Menu Measure Descriptions

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The following descriptions identify the minimum specifications (indicated in bold text) for each measure. The descriptions do not provide the prescriptive design elements for these measures. For the purposes of the menu descriptions, “sheet flow” describes a thin layer of water on the soil surface moving uniformly downhill and “concentrated flow” described non-uniform flow forming small channels. The greater the distance that water flows (and based on field topography), the more likely that sheet flow will become concentrated flow, which can lead to significant sediment erosion.

Because implementation of specific mitigation measures varies by crop and location, pesticide users adopting one or more of these measures would be encouraged to consult with local specialists experienced in planning, building, and maintaining these mitigation measures. Additionally, some measures may have specific state and/or local laws and regulations that must be followed.

The descriptions of the mitigation measures are adapted from the National Pollutant Discharge Elimination System (NPDES) Permit Writers’ Manual for CAFOs (pdf) and information from the open literature. For further discussion and consideration of the application of these mitigation measures, see EPA’s webpage on non-point source pollution reduction in agriculture and National Management Measures to Control Nonpoint Pollution from Agriculture (Chapter 4) (pdf).

Contour Farming (in-field)

Contour farming is the use of ridges and furrows formed by tillage, planting, and other farming operations or the establishment of orchard and other perennial crop rows following the contour to change the direction of runoff from directly downslope to across the slope. The disruption of downslope flow slows the runoff velocity and allows for more time for runoff to infiltrate the field soils, thereby reducing runoff.

The effectiveness of contour farming to reduce runoff and erosion and increase infiltration of runoff is dependent on several factors including the amount of rainfall, the grade and height of rows and row ridges, the steepness and length of the slope, the crop residue and surface roughness, and the soil hydrologic group. Coupling the measure with other mitigation measures, like reduced tillage, cover crops, and in-field vegetated strips, improve the effectiveness of this measure.

For annual crops, orchards, and perennial crops establish and maintain the direction of rows as close to the angle of the contour as possible.

Contour farming with in-field vegetation (in-field)

Contour farming with in-field vegetation are equivalent (in terms of efficacy for runoff/erosion reduction) to practices such as contour buffer strips, contour strip cropping, vegetative barrier, prairie strips if on a contour, and alley cropping. Contour buffer strips and contour strip cropping are described here. Consult later sections for more information on vegetative barriers, prairie strips, and alley cropping.

Contour Buffer Strips (in-field)

Contour buffer strips are strips of permanent herbaceous vegetation, primarily of perennials such as grass, alternated with wider cultivated strips that are farmed on the contour. The strip could also be planted with native plant species. Contour buffer strips help to manage runoff and trap sediment. Because the vegetated buffer strip is established on the contour, runoff flows evenly across the entire surface of the strip, reducing water and sediment erosion. The vegetation slows runoff, helping the water to soak into the soil and reducing erosion. Sediment, nutrients, and other pollutants are filtered from the runoff as it flows through the strip, thereby improving surface water quality.

The specific recommendations for establishing buffers vary from site to site. **Contour buffer strip widths must be a minimum of 15 feet**. Wider distances may be appropriate based on variables such as slope, soil type, field conditions, climate, and erosion potential. Contour buffer strips are unsuitable in fields where irregular, rolling topography makes following a contour impractical.

To ensure maximum performance, **the integrity of the buffer must be maintained for the entire width and length, including:**

- The contour buffer must be harvested or mowed, reseeded, and fertilized as necessary to maintain plant density and vigorous plant growth.
- Vegetation must be kept tall in spring and early summer to help slow runoff flow, maximize disruption of concentrated flow, and reduce the chance of structural damage.
- Regular maintenance must also include inspection after major storms, removal of trapped sediment, and repair of eroding areas.

Contour Strip Cropping (in-field)

In contour strip cropping, a field is managed with planned rotations of row crops, forages, small grains, or fallow in a systematic arrangement of equal width strips following the contour across a field. Crops are typically arranged so that a strip of grass or forage crop (low erosional risk because of their fibrous root system) is alternated with a strip of row crop (high erosional risk; e.g., corn). The crops are planted across the slope of the land, as in contour buffer strips. This practice differs from contour buffer strips in that it allows for crops to be planted across 100% of the field area.

Plant row crops on less than half the field and, at a minimum, 50% of the slope must be planted with low erosional risk plants (e.g., grass plants because of their fibrous root system).

The low erosional risk crops reduce erosion, slow runoff water, and trap sediment entering through runoff from upslope areas. This practice combines the benefits of contouring and crop rotation.

Contour strip cropping is not as effective if the row crop strips are too wide and **are an option on slopes of <10%**. **Establish and maintain the rows as close to the contour as possible**.

Coupling the practice with reduced tillage practices will result in the best performance of contour strip cropping.

Vegetative Barrier (adjacent to the field)

Vegetative barriers are narrow, permanent strips of stiff-stemmed, erect, tall and dense vegetation established in parallel rows on the contour of fields to reduce soil erosion and sediment transport. These buffers function similar to contour buffer strips and may be especially effective in dispersing concentrated flow, thus increasing sediment trapping and water infiltration.

Because the vegetative barrier, typically comprised of grasses, is established on the contour, runoff is restricted, reducing sheet flow and erosion from concentrated flow. The grass slows runoff, helping the water soak into the soil and reducing erosion. The specific recommendations for establishing the vegetative barrier vary from site to site.

Barrier widths are determined by variables such as slope, soil type, field conditions, climate, and erosion potential but **must be a minimum of 20 feet wide**. To ensure maximum performance, the pesticide user **must maintain the integrity of the barrier for the entire width and length, including:**

- The barrier must be harvested, mowed, reseeded, and fertilized as necessary to maintain plant density and vigorous plant growth.
- The maintenance schedule must keep vegetation tall in spring and early summer to help slow runoff flow, maximize disruption of concentrated flow, and reduce the chance of structural damage.

Regular maintenance must also include inspection after major storms, removal of trapped sediment, and repair of eroding areas.

Cover Crop/Continuous Cropping (in-field)

A cover crop is a close-growing crop that temporarily protects the ground from wind and water erosion. Common cover crops include cereal rye, oats, clover, crown vetch, and winter wheat or combinations of those crops. Cover crops are most often used when low residue-producing crops are grown on erodible land. Cover crops increase soil stability, reduce runoff, and reduce erodibility of field soils.

The cover crop must be planted and remain on the field up to the field preparation for planting the crop.

Crop insurance allows for cover crop flexibilities and producers should be mindful of those flexibilities and guidelines.

Planting directly into a standing terminated, mowed, or rolled cover crop will provide the greatest benefit for reducing runoff. Cover crops may be used in conjunction with reduced tillage practices to further reduce surface runoff from production fields.

Vegetative Filter Strips or Prairie Strips or Inter-row Vegetated Strips (infield or adjacent to field)

Filter strips are managed in- or off-field areas of grass or other permanent herbaceous vegetation that intercept and disrupt flow of runoff, trap sediment, and reduce pesticide concentrations in water. Generally, a filter strip can vary in width (typically 20 to 120 feet wide). Filter strips are usually planted with native grasses and perennial herbaceous plants. Nutrients, pesticides, and soils in the runoff water are filtered through the grass, potentially adsorbed by the soil, and potentially taken up by the plants. The effectiveness of filter strips to reduce pesticide loading into an adjacent surface water body depends on many factors, such as topography, field conditions, hydrologic soil group, antecedent moisture conditions, rainfall intensity, properties of the pesticide, application methods, width of the filter strip, and types of vegetation within. Therefore, risk reductions obtained from the use of filter strips may vary. Its use can support or connect other buffer practices within and between fields.

Ideally, filter strips will be comprised of native plants such that they may serve multiple functions such as prairie strips and/or pollinator strips and improve habitat availability for native wildlife. In-field strips could also consist of an erosion-resistant crop such as hay, small grains, or perennial crops. Noxious or invasive weeds should be removed from strips to prevent spread.

To function as a mitigation measure for pesticide runoff/erosion these structures they **must be established and maintained such that the area immediately upslope must eliminate or substantially reduce concentrated flow and promote surface sheet flow runoff. The design and maintenance must consider a lifespan sufficient for multiple growing seasons. Where there is concentrated flow, structural elements must be added within the field to prevent erosion and promote sheet flow across the filter strip. Filter strip vegetative plantings must not contain noxious or invasive species and must be maintained as appropriate to encourage dense growth and maintain upright growth.** Best practices include aligning rows as closely as possible so that they are perpendicular to the slope, use of water bars or berms to break up the concentrated flow and divert concentration flow back into the field, and reduced tillage practices, especially near the vegetative strip.

Alley Cropping (in-field)

Alley cropping is effective at reducing surface water runoff and erosion. This practice involves trees or shrubs being planted in single or multiple rows where other commodities (i.e., agronomic or horticultural crops or forages) are planted in the alleys of the trees or shrubs. **Trees or shrubs must be planted on or near the contour. The vegetation in the alleys must be established in conjunction with the trees/shrubs** to be effective against water erosion. For wind erosion, tree/shrubs must be planted perpendicular to erosive wind patterns. Additionally, the species of trees/shrubs planted must have deep root systems that assist in water infiltration and rapid growth rates. **During the period of establishment, tree/shrubs must be maintained/replaced as needed. Soil erosion must be controlled by vegetative or other means until the alley cropping design is fully functional.**

Strip Cropping (in-field)

In strip cropping, a field is managed with planned rotations of row crops, forages, small grains, or fallow in a systematic arrangement of equal width strips. Crops are typically arranged so that a strip of grass or forage crop (low erosional risk because of their fibrous root system) is alternated with a strip of row crop (high erosional risk; e.g., corn). This practice differs from contour strip cropping in that rows do not need to be planted along a contour, which allows strip cropping to be used on land without a contour.

Alternate strips of row crops considered high erosion risk with strips. A minimum of 50% of the field must be planted with low erosional risk crops or sediment trapping cover.

The low erosional risk crops reduce erosion, slow runoff water, and trap sediment entering through runoff.

Strip cropping is not as effective if the row crop strips are too wide and **must only be implemented on slopes ≤10% slope**.

Coupling the practice with reduced tillage practices will result in the best performance of strip cropping.

Irrigation Water Management (in-field)

Irrigation water management on the field must control the volume, frequency, and rate of irrigation water applied to a field such that no irrigation-induced runoff from the field is generated. Growers should have an irrigation management strategy that is based on the daily water use of the crop, the water-holding capacity of the soil, and the lower limit of soil moisture for each crop and soil; measuring the amount of water applied to the field; and considering any forecasted precipitation. Proper irrigation scheduling depends on daily accounting of the cropland field water budget. The tools required to complete this budget include water measuring devices (e.g., irrigation water meter, flume, or weir) and soil and crop water use data. The method of water application should be suitable to the site-specific conditions of the farm (slopes, soils, types of crop, climate, etc.). **The irrigation water management system must also be properly designed and operated.**

Mulching with Natural Materials (on-field)

This practice is used to reduce runoff and erosion. Natural mulches should be applied such that mulch provides **a minimum of 70 percent ground cover. The minimum depth of mulch must be 2 inches** such that the mulch will remain during heavy rain or winds. Vegetation-based mulches must have a carbon:nitrogen ratio greater than 20:1. If mulch needs to be held in place, appropriate measures must be used (e.g., tacking, crimping) so that the mulch remains on the field. **The mulch must be periodically inspected to ensure that the mulch is intact and repair/reinstall mulch as needed.**

No Tillage/Reduced Tillage (in-field)

This mitigation measure includes conservation tillage practices such as no-till, strip-till, ridge-till, and mulch-till. Each of these involves management of the amount, orientation and distribution of crop and other plant residue on the soil surface year-round while limiting the soil-disturbing activities used to grow and harvest crops in systems where the field surface is tilled, raked, or left undisturbed prior to planting. **The minimum requirement for this measure is that more than 30% of the surface must remain covered with plant residue while this mitigation measure is in place.**

- No-till/strip till: In these systems, the soil is left undisturbed from harvest to planting. Planting or drilling is accomplished using disc openers, coulter(s), and row cleaners. Weeds are controlled primarily with crop protection products.
- Strip till: In these systems, the soil is left undisturbed from harvest to planting except for strips up to one-third of the row width. (The strips could involve only residue disturbance or could include soil disturbance.) Planting or drilling is accomplished using disc openers, coulter(s), row cleaners, in-row chisels, or rototillers; cultivation can be used for emergency weed control. Other common terms used to describe strip-till, include row-till, and slot-till.
- Ridge-till: Ridge-till is a system in which seeds are planted into a seedbed prepared by scraping off the top of the ridge. The scraped-off ridge usually provides an excellent environment for planting. Ridges are formed during cultivation of the previous year’s crop. Ridge-till operations consist of planting in the spring and at least one cultivation to recreate the ridges for the next year. Rows remain in the same place each year and any crop residue on the ridges at planting is pushed between the rows.
- Mulch-till: This system uses full-width tillage involving one or more tillage trips, which disturbs the entire soil surface but leaves a uniform layer on crop residue on the soil surface and is done before or during planting. Tillage tools such as chisels, field cultivators, discs, sweeps, or blades are used. Weeds are controlled with crop protection products or cultivation or both.

Terrace Farming (in-field)

Terraces are described as a stair-stepping technique of creating flat or nearly flat crop areas along a gradient. They can be constructed as earth embankments or a combination of ridge and channel systems. A terrace is an earthen embankment that is built across a slope to intercept and store water runoff. Some terraces are built level from end to end to contain water used to grow crops and recharge groundwater. Others, known as gradient terraces, are built with some slope or grade from one end to the other and can slow water runoff. Both help to reduce runoff and erosion by slowing the velocity of runoff and increasing the time for water infiltration.

On the field, terraces can be used as a part of an overall system based on the topography of the land. Additionally, an earthen ridge or terrace can be constructed across the slope upgrade from a field area to prevent runoff from entering the area or to direct runoff from one area of production to a common runoff collection area. Reduced tillage practices will result in less sediment loading and the best performance of a terraced farming system.

Construct terraces so that the flat cropped areas have 3% slope or less. The ends of terraces, including turnrows, must be structured and maintained to prevent concentrated flow from damaging the function of the terrace.

If runoff outflows are necessary, the runoff must be directed to a system such as a grassed waterway, a grade-stabilization structure, a filter strip, water or sediment basin, or other suitable outlet with adequate capacity to handle the runoff and prevent gully formation.

Reservoir Tillage (in-field)

Reservoir tillage is the use of a specific tillage tool that runs between the rows of a crop and created depressions in the soil. These depressions collect precipitation and irrigation water allowing the water to infiltrate into the soil, thereby reducing erosion and runoff. EPA is working to update this description to reflect best practices.

Erosion Barriers (wattles) (adjacent to field)

Wattles are fiber-filled (e.g., straw, coir) rolls in a mesh netting designed to control soil erosion by capturing sediment and reducing flow velocity by distributing water across the landscape allowing infiltration thereby reducing runoff. Typically, wattles are held in place by wooden stakes and applications can be seen at construction sites and post-forest fire remediation sites where sloping occurs but can also be used as perimeter control surrounding fields and waterbodies. EPA is working to update this description to reflect best practices.

Riparian buffer zone (herbaceous and forest buffer) (adjacent to the field)

These buffers are similar in that they reduce erosion and, at minimum, maintain water quality. **Vegetation for both buffers must be tolerant to intermittent flooding and saturated soil and be managed until established in the transitional zone between a field and an aquatic habitat. Herbaceous buffers must consist of non-woody vegetation and must have a minimal width of 2.5 times the width of the stream or 35 feet if adjacent to a larger water body. Forest buffers must be planted to trees and shrubs and must have a minimal width of 35 feet from the**

waterbody. Riparian buffers should only be used where channel and stream bank stability is adequate to support this practice.

Field Border (20-ft minimum width; adjacent to the field)

A field border is defined as a strip of permanent vegetation established at the edge or around the perimeter of a field. A field border can reduce runoff-based erosion and protect soil and water quality, when down slope of a crop field, by slowing the flow of water, dispersing concentrated flow, and increasing the chance for soil infiltration.

Use of a field border can support or connect other buffer practices within and between fields.

Establishment and maintenance of the field border and any land immediately upslope of the border must aim to eliminate or significantly reduce concentrated water flow and promote surface sheet flow runoff.

To prevent significant erosion within a field border, **concentrated flow must be broken up or redirected**. This may be achieved by aligning the field border and planting rows as closely as possible in a direction that is perpendicular to the slope. Use of water bars or berms to divert concentrated flow back into the field is another useful tool to break up the concentrated flow and promote sheet flow into the border.

A field border must have a minimum width 20 feet for the purpose of reducing pesticides in runoff and be composed of a permanent dense vegetative stand. This stand must be composed of stiff upright grasses. Non-woody flowering plants may also be included in a well-managed border.

Reduced tillage practices, especially near the field border strip, will result in less sediment loading and the best performance of the field border in reducing runoff.

Inspect field borders after major storms and repair eroding areas.

Grassed Waterways (in-field)

Grassed waterways are natural or constructed vegetated channels designed to direct surface water, flowing at non-erosive velocities, to a stable outlet (e.g., another vegetated channel, an earth ditch). In concentrated flow areas, grassed waterways can act as an important component of runoff and erosion control by slowing the flow of water, filtering pesticides and sediment, and allowing for increased water infiltration into the soil. Grassed waterways are usually planted with perennial grasses, preferably native species where possible. Some common grass species used in waterways are Timothy, tall fescue, perennial ryegrass and Kentucky bluegrass.

Users of grassed waterways must establish a maintenance program to maintain waterway capacity, vegetative cover, and outlet stability. Do not damage vegetation within the grassed waterway by machinery, herbicides, or erosion. Grassed waterways must be protected from concentrated flow by using runoff diversions which can include silt fences, mulching and hay bale barriers to stabilize grade during vegetation establishment and after disruption or damage.

Grassed waterways must be inspected regularly, especially following heavy rains. Any damage or disruptions must be repaired as soon as possible and before any pesticide applications by filling, compacting, and reseeding. Remove sediment deposits to maintain capacity of grassed waterway. Maintain a healthy, dense, and functional vegetated strip. Runoff outflow must be directed to a system such as another grassed waterway, an earthen ditch, a grade-stabilization structure, a filter strip, water or sediment basin, or other suitable outlet with adequate capacity to handle the runoff and prevent gully formation.

Established grassed waterways in areas that are susceptible to increasing concentrated flow (shallow channelized flow leading to gullies and rivulets). Plant perennial native grasses (where possible) using broadcast seeder or seed drill. Other plant species can be included as desired.

Regularly inspect grassed waterways, especially after heavy rain events. Maintain grassed waterways by filling compacting and reseeding as necessary.

Vegetative Drainage Ditch (vegetated ditch bank) (adjacent to the field)

A vegetative drainage ditch (or vegetated ditch bank) is a sloped channel, planted with vegetation (grass or otherwise) that transports surface water at such a rate that it does not erode soil to an outlet that is not likely to erode.

- The bottom width of the (trapezoidal) vegetated ditch bank must be less than 100 ft.
- The side slope of the vegetated ditch bank must be flatter than a ratio of 2:1 horizontal: vertical.
- The depth/capacity of the vegetated ditch bank must accommodate peak runoff volume expected from a 10-year frequency, 24-hour duration storm.
- Vegetation must be selected such that the vegetation will achieve an adequate density, height, and vigor, and is stable to peak runoff volume expected from the 10-year frequency, 24-hour duration storm.

Maintenance must include ensuring a healthy grassed or vegetative surface within the vegetated ditch bank, inspections after major storms and repair to damaged areas, as well as removal and redistribution of excess sediment back to the field.

Water and Sediment Control Basins, Tailwater Return Systems, Ponds, and Constructed Wetlands

Water and Sediment Control Basins

Water and sediment control basins are earthen embankments or basins, or a combination ridge and channel constructed across the slope of minor watercourses to form a water detention basin and sediment trap with a stable engineered outlet. The purpose of the practice is to collect runoff, eroded sediment, and other debris in order to minimize runoff and erosion leaving the field.

Construct water and sediment control basins in areas susceptible to gully erosion. Plant and maintain a healthy grassed, vegetated surface within the interior of the basin. Inspect basins after major storms and repair to damaged areas. Remove excess sediment and reapply to the field where appropriate.

Water and sediment control basins should be used in conjunction with other runoff and erosion mitigations practices including:

- Subsurface drainage: This is a practice where an underground pipe is installed to collect and move excess water from a field.
- Tailwater recovery systems (or tailwater return systems): These systems are intended to collect, move, and temporarily store runoff water so that it can be reused later.
- Drainage water management: This conservation practice involves managing the flow of surface and subsurface drainage systems by changing the elevation of outflow.

Ponds

Ponds are similar in function to sediment basins, as they can collect runoff and allow time for the sediment to settle from sediment-laden runoff drained from a field.

- Plan, design, and install constructed wetlands to comply with Federal, State, and local laws and regulations.
- Ensure that failure of the dam will not result in loss of life, damage to homes, commercial or industrial buildings, main highways, or railroads, or in interruption of the use or service of public utilities.

When constructing ponds for runoff an erosion control, ensure that the pond has sufficient capacity to accommodate runoff from all fields draining to the pond.

Maintain pond edges, embankments, and outlets to ensure appropriate function for the life of the pond.

Periodically remove excess sediment from pond.

Constructed wetlands

Constructed wetlands are similar in function to water and sediment basins and ponds. In constructed wetlands water-tolerant vegetation is used to create a manmade wetland that can collect runoff and erosion.

- Plan, design, and install constructed wetlands to comply with Federal, State, and local laws and regulations.

Construct the wetland with sufficient capacity to accommodate runoff from all fields draining to the wetland.

Maintain water depth within the to meet water requirements of the vegetation within the wetland.

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