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.

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. 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 interval exceed that shown in Table 1 for the conditions shown.

Table 1 - Maximum Horizontal Interval for Terraces

Field Slope (%)	Without strip-cropping (feet)	With strip-cropping (feet)	For Concen-trated Flow Control (feet)
0-2	270	420	450
>2-4	210	270	360
>4-6	150	240	300
>6-9	120	180	240
>9-12	105 [1/]	180	180
>12	105 [1/]	120	180

1/ Maximum Horizontal Interval for a narrow based terrace cross section is 120 feet.

The methods that may be used to determine terrace spacing include the current NRCS accepted erosion prediction technology, the Vertical Interval Equation or state developed methods that address unique soil, cropping or other farming practices that affect terrace spacing. Refer to the current NRCS accepted erosion prediction software and user guide to determine soil loss. Refer to the Engineering Field Handbook, Chapter 8, Terraces for use of the Vertical Interval Equation.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resource Conservation Service or download the standard from the electronic Field Office Technical Guide for Missouri.

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. See University of Missouri Agricultural Engineering Guide 1500 "Choosing Terrace Systems" for a discussion on alignment.

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. 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. Sediment volume may be estimated by using Table 9 of the Missouri Supplement to the EFH, Chapter 8 - Terraces.

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. For terraces with open outlets, design the capacity of the outlet to be equal to or greater than the capacity of the terrace channel.

Table 6 of the Missouri Supplement to the EFH, Chapter 8 - Terraces may be used to determine minimum settled ridge height for gradient terraces.

All farmable terrace slopes shall be no steeper than those on which farm equipment can be operated safely and ridge and cut slopes must be 5 (H):1(V) or flatter. 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.

All terrace cross sections shall comply with the minimum dimensions shown in the Missouri Supplement to EFH, Chapter 8 - Terraces for broad base terraces (Figure 2), steep backslope terraces (Figure 3), or narrow base terraces (Figure 4). Other cross sections may be used if stable and maintainable. An example is a steep, vegetated front slope terrace with a 5:1 or flatter farmable back slope. This terrace may be useful where large equipment makes farming around UGO risers and building a front slope of adequate width difficult.

Broad base cross section. Excavation for the terrace ridge is generally made on the uphill side. The cutslope, front slope, and backslope of the broad base terraces may be farmed. Building a broad base terrace cross section from the uphill side can increase the slope of the land by as much as 5 percentage points on steeper ground.

Steep backslope cross section. Excavation for steep backslope terraces shall be made from the downhill side except where cuts and fills are required to improve alignment. Guide dimensions for steep backslope terraces are shown in the Missouri Supplement to EFH, Chapter 8 - Terraces. The backslope must be seeded to grass. This type of terrace decreases the slope of the land between terraces by 2 to 4 percent. Steep backslope terraces are recommended for all field slopes.

Narrow base cross section. Both the front and the backslope of narrow base terraces are seeded to grass and not farmed. Excavation for narrow base terraces shall be made from the downhill side except where channel cuts and fills are required to improve alignment. Guide dimensions for narrow base terraces are shown in the Missouri Supplement EFH, Chapter 8 - Terraces. Narrow base terraces are recommended for all land slopes.

Topsoiling. Topsoil shall be salvaged and spread over the excavated slopes and terrace ridges to facilitate restoration of the field unless the excavated slope or ridge surface is of the same texture as the available topsoil. Where topsoiling is necessary, the topsoil shall be salvaged from both the channel and ridge footprint area. Topsoiling criteria is located in the Missouri Supplement to EFH, Chapter 8 – Terraces.

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.

Terrace channel blocks. Terrace channel blocks may be needed to confine water to the storage basin when underground outlets are used. The top elevation of these blocks shall be the same as the design elevation of the terrace ridge. The cross section of the blocks shall have a minimum top width of 6 feet and side slopes 5 (H):1 (V) or flatter to avoid being destroyed by normal tillage operations.

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.

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 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. The drop from the bottom of the terrace to the bottom of the vegetated outlet should be between 0.3 feet and 1.0 feet.

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. Design the outlet so that the flow release time does not exceed the inundation tolerance of the planned crops. The release time shall not exceed the inundation tolerance of the planned crops or 48 hours, which ever is less. 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.

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 system farmability and the producer's desires should be considered when determining alignment.

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.

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. Consider topsoiling even when not required by the criteria of this standard.

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 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 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.

The following University of Missouri Agricultural Guides provide information on the operation and maintenance of terrace systems and their outlets:

1501 "Operating and Maintaining Underground Outlet Terrace Systems"

1503 "Operating and Maintaining Grassed Outlet Terrace Systems"

1504 "Maintaining Grassed Waterways"

REFERENCES

USDA, NRCS. 2004. Revised Universal Soil Loss Equation, Ver. 2 (RUSLE2).

USDA, NRCS. National Engineering Handbook, Part 650, Engineering Field Handbook, Chapter 8.

University of Missouri Agricultural Guide Sheets:

1501 "Operating and Maintaining Underground Outlet Terrace Systems"

1503 "Operating and Maintaining Grassed Outlet Terrace Systems"

1504 "Maintaining Grassed Waterways"

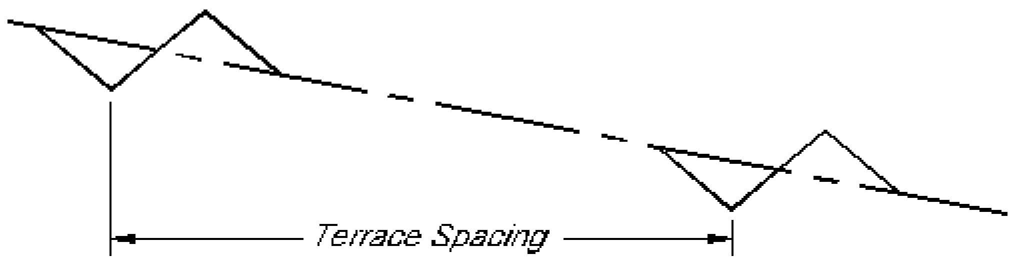

Figure 1
Terrace Spacing *(Not to Scale)*

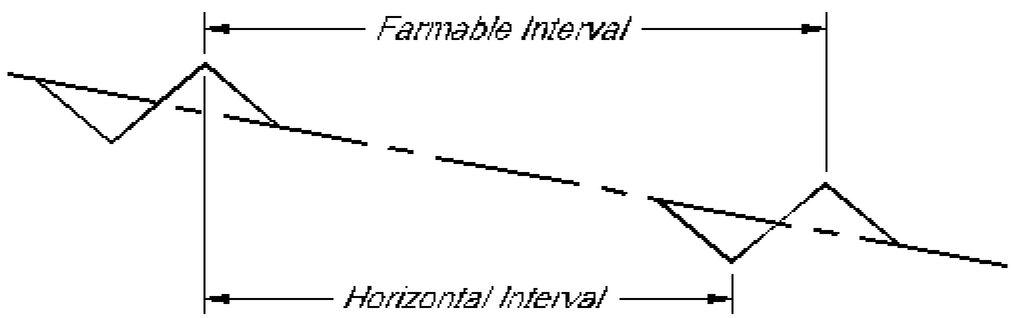

Figure 2
Horizontal Interval for Broad-Based Terraces *(Not to Scale)*

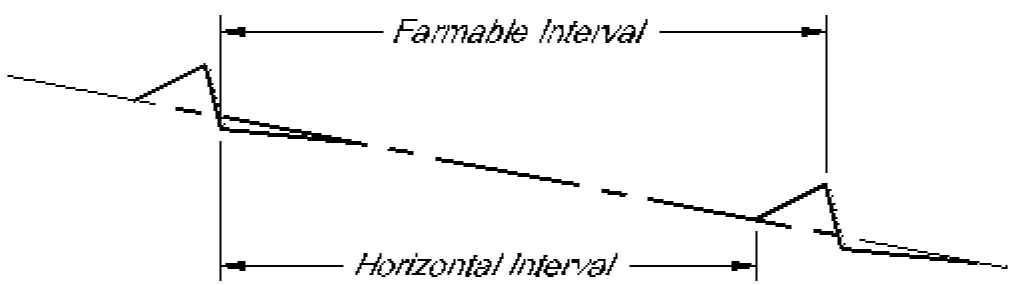

Figure 3
Horizontal Interval for Steep Back-Slope Terraces *(Not to Scale)*

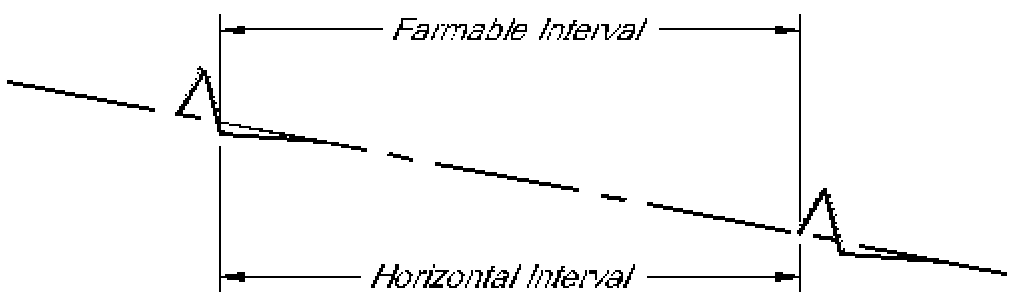

Figure 4
Horizontal Interval for Narrow-Based Terraces *(Not to Scale)*