NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

TERRACE

(Ft.)

CODE 600

DEFINITION

An earth embankment, or a combination ridge and channel, constructed across the field slope.

PURPOSE

This practice is applied as part of a resource management system for one or more of the following purposes:

- Reduce erosion by reducing slope length
- Retain runoff for moisture conservation

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- Soil erosion caused by water and excessive slope length is a problem
- Excess runoff is a problem
- There is a need to conserve water
- The soils and topography are such that terraces can be constructed and reasonably farmed
- A suitable outlet can be provided

CRITERIA

General Criteria Applicable To All Purposes

Comply with all federal, state, and local laws and regulations when planning, designing and constructing terraces.

Spacing. Space terraces at intervals across the slope to achieve the intended purpose. Determine the maximum spacing of terraces for erosion control by using one of the following methods:

1. Vertical Interval Equation:

   V. I. = xs + y, or

   H. I. = (xs + y) (100/s)

   Where:

   V. I. = Vertical interval in feet

   H. I. = Horizontal interval in feet

   x = 0.4 (value of x varies by geographical location from 0.4 to 0.8. For Georgia use 0.4 for all locations)

   s = land slope in percent

   y = a variable with values from 1.0 to 4.0

Values of "y" are influenced by soil erodibility, cropping system, and crop management practices. Use a value of 1.0 for easily erodible soils with tillage systems that provide little or no cover during periods of intense rainfall. Use a value of 4.0 for erosion resistant soils with tillage systems that leave a large amount of cover (1.5 tons of straw equivalent per acre on the surface. Use a value of 2.5 where one of the above factors is favorable and the other unfavorable. Other values between 1.0 and 4.0 may be used according to the estimated quality of the above factors. The horizontal spacing does not have to be less than 90 ft. as shown in Table 600-1.

2. Revised Universal Soil Loss Equation (RUSLE). Do not use a spacing that exceeds the critical slope length as determined using RUSLE. When tables are used to calculate critical slope, refer to Table 600-2 of this standard for terrace P factor. Design the terrace to limit the soil loss in the inter-terrace interval to a value less than or equal to the allowable soil loss.

Do not exceed the maximum horizontal terrace spacing (Table 600-3) when making adjustments indicated below.

Spacing may be increased as much as 10 percent to provide better alignment or location, to adjust for farm machinery, or to reach a satisfactory outlet.

Spacing may be increased an additional 10 percent for terraces with underground outlets. Adjust the spacing to provide for an even number of trips for anticipated row crop equipment and maximum opportunity for changing row widths.

Consider the likelihood of benching of steep slopes by tillage, land forming, and erosion when determining the terrace interval. For example, use the proposed as-built slope and length in RUSLE calculations.

For level terraces used for erosion control and water conservation, determine the spacing as previously described, but in no case shall the maximum horizontal spacing exceed 600 feet. An x value of 0.8 may be used for all level terraces used primarily to impound water. Figures 1 and 2 show the horizontal interval or erosion length to be used in calculating terrace spacing (Figure 3).

For terraces on noncropland, use capacity requirements to determine the maximum spacing.

Design guidance for terraces is contained in NRCS Engineering Field Handbook, Part 650, Chapter 8.

Alignment. Construct cropland terraces parallel if feasible and as parallel as practicable. Use long and gentle curves to accommodate farm machinery.

Capacity. Design terraces to have enough capacity to control the runoff from a 10-year frequency, 24-hour storm without overtopping.

For terraces with underground outlets, the capacity to contain the design storm can be a combination of storage and out flow through the underground outlet. Increase the capacity of terraces with underground outlets by the estimated 10-year sediment accumulation, unless the Operation and Maintenance Plan specifically addresses the annual removal of sediment.

For terraces with open outlets, the capacity is based on the terrace channel size and stability. Base the capacity of the channel on a bare earth channel for crop fields or in the case of a permanently vegetated channel, the appropriate vegetation. For bare earth channels use a Manning's n value of 0.035 or greater to calculate capacity. For permanently vegetated channels refer to Conservation Practice Standard (412), Grassed Waterway for design criteria to determine capacity.

For terrace systems designed to control excess runoff or to function with other structures, choose a larger design storm that is appropriate to the risk associated with the installation.

Terrace cross section. Proportion the terrace cross section to fit the land slope, the crops grown, and the farm machinery used. Add ridge height if necessary to provide for settlement, channel sediment deposits, ridge erosion, the effect of normal tillage operations, or safety. At the design elevation, provide a minimum ridge width of 3 ft. Provide a minimum cross sectional area of the terrace channel for gradient terraces as follows:

1. For slopes up to and including 5%:
   Settled - 8 sq.ft.
   Newly constructed - 9 sq.ft.

2. For slopes above 5%
   Settled - 7 sq.ft.
   Newly constructed - 9 sq.ft.

For terraces with open outlets, design the capacity of the outlet to be equal to or greater than the capacity of the terrace channel.

Design all farmable terrace with slopes no steeper than those on which farm equipment can be operated safely. For non-farmable terrace slopes, the steepest slopes allowable are 2 horizontal to 1 vertical unless an analysis of site specific soil conditions indicate that steeper slopes will be stable.

End closures. Level terraces may have open ends, partial end closures, or complete end closures. Use partial and complete end closures only on soils and slopes where stored water will be absorbed by the soil without appreciable crop damage or where underground outlets are provided.

If terraces with closed or partly closed ends are specified, install the end closures before the terraces are completed. Design end closures so that water flows over the end closure before overtopping the terrace ridge.

End closures less than or equal to half the effective height of the terrace ridge are considered partial closures while those greater than half the height are considered complete closures. The cross sectional area of the end closure fill may be less than the terrace cross section.

For level terraces that have end closures that are lower than the terrace ridge elevation, areas downstream from the end closure must be protected from flow that will exit from the closure before the design storm is reached.

Channel grade. Channel grades may be uniform or variable. Design the terrace channel to be stable with non-erosive velocities but with sufficient grade to prevent damage to crops or to prevent delay of farming activities from prolonged ponding.

Determine channel grade by one of the following methods:

1. Do not exceed 0.6 ft. per 100 ft of length (0.6 percent) for a maximum channel grade to the lower reaches of the channel.

2. Use maximum channel velocity for farmed channels that are nonerosive for the soil and planned treatment. Maximum velocity for erosion resistant soils is 2.5 ft/sec (0.75 m/sec), for average soils 2.0 f/sec, (0.6 m/sec), and for easily erodible soils 1.5 ft/sec (0.45 m/sec). Compute velocities by using Manning’s formula using a minimum “n” value of 0.035.

3. For permanently vegetated channels, base the channel velocity on the appropriate vegetation. Refer to Conservation Practice Standard 412, Grassed Waterway for design criteria to determine stability.

For short distances in the upper reaches (upper 200 feet or less) of a channel, grades may be increased up to a maximum of 1.5% to improve alignment provided the increased grade does not result in erosive velocities.

For terraces with an underground outlet, channel grades can be steeper for short distances within the impoundment area.

If necessary, permanently vegetate channels to control erosion, when the maximum channel grades or velocities are exceeded

Level terrace length. The volume of water stored in level terraces is proportional to the length. To reduce the potential risk from failure, do not design level terraces with lengths that exceed 3,500 feet unless the channel is blocked at intervals not exceeding 3,500 feet.

Normally, gradient terrace length is controlled by the capacity and the nonerosive velocity requirements. Two thousand (2000) feet is generally considered the maximum length of a gradient terrace.

Outlets. Provide adequate outlets for all terraces. Vegetated outlets may be used for gradient or open-end level terraces. Such an outlet may be a grassed waterway constructed in accordance with Georgia NRCS Conservation Practice Standard Grassed Waterway, Code 412 or a vegetated area which will convey runoff without causing erosion. Design the outlet to convey runoff to a point where the outflow will not cause damage. Install and establish vegetation on outlets before the terrace is constructed. Design the water surface in the terrace to be higher than the water surface in the outlet at their junction when both are operating at design flow.

Underground outlets may be used on gradient or level terraces. The outlet consists of an intake and an underground conduit. Install an orifice plate, increase the conduit size, or install other features as needed to control the release rate and prevent excessive pressure in the conduit. Design terraces to control a 10-year frequency, 24-hour storm without overtopping. Design the underground outlet with a release time that does not exceed the inundation tolerance of the planned crops. If sediment retention is desired, adjust release rate according to particle size.

Design the underground conduit in conformance with the requirements specified in Georgia NRCS Conservation Practice Standard Underground Outlet, Code 620 or Subsurface Drain, Code 606. Install outlets deep enough to prevent damage from tillage equipment. Provide a vertical perforated pipe of a material suitable for the intended purpose as the inlet for the conduit. Locate the inlet uphill of the front slope of the terrace ridge, if farmed, to permit passage of farm machinery and, if necessary, provide for the anticipated accumulation of sediment. Design the outlet of the conduit to provide adequate capacity for the design flow without causing erosion. Blind inlets may be used where they are effective, usually in well-drained soils.

Soil infiltration may be used as the outlet for level terraces. Soil infiltration must permit drainage of the design storm from the terrace channel within a reasonable period so that standing water does not significantly damage crops.

Combinations of different types of outlets may be used on the same system to maximize water conservation and to provide for economical installation of a more farmable system.

Vegetation. Stabilize all areas planned for vegetation as soon as possible after construction. Refer to Conservation Practice Standard, 342, Critical Area Planting for seeding criteria.

Drainage. Install subsurface drainage to stabilize soils and improve terrace function as needed. Refer to Conservation Practice Standard, 606, Subsurface Drain for design and installation criteria.

Additional Criteria Applicable to Retaining Runoff for Moisture Control

For terraces installed to retain moisture, perform a water budget analysis to determine the volume of water that must be collected to meet the requirements of the water budget. As a minimum the terrace must still meet the design storm and sediment volume requirements in the **Capacity** section of this standard.

CONSIDERATIONS

One of the keys to a successful terrace system is to make sure that the terrace layout fits the farm equipment. This includes making curves long and gentle and spacing terraces so that the operator can make an even number of trips between terraces so that they end up on the same side of the field they started on.

Terrace ridges and cut slopes can introduce steep and potentially hazardous slopes into a crop field. Where slopes will be farmed, make sure they can be safely negotiated with the operator's equipment. Where steep slopes are unavoidable make sure the operator is aware of the location and potential danger of the slopes.

The soil survey can be a valuable resource when planning and designing terrace systems. The soil survey can identify potential problems such as the presence of limiting layers to plant growth in the soil profile. Field investigations can then identify problem areas to avoid such as shallow bedrock or dense, acid or saline layers that will adversely affect plant growth if construction brings them into the root zone.

Steep sided terraces that are in permanent vegetation can provide significant areas of habitat for wildlife. Consider planting native species that provide food and cover for wildlife. Do not mow these areas until after the nesting season to improve wildlife production.

Hillside seeps in a crop field can cause cropping problems. Consider aligning terraces and/or installing subsurface drainage to intercept and correct seepage problems.

Erosion can be a problem at the outfall of an underground outlet. To ensure an adequate outlet, protect the outfall of the underground outlet so that it is stable.

Outlets from terraces can provide a direct conduit to receiving waters for contaminated runoff from crop land. Terraces should be installed as part of a conservation system that addresses issues such as nutrient and pest management, residue management and filter areas.

Inlets for underground outlets can be easily damaged during cultivation, planting and harvesting operations. Using brightly colored inlets, barriers around the inlet or otherwise clearly marking the inlet will help prevent damage.

For terraces that will be farmed or otherwise revegetated, the stripping and stockpiling of topsoil from the construction area prior to excavation and then spreading the topsoil on the completed terrace will improve the growth of vegetation after construction.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for terraces that describe the requirements for applying the practice according to this standard. As a minimum the plans and specifications include:

1. A plan view of the layout of the terrace system.
2. Typical cross sections of the terrace(s).
3. Profile(s) or planned grade of the terrace(s).
4. Details of the outlet system
5. If underground outlets are used, details of the inlet and profile(s) of the underground outlet.
6. Seeding requirements if needed.
7. Site specific construction specifications that describe in writing the installation of the terrace system.

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the operator. The minimum requirements to be addressed in a written operation and maintenance plan are:

1. Periodic inspections, especially immediately following significant runoff events.
2. Prompt repair or replacement of damaged components.
3. Maintenance of terrace ridge height, channel profile, terrace cross-sections and outlet elevations.
4. Removal of sediment that has accumulated in the terrace channel to maintain capacity and grade.
5. Regular cleaning of inlets for underground outlets. Repair or replacement of inlets damaged by farm equipment. Removal of sediment around inlets to ensure that the inlet remains the lowest spot in the terrace channel.
6. Where vegetation is specified, seasonal mowing and control of trees and brush.
7. Notification of hazards about steep slopes on the terrace.

REFERENCES

USDA, NRCS. 2004. Revised Universal Soil Loss Equation, Ver. 2 (RUSLE2).

USDA, NRCS. National Engineering Handbook, Part 650, Engineering Field Handbook, Chapter 8.

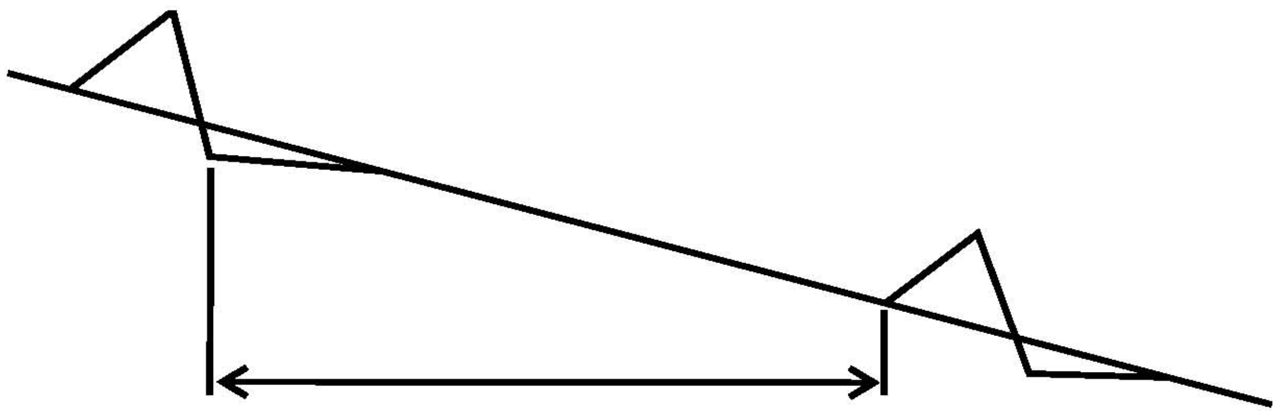

Figure 1 - Horizonal interval for steep back slope terraces.

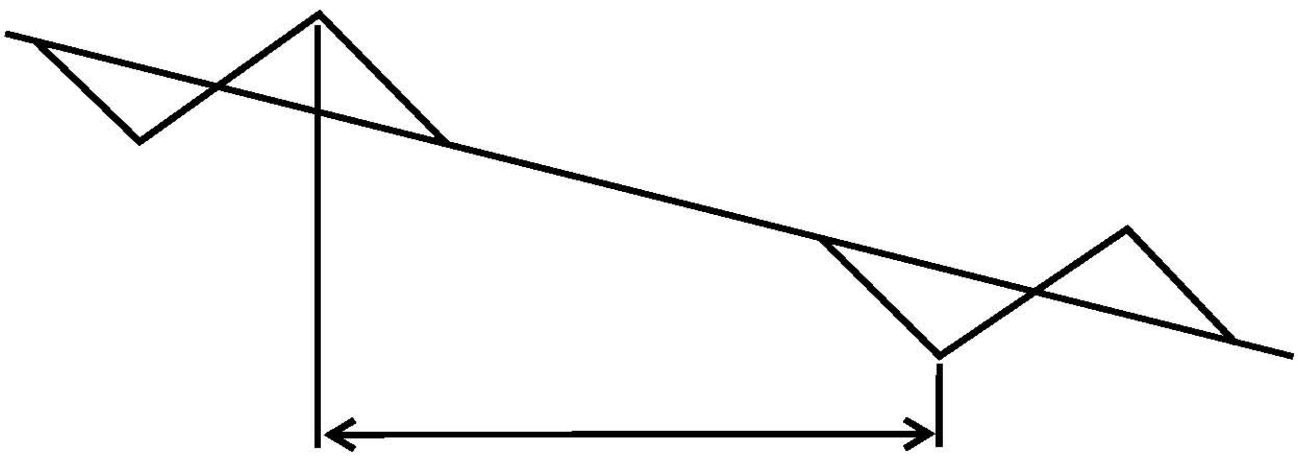

Figure 2 - Horizontal interval for broad-based terraces.

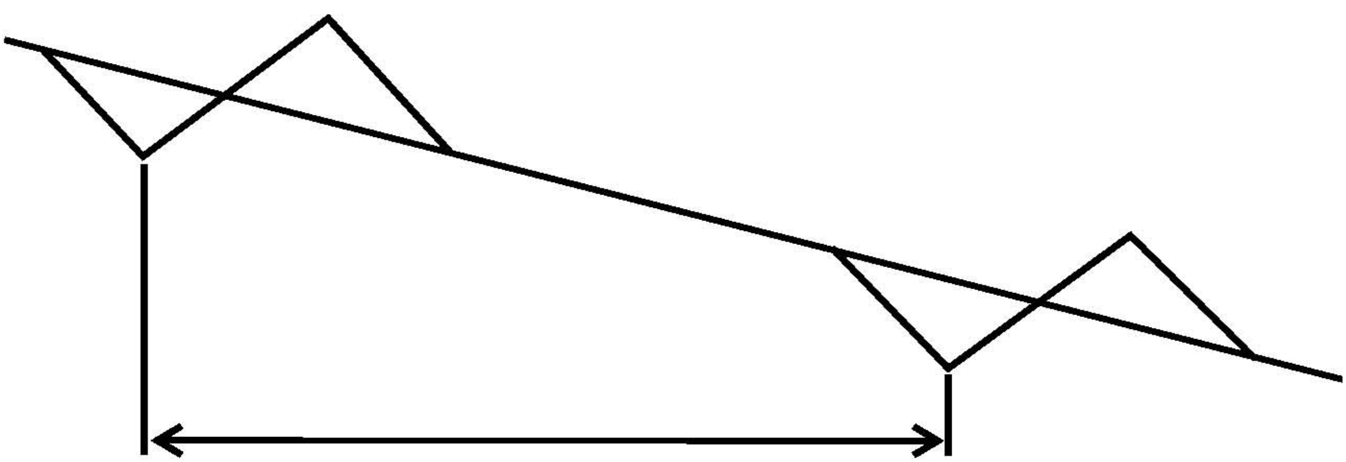

Figure 3 - Terrace spacing.

Table 600-1. Allowable Spacing for Terrace for Conditions						
	GOOD		AVERAGE		POOR	
Average Land Slope in Feet per 100 feet	X = 0.4 Vertical Interval Feet	Y = 4.0 Horizontal Interval Feet	X = 0.4 Vertical Interval Feet	Y = 2.5 Horizontal Interval Feet	X = 0.4 Vertical Interval Feet	Y=1.0 Horizontal Interval Feet
1 or less	4.4	440	2.9	290	1.4	140
2	4.8	240	3.3	175	1.8	90
3	5.2	173	3.7	123	2.2	73*
4	5.6	140	4.1	103	2.6	65*
5	6.0	120	4.5	90	3.0	60*
6	6.4	107	4.9	82*	3.4	57*
7	6.8	97	5.3	76*	3.8	54*
8	7.2	90	5.7	71*	4.2	53*

* Spacing does not have to be less than 90 feet.

Table 600-2. Terrace P factors [1/]

Horizontal Interval	Closed Outlets [2/]	Open outlets with percent grade of: [3/]		
(ft)		0.1 - 0.3	0.4 - 0.7	0.8
Less than 110	0.5	0.6	0.7	1.0
110-140	0.6	0.7	0.8	1.0
140-180	0.7	0.8	0.9	1.0
180-225	0.8	0.8	0.9	1.0
225-300	0.9	0.9	1.0	1.0
More than 300	1.0	1.0	1.0	1.0

NOTE: If contouring or stripcropping P factors are appropriate, they can be multiplied by the terrace P factor for the composite P factor.

1/ These figures are not appropriate for sediment yield estimates.

2/ "P" factors for closed outlet terraces also apply to terraces with underground outlets and to level terraces with open outlets.

3/ The channel grade is measured on the 300 ft. of terrace or the one-third of total terrace length closest to the outlet, whichever distance is less.

Table 600-3. Maximum horizontal spacing for terraces

	RUSLE “R Factor” of			With Contour Stripcropping	For Concentrated Flow Control
	0 - 35	35 - 175	>175		
Percent Slope	Ft	Ft	Ft	Ft	Ft
0-2	700	500	450	600	700
2-4	700	400	300	600	700
4-6	600	400	200	600	600
6-9	400	300	150	400	500
9-12	400	250	150	250	500
12-18	250	200	150	150	400
> 18	250	200	150	150	300
Minimum spacing required, all slopes	200	150	90	90	200