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
- Suitable outlet can be provided
- Excess runoff is a problem

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.

Terraces shall not be installed on land where the predominant land grades are 18 percent or greater or on land with a Soil Survey capability classification higher than IV.

Types of Terraces. Terraces come in many configurations and designs. The type of terrace you choose to apply will depend upon your 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 are 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 water collected.

Level terraces are 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 water collected. 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. Spacing for a single line terrace system and/or top terrace shall be determined as the average distance from the terrace ridge 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 farmed area in between. Factors affecting spacing are the type of terrace cross section, slope and tillage and management practices used.

Terrace spacing shall be determined by using the Revised Universal Soil Loss Equation Version 2 (RUSLE2).

The spacing may be equal to or less than the maximum slope length that will keep soil loss within allowable limits as determined by the RUSLE2 with planned levels of management. Slope length used in the RUSLE2 will be the horizontal interval shown in Figures 2 and 3.

Spacings determined using the RUSLE2 shall not exceed those given in Table 1. The column for spacings with resource management systems shall be used only when the soil loss within the terrace interval is reduced to the tolerable soil loss (“T”).

The column for spacings without resource management systems (soil criteria) shall be used if the terraces and associated installed practices do not bring the soil loss within the terrace interval down to tolerable soil loss ("T").

Spacing 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.

FIGURE 1. TERRACE SPACING

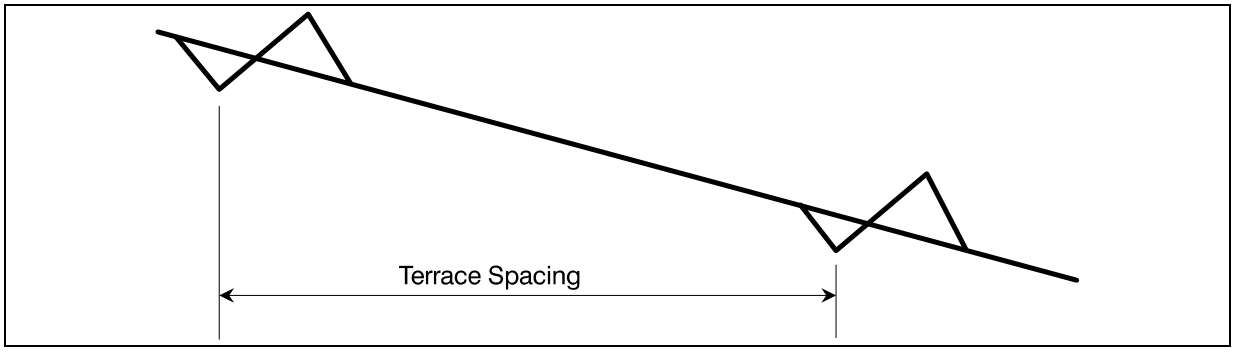


FIGURE 2. HORIZONTAL INTERVAL (HI) FOR STEEP BACK SLOPE TERRACE

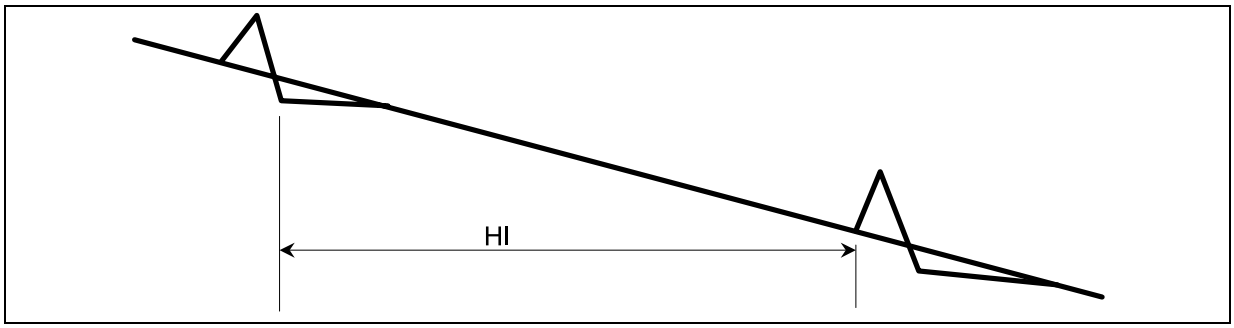


FIGURE 3. HORIZONTAL INTERVAL (HI) FOR BROAD BASE TERRACE & GRASSED FRONT FARMABLE BACK TERRACE

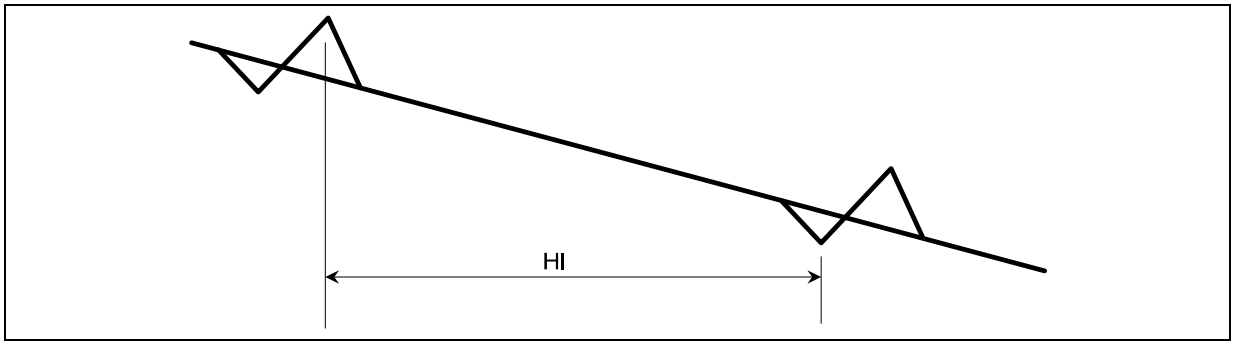


TABLE 1. MAXIMUM TERRACE SPACING (FEET)

Field Grade %	Without a Resource Management Systems (Soil Criteria)	With a Resource Management Systems (Soil Criteria)
0 – 1.5	300	400
1.6 – 3.5	240	350
3.6 – 5.5	180	300
5.6 – 8.5	150	250
8.6 – 12.5	120	200
12.6 – 18	105	150

Alignment. Terraces shall be as parallel as practicable. Curves should 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 shall be used to achieve good alignment. Correction areas will be used where needed to achieve a better contour row pattern.

Capacity. The terrace shall have enough capacity to control the runoff from a 10-year frequency, 24-hour rainfall without overtopping. For level terraces and terraces with underground outlets, the capacity shall be increased by the estimated 10-year sediment accumulation, unless provisions are made to maintain the design capacity through maintenance.

Terraces installed with underground outlets may have a reduced storage capacity as indicated by flood routing results. Regardless of flood routing results the minimum terrace storage capacity must never fall below 60 percent of the total runoff plus sediment accumulation.

Terrace systems designed to provide flood protection or to function with other structures shall have adequate capacity to control the runoff of a frequency consistent with the potential hazard. 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. Vegetated channels shall be designed according to Grassed Waterway (412).

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

Cross Section. The terrace cross section shall be proportioned to fit the land slope, the crops grown, and the farm machinery used. The minimum front and back slopes for terraces are type specific; however no terrace slope shall be steeper than 2:1, except for grassed back farmable front slope terraces built on Ida and Monona soil series may be installed with a back slope no steeper than 1½ horizontal to 1 vertical. All cut slopes shall be in increments of machinery widths but not shorter than 15 feet or steeper than 5:1. The ridge shall have a minimum width of 3 feet at the design elevation.

Additional height shall be added, if necessary, to provide for settlement, channel sediment deposits, ridge erosion, or the effect of normal tillage operations.

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

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.

Terrace cross sections shall comply with the minimum dimensions shown for broad base terraces (Figure 4), grassed front – farmable back slope terrace (Figure 5), grassed back slope terraces (Figure 6), or narrow base terraces (Figure 7). The increment of machinery width noted on these figures is considered as the full width of machinery not capable of conforming to the breaks in slope.

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

Broad base terraces shall not be installed on land that is steeper than 6 percent grade.

Excavation for the terrace ridge is generally taken on the uphill side. All portions of the broad base terrace may be farmed. The length of the cut slope, front slope, and back slope shall be in increments of machinery width but not shorter than 15 feet or steeper than 5:1. Refer to Figure 4 for additional guidance.

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

Grassed front – farmable back slope terraces shall not be installed on land that is steeper than 6 percent grade. The front slope of a grass front 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. The front slope shall not be steeper than 2:1. The back slope shall be in increments of machinery width but not shorter than 15 feet or steeper than 5:1. Refer to Figure 5 for additional guidance.

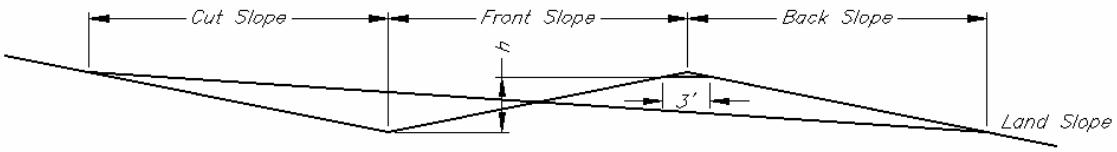
Specific Additional Criteria Applicable to the Cross Section of a Grassed Back Slope Terrace

Excavation for the grassed back slope cross section shall be taken from the downhill side except where borrow 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 types, which may have a back slope constructed no steeper than 1½ horizontal to 1 vertical. The front slope shall be in increments of machinery width but not shorter than 15 feet or steeper than 5:1. Refer to Figure 6 for additional guidance.

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 7 for additional guidance.

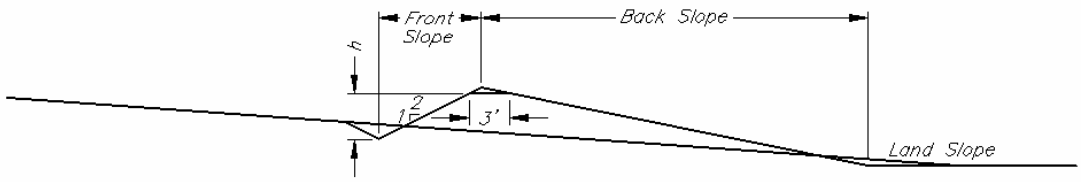
FIGURE 4. MINIMUM DIMENSIONS FOR BROAD BASED



Length of cut slope, front slope and back slope shall be in increments of machinery width but not shorter than 15 feet or steeper than 5:1

h=Design height of terrace

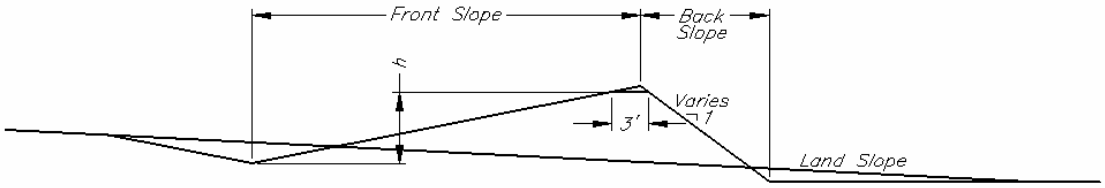
FIGURE 5. MINIMUM DIMENSIONS FOR GRASSED FRONT FARMABLE BACK



Length of back slope shall be in increments of machinery width but not shorter than 15 feet or steeper than 5:1

h=Design height of terrace

FIGURE 6. MINIMUM DIMENSIONS FOR GRASS BACK SLOPE

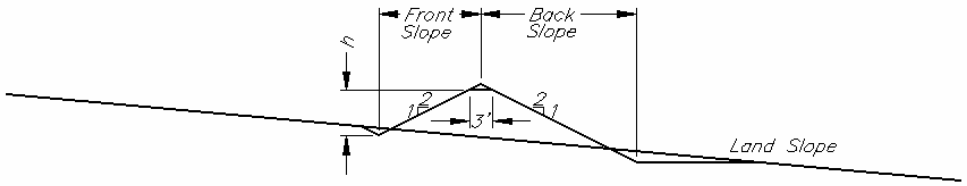


Length of front slope shall be in increments of machinery width but not shorter than 15 feet or steeper than 5:1

The back slope shall be no steeper than 2:1 except when built on Ida and Monona soil series types which may have the back slope constructed no steeper than 1.5:1

h=Design height of terrace

FIGURE 7. MINIMUM DIMENSIONS FOR NARROW BASE TERRACE



h=Design height of terrace

End Closures. Complete end closures are common on level terraces and are required on basin terraces. End closures should be constructed to the terrace design height. If a partial end closure is designed lower than the design terrace height, a stable outlet shall be provided. Upper terraces in a system with partial end closures shall not discharge into lower terraces unless the lower terrace is designed to handle the additional water.

End closures shall be designed so that overtopping occurs over the end closure before overtopping the terrace ridge. Storage terraces with underground outlets shall be constructed so that overtopping, if it occurs, will take place at the ends of the storage section where ridge height is a minimum. This also applies to level and basin terraces where due to topography or layout considerations, an outlet is not possible at an end closure.

Channel Grade. Channel grade shall be determined by one of the following two methods:

1. Maximum channel velocity for farmed channels shall be non-erosive for the soil and planned treatment. Maximum velocity for erosion-resistant soils is 2.5 fps; for average soils, 2.0 fps; and for easily erodible soils, 1.5 fps. Velocity shall be computed by Manning's formula using an "n" value of 0.025.
2. Maximum channel velocities for vegetated channels shall not exceed those used for grassed waterways.

Channel grades may be uniform or variable.

Channel velocity shall not be erosive for the soil and planned treatment. For short distances and in upper reaches, channel grades or velocities may be increased to improve alignment. The maximum channel grade shall not exceed the values published in NEH, Part 650, Chapter 8, Pages IA8-103(45 – 46). If terraces have an underground outlet, water and sediment will pond in the channel, thus reducing the velocity and allowing steeper channel grades near the outlet. Minimum grades shall be such that ponding in the channel because of minor irregularities will not cause serious damage to crops or delay field operations.

Level terraces shall have level channel grades and ridge tops, except that channels of terraces 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. Channel grades shall not exceed those specified for gradient terraces.

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

If an underground outlet is used, steeper grades may be permitted near the outlet below the elevation attained by the design storage volume.

The channel and ridge of a closed end level terrace (a.k.a. basin terraces) constructed on non-cropland areas, where the contributing watershed is in permanent cover of grass and/or timber shall be constructed 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.

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 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. Blocks for this purpose shall be built to the full design height of the terrace with side slopes flat enough to easily accommodate farm machinery. Normally, the gradient terrace length is controlled by the capacity and the non-erosive velocity requirements.

Outlets. All terraces must have adequate outlets. The outlet shall extend to the closest satisfactory surface or underground outlet with no reduction of the required design discharge.

A vertical outlet (i.e.: relief well) may be used downstream of the bottom terrace to discharge water to the ground surface to alleviate capacity and/or cover limitations. The vertical outlet shall meet the criteria found within Underground Outlet (620).

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 48 hour period or shorter if necessary for the health of the growing crops.

Vegetated outlets may be used for gradient or partial open-end level terraces. Such an outlet may be a grassed waterway or a vegetated area. The outlet must convey runoff water to a point where the outflow will not cause damage. Outlets shall be existing, or installed and vegetated before the terrace is constructed, if necessary, to provide a stable non-erodible outlet or to insure establishment of vegetative cover. 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.

Terraces shall not outlet on the right-of-way of a public road or highway or other public utility without approval of proper authorities. State drainage or water laws shall be adhered to in the diversion and disposal of drainage water.

Underground outlets may be used on gradient or level terraces. The outlet consists of an inlet and an underground conduit. An orifice plate, reduction in size of offset line or other features, shall be installed as needed to control the release rate and prevent pressure pipe flow. The discharge, when combined with the storage, shall be such that runoff from a 10-year frequency, 24-hour rainfall will not overtop the terrace and growing crops will not be damaged significantly by standing water.

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 to be grown.

The underground conduit shall meet the requirements specified for Underground Outlet (620) or for Subsurface Drain (606). The inlet shall consist of a vertical perforated pipe of a material suitable for the intended purpose. If the front slope is farmed, the inlet shall be located an adequate distance uphill from the front slope to permit passage of farm machinery.

The inlet shall be offset from the main conduit. Only the top inlet in the terrace system can be placed directly on the main conduit. At least 8 feet of non-perforated conduit shall be installed as the offset between the inlet and the main conduit.

If the topmost inlet is placed directly on the main conduit, the conduit shall be non-perforated from the inlet to the toe of the terrace back slope.

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

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 and to provide for economical installation of a more farmable system.

Vegetation. All areas to be vegetated shall be established to grass as soon as practicable after construction. Seeding shall be done in accordance with Critical Area Planting (342). Sod shall be maintained and trees and brush controlled by chemical or mechanical means.

CONSIDERATIONS

Apply additional cultural and resource management practices along with the terrace system to reduce soil loss and promote soil health.

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.

Terrace Plan (Iowa Standard Drawing No. 652), or equivalent, shall be utilized for the construction and installation of this practice. Additional construction specifications may be added as needed to address particular installation issues.

OPERATION AND MAINTENANCE

An operation and maintenance (O&M) plan shall be prepared for the terrace system. Specified actions include normal repetitive activities in the application and use of the practice (operation) and repair and upkeep of the practice (maintenance). The following activities shall be addressed in the plan:

- Establish a program for maintaining terrace capacity, storage, ridge height, and outlets

- 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
- Repair or replace any damaged surface inlets
- Remove trash from around and inside the surface inlet
- Control weeds, brush, and trees by mechanical methods or chemicals
- Re-seed and fertilize as needed to maintain good vegetation

REFERENCES

USDA-NRCS, National Engineering Handbook (NEH), Part 650, Engineering Field Handbook (EFH), Chapter 8

Iowa Drainage Guide, Iowa State University Special Report 13

USDA-NRCS, National Engineering Handbook (NEH), Part 636, Chapter 52