NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

TERRACE

(ft, m)
CODE 600

DEFINITION

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

PURPOSE

This practice may be applied as part of a resource management system to support one or both of the following:

- Reduce soil erosion
- Retain runoff for moisture conservation

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- Soil erosion by water is a problem
- There is a need to conserve water
- The soils and topography are such that terraces can be constructed and farmed with reasonable effort
- A suitable outlet can be provided
- Excess runoff is a problem

CRITERIA

General Criteria Applicable To All Purposes

Terraces shall be planned, designed, and constructed to comply with all federal, state, and local laws and regulations.

Spacing. The maximum spacing for terraces for erosion control *as shown in Figure 1,* shall be determined by use of one of the following methods:

1. Land in pineapple, sugarcane or orchards

Maximum horizontal terrace spacing shall be determined by using Table 1, but does not have to be less than 200 feet. The flattest field slope above any terrace will be used to determine the horizontal spacing at that point. The horizontal spacing shall not exceed 500 feet for land slopes up to 12 percent, 400 feet for slopes from 13 to 18 percent and 300 feet for slopes exceeding 18 percent. Terraces spaced with Table 1 should also be evaluated if possible with the RUSLE to determine the effect of the terrace system in reducing soil loss. Additional practices which will reduce soil loss to accepted limits should be recommended to the land user.

2. Land in diversified agriculture

Maximum terrace spacing will be determined by the RUSLE but does not have to be less than 100 feet. The horizontal spacing shall not exceed 450 feet for land slope up to 2 percent, 300 feet for land slopes of 2 to 4 percent, 200 feet for slopes of 4 to 6 percent and 150 feet for slopes of 6 percent and over.

Terraces spaced with the RUSLE shall be determined using the allowable soil loss, the most intensive use planned, and the expected level of management. The

RUSLE "C" value may be adjusted to the expected level of management if the land user has made a firm decision or commitment to follow a planned conservation cropping system. The planned crop residue management, tillage operations, contouring, etc., shall be recorded in the cooperator's case file.

The following adjustments to spacing may be made on all terraces that are not limited by the maximum spacing for land slope. 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.

The spacing should be adjusted to provide for an even number of trips for anticipated row crop equipment and maximum opportunity for changing row widths. The likelihood of benching of steep slopes by tillage, land forming, and erosion should be considered when determining the terrace interval.

Terraces are not recommended on land slopes greater than 20 percent.

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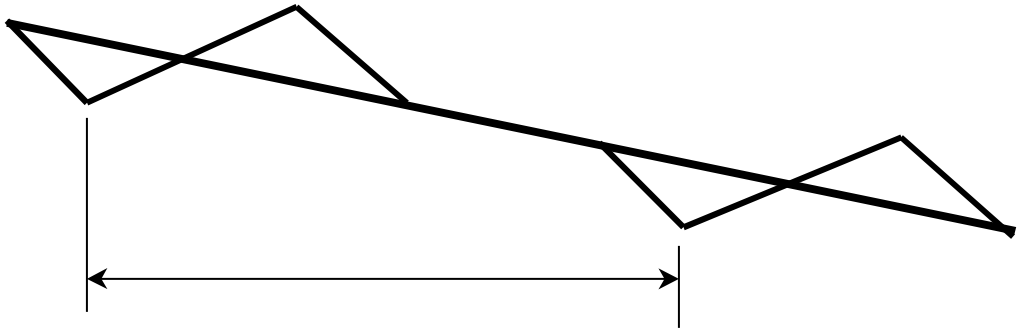

Figure *1*. Terrace Spacing

Alignment. Cropland terraces shall be parallel if feasible and as parallel as practicable. Curves shall be long and gentle to accommodate farm machinery.

Land forming, extra cut or fill along the terrace line, multiple outlets, variations in grade, channel blocks and other methods are to be used to achieve good alignment.

Capacity. The terrace shall have enough capacity to control the runoff from a 10-year frequency, 24-hour storm without overtopping. For terraces with underground outlets, the capacity shall be increased by the estimated 10-year sediment accumulation, unless sediment is removed through maintenance.

Terrace systems designed to provide flood protection or to function with other structures shall have the appropriate design capacity. When the capacity is determined by the formula Q = AV and the V is calculated using Manning's formula, a minimum n value of 0.0*6* shall be used for bare channels. *The National Engineering Handbook Series, Part 650, Engineering Field Handbook, Chapter 8, "Terrace Channel Design Aid" may be used.*

Agricultural Handbook Number 667, Stability Design of Grass-lined Open Channels, or equivalent shall be used for vegetated channels *with a "B" retardance factor.*

Cross section. The terrace cross section shall be proportioned to fit the land slope, the crops grown, and the farm machinery used. *An* additional height *of 10%* shall be added to provide for settlement, channel sediment deposits, ridge erosion, the effect of normal tillage operations, and safety.

The ridge shall have a minimum width of 3 ft. (1 m) at the design elevation. The steepest slope of a vegetated front or back ridge slope is 2 horizontal *to* 1 vertical.

Terrace ridges, especially those with steep back slopes, can be very hazardous. All cropped terrace slopes that are to be farmed shall be no steeper than those on which farm equipment can operated safely. Potential hazards must be brought to the attention of the responsible person.

The opening at the outlet end of gradient and open-end level terraces shall have a cross section equal to that specified for the terrace channel.

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

Level terraces with end closures shall have sufficient storage available to store 60 percent of the runoff from the design storm before overtopping. Level terrace installations should be limited to soils in hydrologic soil groups A, A-1, and B. Hydrologic soil groups can be found in The National Engineering Handbook Series, Part 650, Engineering Field Handbook, Chapter 2.

If terraces with closed or partly closed ends are specified, the end closures must be installed before the terraces are completed. The end closures shall be designed so that the water flows over the end closure before overtopping the terrace ridge.

Partial end closures shall not be more than half the effective height of the terrace ridge. Complete end closures are more than half the height of the ridge. The cross section of the closures may be less than the terrace cross section.

Channel grade*/velocity*. Channel grade shall be determined by one of the following methods:

1. Maximum channel velocities for permanently vegetated channels shall not exceed those used for grassed waterways.

2. Maximum channel velocity for cultivated channels shall be nonerosive for the soil and planned treatment.

The following table shall be used to determine maximum permissible for bare channel velocities.

Soil Erosion Resistance Group [1/]	*Maximum Velocity (fps)*
I	*5.5*
II	*4.5*
III	*3.5*
IV	*2.5*

1/ Soil erosion resistance groups for Hawaii soils may be found in The National Engineering Handbook Series, Part 650, Engineering Field Handbook, Chapter 2.

Velocities are to be computed by Manning's formula using an "n" value of 0.03*0*.

Channel grades should not exceed 3 percent even if maximum velocities are not exceeded. Channel grades may be

uniform or variable. For short distances and in upper reaches, channel grades or velocities may be increased to improve alignment.

If terraces have an underground outlet, water and sediment will pond in the lower reaches of the channel, thus reducing the velocity in those reaches and allowing steeper channel grades within the impoundment area. Minimum grades shall be such that ponding in the channel caused by minor irregularities will not cause serious damage to crops or delay field operations.

Terrace length. The volume of water stored in level terraces is proportional to the length. Therefore, it is necessary that the length be held within reason so that damage in case of a break is minimized. Level terrace length shall not exceed 3,500 ft. (1,000 m) unless the channel is blocked at intervals not exceeding 3,500 ft. (1,000 m).

Normally, the capacity and the non-erosive velocity requirements will control the gradient terrace length.

Outlets. All terraces must have adequate outlets.

1. Vegetated outlets may be used for gradient or open-end level terraces. Such an outlet may be a grassed waterway or other vegetated area. The outlet must convey runoff water to a point where the outflow will not cause damage.

Outlets shall be installed and vegetation established before the terrace is constructed. The water surface in the terrace shall not be lower than the water surface in the outlet at their junction when both are operating at design flow.

2. Underground outlets may be used on gradient or level terraces. The outlet consists of an intake and an underground conduit. An orifice plate, increase in conduit size, or other features shall be installed as needed to control the release rate and prevent excessive pressure in the conduit.

Terraces shall be designed to control a 10 year frequency, 24- hour storm without overtopping. The release time shall not exceed the inundation tolerance of the planned crops. If sediment retention is desired, adjust release rate according to particle size.

The underground conduit shall meet the requirements specified for Underground Outlets (620) or Subsurface Drains (606). Conduits must be installed deep enough to prevent damage from tillage equipment.

The inlet shall consist of a vertical perforated pipe or other structure suitable for the intended purpose. The inlet shall 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.

The outlet of the conduit shall have adequate capacity for the design flow without causing erosion. Blind inlets may be used where they are effective.

3. 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 standing water does not significantly damage crops. .

4. Stable earth outlets may be used in areas where soils have proven resistance to erosion in that type of application. Usually, these outlets will be limited to soils in erosion-resistant groups I and II.

5. A combination of soil infiltration and nonerosive outlet may be used for level terraces with partial end closures.

Combinations of different types of outlets may be used on the same system to

maximize water conservation, to affect water quality, and to provide for economical installation of a more farmable system.

Vegetation. *Steep backslope terraces (and steep frontslope, if used) shall be established to grass as soon as practicable after construction. Terraces constructed in fields with multiple year crops, such as pineapple, sugarcane and macadamia nuts, that provide canopy cover to the steep portion of the terrace, may not be practicable to establish to grass. The sod shall be maintained and trees and brush controlled by chemical or mechanical means.*

No trees shall be planted below the flow depth of gradient terraces.

Drainage. Install subsurface drainage to stabilize terrace where needed.

Additional Criteria Applicable To Retaining Runoff For Moisture Control

Terrace capacity shall be designed in accordance with a water budget analysis.

CONSIDERATIONS

Consider adjusting the spacing to allow an even number of trips with the equipment.

Consider aligning terraces and/or installing subsurface drainage to correct seepage problems.

PLANS AND SPECIFICATIONS

Plans *(design drawings*) and specifications for installing terraces shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Plans should include the:

1. location of each terrace in a field
2. land slopes
3. horizontal spacing;
4. terrace cross section (depth, bottom width, sideslopes),
5. length,
6. channel slope,
7. type of outlet.

If underground outlets are to be used, their plans may be incorporated into the terrace system plans.

OPERATION AND MAINTENANCE

The operation and maintenance guide for terrace shall be provided to and reviewed with the landowner.

TABLE 1
MAXIMUM TERRACE SYSTEM SPACING
(feet)

Hydrologic **Class A** Soils

RAINFALL 10-yr. 24-hr. (inches)	SOIL EROSION RESIST-ANCE GROUPS	FIELD SLOPE (ft./ft.)								
		0.04	0.06	0.08	0.10	0.12	0.14	0.16	0.18	0.20
7	I	500	500	500	500	500	400	400	400	300
	II	500	500	500	500	500	400	400	400	300
	III	500	500	500	470	420	380	350	340	300
	IV	430	350	300	270	260	230	200		
8	I	500	500	500	500	500	400	400	400	300
	II	500	500	S00	500	500	400	400	400	300
	III	500	500	460	400	350	320	290	280	260
	IV	370	290	250	220	210	200			
9	I	500	500	500	500	500	400	400	400	300
	II	500	500	500	500	480	400	390	380	300
	III	500	480	390	340	300	280	260	250	230
	IV	320	260	220	200					
10	I	500	500	500	500	500	400	400	400	300
	II	500	500	500	480	420	380	350	340	300
	III	500	420	350	300	270	240	220	220	200
	IV	280	220	200						
11	I	500	500	500	500	500	400	400	400	300
	II	500	500	500	430	380	340	310	300	280
	III	500	380	310	270	240	220	200		
	IV	250	200							
12	I	500	500	500	500	500	400	400	390	300
	II	500	500	460	390	340	310	280	280	250
	III	470	340	280	240	210	200			
	IV	230	200							
13	I	500	500	500	500	470	400	390	360	300
	II	500	500	420	360	320	280	260	250	230
	III	430	320	260	220	200				
	IV	210	200							
14	I	500	500	500	500	430	390	360	330	300
	II	500	490	390	330	290	260	240	230	220
	III	400	290	240	210	200				
	IV	200								
15	I	500	500	500	470	400	360	340	310	290
	II	500	450	360	310	270	240	220	220	200
	III	370	270	220	200					
	IV	200								
16	I	500	500	500	440	380	340	310	290	270
	II	500	430	340	290	260	230	210	200	
	III	350	260	210						
	IV	200								

TABLE 1
MAXIMUM TERRACE SYSTEM SPACING
(feet)

Hydrologic **Class B-C-D** Soils

RAINFALL 10-yr. 24-hr. (inches)	SOIL EROSION RESIST-ANCE GROUPS	Field Slope (ft./ft.)								
		0.04	0.06	0.08	0.10	0.12	0.14	0.16	0.18	0.20
7	I	500	500	500	500	500	400	400	400	300
	II	500	500	500	480	420	370	340	330	300
	III	500	420	340	300	260	240	220	210	200
	IV	270	220	200						
8	I	500	500	500	500	500	400	400	400	300
	II	500	500	490	420	370	330	300	290	270
	III	500	370	300	260	230	210	200		
	IV	240	200							
9	I	500	500	500	500	490	400	400	380	300
	II	500	500	440	380	330	300	270	260	250
	III	450	330	270	240	210	200			
	IV	220	200							
10	I	500	500	500	500	450	400	370	340	300
	II	500	500	400	340	300	270	250	240	220
	III	410	300	250	210	200				
	IV	200								
11	I	500	500	500	480	410	360	340	310	300
	II	500	460	370	310	280	250	230	220	210
	III	370	280	230	200					
	IV	200								
12	I	500	500	500	450	380	340	320	290	280
	II	500	430	340	290	260	230	210	210	200
	III	350	260	210	200					
	IV	200								
13	I	500	500	490	420	360	320	300	270	250
	II	500	400	320	270	240	210	200	200	
	III	320	240	200						
	IV	200								
14	I	500	500	460	400	340	300	280	250	240
	II	500	380	300	260	220	200	200		
	III	310	220	200						
	IV	200								
15	I	500	500	430	370	320	280	260	240	230
	II	490	360	290	240	210	200			
	III	290	210	200						
	IV	200								
16	I	500	500	410	360	300	270	250	230	220
	II	470	340	280	240	210	200			
	III	280	200							
	IV	200								