NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

TERRACE

CODE 600

(FT.)

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 and trap sediment

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

Spacing. Space terraces at intervals across the slope to achieve the intended purpose. The maximum spacing of terraces for erosion control is that necessary to achieve the soil loss tolerance (T) or other soil loss criteria that is documented in the Field Office Technical Guide. Include both the terrace system with planned as-built slopes and cultural practices such as residue management when determining soil loss. The slope length used when checking soil loss for a proposed terrace spacing is the distance from the terrace ridge to the next lower terrace channel measured along the natural flow direction. Maximum spacing for erosion control based on soil loss tolerance may be increased by as much as 10 percent to provide better location, alignment to accommodate farm machinery or to reach a satisfactory outlet.

The methods that may be used to determine terrace spacing include the current NRCS accepted erosion prediction technology, the Vertical Interval Equation or state-developed methods that address unique soil, cropping or other farming practices that affect terrace spacing. Refer to the current NRCS accepted erosion prediction software and user guide to determine soil loss. Refer to the Engineering Field Handbook, Chapter 8, Terraces for use of the Vertical Interval Equation.

Alignment. To accommodate farm machinery and farming operations, design cropland terraces with long gentle curves, where feasible. When multiple terraces are used in a field, design the terraces to be as parallel to one another as practicable.

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

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. For terraces that store runoff (storage or level terraces), increase the storage capacity by the estimated 10-year sediment accumulation, unless the Operation and Maintenance Plan specifically addresses the periodic removal of sediment.

For terraces with open outlets, base the terrace channel size on the capacity using the densest and longest vegetation. Base the capacity of the channel on a bare earth channel for cropped 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.

Terrace cross section. Proportion the terrace cross section to fit the land slope, the crops grown, and the farm machinery used. Avoid the use of terrace cross-sections that result in disturbance of all of the soil in the spacing between terraces. 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, the ridge must have a minimum width of 3 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 slopes no steeper than 5:1 in order to allow safe operation of farming equipment. 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.

Topsoiling. Salvage topsoil from the footprint of the construction area of the terrace to spread over the excavated slopes and terrace ridges to facilitate restoration of the field unless the excavated slope or ridge surface is of similar texture as the available topsoil.

Channel grade. 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.

For cultivated terraces, base the channel stability on a bare earth condition using a maximum Manning's n value of 0.035. For permanently vegetated channels, base the channel stability on the appropriate vegetation. Refer to Conservation Practice Standard 412, Grassed Waterway and Engineering Field Handbook, Part 650, Chapter 7 for design criteria and procedures to determine stability for both bare and vegetated conditions.

In the upper reaches of a channel, grades may be increased to improve alignment. For terraces with an underground outlet, channel grades can be steeper within the impoundment area.

Level terraces. 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. Level terraces can have either full or partial end closures or be open-end. If a partial end closure is used, areas downstream from the end closure must be protected from flow that will exit from the closure before the design storm is reached.

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. 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.

Outlets. All terraces must have adequate outlets. The outlet must convey runoff water to a point where it will not cause damage.

Vegetated outlets are suitable for gradient or open-end level terraces. Grassed waterways or naturally vegetated drainage ways may be used as a vegetated outlet. Install and stabilize grassed waterways prior to the construction of the terrace so that the terrace will have a stable outlet when it is constructed. The capacity of the vegetated outlet must be large enough so that the water surface in the outlet is at or below the water surface in the terrace at the design flow.

Underground outlets are suitable for use on all terrace types. The outlet consists of an intake and an underground conduit. If underground outlets are required, use Conservation Practice Standard, 620, Underground Outlet.

Underground outlets may be designed for either pressure or gravity flow. If a pressure system is designed, all pipes and joints must be adequate to withstand the design pressure, including surges and vacuum. For gravity flow systems, use a flow-restricting device such as an orifice or weir to limit flow into the conduit or choose conduit sizes that are large enough to prevent pressure flow.

Design the outlet so that the flow release time does not exceed the inundation tolerance of the planned crop. The release time shall not exceed 48 hours for the design storm. Shorter periods may be necessary for some crops, depending on soils characteristics and water tolerance of crops to be grown.

If sediment retention is a primary design goal, adjust the release rate according to sediment particle size. Locate the intake structure for the underground outlet to accommodate farming operations and to allow for sediment accumulation.

Soil infiltration may be used as the outlet for level terraces. Soil infiltration rates, under average rainfall conditions, must permit infiltration of the design storm from the terrace channel within the inundation tolerance of the planned crops.

Combinations of different outlet types may be used on the same terrace system to optimize water conservation, improve water quality, and to accommodate farming operations or to provide for economical installation.

Vegetation. Stabilize all areas planned for vegetation as soon as possible after construction. Refer to Conservation Practice Standard, 342, Critical Area Planting or state planting guide for seeding criteria and as needed, use the criteria in Conservation Practice Standard, 484, Mulching.

Additional Criteria Applicable to Retaining Runoff for Moisture Conservation

For terraces installed to conserve 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 in order to 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 layers in the soil profile that will limit plant growth. 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.

Conduits should be installed deep enough to prevent damage from tillage equipment. The inlet should consist of a vertical perforated pipe of a material suitable for the intended purpose. The inlet should be located 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 and subsequent raising of the terrace ridge. Blind inlets may be used where they are effective, usually in well-drained soils.

Field efficiency may be used to compare alternative terrace systems. Field efficiency is the ratio of time required to farm the field being planned, to that required to farm a rectangular field of the same acreage ½ mile long.

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. Install the drainage prior to terrace construction by using Conservation Practice Standard 606, Subsurface Drain. Drainage should be designed taking into consideration the effect of snowcatch and melt on water budget components.

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

Intakes 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.

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 must include:

- A plan view of the layout of the terrace system.
- Typical cross sections of the terrace(s).
- Profile(s) or planned grade of the terrace(s).
- Details of the outlet system
- If underground outlets are used, details of the inlet and profile(s) of the underground outlet.
- Seeding requirements if needed.
- Bill of materials needed for the construction.
- 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 to follow for the design life of the terrace system. The minimum requirements to be addressed in the written operation and maintenance plan are:

- Periodic inspections, especially immediately following significant runoff events.
- Prompt repair or replacement of damaged components.
- Maintenance of terrace ridge height, channel profile, terrace cross-sections and outlet elevations.
- Removal of sediment that has accumulated in the terrace channel to maintain capacity and grade.
- 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.
- Where vegetation is specified, complete seasonal mowing, control of trees and brush, reseeding and fertilizing as needed.
- 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 7, Grassed Waterways

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

Table 1. Maximum Horizontal Spacing for Terraces

Slope	RUSLE2 R factor of 0 - 35		RUSLE2 R factor of 35 - 175		RUSLE2 R factor of More than 175		With contour stripcropping		For concentrated flow control	
Percent	ft	m	ft	m	ft	m	ft	m	ft	m
0 - 2	700	210	500	150	450	130	600	180	700	210
2 - 4	700	210	400	120	300	90	600	180	700	210
4 - 6	600	180	400	120	200	60	600	180	600	180
6 - 9	400	120	300	90	150	45	400	120	500	150
9 - 16	400	120	250	75	150	45	250	75	500	150
12 - 18	250	75	200	60	150	45	150	45	400	120
More than 18	250	75	200	60	150	45	150	45	300	90
Minimum spacing required, all slopes	200	60	150	45	90	27	90	27	200	60

Table 2. Permissible Velocities for Non-vegetated Terrace Channels

Material on Channel Bottom and Sides			
Descriptive Term or Name	Soil Classification USDA	Soil Classification Unified	Permissible Velocity, fps
Fine Sand (noncolloidal)	s, fs,vfs, lvfs, vfsl	ML(PI≤5), SM(PI≤10) SP, SW, SP-SM	1.5 Easily Erodible
Sandy Loam (noncoloidal)	fsl, sl, ls, lfs, si	SM(PI≥10), ML(PI=5-10), ML-CL, SM-SC, SC(PI<10)	
Silt Loam (noncolloidal), Alluvial silts when noncolloidal	sil, scl, GR-s	ML(PI=10-15), CL(PI≤10), SC(PI=10-15), Coarse clean sand (D50>#10 sieve)	
Ordinary Firm Loam Fine Gravel	l, scl, GR	CL(PI=10-20), ML(PI>15), MH(PI<20), Clean gravels (D50>#4 sieve)	2.0 Average
Stiff Clay (very colloidal) Graded, loam to cobbles, when noncolloidal Alluvial Silts when colloidal	cl, sicl, c, sc, GR-1	CL(PI>20), CH, MH(PI>20), SC(PI>20), GC(PI<10), GM(PI>10)	2.5 Erosion Resistant
Graded, silt to cobbles, when colloidable Coarse Gravel (noncolloidal)	Coarse GR, GR-c	GC(PI>10), Clean gravel (D50>¾")	
Cobbles and Shingles	Cobbles & Flaggy	Cobbles	
Unweathered shales and hardpans			