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:

- To reduce erosion by reducing slope length.
- To 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 soil loss tolerance (T). 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.

The maximum spacing for terraces for erosion control shall be determined by 1 of the 2 equations below. Maximum spacing for erosion control based on T may be increased by as much as 10 percent to provide better location or alignment, to accommodate farm machinery, or to reach a satisfactory outlet. The horizontal interval (H.I.) as determined by either method, after any adjustments, should not exceed that shown in Table 1. The drainage area above the top terrace of a system shall not exceed the area that would be drained by a terrace of equal length with normal spacing.

Table 1. Maximum horizontal interval

Land Slope (percent)	Maximum H.I. (feet)	With Contour Stripcropping (feet)
0-2	450	600
2-4	300	600
4-6	200	600
6-9	150	400
9-12	150	250
12-18	150	150
> 18	150	150

- 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 = 0.6 for gradient and level terraces used for erosion control in Kansas
  - x = 0.8 for level terraces used primarily for water conservation
  - s = Land slope in percent
  - y = A variable with values from 1 to 4

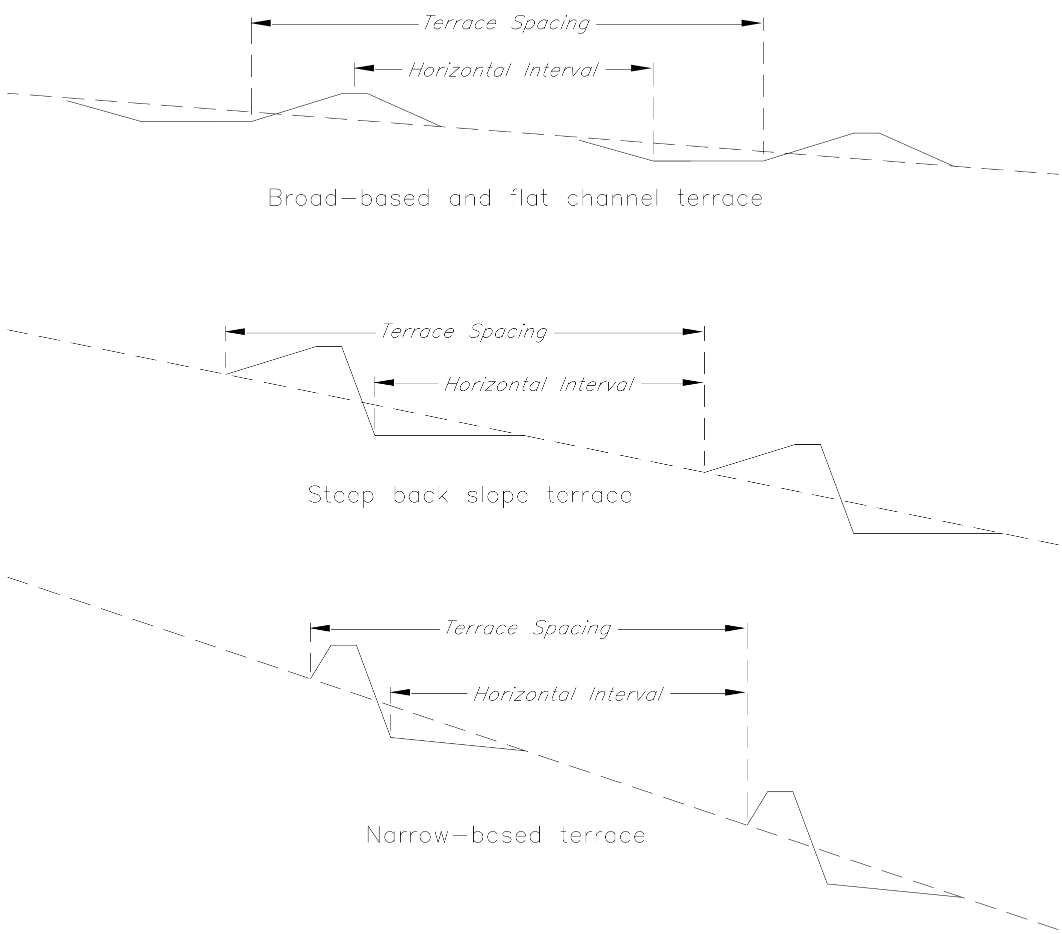
  Values of y are influenced by soil erodibility, cropping system, and crop management practices. A value of 1 shall be selected for erodible soils with tillage systems that provide little or no cover during periods of intense rainfall. A value of 4 shall be used for erosion-resistant soils with tillage systems that leave a large amount of cover (1.5 tons of straw equivalent per acre) on the surface. A value of 2.5 shall be used if 1 of the factors indicated is favorable and the other is unfavorable. Other values between 1 and 4 may be used according to the estimated quality of the factors. The terrace spacing need not be less than 90 feet.

  Figure 1 defines the horizontal interval or erosion length to be used in calculating terrace spacing.

- Revised Universal Soil Loss Equation (RUSLE2)– The horizontal interval shall not exceed the critical slope length as determined using RUSLE2 software. Refer to the Kansas Supplement to Chapter 8 in the National Engineering Handbook Part 650 (NEH 650), *Engineering Field Handbook*, for the support practice factor (P) for terraces. Soil loss in the inter-terrace interval must not exceed the allowable soil loss.

  The likelihood of benching of steep slopes by tillage, land forming, and erosion shall be considered when determining the terrace interval. For example, use the proposed as-built slope and length in RUSLE2 calculations.

Figure 1. Terrace spacing terms by terrace type



Alignment. To accommodate farm machinery and farming operations, design cropland terraces with long, gentle curves. 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 discharge through the underground outlet. Increase the capacity of storage terraces by the estimated 10-year sediment accumulation unless the operation and maintenance (O&M) plan specifically addresses the annual removal of sediment. The Terrace (Storage) Spreadsheet (or equivalent) may be used.

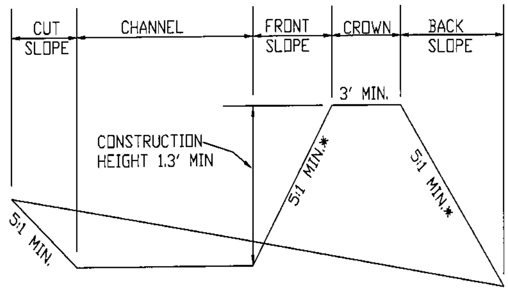
For terraces with open outlets, the capacity is based on the terrace channel size and stability. Base the capacity of the channel on a bare earth channel for crop fields or, in the case of a permanently vegetated channel, the appropriate vegetation. For bare earth channels, use a Manning's equation roughness coefficient "*n*" value of 0.06 to calculate capacity. The Terrace (Gradient) Spreadsheet (or equivalent) may be used. For permanently vegetated channels, refer to Conservation Practice Standard (CPS) 412, Grassed Waterway, for design criteria to determine capacity.

Design level terraces to contain the runoff from a 10-year, 24-hour rainfall event and the expected 10-year sediment accumulation unless the O&M plan specifically addresses the annual removal of sediment. Quantify sediment accumulation using RUSLE2 or the Kansas Supplement to Chapter 8 in NEH 650. The Terrace (Level) Spreadsheet (or equivalent) may be used.

Terrace cross section. Proportion the terrace cross section to fit the land slope, the crops grown, and the farm machinery used. The ridge shall have a minimum crown width of 3 feet. The minimum design height shall be 1 foot. The construction height shall be the design height plus a minimum 0.3 foot for settlement, channel sediment deposits, ridge erosion, the effect of normal tillage operations, or safety. For terraces with open outlets, design the capacity of the outlet to be equal to or greater than the capacity of the terrace channel.

All farmable terrace slopes shall be no steeper than 5 horizontal to 1 vertical (5:1). For non-farmable terrace slopes (back slopes of steep back slope terraces and ridge slopes of narrow-based terraces), the steepest slopes allowable are 2:1 unless an analysis of site-specific soil conditions indicates that steeper slopes will be stable.

Figure 2. Minimum terrace cross section



*Steep back slope and narrow-based terraces may be 2:1.

The terrace type shall be selected from the following cross sections based on the land slope. Broad-based terraces may be used on land with a slope of up to 10 percent. Narrow-based terraces (2:1 front and back slope, both slopes grassed) may be used on land with a slope of up to 12 percent. Terraces built with borrow from the uphill side tends to increase the land slope between terraces on the steeper land, and less earthfill is required in the terrace ridge because part of the capacity is in the excavation.

Grass-back terraces (or steep back slope terraces) and narrow-based terraces (with the majority of the borrow taken from the downhill side) may be used on land with a slope of up to 20 percent. Where borrow is taken from the downhill side, the land is more farmable because the land slope between terraces is reduced. Borrow from both sides reduces the terrace ridge height and the yardage (as compared to terraces built entirely from the lower side).

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.

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. The maximum velocity for erosion-resistant soils (clay textural classification) is 2.5 feet/second (ft/s); for average soils (silt textural classification), 2.0 ft/s; and for easily erodible soils (sand textural classification), 1.5 ft/s. If Manning's equation is used to compute velocity, use a maximum "*n*" value of 0.035 to determine velocity for channel stability.

For permanently vegetated channels, base the channel stability on the appropriate vegetation. Refer to CPS 412, Grassed Waterway, for design criteria to determine stability.

Channel grade may be either uniform or variable. The overall terrace grade shall not exceed 0.4 percent unless the alignment is significantly improved. In order to improve alignment and reach a more suitable terrace design, grades may be varied by sections of terrace. A maximum average grade of 0.9 percent is acceptable for the first 300 feet of terrace nearest the upper end or divide, 0.7 percent from 300 to 600 feet, 0.5 percent from 600 to 900 feet, and 0.4 percent from 900 feet to the outlet (except that a 0.8-foot fall is permitted in the last 100 feet and may be excluded in determining the average terrace grade).

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

To avoid excessive channel wetness, terraces constructed on Hydrologic Group D soils shall have 0.1 percent minimum grade for areas of average annual rainfall of 35 inches or less and 0.2 percent minimum grade for areas of more than 35 inches average annual rainfall.

Terrace length. The volume of water stored in level terraces is proportional to the length. To reduce the potential risk from failure, level terrace length shall not exceed 3,500 feet unless the channel is blocked (complete end closure) at intervals not exceeding 3,500 feet.

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

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 drainageways may be used as vegetated outlets. 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 below the water surface in the terrace at the design flow.

Underground outlets are suitable on gradient or level terraces. The outlet consists of an intake and an underground conduit. Refer to CPS 620, Underground Outlet, for design criteria for the underground outlet.

Design the intake structure for the underground outlet to control the flow out of the terrace and to prevent excessive pressure in the underground conduit. Design the outlet so that the flow release time does not exceed the inundation tolerance of the planned crops and, in no case, is greater than 60 hours. If sediment retention is a primary design goal, adjust the release rate according to sediment particle size. Locate the inlet 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. Generally, only soils of the 0.5 intake family or greater should be used as outlets; however, 0.3 intake soils may be used where experience in the area indicates acceptability. Channels of 0.3 intake shall be deep-ripped a minimum of 6 inches.

Terrace outlet structures may be used on gradient or level terraces. The terrace outlet structure shall meet the requirements of CPS 410, Grade Stabilization, and the requirements shown in the Grade Stabilization Structure (Concrete Terrace Outlet Structure) spreadsheet. Terrace outlet structures shall have adequate capacity for the design flow from the terrace and any upstream drainage or terrace outlets. The outlet shall be designed such that there is adequate tailwater to prevent erosion below the structure. The grade between structures shall be adequate to avoid excessive channel wetness and to ensure that no erosion occurs between structures. The maximum allowable grade between terrace outlet structures is 0.3 percent.

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

Vegetation. Establish grass on steep back slope and narrow-based terraces as soon as possible after construction. Refer to CPS 342, Critical Area Planting, for seeding criteria.

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

Terrace restoration. Terraces are considered to be nonfunctional when any of the following exists:

- The existing terrace system has horizontal intervals that are wider than allowed by current criteria and has soil loss in excess of the allowable T.
- The existing cross-sectional storage area for level or storage-type terraces is less than 50 percent of the storage area at the constructed design height that would comply with this standard.
- The existing cross-sectional flow area for gradient terraces has the capacity to carry less than 50 percent of the design discharge without overtopping or a minimum of 0.5 foot of height.

Supporting data is to be prepared that clearly shows the system is or is not functional in accordance with the above criteria. Restored terraces shall be designed in accordance with this standard.

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 in such a way that the operator can make an even number of trips between terraces so that the operator ends up on the same side of the field on which he or she started.

Adjustments to spacing, alignment, and cross section are often necessary to maintain farmability—particularly where large farm equipment is used. Such adjustments require considering the spacing above and below a particular terrace, including space between the terrace and field boundary; avoiding tight curves; and flattening terrace slopes to as much as 8:1 or 10:1.

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 or burn 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. Refer to CPS 606 for guidance on preventing adverse impacts to delineated wetlands.

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. Consider a plunge pool, riprap armor, a pipe support, and an exit channel to reduce erosion at the outlet.

Outlets from terraces can 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.

Inlets for underground outlets can be easily damaged during cultivating, planting, and harvesting operations. Using brightly colored inlets, adding 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 of 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 shall include the following:

- 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) and any additional cuts or fills.
- 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.
- Site-specific construction specifications that describe in writing the installation of the terrace system.

OPERATION AND MAINTENANCE

Prepare an O&M plan for the operator. The minimum requirements to be addressed in a written O&M plan are the following:

- Periodic inspections, especially immediately following significant runoff events.
- Prompt repair of damaged components such as breaks, overtopped areas, and eroded sections.
- 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, seasonal mowing and control of trees and brush.
- 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.