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
- The predominate land slope is 18% or less
- The soil survey land capability class is IV or less
- A suitable outlet can be provided

CRITERIA

General Criteria Applicable to All Purposes

Terraces must generally fit the contour of the land. Deviations from the contour must be limited and allowed only when necessary to obtain good alignment.

Types of Terraces. Terraces come in many configurations and designs. Choose the type of terrace based on the client's conservation objectives, cultural practices, field topography, soils, etc. The following is a brief description of the types of terraces available and the typical functional settings in which they are applied.

Gradient terraces can be either parallel or nonparallel. They may be constructed of any cross section type defined within this standard and use either a vegetated or an underground outlet to discharge runoff.

Level terraces can be either parallel or nonparallel. They may be constructed of any cross section type defined within this standard and use either the infiltration capacity of the soil or an underground outlet to discharge runoff. Level terraces work best on deep soils with high infiltration rates.

Basin terraces are a specialized case of a closed end level terrace. They are constructed on non-cropland areas and have a contributing drainage area consisting of permanent grass and/or timber.

Spacing.

Space terraces at intervals across the slope to achieve the intended purpose.

Spacing for a single line terrace system and/or top terrace shall be determined as the average distance from the terrace channel to the top of the slope. Spacing for subsequent terraces is measured from channel to channel as shown in Figure 1. Terrace spacing includes the width of front slope, back slope, and farmable interval in between. Factors affecting spacing are rainfall intensity, the type of terrace cross section, land slope and the tillage and management practices used.

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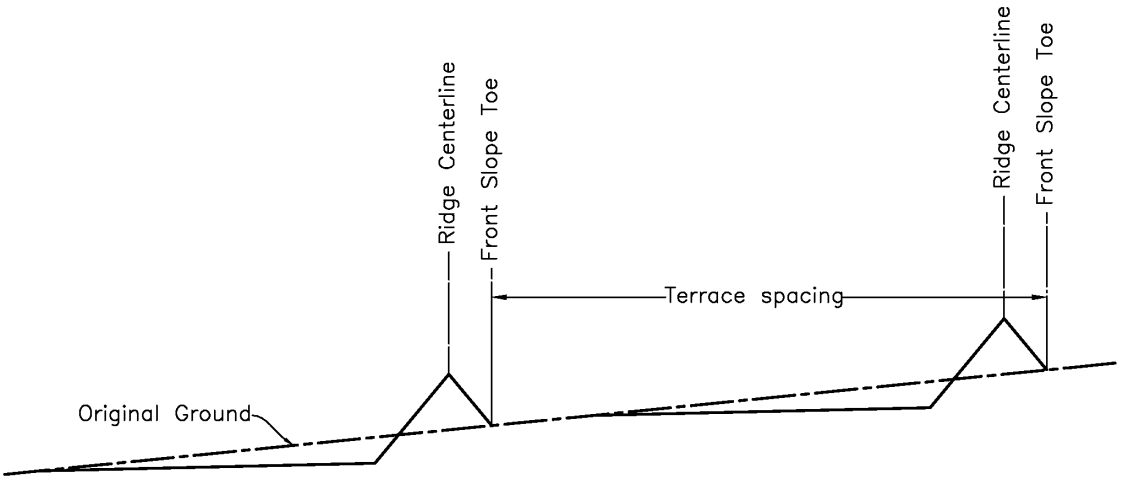

Figure 1.Spacing between terraces

The methods that may be used to determine terrace spacing include:

1. the Revised Universal Soil Loss Equation, Version 2 (RUSLE2).
2. current spacing table(s) published as an Iowa amendment to the Engineering Field Handbook, Chapter 8, Terraces.
3. the Vertical Interval Equation. Refer to the Engineering Field Handbook, Chapter 8, Terraces, for use of the Vertical Interval Equation.

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 measured along the natural flow direction and is the distance from the terrace ridge to the next lower terrace channel.

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.

For terraces on non-cropland, the maximum spacing shall be governed by the capacity requirement.

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. Use land forming, extra cut or fill along the terrace line, multiple outlets, variations in grade, channel blocks, and other methods to achieve good alignment. Use correction areas where needed to achieve a better contour row pattern.

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. Regardless of flood routing results, the minimum storage capacity must not fall below 60 percent of the total

runoff plus the estimated sediment accumulation.

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

Except as noted for Ida and Monona soils in the **Channel grade** section of this standard, storage for runoff must be provided over a sufficient length of the terrace to prevent ponding unless an underground outlet is used.

Terrace cross section. Proportion the terrace cross section to fit the land slope, the crops grown, and the 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 ft.

Settlement allowance for narrow base terraces shall be a minimum 10 percent and a minimum of 5 percent for other terrace types.

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 gradient terraces, non-storage sections of level terraces, and terraces with underground outlets with a minimum design height of 1 foot as measured from the bottom of the channel to the top of the terrace ridge.

Design all farmable terrace slopes to be no steeper than those on which farm equipment can be operated safely. Construct all cut slopes and farmable slope in increments of machinery widths but not shorter than 15 feet or steeper than 5:1. The increment of machinery width is defined in this standard as the full width of machinery not capable of conforming to the breaks in slope.

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.

Specific Additional Criteria Applicable to the Cross Section of a Broad Base Terrace

Do not install broad base terraces on land that is steeper than 6 percent slope.

Where excavation for the terrace ridge is taken on the uphill side, the final cut slope shall not exceed 8 percent. All portions of the broad base terrace may be farmed. Refer to Figure 2 for additional guidance.

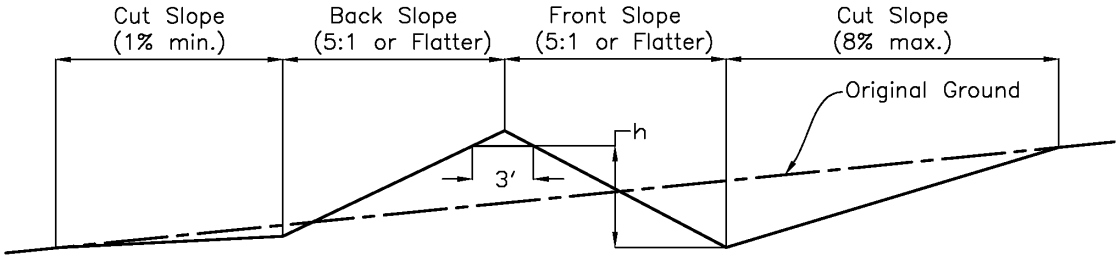

Figure 2. Broad-base terrace cross section.

Specific Additional Criteria Applicable to the Cross Section of a Grass Front – Farmable Back Slope Terrace

Do not install grassed front, farmable back slope terraces on land that is steeper than 6 percent slope.

Borrow excavation for this type of terrace may be taken from either uphill or downhill sides of the terrace. Where borrow is obtained from the uphill side, the final cut slope shall not exceed 8 percent.

The front slope shall be seeded to grass. The front slope shall not be steeper than 2:1.

Refer to Figure 3 for additional guidance.

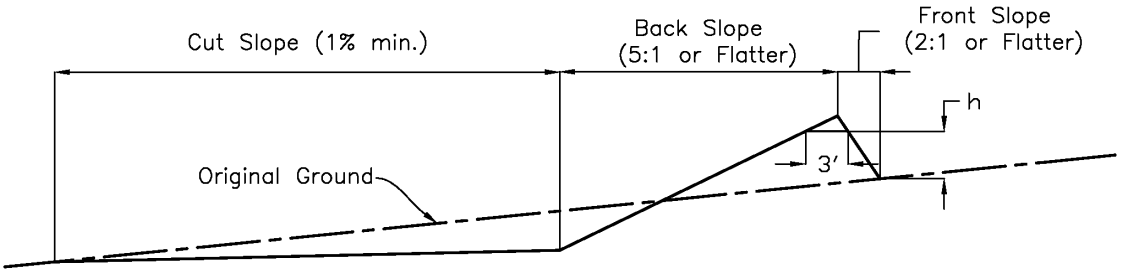

Figure 3. Grassed Front, Farmable Back Slope (GFFB) terrace cross section.

Specific Additional Criteria Applicable to the Cross Section of a Grassed Back Farmable Front Slope Terrace

Borrow for the grassed back slope cross section shall be taken from the downhill side except where excavation from other areas is needed to enhance alignment or farmability.

The back slope shall be seeded to grass. The back slope shall not be steeper than 2:1, except on the Ida and Monona soil series, which may have a back slope constructed no steeper than 1½ horizontal to 1 vertical.

Refer to Figure 4 for additional guidance.

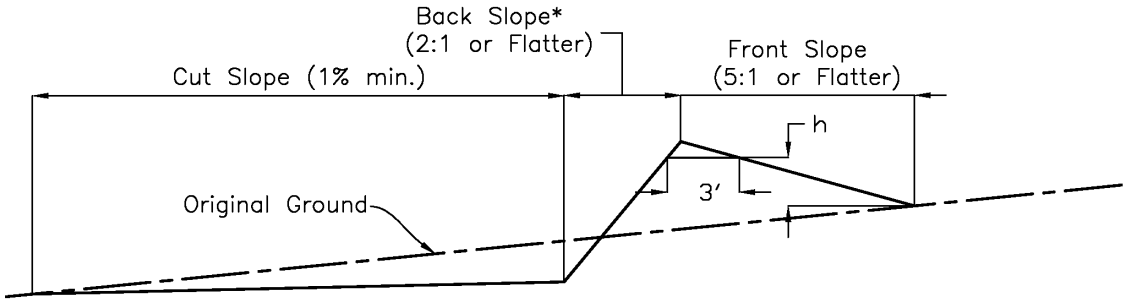

Figure 4. Grass Back Slope, Farmable Front terrace cross-section. *See text for variance for Ida and Monona soils.

Specific Additional Criteria Applicable to the Cross Section of a Narrow Base Terrace

The front and back slope of a narrow based terrace shall be seeded to grass. Excavation for this type of terrace shall be taken from the downhill side except where borrow from other areas is needed to enhance alignment or farmability.

Neither the front slope nor the back slope shall be steeper than 2:1.

Refer to Figure 5 for additional guidance.

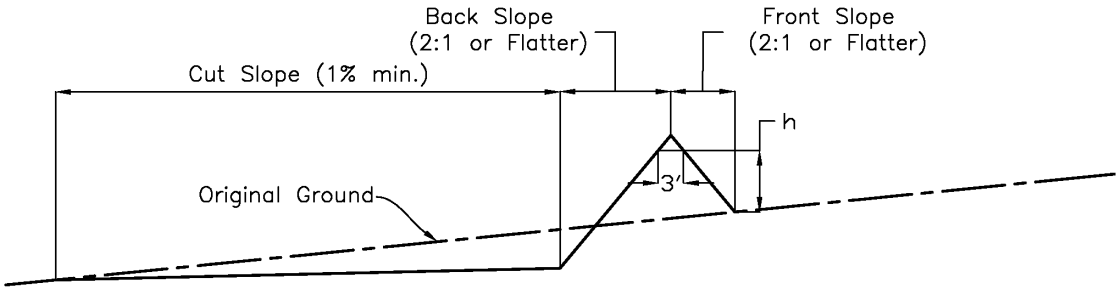

Figure 5. Narrow Base terrace cross section.

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.

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.

Design end closures that will be crossed with farm equipment with a minimum 6 foot top width and side slopes 5:1 or flatter. Design end closures that will not be crossed with farm equipment with a minimum 3 foot top width and sides slopes 2:1 or flatter.

Design end closures so that overtopping occurs over the end closure before overtopping the terrace ridge. 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. Where upper terraces with partial end closures discharge into lower terraces, design the lower terrace to handle the additional water without overtopping.

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. 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 both bare and vegetated channels.

For distances less than 100 feet in the upper reaches of a channel, grades may be increased up to 3% above the stable grade to improve alignment.

For terraces with an underground outlet, channel grades can be steeper for short distances within the impoundment area. Limit the steep channel grade to 8% and less than 70% of the storage depth.

Construct the channel and ridge of level terraces, including basin terraces, to be level over the entire length of the terrace, except that the channels on Ida or Monona soils need not be leveled if the temporary ponding is acceptable to the landowner.

For short reaches near the end of the terrace, graded channels may be used if adequate storage is provided in the storage sections. Do not exceed channel grades specified for gradient terraces.

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 2,000 feet unless the channel is blocked at intervals not exceeding 2,000 feet.

Blocks may also be used to separate adjacent level terrace reaches with different elevations. Construct blocks for this purpose to the full design height of the terrace with side slopes 5:1 or flatter to easily accommodate farm machinery.

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 below the water surface in the terrace at the design flow.

Do not outlet terraces on the right-of-way of a public road or highway or other public utility without approval of proper authorities.

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 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. All inlets shall be fabricated so that an orifice can easily be installed.

Offset the inlet from the main conduit with at least 8 feet of non-perforated conduit between the inlet and the main conduit. The topmost inlet may be placed directly on the main conduit when non-perforated conduit is installed from the inlet to the toe of the terrace back slope.

Design the outlet so that the flow release time does not exceed the inundation tolerance of the planned crops. 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 a 48 hour period or shorter if necessary for the health of the growing 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 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 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 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 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, provided these areas do not meet wetland criteria.

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 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, the stripping and stockpiling of topsoil from the construction area prior to excavation and then spreading 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:

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) or planned grade of the underground outlet.
6. Seeding requirements if needed.
7. Site specific construction specifications that describe in writing the installation of the terrace system.

Use Iowa NRCS standard drawings where appropriate.

The following list of Construction Specifications is intended as a guide to selecting the appropriate specifications for a specific project. The list includes most, but may not contain all, of the specifications needed:

IA-5 Pollution Control
IA-6 Seeding and Mulching for Protective Cover
IA-600 Terraces
IA-620 Underground Outlets

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 that has 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 that 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. 2011. National Engineering Handbook, Part 650 (Engineering Field Handbook) Chapter 8.