rock Riprap	10
Grass Channel	10
Temporary Swale	50
Level Lip Spreader	50
Tree Protection	50
Rock Outlet Structure	20

Cost Estimate—SITE EXAMPLE

This example illustrates the use of Tables C.1 and C.2 to compute a cost estimate for erosion and sediment control for a site plan.

For the site example shown in Appendix F, the following cost estimate table (Table C.3) can be constructed. Unit costs are based on the median value in Table C.1. Since the construction schedule indicates a 9-month period to complete, we will use the annual maintenance figure in Table C.2 for the estimate.

It should be noted that many items are permanent practices, such as the rock riprap lined channel, permanent seeding, grass-lined channel, level lip spreader, and the rock outlet structures.

Table C.3
Cost Estimate For Site Example in Appendix F

ITEM	QUANTITY	UNIT COST	AMOUNT ($)	MAINTENANCE ($)	TOTAL ESIMATED COST ($)
1. Stabilized Construction Entrance	22.2 cu.yd.	$30 cu.yd.	666	666	1,332
2. Rock Riprap	350 cu.yd.	$45/cu.yd.	15,750	1,575	17,325
3. Seeding	2.5 ac.	$2,000/ac.	5,000	1,000	6,000
4. Grass Channel	1,100 ln.ft..	$10/ln.ft.	11,000	1,100	12,100
5. Temporary Swale	900 ln.ft.	$2.50/ln.ft.	2,250	1,125	3,375
6. Level Lip Spreader	10 ln.ft.	$25/ln.ft.	250	125	375
7. Drop Inlet Protection					
a. Filter Fabric	1 ea.	$100/ea.	100	60	160
b. Block & Gravel	1 ea.	$500/ea.	500	300	800
8. Silt Fence	100 ft.	2.50/ln.ft.	250	250	500
9. Tree Protection	80 ln.ft.	$5.00/ln.ft.	400	200	600
10. Sediment Trap	1 ea.	$1,500/ea.	1,500	300	1,800
11. Sediment Basin	285 cu.yd.	$50/cu.yd.	14,250	3,600	17,850
12. Rock Outlet Structure	2 ea.	$1,000/ea.	2,000	400	2,400
				TOTAL	64,617

References

1. Soil Conservation Service, USDA. Oct. 1977. National Handbook for Conservation Practices, U.S. Government Printing Office, Washington, D.C.

2. Soil Conservation Service, USDA. July 1984. Engineering Field Manual of Conservation Practices, 4th Printing, U.S. Government Printing Office, Washington, D.C.

3. Soil Conservation Service, USDA. June 1986. Urban Hydrology for Small Watersheds, Technical Release 55, Second Edition, U.S. Government Printing Office, Washington, D.C.

4. Soil Conservation Service, USDA. Sept. 1987. Drainage Guide for New York State, Syracuse, N.Y.

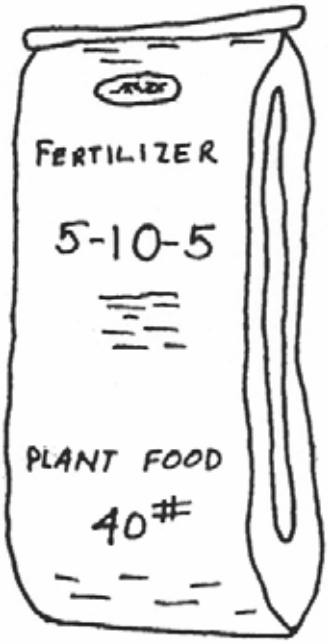
APPENDIX D
FERTILIZER LABELS AND PURE LIVE SEED

FERTILIZER GRADE

5-10-5

MEANS

5%	-	10%	-	5%
NITROGEN	-	PHOSPHORUS	-	POTASH
(N)	-	(P_2O_5)	-	(K_2O)



OR

2 lbs.	-	4 lbs.	-	2 lbs.
N/40 lb. bag	-	P_2O_5/40 lb. bag	-	K_2O/40 lb. bag

FERTILZER CALCULATION EXAMPLE

EXAMPLE

A one-half acre lawn area needs 20 pounds of nitrogen (N) (40 pounds per acre) to achieve vigorous, green growth. The supplier has 10-10-10 in 50 pound bags. How many bags of fertilizer are needed?

NOTE: Always apply as closely as possible the required amount of fertilizer to meet the requirements of the site. Adding surplus nitrogen may cause pollution of drinking water and saltwater ecosystems. Excessive phosphorus may accelerate the aging process of freshwater ecosystems. Excessive amounts of N and K2O may result in 'burning' the grass and killing it.

ANSWER

10-10-10 has 10% of each N, P2O5, and K2O in the bag. Based on the N needed,

40-lbs/ac divided by 0.1 (10%) = 400 lbs. for one acre.
Divide by 2 for ½ acre=200 lbs. of fertilizer or 4-fifty pound bags of 10-10-10 fertilizer.

HOW TO CALCULATE PURE LIVE SEED

Pure Live Seed, or PLS, refers to the amount of live seed in a lot of bulk seed. The cost of PLS seed is proportionally higher than bulk price. Calculating Pure Live Seed can help you save money and do the best jobs possible. Take a look at the label on a bag of seed. You will find a lot of information such as the type of seed, the supplier, test date and where the seed came from. More importantly, you will see seed purity, and germination percent. To compute pure live seed, multiply the "germination percent" times the "purity" and divide that by "100" to get PURE LIVE SEED.

(*Purity* is the percentage of pure seed. A high percentage of pure seed is required for crop seed, but some chaffy grasses and native plants may have a lower percent purity. A high pure seed percentage will provide the best results. *Germination percentage* is the percentage of pure seed that will produce normal plants when planted under favorable conditions.)

Example:

$$\frac{\text{96\% germination x 75\% purity}}{100} = \text{72\% PLS}$$

Then divide the "Cost per pound" by "Pure Live Seed" and you will have the cost per pound of the Pure Live Seed.

$$\frac{\$2.50 \text{ per pound}}{72\%} = \$\ 3.47 \text{ per Pound of PLS}$$