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 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

Spacing. Spacing for terraces as set forth in this standard is for the control of sheet and rill erosion. For treatment of ephemeral gully or other concentrated flow erosion, terraces must be individually designed using criteria in Oklahoma NRCS Diversion (362) standard.

The maximum spacing for terraces shall be determined by the following formula:

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

Where:

V.I. = vertical interval in feet

H.I. = horizontal interval in feet

(See figure 1 and 2)

x = 0.6 for areas of the state west of I-35;

0.5 for areas of the state east of I-35.

0.8 for level terraces that impound water

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. Values for y are given in Table 1.

Table 1. Values for "y"

	y Values	
CP_f*	T/K $\geq$ 15.2	T/K < 15.2
< 0.22	4.0	3.5
0.22 – 0.35	3.5	3.0
0.36 – 0.43	3.0	2.0
> 0.43	2.0	1.0

* CP_f is calculated from the RUSLE2 Net C factor (C) times P_f. P_f is the Net Contour factor (Pc) times the Net Ridge factor (Pr).

$$CP_f = C \times Pc \times Pr$$

Table 2. Maximum horizontal spacing for terraces

	RUSLE R Factor of			With Contour Stripcropping
	0 - 35	35 – 175	> 175	
Percent Slope	Ft	Ft	Ft	Ft
0 - 2	700	500	450	600
2.1 - 4	700	400	300	600
4.1 - 6	600	400	200	600
6.1 - 9	400	300	150	400
9.1 - 12	400	250	150	250
12.1 - 18	250	200	150	150
> 18	250	200	150	150

The average horizontal spacing does not have to be less than 100 feet.

In no case shall the maximum horizontal spacing exceed that shown in Table 2 for the condition shown. The maximum limits may not be exceeded when making adjustments indicated below.

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

The likelihood of benching of steep slopes by tillage, land forming, and erosion shall be considered when determining the terrace interval.

When estimating sheet and rill erosion for terraces spaced using the V.I. or H.I. spacing method, Figures 1 and 2 show the horizontal interval or erosion length to be used. Figure 3 represents actual terrace spacing.

Alignment. Cropland terraces shall be parallel if feasible and as parallel as practical. Curves shall be long and gentle to accommodate farm machinery. Terraces shall be aligned such that water is not diverted from one watershed to another.

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 = A * V and the V is calculated using Manning's formula, an n value of 0.06 shall be used for bare channels. For vegetated channels, Agricultural Handbook Number 667, Stability Design of Grass-lined Open Channels, or equivalent shall be used.

Cross section. Dimensions for field terraces are given in Table 3. The terrace cross section shall be proportioned to fit the land slope, the crops grown, and the farm machinery used. Additional height shall be added if necessary 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 4 feet at the design elevation. The front and back slopes of the terrace shall be approximately the same except when a grass back slope is used. The steepest slope of a vegetated front or back ridge slope is 2 horizontal: 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

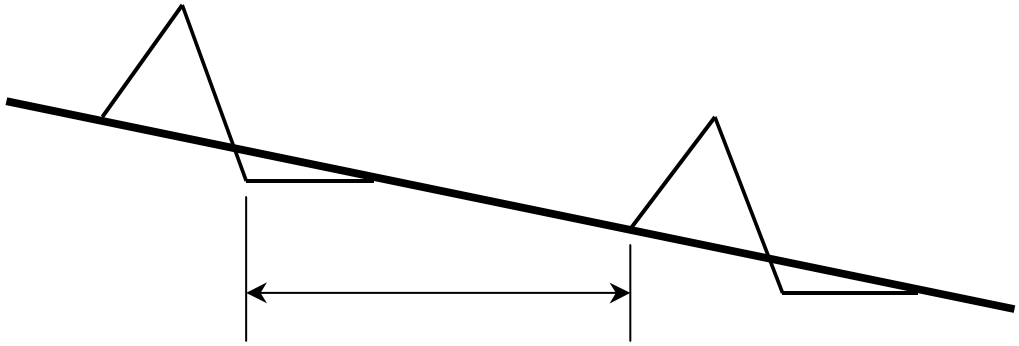

Figure 1. Erosion Length or Horizontal Interval for Steep Back-slope Terraces

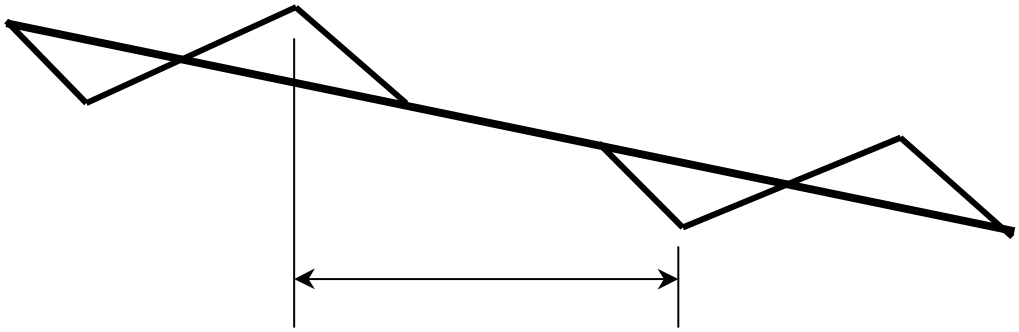

Figure 2. Erosion Length or Horizontal Interval for Broad-Based Terraces

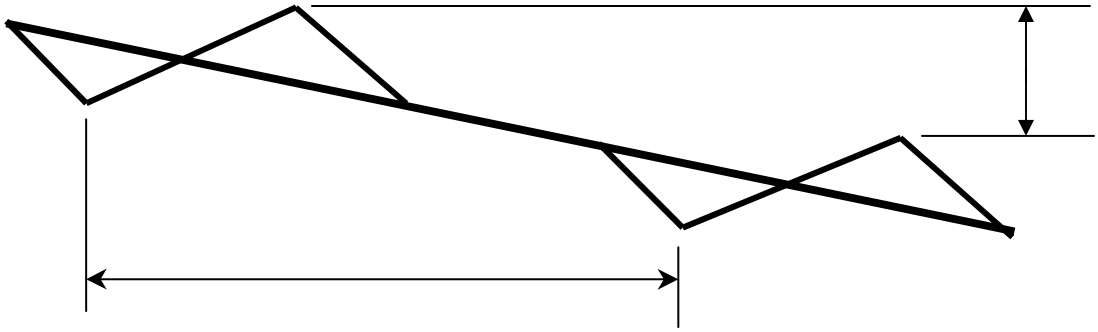

Figure 3. Terrace Spacing

Table 3 - Dimensions for Field Terraces

Percent Slope	Height above Channel Ft.	Channel Bottom Width Ft.	Cross Section Area of Channel $Ft.^2$	Width* Standard Ft.	Width* Broadbase Ft.
4% or less	1.2	8	20	22	30
4.1 to 8	1.4	8	20	20	28
8.1 to 10	1.0	4	10	20	28
10.1 to 12	1.0	4	10	20**	28

* Width is measured from the intersection of the toe and the channel on the front slope to the intersection of the toe and natural ground on the back slope.

** Use permanently vegetated grass back slope and top for terrace ridge. Back slope would be 3:1 or steeper.

Note: For terraces with $\leq$ 0.1' grade and for terraces with end closures, add 0.2 ft. to height above channel.

equipment can operate 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.

Freeboard. The Height above Channel values found in Table 3 include freeboard. No additional freeboard is needed except as noted in Table 3 for terraces with very flat or level grades and for terraces with end closures.

End closures. 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 uphill side of the end closure (away from the terrace ridge) 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 base width of the end closures and blocks shall be equal to that of the terrace.

Channel grade. When making an individual terrace design, 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. Maximum design velocities or channel grades are:

   2.5 ft/s or a channel grade of 0.5 percent for erosion-resistant soils;

   2.0 ft/s or a channel grade of 0.4 percent for average soils; and

   1.5 ft/s or a channel grade of 0.2 percent for easily erodible soils.

Velocity shall be computed by Manning's formula, using a maximum n value of 0.035.

Channel grades may be uniform or variable. For short distances and in upper reaches, channel grades or velocities may be increased to improve alignment. In no case shall the grade exceed the length and grade requirements listed in the Terrace Length section of this standard. 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. For gradient terraces, the capacity and the non-erosive velocity requirements will normally control length. Maximum length for gradient terraces shall be governed by the following:

2500 feet for terrace grades of $\leq$ 0.1%,

3000 feet for grades > 0.1% and $\leq$ 0.3%,

2000 feet for terrace grades of 0.4%

1000 feet for terrace grades of 0.5%

If lengths longer than those specified above are needed for a gradient terrace, an individual design is required.

Outlets. All terraces must have adequate outlets.

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 to provide a stable outlet.

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.

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 48 hours for the design storm. Shorter periods may be necessary for some crops depending on soil characteristics and water tolerance of crops being grown. If sediment retention is desired, adjust release rate according to particle size.

The underground conduit shall meet the requirements specified in Oklahoma NRCS Underground Outlet (620) or Subsurface Drain (606) standards. 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.

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.

Upper terraces in a system, especially level terraces or those with complete or partial end closures, shall not discharge into lower terraces unless the lower terrace is designed to handle the additional water.

Vegetation. All areas to be vegetated shall be established as soon as practicable after construction.

Additional Criteria Applicable To Retaining Runoff For Moisture Control

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

Additional Criteria Applicable to Level Terraces

Level terraces are applicable only on land slopes of 8% or less.

Spacing. For level terraces used for erosion control and water conservation, the spacing shall be determined as previously described, but in no case shall the maximum horizontal spacing exceed 600 ft. The average horizontal spacing does not have to be less than 100

feet; however, if spacing formulas indicate a terrace spacing less than 100 feet and a 100 foot spacing is used, the capacity shall be checked. The height shall be set at either that specified in Table 3 or that needed for capacity for an individually designed terrace, whichever is greater. An x value of 0.8 may be used for all level terraces used primarily to impound water.

Capacity. The capacity of a level terrace shall be increased by the estimated 10-year sediment accumulation.

Terrace Length. Level terrace length shall not exceed 3,500 ft. unless the channel is blocked at intervals not exceeding 3,500 ft.

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.

Outlets. 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.

Additional Criteria Applicable To Individual Terrace Designs

When terraces are spaced with an individual terrace design, sheet and rill erosion rates shall be analyzed. If sheet and rill erosion are not a concern, Oklahoma NRCS Diversion (362) standard shall be used.

Additional Criteria Applicable To Evaluating Existing Terraces

Existing terraces may need to be evaluated for two reasons: 1) Adding new terraces below the existing terraces, and/or 2) Justifying the need to rebuild.

Adding Terraces Below Existing Terraces. When adding new terraces below existing terraces, a visual inspection is needed to assure that the terraces are functioning properly and do not have any ridge breaks or channel blocks. At least one cross section shall be taken at a point that appears to be the weakest in the terrace system. This cross section must meet the criteria outlined in Table 4 in order to construct new terraces below the existing ones.

Table 4. Existing Terrace Evaluation

Ht. Above Channel (Ft)	Channel Cross Sectional Area (Ft^2)
0.7	20
0.8	18
0.9	17
1.0	16

An alternative evaluation would be to show by individual terrace design that the existing terraces meet the channel capacity and grade requirements of this standard.

Justifying the Need to Rebuild Terraces. Terrace reconstruction is warranted only if the terraces meet current spacing and channel grade criteria and have a stable outlet. Terraces meeting any of the following should be considered for rebuilding:

Terrace has numerous breaches,
Ht. Above Channel is < 0.7 feet,
Channel capacity is < 50% of design.

Each terrace in a system must be evaluated. Terraces not meeting the above criteria are considered adequate and would not need to be rebuilt.

Existing terraces shall not be removed prior to rebuilding. Rebuilt terraces shall meet all criteria for a new terrace.

Isolated low points in the terrace profile should be repaired through normal operation and maintenance.

Additional Criteria Applicable To Removing Old Terraces

Old terraces shall be removed if new terraces will not function properly due to the existence of the old terraces, if the old terraces will cause

erosion or ponding in the field, or if the old terraces will concentrate flows into portions of the new terrace system. In addition, terraces that exceed current spacing limits or current channel grade criteria, or terraces that lack a stable outlet shall be removed. The entire old terrace system shall be removed prior to or in conjunction with the installation of the new terrace system. Removal shall be in accordance with this standard.

Old terraces replaced with cropland diversions shall be removed if any of the above criteria applies. Criteria for this type of removal is found in the Oklahoma NRCS Obstruction Removal (500) standard.

Cropland that is being converted to grass should have existing terraces removed. Criteria for this type of removal is found in the Oklahoma NRCS Obstruction Removal (500) standard. If the existing terraces are broken and causing active erosion, removal is required.

Proper planning procedures shall be utilized when removing old terraces in non-cropland areas to minimize erosion problems prior to establishment of vegetation. This may include staggered removals or vegetating between terraces prior to removal.

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 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.

OPERATION AND MAINTENANCE

A written operation and maintenance plan shall be prepared for the operator.

The minimum requirements to be addressed in the operation and maintenance plan are:

1. Provide periodic inspections, especially immediately following runoff events.

2. Promptly repair or replace damaged components as necessary.

3. Maintain terrace ridge height and outlet elevations.

4. Remove sediment that has accumulated in the terrace to maintain capacity, a positive channel grade, and to maintain capacity where soil infiltration serves as the outlet.

5. Each inlet for underground outlets must be kept clean and sediment buildup redistributed so that the inlet is in the lowest place. Inlets damaged or cut off by farm machinery must be replaced or repaired immediately.

6. Vegetation, where specified, shall be maintained and trees and brush controlled by chemical or mechanical means.

7. Keep machinery away from steep back sloped terraces. Keep equipment operators informed of all potential hazards.

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NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE GENERAL SPECIFICATIONS

TERRACE

(FT.)

CODE 600

CONSTRUCTION SPECIFICATIONS

All dead furrows, ditches, or gullies shall be filled before constructing the terrace or shall be part of the construction. All old terraces, fence rows, hedge rows, trees, and other obstructions shall be removed, as necessary, to install a farmable system. The banks of gullies and ditches to be crossed shall be sloped to a minimum of 1.5:1 before the fill is made.

The terraces shall be constructed to planned alignment, grade, and cross section with the specified overfill for settlement and for graded terraces, the channel graded to drain reasonably well.

Any ditch or depression at the bottom of the back slope shall be filled and smoothed so that drainage will be away from the terrace and not parallel to it.

The entire cross section of the channel and ridge shall be uniform, full bodied, and smooth to the extent that farming operations may be accomplished with regular farm equipment.

The slopes on excavated areas shall be approximately equal to the ridge slopes. The openings at the outlet end of the terrace shall have a cross section at least equal to that specified for the terrace channel. End closures, where specified, shall be made before the terrace is considered complete.

The channel grade shall be constructed to such uniformity that unnecessary water impoundment will not be caused by blocks in the channel. Channel blocks or “highs” of 0.2 feet will be allowed in erosion resistant and average soils, 0.3 feet in easily eroded soils, where such tolerance does not affect the minimum height requirements. For level terraces, variations in grade shall be undulating so that the average grade will approach zero.

Where terraces are to be constructed across field ditches and gullies, channel lows will be permitted at these locations when the original ditch or gully is deeper than the normal cut to construct the terrace. Such lows will, therefore, not be used when checking terrace channel grade. The terrace ridge height shall be maintained across these lows in order to meet minimum height requirements. Additional compaction by machinery routing or other suitable means may be required to insure proper function of the terrace.

Acceptable average grades for terraces are those within $\pm$ 0.10 feet per 100 feet of design grade as long as there is positive grade. This average grade shall be figured for the terrace length excluding 100 feet on each end. A tolerance of $\pm$ 0.20 feet per 100 feet may be allowed for not more than 300 feet consecutive length even though the average grade is within the specified tolerance of the design grade. A

constructed grade of 0.6 feet is allowed on the last 100 feet of the spill end.

Provisions shall be made to prevent piping if conduits for underground outlets are located under terrace ridges. The conduit shall be placed deep enough to prevent damage by machinery for both present and future conditions. In no case shall the conduit have less than 2 feet of cover.

If necessary, top soil shall be stockpiled and spread over excavations and other areas to facilitate restoration of productivity.

If vegetation is required, seedbed preparation, fertilizing, seeding, and mulching shall comply with specifications in technical guides.

When terraces are removed and replaced with a new or improved terrace system, the land shall be graded such that there is no impoundment of water from the old terraces and that the land slope is not greater than twice the slope of the surrounding ground or greater than a 10:1 slope, whichever is less.