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

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

Utilities and Permits. The landowner and/or contractor shall be responsible for locating all buried utilities in the project area, including drainage tile and other structural measures.

The landowner shall obtain all necessary permissions from regulatory agencies, including the Illinois Department of Agriculture, US Army Corps of Engineers, US Environmental Protection Agency, Illinois Environmental Protection Agency and Illinois Department of Natural Resources – Office of Water Resources, or document that no permits are required.

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 erosion control shall be determined by either method 1 or method 2, as shown below. 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. In no case shall the maximum horizontal spacing exceed that shown in Table 1 for the condition shown.

Method 1. 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 Figures 2 and 3)

x = a variable with values from 0.4 to 0.8

s = land slope in percent

y = a variable with values from 1.0 to 4.0

Values of x for different geographical zones are shown in Figure 1. Values of y are influenced by soil erodibility, cropping system and crop management practices. A value of 1.0 shall be selected for erodible soils (as defined in NEH 650, Engineering Field Handbook, Chapter 4) with tillage systems that provide little or no cover during periods of intense rainfall. A value of 4.0 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 or 50% residue cover) on the surface. A value of 2.5 shall be used if one of the factors indicated is favorable and the other unfavorable. Other values between 1.0 and 4.0 may be used according to the estimated quality of the factors. The horizontal interval does not have to be less than 90 feet. Refer to the Engineering Field Handbook, Chapter 8, Terraces, for more information on the Vertical Interval Equation.

Method 2. Revised Universal Soil Loss Equation Version 2 (RUSLE2). To determine the maximum interval for terraces using the RUSLE2 method, use the proposed as-built slopes and cultural practices (including residue management) in the RUSLE2 model to determine a slope length that will achieve the allowable soil loss tolerance (T) in the inter-terrace interval.

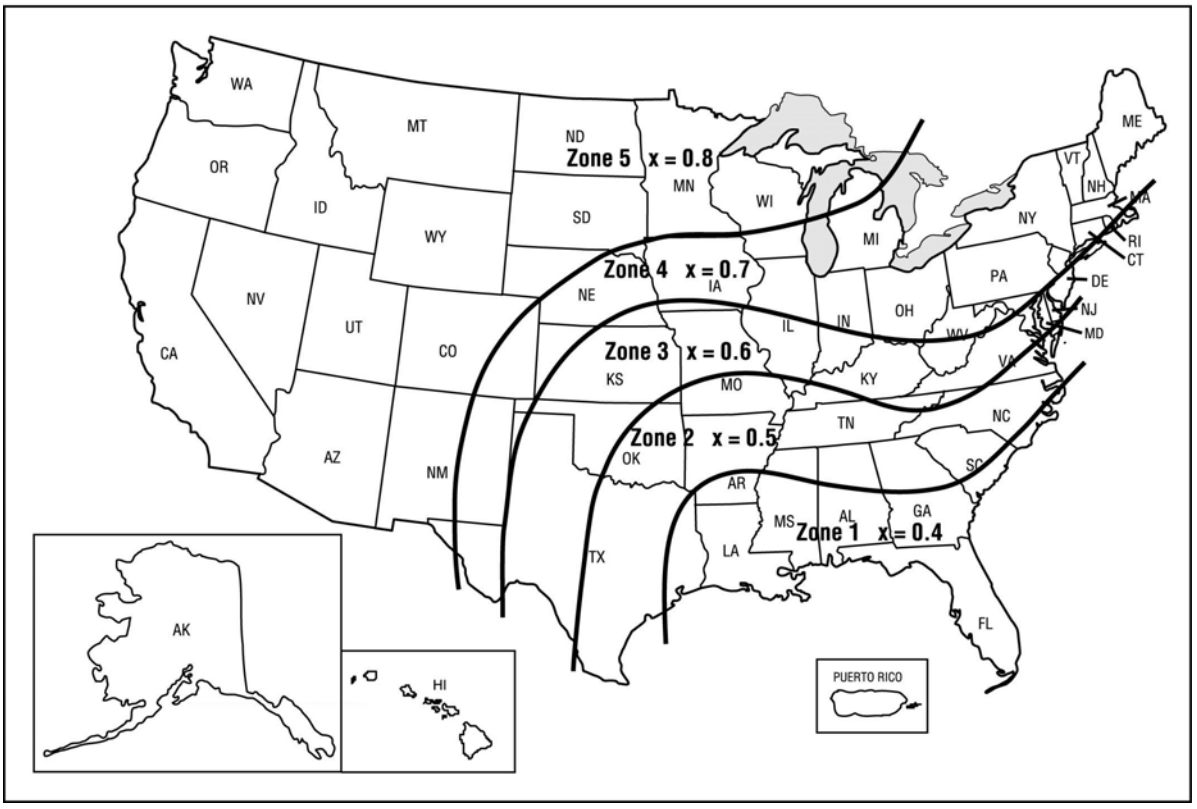

Figure 1. Values of x in equation V.I. = xs + y or H.I. = (xs + y) (100/s)

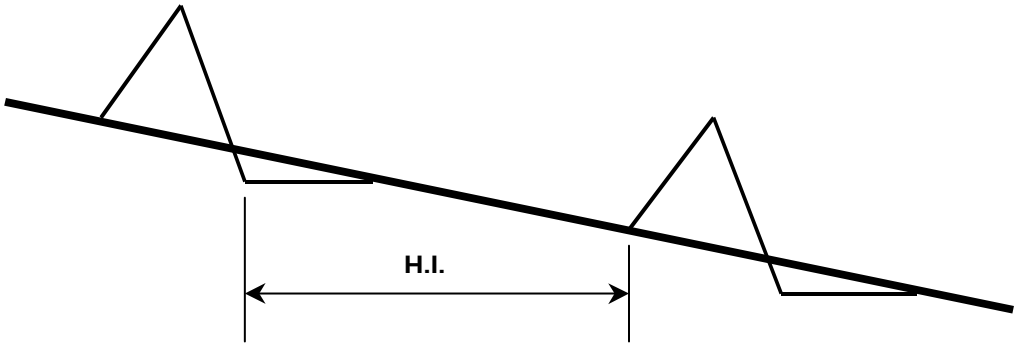

Figure 2. Horizontal Interval for Steep Backslope Terraces

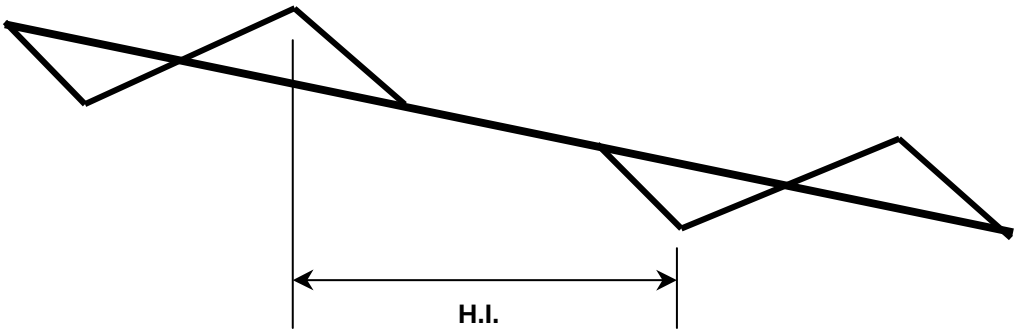

Figure 3. Horizontal Interval for Broadbased Terraces

Percent Slope	Ft
0-4	700
4-6	600
6-12	400
12-18	250
> 18	250

Table 1. Maximum Horizontal Interval for Terraces

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 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 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. Increase the capacity of terraces 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.

Design level terraces to contain runoff from a 10-year 24-hour rainfall event, and the expected 10-year sediment accumulation, unless the Operation and Maintenance Plan specifically addresses annual removal of sediment.

Terrace cross section. Proportion the terrace cross section to fit the land slope, crops grown, and 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, the ridge shall have a minimum width of 3 feet. 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 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. 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 that of 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 storage elevation 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 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 Conservation Practice Standard 412, Grassed Waterway for design criteria to determine stability.

For short distances 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 for short distances 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.

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.

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 construction of the terrace so that the terrace will have a stable outlet when 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 Conservation Practice Standard (620), Underground Outlet for design criteria.

Design the intake structure for the underground outlet to control flow out of the terrace and to prevent excessive pressure in the 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. Orifice plates may be omitted if a pressure flow outlet system is designed. Conduits must be installed deep enough to prevent damage from tillage equipment. Design the underground outlet so that the flow release time does not exceed the inundation tolerance of the planned crops or 48 hours, whichever is less. If sediment retention is a primary design goal, adjust the release rate according to sediment particle size.

The inlet to the underground outlet shall consist of a vertical, perforated pipe or other structure suitable for the intended purpose. The perforated riser shall have adequate capacity to prevent the riser from becoming the restricting factor in the underground outlet system. Locate the inlet for the underground outlet uphill of the front slope 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 planned crops.

Combinations of different outlet types may be used on the same terrace system to optimize water conservation, improve water quality, 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 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 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 used. 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, ensure 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 remains 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, stripping and stockpiling of topsoil from the construction area prior to excavation and then spreading 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:

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 requirements for 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 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 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, Chapters 4, 7, 8.

USDA – Agricultural Research Service, Agriculture Handbook 667, Stability Design of Grass-Lined Open Channels.

NATURAL RESOURCES CONSERVATION SERVICE

CONSTRUCTION SPECIFICATION

TERRACE

SCOPE

Work shall consist of constructing the terrace channels and ridges, and excavating, filling and shaping as required by the construction plans.

LOCATION

The location of the terrace shall be as shown on the construction plans or as staked in the field.

SITE PREPARATION

All dead furrows, ditches, and gullies shall be filled prior to, or as a part of, construction. Old terraces, fencerows, brush, and tall standing vegetation shall be removed from the area occupied by the terrace ridge and the area from which the earthen construction material will be taken.

MATERIAL

Earthfill material shall be free from frozen particles, roots, sod, brush, and other objectionable materials that might endanger the performance of the terrace. The fill material shall have no rock particles larger than 3 inches in diameter.

Moisture content of the earthfill material shall be sufficient to permit satisfactory compaction. Moisture content can generally be considered as satisfactory if fill material can be molded into a round ball between the hands without readily separating or squeezing out free water.

For broadbase terrace ridges, required fill material shall come from the terrace channel unless otherwise specified. For grassed back and narrow base terrace ridges, fill material shall come from the downhill side of the terrace ridge, except for cuts that are required to construct the channel to the specified grade and cross section.

PLACEMENT OF EARTHFILL

All ridges shall be constructed to the planned alignment, grade, and cross section shown on the plans, with the specified overfill for settlement and 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. All fill cross sections shall conform to that specified for all stations. The ridge portion of the terrace shall be compacted by routing hauling and spreading equipment over the fill in such a manner that the entire surface of the completed ridge will be traversed by not less than one tread/track of equipment. The terrace channels, side slopes, ridges, cut areas, and fill areas shall be finished to a smoothness so the surface can be readily traveled upon by farm-type equipment.

When topsoil salvaging is specified, areas to receive topsoil shall be brought to within 4 inches of final grade, or as specified on the construction plans. Topsoil shall be evenly placed and spread over specified area to bring it to final grade.

OUTLETS

Underground tile outlets are to be installed at locations shown on the drawings or as staked in the field. Provisions must be made to prevent piping if underground conduits are located under terrace ridges. Methods that can be used include mechanical compaction, water packing, trench sidewall sloping, and installation and backfill of conduit trenches early enough to allow adequate settlement are. Refer to Construction Specification (620), Underground Outlet, for detailed installation requirements.

Terrace outlet structures are to be installed at locations shown on the drawings or as staked in the field. Refer to Construction Specification (410), Grade Stabilization Structures, for detailed installation requirements.

Where terraces outlet into established grassed waterways or vegetated areas, care shall be taken during construction to minimize disturbance of existing vegetation. The transition from the terrace channel to the center of the waterway shall be free of abrupt changes in grade.

VEGETATION

A protective cover of vegetation shall be established on steep back slope and narrow-based terraces when specified in the design plans. Refer to Construction Specification (342), Critical Area Planting, for detailed seeding requirements.

UTILITIES

The landowner and/or contractor shall be responsible for locating all buried utilities in the project area, including drainage tile and other structural measures.

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ILLINOIS OPERATION AND MAINTENANCE

TERRACE

Follow the operation and maintenance plan below to keep your terrace system functioning as intended:

- Inspect terrace system periodically, especially immediately following runoff events, to identify maintenance needs.
- Promptly repair or replace damaged components, as necessary.
- Maintain design terrace ridge height and outlet elevations, including filling any settling of underground outlet tile trenches or filling any damage caused by burrowing animals.
- Remove sediment that has accumulated in the terrace to maintain storage capacity and a positive channel grade.
- Inlets for underground outlets must be kept clean and clear of trash. Sediment buildup shall be redistributed so that the inlet remains the lowest elevation in the storage area.
- Inlets for underground outlets damaged or cut off by farm machinery must be replaced or repaired immediately.
- Where vegetation is specified, a vigorous stand shall be maintained and trees and brush controlled by chemical or mechanical means.
- Keep machinery away from steep side sloped terraces. Keep equipment operators informed of all potential hazards.

Additional Details:

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NRCS, Illinois

September 2010