Cropland Best Management Practice Manual

Conservation Practices to Protect Surface and Ground Water

Wyoming Department of Environmental Quality
Water Quality Division
Nonpoint Source Program

2013 Update
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The purpose of this document is to provide information about best management practices that the Wyoming Nonpoint Source Program supports as eligible for Clean Water Act Section 319 funding. This document is prepared as part of the Wyoming Nonpoint Source Management Plan as required by Section 319(b) of the Clean Water Act.

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Introduction

1.1 Purpose of this Document

The purpose of this document is to provide information about cropland best management practices (BMPs) that can be voluntarily implemented to prevent, reduce, or eliminate nonpoint source pollution to Wyoming's water resources. This document focuses on those BMPs that the Wyoming Department of Environmental Quality (WDEQ) Nonpoint Source Program has determined to be eligible for Clean Water Act (CWA) Section 319 funding. This document is prepared as part of the Wyoming Nonpoint Source Management Plan as required by Section 319(b) of the CWA, which states that management programs and BMPs must be developed by each state to reduce identified causes of nonpoint source pollution.

The Wyoming Nonpoint Source Program works through voluntary and incentive methods to reduce nonpoint source pollution and will work with agencies, individual producers, and other stakeholders to promote the implementation of BMPs on a voluntary basis with financial assistance from Section 319 grants. More information about Section 319 grants and how to apply for grant funding can be found on the Nonpoint Source Program website. Please note that Section 319 funds are not eligible for activities that are required as part of a permitting or regulatory action.

Inclusion of a BMP in this manual does not guarantee Section 319 funding for that BMP. The Wyoming Nonpoint Source Program will recommend funding for BMP implementation projects on a project-by-project basis, and will take into consideration the advantages and limitations of proposed BMPs to evaluate the most efficient and cost-effective solutions possible.

1.2 How to Use this Document

This document provides a summary of selected BMPs and references to more detailed information about those BMPs. This document should be used as follows:

- As documentation of which BMPs the Wyoming Nonpoint Source Program and Nonpoint Source Task Force endorse as eligible for funding through the Section 319 grant program,
- As an educational tool about BMPs, and
- As a tool to direct users to detailed information about selected BMPs.

This document provides a basic description of each BMP, a brief summary of their criteria and maintenance needs, and links to reference documents where more information can be found on that BMP. This document is not an exhaustive resource on BMP design and implementation, but rather, should be used as an educational tool and as a directory of where to find more information about selected BMPs.

The blue, underlined text in this document represents a website link. If viewing this document in an electronic format, the user can be directed to the appropriate website by clicking on the blue, underlined text or on the URL address link. The full URL addresses are also provided for all referenced websites to accommodate users who are not viewing an electronic copy of this document. Typing the URL address into an internet browsing application will direct the user to the appropriate website. For websites outside the WDEQ, the WDEQ is not responsible for the content or maintenance of those websites.

1.3 Nonpoint Source Pollution from Croplands

Unlike point source pollution, which can be traced back to a single defined source, nonpoint source pollution is caused by surface water runoff that is diffuse in nature and often widespread, making it difficult to assess the source of the problem. Nonpoint source pollution occurs when runoff from rainfall or snowmelt travels over and/or percolates through the ground and picks up contaminants. These contaminants are deposited into streams, lakes, rivers, and ground water. Nonpoint sources of pollution continue to be recognized as the nation's largest remaining cause of surface water quality impairments, and the 2012 Wyoming Integrated 305(b)/303(d) Report shows that the majority of surface water quality impairments in Wyoming are due wholly or in part to nonpoint source pollution.

Cropland activities have the potential to contribute to nonpoint source pollution. For example, the application of commercial fertilizer to cropland can introduce nutrients, such as nitrogen and phosphorous, to surface or ground water. In addition, the decomposition of organic matter from croplands and crop residue may be a source of mobile forms of nutrients that can be transported by surface water runoff or ground water infiltration from agricultural lands to water systems. When nutrients are introduced to a natural water body, they can potentially cause dramatic increases in aquatic plant growth, also referred to as eutrophication. This excessive aquatic plant growth can lead to reduced or depleted dissolved oxygen levels that are detrimental to fisheries.

Pesticides and herbicides applied to croplands can also potentially impact surface and ground water quality. Chemicals can be transported to surface and ground water through surface runoff and/or soil infiltration. Chemicals that are resistant to degradation can persist in natural waterbodies and can bioaccumulate in aquatic organisms. Therefore, not only can pesticides cause acute negative effects, they can also have chronic effects by persisting in the environment and triggering negative responses in aquatic life and wildlife as the chemical biomagnifies through the food chain.

Cultivated croplands can also destabilize soils and lead to excess soil erosion and sedimentation. Transported soil and sediment from croplands often contain nutrients and chemicals, which can further impact local water quality. In addition, salts, produced through the natural weathering of the soil, can be transported and deposited to surface waters by runoff from rainfall or irrigation. In addition, irrigation waters generally have a natural base load of dissolved mineral salts. The repeated introduction of salts to surface waterbodies can progressively degrade water quality.

On cropland, pastureland, or hayland where manure is applied, there is the potential of causing excessive levels of pathogen or heavy metal loading into nearby surface or ground waters. Care should be taken to reduce adverse water quality impacts that may be caused by the pathogens or heavy metals present in manure, and management techniques should be based on soil characteristics, soil types, crops grown, amount of manure applied, rate of application, timing of application, and other similar factors. The use of BMPs can help ensure that ground and surface water resources are protected when landowners apply manure.

Irrigation of seleniferous soils can dissolve and mobilize selenium into surface and ground waters. The amount of transported selenium depends on soil characteristics and chemistry, soil types, crops grown, source of irrigation water, and method of irrigation. For example, soils derived from Cretaceous shales in Wyoming are likely to contain higher concentrations of selenium. Deep percolation and excess runoff from irrigation can mobilize and transport selenium into surface and ground water and eventually into wetlands inhabited by fish and migratory birds. Excessive selenium in these waters can cause mortality and reproductive impairment in wildlife.

1.4 Cropland Best Management Practices

Cropland BMPs are designed to reduce the quantities of pollutants that are introduced to receiving waterbodies due to cropland activities. BMPs can be designed to either prevent runoff from becoming polluted or to treat polluted runoff before it reaches a water system. In addition, BMPs can be managerial or structural. This document covers both managerial and structural BMPs, as both methods are important for improved cropland management.

Managerial practices, such as nutrient or pesticide management, entail proper handling and application of these crop enablers. Managerial BMPs aim to improve water quality by preventing the over-application of nutrients or chemicals, and therefore, reducing the amount of excess nutrients or chemicals available for transport by runoff. Irrigation management also works to apply appropriate quantities of water on irrigated fields to prevent excess irrigation runoff which can transport pollutants and alter natural water flows. Proper maintenance and management of irrigation systems can reduce damage caused by cropland runoff and irrigation return flow and can reduce transportation of pollutants into waterbodies.

Often, managerial BMPs require the use of structural BMPs to be properly implemented. Structural BMPs aim to improve water quality primarily by preventing excessive erosion from croplands. Erosion prevention can help prevent the transport of sediment and attached pollutants to natural waterbodies. Practices such as crop rotation, strip cropping, or cover cropping, work to reduce cropland erosion by stabilizing soils and decreasing exposed soils. Other structural practices, such as contour farming, diversions, or terraces, are designed to prevent sheet or rill erosion caused by slope runoff. Windbreaks also help prevent erosion caused by winds, along with protecting crops from any damage caused by high winds. BMPs such as riparian buffers, filter strips, or grassed swales, work to intercept and filter possible contaminated runoff from croplands before it reaches natural waterways. The installation of these practices can also promote infiltration and can slow

and cool runoff; cooler runoff helps prevent temperature increases in receiving waterbodies that could lower dissolved oxygen levels and affect fisheries.

Often, it is appropriate to use multiple BMPs to achieve a desired management objective. The choice of a particular BMP or series of BMPs depends on many factors. When choosing a BMP, a land manager must consider local climate, location, topography, maintenance, ground water, installation costs, and the pollutants needing to be addressed.

Some of the BMPs discussed in this manual may also require design and construction oversight by an engineer or other natural resource professional. Permits may also be required from local, state, or federal government for some types of BMPs (see Appendix A for more information). Be certain to check with appropriate agencies during the planning process to determine permit or other regulatory requirements.

Specific BMPs may or may not always be appropriate for a particular site or situation; therefore, thorough research, planning, and design should always go into the selection, implementation, and installation of any cropland BMP. BMPs are often not complete in themselves and should be used as part of an integrated management plan to improve and maintain cropland resources, including soil, vegetation, and water. Implementing or installing more than one BMP in a series can overcome the drawbacks of any single method, while providing enhanced pollutant removal.

Conservation plans, management plans, and similar documents should contain a list of the BMPs most appropriate for the area. Practices should be selected, designed, implemented, and maintained in accordance with site-specific considerations to ensure that the practices function together to achieve the overall management goals. In addition, management plans should be developed with reasonable goals and objectives, and progress toward goals and objectives should be monitored.

Monitoring must include measures of changes in resource conditions as well as measurements of completion of objectives and tasks. Monitoring the success of BMP implementation is important to allow for flexibility and adjustment of the BMPs as needed. Finally, ensuring proper operation and maintenance of implemented BMPs is important to ensure that water quality protection occurs in both the short-term and long-term timeframes.

The BMP factsheets in this manual provide information on some of the most common cropland BMPs. In addition, BMPs and conservation practices that are listed in United States Department of Agriculture (USDA) technical guides, manuals, or handbooks will be considered for Section 319 funding, even if not listed in this manual. In particular, the USDA Natural Resources Conservation Service's (NRCS) Field Office Technical Guides (FOTGs) offer information about BMPs and conservation practices that are utilized by the NRCS throughout Wyoming. Wyoming's electronic FOTG (eFOTG) is available on the NRCS Wyoming website. Other BMPs will be evaluated on a case-by-case basis for funding by the Wyoming Nonpoint Source Program and the Nonpoint Source Task Force.

1.5 General Resources

Many resources already exist that provide information about cropland management and BMPs. The WDEQ notes the following references as good general sources of information about cropland BMPs:

NRCS Wyoming Electronic Field Office Technical Guide, County Locator. 2012. U.S. Department of Agriculture, Natural Resources Conservation Service, Wyoming.
http://efotg.sc.egov.usda.gov//efotg_locator.aspx

National Management Measures for the Control of Nonpoint Pollution from Agriculture. 2003. EPA 841-B-03-004. U. S. Environmental Protection Agency, Office of Water, Washington, D.C.
http://water.epa.gov/polwaste/nps/agriculture/agmm_index.cfm

Agricultural Research Service Website. 2012. United States Department of Agriculture.
http://www.ars.usda.gov/main/main.htm

University of Wyoming Cooperative Extension, Publications Database Search. 2011. University of Wyoming, College of Agriculture and Natural Resources.
http://www.wyomingextension.org/publications/Search_Start.asp

University of Wyoming Cooperative Extension Resource Areas Website. 2012. University of Wyoming, College of Agriculture and Natural Resources.
http://www.extension.org/main/communities

University of Wyoming Agricultural Experiment Station Website. 2012. University of Wyoming, College of Agriculture and Natural Resources.
http://www.uwyo.edu/uwexpstn/

Barnyards & Backyards: Rural Living in Wyoming. 2012. University of Wyoming.
http://www.uwyo.edu/barnbackyard/

"This Land" Information Series. 2012. University of Illinois Extension, College of Agricultural, Consumer, and Environmental Sciences.
http://www.thisland.illinois.edu/
(includes "57 Ways to Protect Your Home Environment (and Yourself)", 50 Ways Farmers Can Protect Their Groundwater", and 60 Ways Farmers Can Protect Surface Water")

In addition, the following agencies are important resources for cropland management technical and/or financial assistance (additional contact information for these agencies is listed in Appendix B).

- Natural Resources Conservation Service (NRCS) Wyoming
- Wyoming Department of Agriculture (WDA)
- Wyoming Association of Conservation Districts (WACD)
- University of Wyoming College of Agriculture and Natural Resources
- University of Wyoming Cooperative Extension (UWCES)
- Wyoming Water Development Commission (WWDC)
- Wyoming Irrigation Districts (see Appendix B)
- Wyoming Weed and Pest Council

BMP 1: Conservation Crop Rotation

Photo of crop rotation. Source: University of Wyoming

Growing various crops on the same piece of land in a planned, recurring sequence in order to reduce erosion by maintaining a high degree of soil cover and improve soil by increasing organic matter.

Water Quality Benefits

Decreased runoff and erosion leading to less sediment, nutrients, and other pollutants in nearby surface waters

Increased soil organic matter reduces need for fertilizer application

Reduced need for pesticides due to disruption of disease, insect, and weed cycles

Increased water use efficiency

Description:

The practice of crop rotation entails growing various crops on the same piece of land in a planned, recurring sequence. The crop sequence is selected in such a way to provide a high degree of soil cover and provide an adequate amount of organic residue to help maintain or improve the soil tilth. This sequence may alternate production of high residue producing crops with production of low residue producing crops. This alternation is often recommended, as properly managed levels of crop residue can increase soil moisture, which in turn, can increase crop yields and residue production. In addition, including a legume or grass crop in the sequence can be very effective for improving soil structure and reducing erosion. Several rows of crop around the edges of the field can also be left unharvested to improve water quality by serving as vegetated filter strips and intercepting, straining, and infiltrating cropland runoff.

The practice of conservation crop rotation can help maintain and improve water quality in various ways. For example, by improving the physical, chemical, and biological conditions of the soils, crop rotation can help reduce sheet, rill, and wind erosion and reduce the detachment and transport of sediment and sediment-bound pollutants, such as nitrogen, phosphorous, and pesticides. Alternating crops can also help break up life cycles of insects, diseases, and weeds, thereby reducing the need for the applications of pesticides and herbicides. Crop rotation can also help improve soil organic matter content, maintain the balance of plant nutrients, and increase soil fertility, thereby reducing the need for excessive applications of fertilizers. The reduced application of chemicals to crops can reduce the amount of contaminated cropland runoff and can improve water quality. In addition, alternating crops can maximize water use efficiency and can provide food for animals. In particular, rotating or combining deep-rooted crops with shallow-rooted crops can help utilize all available waters in the soil.

Criteria:

Crop rotation can be applied to any lands where crops are grown but should not be applied to pastureland, hay land, or other lands where crops are only grown occasionally. Selected crops should be adapted to the local climates and soils and should be selected to meet the desired objectives. In windy regions, crops that are tolerant to abrasion from windblown soil or tolerant to high wind velocities should be selected. Windbreaks, intercropping, and other wind control methods can be utilized to

BMP 1: Conservation Crop Rotation

Criteria continued:

reduce plant damage by winds. In addition, deep-rooted plants or cover crops should be utilized where excess plant nutrients or soil contaminants are a concern, as they can help recover or remove the nutrients or contaminants from the soils. Soil compaction should also be avoided and can be reduced by including deep rooted crops in the rotation that are able to penetrate the compacted soil layers and by avoiding crops that require field operations when the soils are wet. In areas with winter snows, standing residue, windbreaks, and other barriers can also be utilized to capture moisture. Crop residue in the winter can also serve as a valuable food source for wildlife when winter browse is sparse.

Maintenance:

Maintenance needs for crop rotations vary with objective of the rotation. For example, when trying to maintain, increase, or improve concentrations of soil organic matter, crop residues should be maintained and tillage reduced. In addition, if windbreaks or other wind control methods are utilized, they should be maintained, repaired, and replaced as needed. Where chemicals, such as fertilizers, pesticides, or herbicides, are used, the application, storage, and disposal of these chemicals should be performed in such a way that does not compromise local ground and surface water quality.

Crop rotations should also plan for possible crop failures or shifts in planting intentions due to weather or economic reasons. Acceptable substitute crops that have similar properties and meet the criteria for the local resource concerns should be provided when needed. The soil moisture at planting time may also determine whether summer fallow is practiced. Summer fallow, or cropland that is purposefully kept out of production during a regular growing season, should be used when soil moisture is not adequate enough to produce a crop. In addition, if moisture is adequate but limited, short-season, shallow-rooted crops are recommended, and if needed, deep-rooted crops can follow shallow-rooted crops in later years to utilize all plant available water in the root-zone.

References:

Conservation Crop Rotation Standard: Code 328. 2011. Natural Resources Conservation Service.
http://efotg.sc.egov.usda.gov/references/public/WY/Conservation_Crop_Rotation_(AC)_(328)_Standard.pdf

Conservation Crop Rotation Fact Sheet. 2007. USDA Natural Resources Conservation Service – Wyoming.
http://efotg.sc.egov.usda.gov/references/public/WY/Conservation_Crop_Rotation_Fact_Sheet.pdf

Crop Rotations for Row Crops. 2009. Singer, J. and P. Bauer, Contributors. Soilquality.org website collaboration between the NRCS East National Technology Support Center, NRCS National Soil Survey Center, ARS National Laboratory for Agriculture and the Environment, NCERA-59 Scientists, and Department of Natural Resources and Environmental Sciences, University of Illinois at Urbana-Champaign.
http://soilquality.org/practices/row_crop_rotations.html

BMP 2: Strip Cropping

Photo of strip cropping with corn and alfalfa. Source: NRCS

Growing alternating crops in a systematic arrangement to reduce erosion from surface runoff and wind, protect growing crops, and reduce dust emissions.

Water Quality Benefits

Decreased runoff and erosion leading to less sediment, nutrients, and other pollutants in nearby surface waters

Erosion-resistant cover strips act as buffers against wind and help filter polluted runoff

Increased infiltration of runoff

Description:

Strip cropping is the practice of growing alternating crops in a systematic arrangement across a field. Plantings used in strip cropping alternate between crops that provide protective soil cover with crops that provide limited soil cover. Erosion-resistant, protective cover strips effectively work as individual buffer strips, and this alternating arrangement of strip cropping can be extremely effective at reducing soil erosion from water and wind, protecting growing crops from damage by wind-borne soil particles, and reducing dust emissions. In addition, by reducing the transport of sediment and other sediment-bound contaminants, strip cropping can help improve water quality. Soil quality and crop growth can also be improved, as the practice of strip cropping can increase infiltration rates and increase available soil moisture. Using legumes in rotations can also contribute soil nitrogen and improve plant growth.

Criteria:

Strip cropping can be used on cropland or other land where crops are grown. Crops should alternate between crops that provide protected soil cover and those that provide limited soil cover. No two adjacent strips should be in a simultaneous erosion-susceptible condition; however, adjacent strips can have simultaneous erosion-resistant cover. Erosion-resistant strips should consist of crops or crop residues that provide the needed protective cover. Acceptable protective cover crops include grasses, legumes, standing stubble, or residue that provides a significant amount of protective cover. In addition, vegetation used for erosive-resistance strips should be tolerant to or protected from herbicides that are used on the alternate adjacent strips.

Strip cropping can also be used where sheet and rill erosion is a concern on sloping lands. Similar to contour farming, when used on hills or slopes, strip crops should be laid out on the contour or laterally across the general slope. In addition, where wind erosion is an issue, it is recommended that strips be laid out as close as possible to perpendicular to the prevailing wind direction. Windbreaks and other wind barriers can also be utilized around the crops to prevent wind erosion.

Strip cropping is most effective when used in combination with other practices in a resource management system. The effectiveness is maximized when the strips are aligned parallel to each other, as close as possible to the contour of the land and when the strips are oriented as close as possible to perpendicular to the prevailing wind direction. Strip widths should be based on the planning objective and the predicted

BMP 2: Strip Cropping

Criteria Continued:

amounts of erosion, but can be adjusted, within the limits of the criteria, to accommodate the widths of farm equipment to prevent crop or soil disturbance. In addition, when field contours become too sharp for machinery to stay aligned with the strips, it is recommended that sod turn strips be established at the ridge points to allow machines to turn without disturbing the soils or the establishing crops. Strip crops should never be plotted on slopes that are longer than the critical slope length unless they are supported by other practices that can reduce slope length to a distance below the critical level, such as diversions or terraces. In addition, critical slope lengths can be maximized by using residue management practices to retain as much residue as possible on the soil surface. When strip cropping is used in combination with these practices, the strips should be coordinated with and parallel to the diversions or terraces grades, spacing, and contours.

Maintenance:

Specification for the installation and maintenance should be prepared and followed for each field of strip crops. To maintain practice effectiveness, sediment accumulations along strip edges should be smoothed or removed and distributed over the field as necessary. All farming operations should also be done parallel to the strip boundaries, and if chemicals, such as fertilizers, pesticides, or herbicides, are used, the application, storage, and disposal of these chemicals should be performed in such a way that does not compromise local ground and surface water quality.

If headlands are in permanent cover, vegetation should be renovated, repaired, and reseeded as needed to keep the ground cover above 65 percent. Any grassed swales or sod turn strips utilized with strip cropping may also need weeding and mowing and should be examined for barren or eroded areas and reseeded as necessary. In addition, if windbreaks or other wind control methods are utilized, they should be maintained, repaired, and replaced as needed. Erosion-resistant strips used in rotation should also be managed to maintain the vegetative cover and surface roughness, especially in periods when fields are most susceptible to wind erosion.

References:

Stripcropping: Code 585. 2005. Natural Resources Conservation Service.
http://efotg.sc.egov.usda.gov/references/public/WY/Stripcropping_(AC)_(585)_Standard.pdf

Strip Cropping. Carman, D. SERA-17, USDA NRCS Little Rock, AR, and University of Tennessee Extension.
http://www.sera17.ext.vt.edu/Documents/BMP_strip_cropping.pdf

Strip Intercropping. Ghaffarzadeh, M. 1999. Iowa State University Extension Publication PM1763.
http://www.extension.iastate.edu/publications/pm1763.pdf

BMP 3: Cover Cropping

Photo of a cover crop of clover in an orchard. Source: NRCS

Establishing seasonal or permanent crops on areas that would otherwise be bare soil after harvest in order to help reduce erosion from wind and water.

Water Quality Benefits

Decreased runoff and erosion leading to less sediment, nutrients, and other pollutants in nearby surface waters

Decreased velocity and volume of runoff

Increased infiltration of runoff

Increased uptake of excess nutrients

Description:

Cover crops are composed of close-growing grasses, legumes, forbs, or other herbaceous plants that are established for seasonal or permanent protection and soil improvement. The practice of cover cropping is often applied when the major crops do not furnish adequate cover, after harvest, or during the winter months. Usually they are planted annually but can be used as permanent cover. By providing a vegetated soil cover and reducing the amount of exposed soil particles, cover cropping can reduce soil erosion from wind and water. In addition, by reducing erosion and reducing the transport of sediment and other sediment-bound contaminants, cover cropping can help improve water quality.

Cover crops can also improve water quality by reducing the velocity and volume of runoff and by increasing infiltration rates, thereby promoting the infiltration of runoff and excess nutrients and preventing pollutants and excess nutrients from reaching natural waters. Cover cropping can also improve air quality, as plants can sequester carbon and plant cover can reduce air-borne particulate emissions. In addition, cover cropping can improve soil quality as cover and green manure crops can add organic material to the soil and manage soil moisture. In particular, using legumes or legume grass mixtures as cover crops can promote biological nitrogen fixation and improve plant growth. Cover crops can also benefit wildlife by providing habitat and supplemental forage.

Criteria:

Cover cropping can be applied on any land that requires vegetative cover for natural resource protection. Selected crop species should be adapted to local soils and climate and should be suitable to for all planned purposes and site conditions. Crop selection can be tailored to meet specific, desired objectives. However, plant species and seeding and planting methods should be consistent with all approved local criteria, and selected species should be compatible with nutrient and pest management objectives.

In general, it is recommended to use rapidly growing plants, such as small grains or annual grasses, as temporary cover crops. In addition, green manure crops, or leguminous crops that have a symbiotic relationship with nitrogen-fixing bacteria, are recommended as they can enrich the soils with nitrogen which can benefit succeeding crops. Deep-rooted species are also recommended for use as cover crops, as they can maximize nutrient recovery, and although not recommended, fertilizer can be utilized if needed to increase the effectiveness of cover plants.

BMP 3: Cover Cropping

Criteria continued:

Temporary cover crops used in alternation with harvested crops, should be actively growing as long as feasible to maximize plant growth while allowing time to prepare the field for the next crop. Crops should be established as soon as possible after harvest and should be terminated by frost, mowing, tillage, harvest, or herbicides in preparation for the subsequent crop. In addition, if herbicides are used with temporary cover crops, they should be compatible with the following crop. It is also not recommended to use plant species that can attract potentially damaging insects as cover crops.

Permanent cover crops, also referred to as conservation crops, do not need removal, and the selection of native plant species as permanent cover crops is recommended, as they are adapted to local site conditions and can be beneficial for native wildlife. The native plant community of a site can also be re-established to serve as a permanent cover crop as long as it meets the desired objectives. In general, plant species used for permanent cover crops should always be suited for desired resource management objective.

Maintenance:

Specifications for establishment and maintenance requirements should be prepared and followed for each cover crop. Establishment plans should include recommended species, seeding rates and dates, establishment methods, and removal methods and dates for temporary cover crops. Crops and adjacent areas should be monitored to ensure early detection and control of invasive plants. In addition, mowing and other maintenance measures may be necessary throughout to control noxious weeds and to reduce resource competition from invasive species. However, if pesticides are used to control weeds, it should be done on a spot basis to protect vegetation and wildlife, and in general, if any chemicals, such as fertilizers, pesticides, or herbicides, are used, the application, storage, and disposal of these chemicals should be performed in such a way that does not compromise local ground and surface water quality.

Mowing and other harvesting operations should also be done in a manner which minimizes the generation of particulate matter. In addition, if wildlife habitat enhancement is a desired objective for a permanent cover crop, maintenance activities should avoid disturbing cover during the reproduction period of the target species. Management and maintenance activities, such as mowing or prescribed burning, can also be rotated throughout the managed area to maximize habitat diversity.

References:

Conservation Cover: Code 327. 2011. Natural Resources Conservation Service.
http://efotg.sc.egov.usda.gov/references/public/WY/Conservation_Cover_(AC)_(327)_Standard.pdf

Cover Crop: Code 340. 2009. Natural Resources Conservation Service.
http://efotg.sc.egov.usda.gov/references/public/WY/Cover_Crop_(AC)_(340)_Standard.pdf

Cover Crops. 2009. Schomberg, H. and K. Balcom, Contributors. Soilquality.org website collaboration between the NRCS East National Technology Support Center, NRCS National Soil Survey Center, ARS National Laboratory for Agriculture and the Environment, NCERA-59 Scientists, and Department of Natural Resources and Environmental Sciences, University of Illinois at Urbana-Champaign.
http://soilquality.org/practices/cover_crops.html

Cover Crop Fundamentals. Sundermeier, A. Ohio State University, Department of Horticulture and Crop Science Fact Sheet AGF-142-99.
http://ohioline.osu.edu/agf-fact/0142.html

BMP 4: Contour Farming

Photo of a contoured field. Source: NRCS

Cultivating crops laterally across slopes as a means to reduce the amount of runoff and erosion.

Water Quality Benefits

Decreased runoff and erosion leading to less sediment, nutrients, and other pollutants in nearby surface waters

Reduced velocity and volume of runoff

Sediment capture

Increased infiltration of runoff

Description: Contour farming is the practice of tilling, planting, cultivating, and harvesting crops laterally across slopes as a means to reduce runoff and sheet and rill erosion. Downslope runoff can be intercepted and redirected by using ridges and furrows formed by crop farming operations. Farming on the contour also reduces velocity and volume of runoff, as the ridges and furrows block water movement, promote infiltration, and prevent soil particles from moving.

The practice of contour farming benefits water quality by reducing slope runoff and preventing the transport of sediment and its associated contaminants. In addition, by increasing infiltration rates, more pesticides or nutrients can be infiltrated into the soils instead of being transported and introduced to natural waterbodies. Increased infiltration of water and nutrients can also promote better crop growth and soil tilth.

Criteria: Contour farming can be applied on sloping land where annual crops are grown. Several other factors influence how effective contour farming is at reducing soil erosion. Row grade, ridge height, slope steepness, slope length, rainfall amounts, and soil type are all factors that can influence the effectiveness of the practice. Crop rows should have a sufficient grade to ensure that water does not pond and cause crop damage. However, crop rows should also not have too steep a grade, as it would override the effectiveness. In addition, the minimum ridge heights vary upon the spacing between rows. For row spacing greater than 10 inches, the minimum ridge height should be 2 inches, and for row spacing for 10 inches or less, the minimum ridge height should be 1 inch. In general, the greater the ridge height, the more effective the operation is in slowing overland flow.

Contour farming is most effective on slopes that are between 2 and 10 percent. The practice is not well suited to areas with rolling topographies that have a high degree of slope irregularity because it makes it difficult to meet grade criteria. Slopes are also recommended to be no longer than 400 feet, as the volume and velocity of sheet flow may exceed the capacity of the contour ridges on slopes greater than 400 feet long. In addition, the closer the row grades are to the true contour of the land, the greater the erosion reduction. Contour farming can also be used in conjunction with diversions, terraces, and contour buffer strips to ensure the reduction of slope runoff and erosion. If used in conjunction with these practices, all tillage and planting should be done parallel to the contour baselines, diversions, terraces and buffer strips.

BMP 4: Contour Farming

Criteria Continued: Diversions, terraces, or buffer strips can also serve as markers and field boundaries. However, where these practices are not used in conjunction with contour farming, other identifiable, continuous markers should be utilized to mark the key contour baseline. Contour markers can be defined by an unharvested crop row left near the original contour baseline, an established permanent strip of grass, a field boundary, or another type of permanent, lasting marker. Markers should be established on grades that when followed to establish crops, will maintain crop rows at designated grades. Farming operations should also always begin on the contour baselines, following the baselines in a parallel pattern. When contour row curves become too sharp for machinery, it is recommended that sod turn strips be established at the ridge points to allow machines to turn without disturbing the soils or the establishing crops.

Maintenance: Several of the maintenance needs required for contour farming focus on maintaining contour baselines, markers, and boundaries. Whether using a diversion, terrace, grass strip, or other means of marking, the methods should all be inspected, maintained, and repaired as necessary. Grass strips, sod turn strips, or other vegetated buffer strips may need weeding and mowing and should be examined for barren or eroded areas and reseeded as necessary. If a marker is completely lost, the contour baseline should be re-established following the prior applicable criteria. In addition, if chemicals, such as fertilizers, pesticides, or herbicides, are used, the application, storage, and disposal of these chemicals should be performed in such a way that does not compromise local ground and surface water quality.

References: Contour Farming: Code 330. 2008. Natural Resources Conservation Service. http://efotg.sc.egov.usda.gov/references/public/WY/Contour_Farming_(AC)_(330)_Standard.pdf

BMP 5: Residue Management

Photo of cropland with corn residues from past year. Source: NRCS

Utilizing crop residues to protect cultivated fields during critical erosion periods.

Water Quality Benefits

Decreased runoff and erosion leading to less sediment, nutrients, and other pollutants in nearby surface waters

Reduced velocity and volume of runoff

Captured sediment and other pollutants

Increased infiltration of runoff and excess nutrients.

Improved soil aggregation and soil tilth

Description:

The practice of residue management utilizes plant residues to protect cultivated fields during critical erosion periods. By managing the selection, amount, orientation, and distribution of crop and other plant residues on the soil surface, crop residues can be used to help croplands retain moisture and reduce erosion. Residue cover can help protect and stabilize soils, thereby preventing excessive sheet and rill erosion, splash erosion, and wind erosion. By reducing erosion, the transport of sediment and sediment bound chemicals can also be greatly reduced and water quality can be improved.

Properly managed residue can also slow and capture runoff, allowing for increased infiltration and enhancing the utilization of applied nutrients and pesticides. In general, crop residues can help intercept nutrients and chemicals, making them less available for transport to surface or ground waters. In addition, crop residue can increase the microbial and bacterial action on or near the soil surface and can promote soil aggregation and improve soil tilth. This can lead to increased soil productivity and higher crop yields with lower input costs. Crop residue can also help trap and retain moisture from snow and can provide food and escape cover for wildlife.

Concentrated crop residue, however, can sometimes hinder plant growth, as it can reduce seed to soil contact and block sunlight from reaching the soil surface. This, in turn, can slow seed germination and crop development. Managed tillage operations, also called conservation tillage, can help break up concentrated crop residues and in general can reduce residue cover in the field. When used with residue management, conservation tillage practices should minimize soil disturbance and leave approximately 30 percent of the field surface covered by crop residue after planting. Conservation tillage systems can include no-till, ridge-till, or mulch-till systems, but regardless of which system is utilized, they should all leave at least the minimum residue coverage.

Criteria:

Residue management can be applied to any cropland. Residue should be uniformly distributed over the entire field, and if utilizing crop residues, farming machines used for harvesting should be equipped with spreaders capable of distributing new residues. Approved erosion prediction technology should also be utilized to determine the amount of residue needed to meet desired erosion reduction objectives. Residue can be partially removed by means such as baling or grazing, but these methods should be limited to retain the amount of residue needed to meet the desired objective.

BMP 5: Residue Management

Criteria cont'd:

In addition, excess removal of plant residue by baling or grazing can often have negative impacts on resources; therefore, the impacts of baling or grazing on soil, water, animal, plant, and air resources should be fully evaluated before using these methods for residue removal.

Tillage methods used with residue management should be those which minimize the loss of surface residue cover and maintain the planned cover conditions. In addition, if using crop residue to manage snow to increase plant available moisture, stubble should be left standing as high as possible after harvest and should be maintained in a standing orientation over the winter season in order to trap and retain snow. The effectiveness of stubble to trap snow increases with stubble height.

The amount of crop residue produced can be influenced by the type of crop planted. If a high amount of crop residue is necessary for a certain desired objective, high residue producing crops or crop varieties that provide long-lasting residue can be selected. In addition, cover crops can be utilized, and plant populations and row spacing can be adjusted to enhance the amount of crop residue produced. Residue management is often used in conjunction with crop rotation, allowing for the selection of a crop sequence that frequently renews the residue cover.

Maintenance:

There are few maintenance requirements for the practice or residue management. However, it is useful to estimate and measure the amount of crop residue in the field and the subsequent crop's productivity. These measurements can be used to determine the benefits of residue management and can help provide guidelines for any beneficial adjustments in the amounts or type of managed residue. In addition, when applying nutrients or pesticides to a cropland with managed residue, crop residues should be factored in when calculating proper timing and placement of nutrients or chemicals, as residues can alter the timing and amount of nutrient and chemical uptake by plants.

References:

4.2 Crop Residue Management. *Production Management*. Agricultural Resources and Environmental Indicators.
http://www.ers.usda.gov/publications/arei/ah712/AH7124-2.PDF

Residue Management, Seasonal: Code 344. 2007. Natural Resources Conservation Service.
http://efotg.sc.egov.usda.gov/references/public/WY/Residue_Management,_Seasonal_(AC)_(344)_Standard.pdf

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http://extension.missouri.edu/p/G1650

Nutrient Management: Residue Management. 2002. Iowa State University Extension.
http://www.extension.iastate.edu/Publications/NMEP4.pdf

Residue Management & Cultural Practices. 2009. Iowa State University Extension.
http://www.extension.iastate.edu/publications/pm1901a.pdf

BMP 6: Nutrient Management

Photo of nitrogen application on growing corn. Source: NRCS

Properly managing the application of nutrients and soil amendments in order to successfully grow crops while preventing nutrient pollution of surface and ground water.

Water Quality Benefits

Reduced nutrient loading to surface and ground water

Proper utilization of manure

Maintained or improved soil conditions

Description:

In order to successfully grow and produce a crop, plants must receive sufficient and proper nutrients at correct times and in appropriate amounts. The practice of nutrient management involves properly managing the amount, source, placement, form, and timing of the application of plant nutrients and soil amendments. Nutrient management not only can help attain optimum production levels but can also protect water quality and reduce input costs. By carefully managing nutrients and preventing the over-application of fertilizers and manure, the amount of excess nutrients lost to stormwater runoff can be greatly reduced, thereby reducing the amount of nonpoint source pollution from cropland and improving local water quality. In addition, by applying and using less fertilizer, costs can be reduced. Soil tilth and organic matter can also be improved by correctly applying fertilizer and manure, and air quality can be improved by reducing nitrogen emissions and reducing the formation of atmospheric particulates.

Criteria:

The practice of nutrient management applies to any land where nutrients and soil amendments are applied. In order to successfully carryout the practice of nutrient management, a nutrient management plan should be developed that provides a comprehensive strategy for addressing nutrient input needs. The plan should provide information on site conditions, crop requirements, nutrient source and availability, and proper timing, amount, and method of nutrient application. In addition, both a nutrient budget that considers all potential sources of nutrients and a realistic yield goal that is based on local conditions should be established in the nutrient management plan. The amount of nutrients lost to erosion, runoff, and irrigation should also be addressed.

In general, it is necessary to have a good understanding of crop requirements, soil types, and sensitive areas on or near croplands in order to create an effective nutrient management plan. Timing and method of nutrient application should correspond as closely as possible with plant nutrient uptake characteristics to ensure that the maximum amount of nutrients are properly taken up by plants or stored in the soil. Landowners should use caution when applying manure to frozen cropland where land is steeply sloped and runoff of nutrients to surface water is likely. For this same reason, the application of nutrients under rainy conditions or when soils are fully saturated should also be avoided. Similarly, the application of nutrients to very shallow soils or to exposed bedrock should be avoided to prevent ground water contamination. Nutrient planning should be based on current soil and tissue test results developed in accordance with or recognized by the University of Wyoming.

BMP 6: Nutrient Management

Criteria continued:

Soil and plant tissue testing can provide essential information for determining a crop's exact nutrient needs. Recommended nutrient application rates should also be based on the Guide to Wyoming Fertilizer Recommendations. In addition, the use of other cropland erosion and runoff reduction practices, such as the BMPs discussed in this manual, is highly recommended to help minimize nutrient contamination of surface and ground waters.

Maintenance:

The practice of nutrient management requires safe and proper operation and maintenance needs. Nutrient management plans should be periodically reviewed and adjusted or modified as needed. Nutrient budgets should also be reviewed annually to determine if any changes are needed for the next planned crop. Several factors should be documented and recorded in order to develop the most effective plan; the rates, dates, sources, and methods of nutrient application should be recorded, along with the weather and soil conditions at the time of application and the types of crops planted. Record keeping is an important part of nutrient management plans as it provides the data necessary to make informed decisions about any changes that need to be made to increase nutrient application efficiency. Keeping records of nutrient applications and results can greatly help maximize the effect of nutrient applications and minimize any unnecessary or excessive uses.

Utilized nutrients should be stored, handled, and disposed of in such a way that does not compromise surface or ground water. Any utilized fertilizer or organic by-product should be stored in suitable secure containers in proper storage facilities that protect against weather and any accidental leakage or spillage. Storage facilities should be located away from wells, highly permeable areas, or any surface waterbodies and should be annually inspected to ensure safety. In addition, the application equipment should always be properly maintained and calibrated to prevent leaks and spills and to ensure the uniform distribution of nutrients.

References:

4A: Nutrient Management. *National Management Measures for the Control of Nonpoint Pollution from Agriculture.* 2003. EPA 841-B-03-004. U. S. Environmental Protection Agency, Office of Water, Washington, D.C.
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http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1046433.pdf

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http://uwadmnweb.uwyo.edu/SOILFERT/

Guide to Wyoming Fertilizer Recommendations. Blaylock, A., K. Belden, and H.W. Hough. 1996. University of Wyoming Cooperative Extension Service Publication B-1045.
http://uwadmnweb.uwyo.edu/soilfert/Pubs/Blaylock_etal_1996.pdf

BMP 7: Pest Management

Photo of pesticide application on crop. Source: NRCS

Properly managing weeds, insects, diseases, animals, and other pests in order to maintain healthy crops at high yields while minimizing negative impacts to natural resources.

Water Quality Benefits

Reduced pesticide and herbicide contamination of surface and ground water

Aquatic life protected from harmful chemicals and minimized entry of chemicals into food chains

Health of riparian habitats protected

Description:

The practice of pest management encompasses the utilization of prevention, avoidance, monitoring, and suppression techniques to manage weeds, insects, diseases, animals, and other pests. When properly implemented, pest management can help maintain healthy crops with high yields, while minimizing the negative impacts of pest control on water, soil, and air quality.

One vital component of pest management is the practice of integrated pest management (IPM). IPM is an approach aimed at reducing pesticide use to the minimum quantity while ensuring high quality crops and protecting human health and environmental quality. IPM bases its selection of suitable pest control methods on the predicted economic, ecological, and sociological consequences, and it strives to avoid using chemical pesticides. Pesticides are only utilized in IPM when pest populations exceed economic thresholds and when alternative methods are not appropriate or not available.

Pests can be suppressed in various ways, including biological, physical, cultural, and chemical controls. Biological pest controls utilize natural enemies, including predators, parasites, and diseases, to help keep pest populations in check, while physical pest controls utilize physical barriers, such as netting or screening, to exclude pests from crops. Cultural pest controls utilize various farming practices to impact pest populations. For example, alternating crops of different families can prevent weed growth and break up pest cycles. In addition, crop sites and crop varieties can be selected based on how unfavorable or how resistant they are to certain pests. Chemicals, such as pesticides and herbicides, can also be used to control pest populations, but if utilized, should be managed and applied in a safe and efficient manner that prevents surface and ground water contamination and minimizes any other environmental impairment that the chemicals may cause.

In general, by emphasizing the use of natural pest controls and non-chemical pest management tactics and by carefully managing the chemical pesticides that are used and preventing the over-application of pesticides, the amount of harmful pesticides lost to stormwater runoff can be greatly reduced, thereby reducing the amount of nonpoint source pollution from cropland and improving local surface and ground water quality.

Criteria:

The most effective way to handle environmentally sensitive pest control is to develop and implement a pest management plan that evaluates past and present pest problems, along with site conditions.

BMP 7: Pest Management

Criteria continued:

Pest management plans should also evaluate, select, and implement any suitable alternative pest management strategies, and if any chemical pesticides are used, they should be selected, applied, handled, and stored in such a way that does not compromise surface or ground water quality.

When using chemicals for pest control, the use of mitigating practices such as filter strips can limit potential water contamination. Pesticide use should be avoided in areas that are susceptible to surface or ground water contamination, and application before a heavy rain or during windy conditions is not recommended. Any transfer, mixing, loading, and unloading of chemicals should always be performed at least 100 feet down-gradient of any wells or surface waterbodies, and any pesticide storage buildings should located far down-gradient from any surface waterbodies or wellheads. Chemical mixing, storing, and equipment rinse stations should be set on impervious ground or pads to contain any accidental spills and facilitate clean-up. All stations and storage facilities should also have proper posted warning signs.

In general, the environmental risks of any pest management practice should always be evaluated, and any implemented method should comply with all Federal, State, and local regulations. Several resources can be protected simply by carefully reading and following the pesticide label instructions. An applicator's license, either commercial or private, is required for the application of many chemicals. It is important to have the appropriate applicator license(s) before using these chemicals. The WDA is responsible for the regulation of pesticides through the registration, training, and certification of applicators. Please see the WDA Pesticide Program website for more information.

Maintenance:

The practice of pest management requires various maintenances needs. Pest management plans should be periodically reviewed and updated in order to incorporate new technology, respond to crop and pest changes, and avoid the development of pest resistance. Record keeping and data collection of field, crop, and pest information in particular is vital for developing informed pest management decisions. Keeping records of pesticide applications and results can greatly help maximize the effect of pesticide use and minimize any unnecessary or excessive uses.

Pesticide application equipment should always be properly calibrated and maintained to ensure proper pesticide application rates. Calibration rates should be checked and recalibrated as necessary before each seasonal use and with each major chemical change. Sprayer equipment should also be regularly maintained, and any worn nozzle tips, cracked hoses, or faulty gauges should be replaced. Storage facilities should be closed and locked at all times, and pesticides and pesticide containers should be properly disposed of in accordance with the label directions and in adherence with all Federal, State, and local regulations. In addition, any mitigation techniques utilized should be maintained in order to ensure continued effectiveness.

Natural pest control methods also require some maintenance. For example, when using physical controls, barriers and netting must be inspected, maintained, and replaced as necessary. Beneficial species used for biological control should be monitored and their populations should be regulated to meet desired objectives.

BMP 7: Pest Management

Maintenance continued:

Beneficial species populations can be encouraged by providing shelter and food sources, by fostering and maintaining their natural habitats, and by selecting and applying pesticides in a way that will have minimal negative effects on the beneficial species. Cultural pest control methods also require maintenance and often use maintenance activities, such as mowing or prescribed burning, to achieve pest control objectives. Contact the Wyoming Weed and Pest Council or a local Weed and Pest District for additional information about pest management.

References:

4B: Pesticide Management. *National Management Measures for the Control of Nonpoint Pollution from Agriculture.* 2003. EPA 841-B-03-004. U. S. Environmental Protection Agency, Office of Water, Washington, D.C.
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http://www.epa.gov/pesp/htmlpublications/ipm_fact_sheet.html

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http://efotg.sc.egov.usda.gov/references/public/WY/Integrated_Pest_Management__AC___595__Standard_Update_Jan_2012.pdf

Pesticide Program Website, Wyoming Department of Agriculture.
http://wyagric.state.wy.us/divisions/ts/sections-a-programs/148

BMP 8: Irrigation Water Management

Photo of gated pipe irrigation. Source: NRCS

Properly managing and controlling the application of irrigation water in a planned, efficient manner in order to reduce the volume of irrigation runoff and return flow.

Water Quality Benefits

Decreased runoff and erosion leads to less sediment, nutrients, and other pollutants in nearby surface waters

Improved overall system efficiency conserves water

Reduced leaching of pollutants into ground water

Description: Irrigation water management involves the control of the volume, frequency, and application rate of irrigation water in a planned, efficient manner. The goal of this management measure is to reduce nonpoint source pollution caused by irrigation. Pollutants collected by the irrigation waters that are not consumed by crops can become concentrated in the soil, in the seepage, or in the runoff, and can thus contaminate surface and ground waters. Irrigation water management aims to prevent water contamination by finding ways to operate the irrigation system so that the timing and amount of irrigation water applied will match crop water needs. Proper irrigation scheduling can help reduce the amount of irrigation runoff, thereby reducing the transport of pollutants to nearby surface waters. The practice of irrigation water management also works to prevent surface water contamination by controlling any runoff created by irrigation systems and to prevent ground water contamination by minimizing deep percolation.

Along with helping improve water quality, implementation of irrigation water management can help conserve water supplies by optimizing the use of available water and can help improve producer net returns by managing soil moisture to promote the desired crop response. The proper application of irrigation water management can reduce the waste of irrigation water, improve water use efficiency, and reduce the total pollutant discharge from an irrigation system. In addition, this practice can help minimize irrigation induced soil erosion and can improve air quality by maintaining soil moisture to reduce the amount of airborne particulate matter.

Criteria: Five basic aspects of an irrigation system should be addressed for successful irrigation water management: irrigation scheduling, efficient application of irrigation water, efficient transport of irrigation water, use of runoff or tailwater, and management of drainage water. The accurate measurement and determination of flow rate is also a critical component of proper irrigation water management. Although it is not required to implement all of these practices, the application of one or more of these practices has been found by the EPA to help successfully achieve irrigation water management.

Proper irrigation scheduling is a key component in irrigation water management. Determining the most appropriate time and amount of irrigation water to apply is essential in the irrigation management process, as it can increase the likelihood that applied water will match crop needs and minimize water loss.

BMP 8: Irrigation Water Management

Criteria continued:

Irrigation scheduling involves the application of irrigation water based on a systematic monitoring of crop soil-moisture requirements. It should be based on the daily water use of the crop, the water-holding capacity of the soil, the lower limit of soil moisture for the crop, and the volume of water applied to the field. Natural precipitation patterns should also figure in the scheduled irrigations.

Irrigation water should be applied in a manner that ensures efficient use and distribution and that minimizes runoff, deep percolation, and soil erosion. The method of irrigation employed should always be carefully selected based on the type of crop grown, the topography of the cropland, and the soil type. Water should be uniformly applied at rates that minimize the transport of sediment, nutrients, and chemicals to surface or ground waters.

Transporting irrigation water from the supply source to the field irrigation system can be a significant source of water loss and can cause degradation to both surface and ground water. Therefore, irrigation water management plans should emphasize the use of efficient methods of water transportation that minimize evaporation, seepage, and flow-through water losses from canals and ditches.

In addition, water can be conserved and water use can be optimized by capturing and utilizing excess runoff and tailwater to provide additional irrigation needs. Tailwater recovery systems are actually required for surface irrigation methods that necessitate runoff or tailwater as part of their operation. The practice of tailwater recovery entails providing a facility to collect, store, and transport irrigation tailwater for reuse in the irrigation distribution system. Total drainage systems are also essential in the planning and design of efficient irrigation systems, as there are several practices that can help manage drainage water and can thereby help prevent any water quality degradation caused by drainage water.

When chemigation, or the application of fertilizers, pesticides, or other chemicals through irrigation water, is used in conjunction with irrigation systems, extra precautions should be taken to prevent chemigated waters from contaminating surface or ground waters. The amount of harmful chemigated waters that discharge from the edge of the field should be minimized, backflow preventers should be included for wells, and deep percolation should be controlled and minimized. Nutrient and pest management techniques should be used to assist with proper chemigation, and as emphasized with these management practices, the scheduling of chemical application should be timed in a manner that reduces excess leaching or runoff. It also should be noted that irrigation can affect the optimal timing and application rate for nutrients and pesticides and should be factored when managing chemical applications.

Maintenance:

In order to successfully implement irrigation water management, regular maintenance and monitoring is necessary. Soil moisture, changes in crop evapotranspiration rates, and changes in soil intake rates should all be monitored, and adjustments should be made to the volume, application rate, or frequency of water application as needed to achieve the intended goals. In general, soil-water depletion volume and the volume of irrigation water should be accurately measure and adjusted to the ideal balance. Systems and practices utilized within irrigation management should also be inspected, maintained, repaired, and replaced as needed to ensure proper operation.

BMP 8: Irrigation Water Management

References:

2.2 Irrigation Water Management. Agricultural Resources and Environmental Indicators.
http://www.ers.usda.gov/publications/arei/ah722/arei2_2/arei2_2irrigationwatermgmt.pdf

4F: Irrigation Water Management. *National Management Measures for the Control of Nonpoint Pollution from Agriculture.* 2003. EPA 841-B-03-004. U. S. Environmental Protection Agency, Office of Water, Washington, D.C.
http://water.epa.gov/polwaste/nps/agriculture/upload/2003_09_24_NPS_agmm_chap4f.pdf

Irrigation Water Management: Code 449. 2010. Natural Resources Conservation Service.
http://efotg.sc.egov.usda.gov/references/public/WY/Irrigation_Water_Management__AC___449__Standard.pdf

Management Measures for Agricultural Sources: Irrigation Water Management. 2010. Polluted Runoff (Nonpoint Source Pollution). U.S. Environmental Protection Agency.
http://www.epa.gov/owow/NPS/MMGI/Chapter2/ch2-2f.html

BMP 9: Vegetated Filter Strips

Photo of a vegetated filter strip. Source: NRCS

Strips of planted vegetation between cropland and surface waters that reduce the amount of pollutants reaching surface waters by filtering and treating polluted runoff.

Water Quality Benefits

Reduced runoff velocity which traps sediment, nutrients, pesticides, and other pollutants

Increased infiltration of runoff

Increased uptake of excess nutrients

Description:

Vegetated filter strips (a.k.a. field borders, contour buffer strips, filter strips, grass buffer strips, grassed filters) are uniformly graded, densely vegetated sections of land that are designed to treat sheet flow runoff from adjacent land. When used for agricultural purposes, they are often situated between cropland/pastureland and environmentally sensitive areas. Vegetated filter strips can have different practice titles depending upon their placement and arrangement in relation to the agricultural field. For example, field border filter strips are established at the edge or around the perimeter of an agricultural field, while contour buffer strips are established around a hill slope or alternated with wider cropped strips along the contour down the slope.

Vegetated filter strips generally treat sheet flow runoff, and the overland flow entering the filter strip should be primarily sheet flow. Concentrated flows should be dispersed to prevent damage to the filter strips caused by gully or rill erosion. Level spreaders can be used to help distribute concentrated flows of runoff evenly across the filter strips. Vegetated filter strips are designed to slow runoff velocities, to trap sediments and other pollutants, and to promote infiltration into underlying soils. Filter strips can provide effective pollutant control, especially for particulate pollutants. In addition, filter strips can help increase carbon storage and provide wildlife habitat and forage.

Although filter strips are often planted with turf grass, native vegetation can also be utilized, and their use can lead to more effective pollutant removal. Native, deep rooted plant species that produce dense foliage are highly recommended as they have the best ability to hold and capture eroded soil during runoff events. In addition, trees and shrubs can be incorporated into filter strips to increase runoff treatment efficiency, protect against wind erosion, provide additional wildlife habitat and forage, and create an aesthetic visual buffer. Filter strips differ from natural buffers in that they are constructed areas, designed specifically for the purpose of runoff control and pollutant and sediment capture and removal. Filter strips are often used in conjunction with other BMPs for runoff pretreatment.

Criteria:

Filter strips should be strategically located to reduce runoff and increase infiltration and ground water recharge. It is recommended that they be located along the downslope edge of the agricultural land, but as mentioned previously, can also be used around the entire perimeter of a field or on sloping cropland in alternation with strip crops. Filter strips can also be used in conjunction with riparian buffers, often located up-gradient and adjacent to the riparian areas.

BMP 9: Vegetated Filter Strips

Criteria continued:

Vegetation for filter strips can consist of either a single plant species or mixture of plant species that are adapted to the local soil and climate. The use of native perennial plant species is highly recommended, as they are already adapted to local site conditions, provide longer periods of resource protection, and are best suited for wildlife habitat enhancement. The use of native species can also reduce the need for the use of fertilizers and pesticides. Chosen plant species should also be tolerant to sediment deposition and to any of the chemicals applied to the adjacent cropland. Filter strips should not be used as access roads, and vehicle, equipment, or livestock traffic should be limited and especially avoided when soils are saturated and susceptible to compaction.

Maintenance:

Adequate maintenance is essential for filter strips to remain effective. Filter strips should be routinely inspected. Inspections should look for signs of erosion, for bare spots, and for other damage to the vegetation cover. Disturbed areas should be reseeded and repaired as necessary, and any gullies and rills that develop in the vegetated buffer strip should be filled and reseeded. Sediment build up should also be removed and redistributed from the filter strips as needed. In addition, it is recommended that sediment be removed from the top of the strip to maintain sheet flow. If a level spreader is utilized, it should be inspected and removed of sediment accumulation.

Vegetation should be mowed or harvested as needed to encourage dense growth, to maintain ideal growing conditions, and to remove excess nutrients or contaminants that may be contained in the plant tissue. Prescribed burning and prescribed grazing may be used to manage filter strip vegetation when approved and if properly implemented. Noxious weeds and invasive plants should be controlled to sustain the effectiveness of the strip. Fertilizers, pesticides, and herbicides should only be used for maintenance of vegetated filter strips if needed and should be applied in such a manner that does not compromise local water quality. In addition, maintenance activities that result in the disturbance of vegetation, such as mowing, harvesting, or weed control activities, should be conducted with caution to avoid harming any potential residing wildlife.

References:

Filter Strips: Code 393. 2005. Natural Resources Conservation Service.
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Vegetated Filter Strip. National Pollutant Discharge Elimination System (NPDES). 2006. U.S. Environmental Protection Agency.
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Contour Buffer Strips: Code 332. 2008. Natural Resources Conservation Service.
http://efotg.sc.egov.usda.gov/references/public/WY/Contour_Buffer_Strip_(AC)_(332)_Standard.pdf

Field Border: Code 386. 2008. Natural Resources Conservation Service.
http://efotg.sc.egov.usda.gov/references/public/WY/Field_Border_(FT)_(386)_Standard.pdf

Field Borders. 2005. Oregon Department of Agriculture, Oregon Association of Nurseries, and Soil & Water Conservation Districts.
http://www.oregon.gov/ODA/NRD/docs/pdf/water/fieldborders.pdf?ga=t

BMP 10: Grassed Swales

Photo of a grassed channel. Source: NRCS

Vegetated channels used to treat and convey runoff at a slow, controlled rate in order to allow time for nutrient absorption and sediment capture.

Water Quality Benefits

Captured sediment is prevented from reaching surface waters

Increased infiltration of runoff

Increased uptake of excess nutrients

Gully erosion prevented

Description:

Grassed swales (a.k.a. grassed channels, grassed waterways, bioswales) are vegetated channels designed to treat and convey stormwater runoff at a slow, controlled rate. Pollutant and sediment removal in grassed channels is primarily accomplished by gravitational settling, filtration through the grass and soil, and infiltration through the subsoil. Grassed swales are often useful when utilized in a series of BMPs as a pretreatment mechanism. Grassed swales differ from filter strips, in that swales are concave, channelized, vegetated systems, whereas filter strips are level-to-gently-sloped vegetated surfaces.

Although vegetation within swales serves to reduce flow velocities, grassed swales should be constructed with a relatively wide, flat bottom to promote slow and even flow rates and to avoid channelization, erosion, and high velocities. Check dams, constructed perpendicular to the direction of flow, can be used within the swale to increase the detention time, allowing for more pollutant removal through settling, filtration, and infiltration. A variation of the grassed swale, referred to as a wet swale, utilizes wetland vegetation to increase pollutant removal. Wet swales are designed to have shallow permanent pools of water at the bottom of the swale that support wetland vegetation.

Criteria:

Grassed swales are applicable in most regions, with the exception of areas with arid climates, where irrigation needs may outweigh benefits, and in areas with extreme cold climates, where ground freezing may decrease effectiveness. When siting a grassed channel, important wildlife habitat and ecological sensitive areas should be avoided and protected. In addition, tall grasses and forbs can be planted along the channel margins to provide wildlife habitat. Grassed waterways should not be used as access roads, and proper equipment and vehicle crossings should be provided to prevent damage. Livestock grazing should also be managed to protect grassed swales. Vegetation should always be established within the channel as soon as conditions permit and should be protected from erosion using mulching, filter fences, temporary diversion structures, or through other erosion control means until the vegetation is fully established. Waterways should have stable outlets with adequate capacities to prevent ponding or flooding. Vegetation for grassed waterways can consist of either a single grass species or mixture of plant species that are adapted to the local soil and climate. The use of native perennial grass species is highly recommended, as they are already adapted to local site conditions and effective at pollutant removal.

BMP 10: Grassed Swales

Criteria continued:

Deep-rooted native grasses can increase swale effectiveness, as deep-roots can increase infiltration rates and stabilize soils. The use of native species can also reduce the need for the use of fertilizers and pesticides. Chosen plant species should be tolerant to sediment deposition and to any of the chemicals applied to the adjacent cropland. Grassed channels can be used in conjunction with vegetated filter strips, with the filter strips lining each side of the channel, to increase pollutant removal efficiency and improve water quality.

Maintenance:

Grassed swales can last an indefinite period of time if properly designed and maintained. A maintenance program should be established to maintain waterway capacity, vegetative cover, and outlet stability. When initially establishing vegetation, channels should be protected from concentrated flows and grazing. Established vegetation should be periodically inspected for damage and repaired and reseeded when necessary. For wet swales, failing wetland plants may also need replacement. Periodic prescribed grazing or mowing of the established vegetation may help improve the grassed channel's function, but livestock can cause soil compaction and damage to swales and should be excluded when possible. Removal of accumulated sediment is also necessary to ensure proper functioning of the grassed waterway.

References:

Grassed Waterway: Code 412. 2005. Natural Resources Conservation Service.
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Grassed Channel (Biofilter Swale). *Structural BMP Specifications for the Massachusetts Stormwater Handbook: Chapter 2.* Vol. 2. 73-76.
http://www.mass.gov/dep/water/laws/v2c2.pdf

Grassed Swales. National Pollutant Discharge Elimination System (NPDES). 2006. U.S. Environmental Protection Agency.
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=75

BMP 11: Riparian Buffers

Photo of a riparian buffer along a creek. Source: NRCS

Established areas of dense vegetation adjacent to natural water bodies, which maintain the integrity of waterways and reduce pollution by preventing streambank erosion and treating polluted runoff.

Water Quality Benefits

Stabilized stream banks and reduced soil erosion

Sediment and other pollutants filtered and captured

Increased infiltration of runoff and uptake of excess nutrients

Temperature of streams and rivers is lowered by the slowing and cooling runoff and provision of shade

Description:

Riparian buffers are established areas of dense vegetation located adjacent to and up-gradient from natural watercourses, waterbodies, and associated wetlands. Riparian forest buffers are comprised of trees, shrubs, and grasses and are managed to maintain the integrity of the waterways and to reduce nonpoint source pollution. Riparian buffers can be used to maintain or improve water quality by preventing streambank erosion and by reducing sediment, organic material, and nutrient loads. Vegetation can help intercept, filter, slow, and cool runoff, increase soil infiltration rates, and stabilize soils, thereby absorbing nutrients and pesticides and preventing excess sedimentation.

Studies have shown riparian buffers to be particularly effective at reducing nitrogen levels in ground water and streams, making them beneficial for treatment of runoff from fertilized cropland. When using riparian buffers as a cropland runoff management practice, locate riparian buffers in areas downslope from the croplands to ensure effectiveness. Riparian buffers are often used in conjunction with other nutrient and sediment control best management practices, such as vegetated filter strips, to increase pollutant removal efficiency.

The use of riparian buffers can also provide terrestrial and aquatic wildlife habitat, can provide food and thermal protection for fish and wildlife, and can help lower or maintain water temperatures by creating shade. The creation or maintenance of a riparian buffer can also help restore riparian plant communities, and it is generally recommended that native plant species be utilized or preserved when creating or maintaining a riparian area.

Criteria:

In order to obtain maximum efficiency, riparian forest buffers should be designed and positioned appropriately to accomplish their intended purpose. The buffer width varies with soil type, vegetation cover, and pollutant load amounts, but in general, the minimum width should be at least 35 feet. In addition, an up-gradient filter strip should be installed adjacent to the riparian buffer. Vegetation for riparian buffers should be carefully selected. Dominant vegetation should consist of existing, native, non-invasive species. The use of native species can also reduce the need for the use of fertilizers and pesticides. Species diversity is very important and recommended to avoid devastation and loss of function from a species-specific pest.

BMP 11: Riparian Buffers

Criteria continued:

Use plant communities that benefit aquatic and terrestrial wildlife and have multiple values. In general, the location, layout, and density of a constructed riparian buffer should complement and mimic natural riparian forests. When the plantings are properly selected and maintained and the practice is used in conjunction with other nutrient and sediment control practices, riparian buffers can be highly effective and low maintenance.

Maintenance:

Riparian buffers should be periodically inspected to ensure proper functioning, and any damaged areas should be repaired as necessary. Riparian areas should be protected from activities that can cause adverse impacts such as heavy vehicle, equipment, wildlife, livestock, and pedestrian traffic, concentrated flows, or fire.

Livestock and wildlife should be controlled or excluded from riparian buffer zones, especially when initially being established. Exclusion fencing and proper stream crossings may need to be installed to ensure controlled access of grazing and browsing animals. Vegetation maintenance, such as removing and replacing dead trees or shrubs, weeding, and controlling undesirable vegetation, should be performed until the desired riparian vegetation has fully established itself and the buffer is fully functional. Even after the riparian area has established itself, vegetation maintenance will be periodically necessary to maintain practice efficiency. Fertilizers, pesticides, and herbicides should be applied in such a manner that does not compromise the local water quality.

References:

Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations. 2005. EPA 600-R-05-118. U.S. Environmental Protection Agency.
http://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=140503

Riparian Buffer Zone. NRCS Planning & Design Manual. Natural Resources Conservation Service.
ftp://ftp-fc.sc.egov.usda.gov/WSI/UrbanBMPs/streams/bank/riparianzone.pdf

Riparian Forest Buffer: Code 391. 2010. Natural Resources Conservation Service.
http://efotg.sc.egov.usda.gov/references/public/WY/Riparian_Forest_Buffer_(391)_Standard.pdf

BMP 12: Diversion Structures

Photo of a diversion structure. Source: Coshocton

Channels constructed to intercept and divert slope runoff to a desired location to prevent erosion.

Water Quality Benefits

Decreased runoff and erosion leading to less sediment, nutrients, and other pollutants in nearby surface waters

Improved ability to establish vegetation on slopes

Reduced velocity and volume of runoff

Description:

Diversion structures (a.k.a. permanent slope diversions) are typically channels with supporting ridges on the downhill side that are constructed in a manner to intercept and divert slope runoff to a desired location. Diversion structures are generally placed laterally across a slope and are designed to prevent slope erosion by collecting the down-slope runoff and redirecting the runoff to outlets that can convey the water without causing erosion. Slope diversion structures intercept surface runoff water, thereby breaking up the length of the slope and preventing water from proceeding downslope at an increasing volume and velocity. Diversion structures can also be used at the top of a slope to prevent down-slope runoff or at the middle or bottom of a slope to intercept and divert excess slope runoff.

Slope diversions can be very effective for erosion control on steep or long slopes. In addition, their use can help promote the successful establishment of vegetation growing on slopes. Permanent slope diversions are often used on slopes where surface runoff water control and management is needed.

Diversion structures can also be used as temporary erosion control measures to divert runoff until permanent management systems can be put in place or until vegetation is able to properly establish itself. In addition, diversion structures are often used to break up a slope and reduce the slope length to a distance below the critical level, making the slope viable for plotting crops.

Criteria:

Diversion structures have few limitations, can be easily modified, and are applicable in all regions where soils and topography are such that the diversion can be constructed and a suitable outlet is available. Diversion structures can be constructed with vegetated swales as channels, which would additionally promote infiltration along with collecting and conveying slope runoff. However, channels do not have to be vegetated and can be constructed with rock or concrete lining. Hardened channels may be more appropriate in arid climates where vegetated swales may be infeasible due to irrigation needs. A diversion in a cultivated field should be aligned and spaced from other structures and practices in such a manner that allows the use of farming equipment.

Diversions are not recommended below areas with high sediment loads, due to potential damaging effects of large amounts of accumulated sediment. Each diversion should have a safe and stable outlet that will convey runoff to a point where outflow will not cause damage. Outlets can be grassed waterways, vegetated areas, sediment basins, stable watercourses, or combinations of these practices.

BMP 12: Diversion Structures

Maintenance: Diversion structures require periodic inspection and maintenance. Frequent inspections should be performed when the diversion structure is first being established, but the demand decreases once stabilized. Established slope diversions should still be inspected regularly, cleared of sediment, and repaired as needed. Accumulated sediment does not always have to be removed, but instead can be redistributed in a way that maintains the capacity of the diversion. Diversion ridge heights and outlet elevations should also be maintained to sustain diversion capacity. If vegetation is utilized, weeding and reseeding may be necessary, and trees and brush should be controlled.

References:

Diversion: Code 362. 2006. Natural Resources Conservation Service.
http://efotg.sc.egov.usda.gov/references/public/WY/Diversion_(FT)_(362)_Standard.pdf

Permanent Slope Diversions. National Pollutant Discharge Elimination System (NPDES). 2006. U.S. Environmental Protection Agency.
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=33

Soil Erosion Control: Structural Methods. *Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates*. 2001. Prepared by Barr Engineering Co. Prepared for the Metropolitan Council.
http://www.metrocouncil.org/environment/Water/BMP/CH3_RPPSoilStructural.pdf

BMP 13: Terraces

Photo of cropland terraces. Source: NRCS

Embankments, channels, or ridges constructed laterally across a slope as a means to intercept runoff and conduct it to a stable outlet.

Water Quality Benefits

Decreased runoff and erosion leading to less sediment, nutrients, and other pollutants in nearby surface waters

Reduced gully erosion

Reduced velocity and volume of runoff

Increased infiltration of runoff and uptake of excess nutrients

Description:

Terraces are earth embankments, channels, or combination of channels and ridges constructed laterally across a slope. Terraces can be somewhat similar to diversion structures in form and purpose, but differ in that the practice of terracing often involves the construction of a series of terrace embankments. Terraces are often constructed as a series of parallel contour terraces across a cropland slope and spaced at designed widths that allow for the effective cultivation of crops with modern farming equipment.

Terracing is used to intercept runoff on moderate to steep slopes. Terraces break up slope length and transform long slopes into a series of shorter slopes, thereby preventing water from proceeding downslope at an increasing volume and velocity. This practice can reduce sheet-and-rill erosion and prevent gully development. Reducing the rate of runoff allows for increased settling of soil particles and therefore can improve water quality by reducing the transport of sediment and its associated pollutants to nearby sensitive waterbodies. Terracing can also help improve water quality by increasing infiltration, which can help reduce the volume of runoff and help capture excess cropland nutrients. Retained runoff and nutrients can in turn help with moisture conservation and improve soil fertility.

Criteria:

Terraces can be applied where soil erosion by water is a problem, where excess runoff and sedimentation is a problem, or where there is a need to conserve water. The soils and topography of the site should allow for terraces to be constructed and farmed with reasonable effort. Terraces should be constructed as parallel as physically practical along the contour of the land. The contours and curves of the terraces should be long and gentle to accommodate farming machinery, and the spacing of the terraces should be methodically determined. When constructing terraces, the short-term construction-related effects on water quality should be considered.

All terraces should have adequate outlets. Vegetated outlets, such as grassed waterways, should convey collected runoff to a point where outflow will not cause damage, and outlets should be installed and vegetated before the construction of the terrace to ensure vegetation establishment and to help reduce any excessive sedimentation caused by the initial construction of the terraces. Underground outlets can also be used on gradient or level terraces, but must meet all the specified requirements and should be installed deep enough to prevent damage from tillage

BMP 13: Terraces

Criteria continued: equipment. Soil infiltration can be used as the outlet for level terraces, but soil permeability should permit drainage within a reasonable period of time so that crops are not significantly damaged by standing water.

Maintenance: Terrace capacity, storage, ridge height, and outlets all need to be maintained for proper functioning of this this practice. Sediment build-up in terrace channels should be removed or redistributed to maintain the required water-retaining capacity, and any section of the terrace that has eroded or has excessive settlement should be repaired and reseeded as needed. If utilizing underground outlets, the inlets for these outlets must be kept clean and removed of sediment buildup, and any inlet damaged by farm machinery should be replace or repaired immediately.

Any structure within the terrace system that requires vegetation should be vegetated as soon as practicable after construction. The vegetation should be periodically maintained, mowed, weeded, and reseeded, and trees and brush should be controlled by chemical or mechanical means as necessary. In addition, if fertilizers, pesticides, or herbicides are used on vegetated areas, they should be applied in such a manner that does not compromise the local water quality.

References:

Terrace: Code 600. 2000. Natural Resources Conservation Service.
http://efotg.sc.egov.usda.gov/references/public/WY/Terrace_(FT,_M)_(600)_Standard.pdf

Terraces. Carman, D. SERA-17, Natural Resources Conservation Service and University of Tennessee Extension.
http://www.sera17.ext.vt.edu/Documents/BMP_Terraces.pdf

BMP 14: Windbreaks

Photo of a multi-row windbreak. Source: NRCS

Rows of vegetation or constructed structures used to obstruct and slow wind in order to reduce erosion and protect crops.

Water Quality Benefits

Reduced wind erosion reduces amount of sediment deposited in surface waters.

Stabilized soils reduce sediment transport in runoff

Description:

Windbreaks or shelterbelts are single or multiple rows of trees or shrubs in linear configurations that help with dust control by obstructing and slowing the wind near the ground and preventing soil from blowing off site. Windbreaks can help improve water quality and air quality. By preventing wind erosion, windbreaks can reduce the transport of sediment and its associated pollutants and can thereby improve local water quality. In addition, the practice can improve air quality by reducing and intercepting amount of harmful airborne particulates, chemicals, and odors introduced to the atmosphere. Windbreaks can also help protect agricultural operations from damage caused by high winds and wind borne particles.

Vegetated windbreaks can help with managing stormwater runoff by stabilizing soils, slowing runoff, promoting infiltration, and providing some pollutant removal capabilities. Windbreaks can provide other benefits, such as managing snow deposition, providing wildlife habitat, improving irrigation efficiency, increasing carbon storage in biomass and soils, and enhancing aesthetics. Wood board fences and straw bales can also function as wind barriers, but function primarily only to obstruct wind born erosion and manage snow deposition.

Criteria:

Windbreaks can be applied on any lands that require protection against wind erosion and wind damage. Plant species used for windbreaks and shelterbelts should be adapted to the local soils, climate, and site conditions. Native species are the most ideal, as they are already adapted to the local conditions. The use of native species can also reduce the need for the use of fertilizers and pesticides. Planting should be done at a time and manner that ensures the survival and growth of the selected species. The installation of temporary wind control measures may be necessary to protect and ensure initial vegetation establishment and to provide supplemental wind erosion control.

It is also recommended that a diverse variety of species be provided to ensure that a species-specific pest does not cause the complete loss of function of the windbreak. Plant species selection can be tailored to provide additional benefits; for example, if the provision of wildlife habitat is valued, the establishment of plant species that benefit targeted wildlife species should be considered, and if aesthetics are valued, the establishment of evergreen species or other visually pleasing plant species should be considered. Selected plant species should not compete with any adjacent crops for resources and should have minimal adverse effects on adjacent crops and croplands.

BMP 14: Windbreaks

Criteria continued:

To improve their overall efficiency, windbreaks and shelterbelts should be oriented as close to perpendicular as possible to the oncoming winds and snow bearing winds. Windbreaks should not interfere with the operation of the irrigation systems, but can sometimes be designed to help improve irrigation efficiency. For example, windbreaks with vegetation taller than the spray height of a sprinkler irrigation system can help improve the irrigation system's efficiency by blocking overspray.

Maintenance:

Windbreaks should be periodically inspected, maintained, and repaired to ensure proper functioning. Vegetated windbreaks should be protected from activities that can cause adverse impacts, such as heavy vehicle, equipment, livestock, wildlife, or pedestrian traffic, concentrated flows, and fire.

Vegetation maintenance, such as providing supplemental water, thinning and pruning, removing and replacing dead trees or shrubs, and controlling undesirable vegetation, should be periodically performed until the desired vegetation has fully established itself and the windbreak is fully functional. Fertilizers, pesticides, and herbicides should be applied in such a way that does not compromise the local water quality. Other barrier structures, such as fences, should also be annually inspected for damage and repaired or replaced as necessary.

References:

Dust Control: BMP 7. *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties. Volume 2: Erosion and Sediment Controls; Section 4.* 2005. Idaho Department of Environmental Quality Water Quality Division. 38-40.
http://www.deq.idaho.gov/media/616476-7.pdf

Windbreak/Shelterbelt Establishment: Code 380. 2007. Natural Resources Conservation Service.
http://efotg.sc.egov.usda.gov/references/public/WY/Windbreak-Shelterbelt_Establishment_(380)_WY_standard.pdf

Principles of Wind Erosion and its Control. Presley, D. and J. Tatarko. 2009. Kansas State University Agricultural Experiment Station and Cooperative Extension Service Publication MF-2860.
http://www.ars.usda.gov/SP2UserFiles/Place/54300520/419PrinciplesofWinderosionanditscontrol.pdf

BMP 15: Mulching

Photo of mulching used with crop. Source: University of Wyoming

Using organic materials to stabilize exposed or recently planted soil surfaces and to promote infiltration, thereby reducing erosion and runoff.

Water Quality Benefits

Stabilized soils reduce sediment transport in runoff

Reduced velocity of runoff

Temperature of runoff reduced

Increased soil infiltration and reduced volume of runoff

Description:

Mulching is a temporary erosion control practice that uses materials such as straw, grass, hay, compost, wood chips, or wood fibers to stabilize exposed or recently planted soil surface. In addition to decreasing soil erosion by stabilizing soils, mulching can reduce the velocity of stormwater runoff over an area, can cool surface runoff, and can decrease the volume of runoff by increasing infiltration. Mulching can also help retain moisture, thereby conserving water and reducing the need for excessive irrigation.

Mulching is highly recommended and most effective when used in conjunction with vegetation, as it can improve soil conditions and increase soil fertility. When used together with seeding or planting, mulching can assist with plant growth by holding the seed, fertilizers, and topsoil in place, by helping conserve and retain moisture, by increasing soil microbial activity and nutrient uptake, and by insulating against extreme temperatures. Mulching can also protect soil surface from splash erosion and can suppress weed growth. In addition, mulching can retard runoff, trap sediment, and create more favorable conditions for the germination and early development of plants.

Criteria:

Mulching can be applied to any land where mulches are needed. It is often used to provide immediate and inexpensive erosion control in areas with exposed soils where vegetation cannot be established due to season or climate. However, mulches can be used with vegetation, and they are especially recommended on seeded and planted areas with steep slopes or on seeded and planted areas that require moisture retention and insulation from extreme climates or strenuous site conditions.

The selection of mulching materials depends primarily on site conditions and material availability. Mulch should generally be applied after grading, soil surface preparation, and seeding and plantings are completed, and the material should be evenly applied and anchored to the soils. The percent of cover that the mulch should provide varies with the target objective. For example, if mulching is applied to conserve soil moisture, it should provide at least 60 percent cover and should be applied prior to moisture loss, and if mulching is applied to help establish vegetation, it should provide 50 percent cover to provide protection from erosion and runoff while allowing adequate light and air penetration to the seedbed to ensure proper germination and emergence.

The practice of mulching does have some limitations. For example, it can delay seed germination by changing the soil surface temperatures, and some mulch types may absorb nutrients necessary for plant growth.

BMP 15: Mulching

Criteria continued:

In addition, mulch material can sometimes carry disease and undesired plant seeds. Therefore, when using mulch with cropland, it is important to thoroughly research the type of mulch and its effect on vegetation growth. Mulch material should be tested to make sure that it's relatively free of disease, noxious weed seeds, and other pests and pathogens, and mulches should be kept at least 3 to 6 inches away from plant stems and crowns to prevent disease and pest problems. Proper timing of mulch application can also improve the efficiency of this practice.

Mulches themselves are also subject to erosion and can be blown or washed away in high winds or large storms. For this reason, it is recommended to use other BMP practices, such as windbreaks, filter strips, or riparian buffers, in areas downwind or downslope of mulched lands to prevent the transport of mulching materials to sensitive waterbodies. Mulching should generally not be the only control method used for long slopes. Other practices, such as diversions and terraces, should be used alongside mulching to help break up and slow concentrated flows.

Maintenance:

Maintenance of mulching practices is necessary to ensure that the practice provides effective erosion control. Mulched areas should be periodically inspected to identify areas where mulch has been loosened or removed. Damaged or barren areas should be repaired and replaced immediately and may need to be reseeded or replanted before replacing the mulch cover. Undesirable weeds should be monitored and controlled in the mulched areas. In addition, operation of equipment near or on the site should not compromise the intended purpose of the mulch.

References:

Mulching. National Pollutant Discharge Elimination System (NPDES). 2006. U.S. Environmental Protection Agency.
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=41

Mulching: BMP 15. *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties. Volume 2: Erosion and Sediment Controls; Section 5.* 2005. Idaho Department of Environmental Quality Water Quality Division. 56-60.
http://www.deq.idaho.gov/media/616508-15.pdf

Mulching: Code 484. 2005. Natural Resources Conservation Service.
http://efotg.sc.egov.usda.gov/references/public/WY/Mulching_(AC)_(484)_Standard.pdf

BMP 16: Composting

Photo of a large compost pile. Source: Colorado State University.

Uses biological processes to turn organic waste into a product that can be used to improve soil organic matter.

Water Quality Benefits

Increased plant growth and soil cover

Stabilized nutrients in soil prevents transport of excess nutrients to surface and ground water

Conserves and re-uses nutrients

Improved soil structure and organic content

Description: Composting, or the process of controlled and accelerated aerobic biodegradation and stabilization of organic waste, can be used for crop residue and residual plant material from agricultural operations. Agricultural composting can provide several benefits including lowering the risk of pollution by stabilizing nitrogen in an organic form and reducing the transport of excess nitrogen to ground and surface water. In addition, composting can conserve and reuse the nutrients produced on the farm. Composted agricultural waste can be used as an excellent soil amendment, as most of the nutrients contained in the compost are in a stable organic form and are slowly released to crops.

Criteria: To successfully utilize the practice of composting for agricultural waste management, several factors must be considered, such as site selection, carbon-nitrogen ratio, moisture levels, temperature of compost mix, and proper management. Composting is a natural process, but it can be enhanced and accelerated by selecting recipes with proper carbon-nitrogen ratios, by mixing piles to provide proper aeration, and by monitoring piles to assure that the ideal moisture levels and temperatures are maintained. When using compost as a soil amendment for crops, nutrient availability, timing, and rate of application need to be accounted for to ensure successful utilization.

Composting facilities, where active composting will take place, should not be located in areas where there is a potential for ground water contamination, such as areas with shallow water tables or in areas with highly permeable soils. Sites should also be selected and managed to minimize surface runoff water from entering the site and to minimize contaminated runoff spawning from the compost piles. For this reason, facilities should be located outside of floodplains. Any contaminated runoff from composting facilities should always be directed to management facilities for further treatment. Compost facilities should be protected from wind in cold or dry climates to prevent excess drying of the compost materials and to prevent any airborne particulate pollutants from being introduced to the atmosphere.

Maintenance: The practice of composting requires frequent maintenance. An operation and maintenance plan that complies with all regulations and is consistent with the purpose of the practice should initially be developed, and while the practice is ongoing compost piles should be monitored and managed for carbon-nitrogen ratios, temperature, moisture levels, oxygen levels, and odors. Adjustments may be necessary throughout the composting period to ensure that the waste is properly composted and to find the ideal compost “recipe”.

BMP 16: Composting

References:

Composting Facility: Code 317. 2003. Natural Resources Conservation Service.
http://efotg.sc.egov.usda.gov/references/public/WY/Composting_Facility_(NO)_(317)_Standard.pdf

Agricultural Composting Basics. 2005. Ontario Ministry of Agriculture and Food.
http://www.omafra.gov.on.ca/english/engineer/facts/05-023.pdf

Composting to Reduce Weed Seeds and Plant Pathogens. Organic Agriculture. 2011. Cooperative Extension System and University of Wyoming. Author Ed Zaborski.
http://www.extension.org/pages/28585/composting-to-reduce-weed-seeds-and-plant-pathogens

BMP 17: Access Roads

Photo of access road adjacent to cropland. Source: Georgia Soil and Water Conservation Commission

Fixed routes provided for vehicular travel necessary for agricultural operation management as a means to reduce land degradation and erosion.

Water Quality Benefits

Reduced soil erosion

Reduces transport of sediment to nearby surface waters.

Downstream water quality protected.

Description:

Access roads are travel-ways that provide fixed routes for vehicular travel necessary for resource activities involved in the management of cropland, wildlife, livestock, and other conservation enterprises. All access roads should be sited, designed, and constructed in such a way that minimizes erosion and sedimentation and protects adjacent soil, water, cropland, wildlife, and other natural resources.

Access roads are applicable where access is needed from a private or public road to an agricultural or conservation land use enterprise. However, access roads should be kept to a minimum and used only when necessary, and roads that are not needed should be closed and reclaimed when possible. Road types can range from seasonal use, gravel roads that are designed for low speed, infrequent use to all-weather roads that are heavily used by the public.

Criteria:

When planning and designing access roads, environmental values and impacts should be considered. Access roads should be sited in ways that serve the intended vehicular travel-way purpose while avoiding adverse impacts to water quality, air quality, and environmentally sensitive areas. Roads should generally follow the natural contours and slopes to minimize the disturbance of drainage patterns. Access roads should also be located away from watercourses and sited where water management problems are not created. Stream crossings should be minimized, but if necessary, they should be located and constructed in a way that minimizes adverse impacts to riparian vegetation, stream banks, and stream channels.

All access roads should also be designed with proper drainage systems, such as culverts, roadside ditches, or water bars, and where possible, filter strips, or grassed channels should be utilized alongside roadways to provide some stormwater runoff management. The effects of access road construction on downstream watercourses and waterbodies should also be considered, and measures should be taken to minimize erosion and sedimentation. After construction of access roads, road banks, and disturbed areas should be vegetated as soon as possible.

Maintenance:

Proper maintenance of access roads is necessary to minimize erosion and sedimentation. Drainage systems should be inspected and repaired as necessary to maintain their full flow capacity. Gravel access roads may also need occasional re-grading and re-graveling. When vegetated buffer areas, such as filter strips or grassed channels, are used alongside access roads, vegetation cover should be maintained, repaired, and reseeded as necessary.

BMP 17: Access Roads

Maintenance continued:

The use of fertilizers and pesticides on vegetation is not recommended, but if necessary, they should be applied in such a way that does not compromise the local water quality.

References:

Access Road: Code 560. 2011. Natural Resources Conservation Service.
http://efotg.sc.egov.usda.gov/references/public/WY/Access_Road_(FT)_(560)_Standard_2011.pdf

BMP 18: No-Till Farming

Photo of no-till farmland. Source: NRCS

A type of conservation tillage that minimizes soil disruption and reduces soil erosion by leaving crop residue on fields after harvest.

Water Quality Benefits

Decreased runoff and erosion leading to less sediment, nutrients, and other pollutants in nearby surface waters

Increased infiltration of runoff.

Soil productivity can be improved due to increased soil organic matter.

Description:

No-till farming is a type of farming which seeks to minimize soil disruption and entails leaving crop residue on the fields after harvest. No-till farming can be considered a type of conservation tillage. Conservation tillage includes any method of farming that retains enough previous crop residues that at least 30 percent of the soil surface is covered after planting. This residue cover acts as a mulch to stabilize and protect the soil from wind and water erosion. The erosion control provided by a no-till farming system is particularly beneficial on moderately to steeply sloping farm lands that are more at risk of sheet erosion.

Leaving crop residues on the soil surface can also increase water infiltration by helping slow and capture runoff, which, in turn, can help conserve water and enhance the utilization of applied fertilizers and pesticides. By reducing the amount of surface runoff, no-till can help reduce contamination of nearby waterbodies by reducing the transport of sediment, fertilizers, and pesticides. It can also help foster soil productivity by increasing soil organic matter and by improving soil tilth. This can lead to increased soil productivity and higher crop yield with lower input costs. Furthermore, crop residue can help retain moisture from snow melt, provide food and escape cover for wildlife, and increase soil carbon sequestration.

One consideration of no-till farming is that concentrated crop residue can sometimes slow seed germination and crop development by reducing seed to soil contact and blocking sunlight from reaching the soil surface. In addition, no-till farming can require a greater dependency on herbicides and requires a no-till planter or planter modification for successful implementation.

Criteria:

In order to successfully implement no-till farming, specialized no-till seeding equipment is needed. These no-till planters are designed to ensure sufficient seed to soil contact in a residue-covered field. Although special no-till planters can initially be expensive, the cost of running and maintaining other tillage equipment is no longer necessary, which can help offset the initial costs of no-till planters.

No-till farming systems are the most fiscally successful on fields with weeds that can be economically controlled with existing herbicides. Delayed planting may be required, as residue-covered soils often dry and warm up more slowly than fields that use conventional tillage methods. Fields with good drainage are best for earlier plantings and higher yields.

BMP 18: No-Till Farming

Maintenance:

No-till farming initially requires the use of extra nitrogen fertilizer to meet the requirements of some crops. However, once the no-till cropland's soil fertility is fully established, nutrients will be naturally made available through biological processes in the soil. In addition, as mentioned previously, maintenance of tillage equipment will become mostly obsolete, although occasional tillage can be utilized to reduce certain issues that may result from lack of tillage, including soil compaction and pest problems.

High-residue fields can increase the potential for pests and diseases but do not necessarily increase their occurrence. In the absence of tillage, the use of herbicides will be more heavily depended on for weed control. However, more diverse pest and weed management strategies can be employed with no-till farming to prevent herbicide and pesticide resistance. For example, implementing the practice of crop rotation with no-till farming systems is one way to help break weed, pest, and disease cycles.

References:

No-Till: the Quiet Revolution. Huggins, D. R., and J. P. Reganold. 2008. Scientific American, Inc. 70-77.
http://research.wsu.edu/resources/files/no-till.pdf

No-Till Planting Systems. Buchholz, D. D., Palm, E., Thomas, G., and D. L. Pfost. 1993. University of Missouri Extension.
http://extension.missouri.edu/p/G4080

The Real Dirt on No tillage. Clapperton, Jill. Rhizosphere Ecology Research Group. Agriculture and Agri-Food Canada.
http://www.notill.org/KnowledgeBase/03_realdirt_Clapperton.pdf

No-till on the plains.
http://www.notill.org/

Appendix A: State and Federal Agency Resources for Regulatory Requirements

The following lists some common state and federal regulatory requirements, such as permits, that may need to be considered as part of BMP implementation. This list is not intended to be comprehensive and additional local permits or regulations may also apply. Please contact the appropriate government agency for more information. Your local NRCS and/or conservation district may also be able to assist with understanding regulatory requirements associated with BMP implementation (see also Appendix B**).**

Permit/ Regulation	**Description**	**Agency**	**Contact and Website**
WYPDES Storm Water Permits	Some activities require WYPDES permits for storm water discharge, including runoff from large and small construction sites.	Wyoming Department of Environmental Quality, Water Quality Division, WYPDES Program	Barb Sahl 307-777-7570 http://deq.state.wy.us/wqd/WYPDES_Permitting/WYPDES_Storm_Water/stormwater.asp
Temporary Turbidity Waivers	Waiver to authorize temporary increases in turbidity for certain short-term, construction-related activities. Projects working in live waters and activities that may cause an excursion above allowable turbidity levels may qualify for a turbidity waiver.	Wyoming Department of Environmental Quality, Water Quality Division, Watershed Protection Program	Jeff Clark 307-777-6891 http://deq.state.wy.us/wqd/watershed/index.asp#Assure
Clean Water Act Section 404 permits	Any person, firm, or agency (including Federal, state, and local government agencies) planning to work in navigable waters of the United States, or discharge dredged or fill material in waters of the United States, including wetlands, must first obtain a permit from the Corps of Engineers.	United States Army Corps Engineers, Wyoming Regulatory Office	Matt Bilodeau 307-777-772-2300 http://www.nwo.usace.army.mil/html/od-rwy/Wyoming.htm
Section 401 Certifications	The WDEQ Water Quality Division reviews and issues water quality certifications under Section 401 of the Clean Water Act. Section 401 water quality certification is required for any federal license or permit which may result in a fill or discharge into waters of the United States (see Section 404 permits).	Wyoming Department of Environmental Quality, Water Quality Division, Watershed Protection Program	Jeremy ZumBerge 307-675-5638 http://deq.state.wy.us/wqd/watershed/index.asp#401_Certification_

Permit/ Regulation	Description	Agency	Contact and Website
Surface Water Rights Permits	Permits for any request for putting surface waters of the state to a beneficial use: includes transporting water through ditch or pipelines, storage in reservoirs, storage in smaller reservoir facilities for stockwater or wildlife purposes, and enlargements to existing ditch or storage facilities, and for instream flow purposes.	Wyoming State Engineer's Office	John Barnes 307-777-6475 http://seo.state.wy.us/SW/index.aspx
Ground Water Rights Permits	A permit is required from the State Engineer's Office prior to the drilling of all water wells; ground water rights are issued for the same beneficial uses as for surface water rights.	Wyoming State Engineer's Office	Lisa Lindemann 307-777-6163 http://seo.state.wy.us/GW/index.aspx
Pesticide Certification	Training, licensing, certification, and/or inspection of pesticide users, dealers, commercial applicators, and public agencies using restricted use pesticides.	Wyoming Department of Agriculture	Slade Franklin 307-777-6585 http://wyagric.state.wy.us/divisions/ts/sections-a-programs/148
Open Burn and Smoke Management	Vegetative and non-vegetative burns may require a permit and/or registration with the WDEQ Air Quality Division.	Wyoming Department of Environmental Quality, Air Quality Division	Brian Bohlmann 307-777-6993 http://deq.state.wy.us/aqd/Smoke%20Management%20and%20Open%20Burning.asp

Appendix B: Sources of BMP Technical Assistance and Contact Information

University of Wyoming Cooperative Extension Service
Department 3354
1000 East University Avenue
Laramie, WY 82071
Phone: (307) 766-5124
Website: http://www.uwyo.edu/ces

University of Wyoming College of Agriculture and Natural Resources
Department 3354
1000 East University Avenue
Laramie, WY 82071
Phone: (307) 766-4133
Website: http://www.uwyo.edu/uwag/

Wyoming Association of Conservation Districts
517 E. 19th Street
Cheyenne, WY 82001
Phone: (307) 632-5716
Fax: (307) 638-4099
Website: http://www.conservewy.com/

Wyoming Department of Agriculture
2219 Carey Avenue
Cheyenne, WY 82002
Phone: (307) 777-7321
Fax: (307) 777-6593
Website: http://wyagric.state.wy.us

Wyoming Water Development Commission
6920 Yellowtail Rd.
Cheyenne, WY 82002
Phone: (307) 777-7626
Website:
http://wwdc.state.wy.us/wconsprog/wconsprog.html

Wyoming Weed and Pest Council
c/o State Weed & Pest Coordinator
2219 Carey Ave.
Cheyenne, WY 82002
Phone: (307) 777-6585
Website: http://www.wyoweed.org/

Wyoming NRCS State Office
P.O. Box 33124
100 East B Street, 3rd Floor
Casper, WY 82602-5011
Phone: (307) 233-6750
Fax (mailroom): (307) 233-6795
Fax (Admin): (307) 233-6783
Fax (Front Office): (307) 233-6753
Website: http://www.wy.nrcs.usda.gov

NRCS Field Offices

East Area NRCS Office
911 South Wind River Drive
Douglas, Wyoming 82633
Phone: (307) 358-3050, ext. 5
Fax: (307) 358-5719

West Area NRCS Office
508 N. Broadway Ave.
Riverton, Wyoming 82501-3458
Phone: (307) 856-7524
Fax: (307) 856-2383

Afton NRCS Field Office (West)
P.O. Box 1606
625 Washington Street, Room C
Afton, Wyoming 83110
Phone: (307) 886-9001
Fax: (307) 886-3744

Baggs NRCS District Office (East)
P.O. Box 217
285 North Penland Street
Baggs, Wyoming 82321-0217
Phone: (307) 383-2550
Fax: (307) 383-7861

Buffalo NRCS Field Office (East)
621 West Fetterman
Buffalo, Wyoming 82834-2342
Phone: (307) 684-2526
Fax: (307) 684-5972

Casper NRCS Field Office (East)
5880 Enterprise Drive, Suite 100
Casper, Wyoming 82609
Phone: (307) 261-5436 or (307) 261-5402
Fax: (307) 261-5435

Cheyenne NRCS Field Office (East)
11221 East Highway 30
Cheyenne, Wyoming 82009
Phone: (307) 772-2314
Fax: (307) 772-2120

Cokeville NRCS District Office (West)
P.O. Box 98
110 Pine Street, Cokeville Town Hall, Room 1
Cokeville, Wyoming 83114-0098
Phone: (307) 279-3256
Fax: (307) 279-3024

Douglas NRCS Field Office (East)
911 South Wind River Drive
Douglas, Wyoming 82633
Phone: (307) 358-3050
Fax: (307) 358-5719

Dubois NRCS Field Office (West)
P.O. Box 27
706 Meckem Street
Dubois, Wyoming 82513-0027
Phone: (307) 455-2388
Fax: (307) 455-3098

Fort Washakie NRCS Field Office (West)
P.O. Box 127
Ft. Washakie, Wyoming 82514-0127
Phone: (307) 332-9636

Gillette NRCS Field Office (East)
601 4J Court, Suite C
Gillette, Wyoming 82716
Phone: (307) 682-8843
Fax: (307) 682-3813

Greybull NRCS Field Office (West)
408 Greybull Avenue
Greybull, Wyoming 82426-2036
Phone: (307) 765-2483
Fax: (307) 765-9243

Kaycee NRCS District Office (East)
P.O. Box 48 (350 Nolan Avenue)
Kaycee, Wyoming 82639-9900
Phone: (307) 738-2321

Lander Quiet Presence NRCS Office (West)
221 South 2nd Street
Lander, Wyoming 82520-2801
Phone: (307) 332-3114
Fax: (307) 332-3154

Laramie NRCS Field Office (East)
5015 Stone Road
Laramie, Wyoming 82072
Phone: (307) 745-3698
Fax: (307) 745-6764

Lovell NRCS District Office (West)
359 Nevada Avenue
Lovell, Wyoming 82431-2007
(307) 548-7422
FAX (307) 548-7422

Lusk NRCS Field Office (East)
P.O. Box 659 (905 South Main, Suite 120)
Lusk, Wyoming 82225-0659
Phone: (307) 334-2953
Fax: (307) 334-3539

Lyman NRCS Field Office (West)
P.O. Box 370
100 East Sage Street
Lyman, Wyoming 82937-0370
Phone: (307) 787-3211
Fax: (307) 787-3810

Medicine Bow NRCS District Office (East)
P.O. Box 6
510 Utah
Medicine Bow, Wyoming 82329-0006
Phone: (307) 379-2542

Newcastle NRCS Field Office (East)
1225 Washington Boulevard, Suite 3
Newcastle, Wyoming 82701-2930
Phone: (307) 746-3264
Fax: (307) 746-2870

Pinedale NRCS Field Office (West)
P.O. Box 36 (1625 W Pine)
Pinedale, Wyoming 82941-0036
Phone: (307) 367-2257
Fax: (307) 367-2282

Powell NRCS Field Office (West)
1017 Highway 14A
Powell, Wyoming 82435
Phone: (307) 754-9301
Fax: (307) 754-2761

Riverton NRCS Field Office (West)
508 N. Broadway Ave.
Riverton, Wyoming 82501-3458
Phone: (307) 856-7524
Fax: (307) 856-2383

Rock Springs NRCS Field Office (West)
Gateway Office Bldg.
79 Winston Drive, Suite 110
Rock Springs, Wyoming 82901
Phone: (307) 362-3062
Fax: (307) 362-1459

Saratoga NRCS Field Office (East)
P.O. Box 607
101 Cypress
Saratoga, Wyoming 82331
Phone: (307) 326-5657
Fax: (307) 326-8572

Sheridan NRCS Field Office (East)
1949 Sugarland Drive, Suite 102
Sheridan, Wyoming 82801-5720
Phone: (307) 672-5820
Fax: (307) 672-0052

Sundance NRCS Field Office (East)
P.O. Box 1070
117 S. 21st
Sundance, Wyoming 82729-1070
Phone: (307) 283-2870
Fax: (307) 283-2170

Thermopolis NRCS Field Office (West)
601 Broadway, Suite A
Thermopolis, Wyoming 82443
Phone: (307) 864-3488
Fax: (307) 864-4167

Torrington NRCS Field Office (East)
1441 East M Street, Suite B
Torrington, Wyoming 82240-3521
Phone: (307) 532-4880
Fax: (307) 532-5783

Wheatland NRCS Field Office (East)
1502 Progress Ct.
Wheatland, Wyoming 82201-3211
Phone: (307) 322-9060
Fax: (307) 322-4109

Worland NRCS Field Office (West)
208 Shiloh Road
Worland, Wyoming 82401
Phone: (307) 347-2456
Fax (307) 347-8806
www.conservewy.com/hscd.html

Wyoming Conservation Districts

Campbell County Conservation District
PO Box 2577
601 4J Ct, Suite D
Gillette, WY 82717
307-682-1824 (phone) 307-682-3813 (fax)
www.cccdwy.net
icd@vcn.com

Cody Conservation District
1145 Sheridan Ave, Suite 5
Cody, WY 82414
307-899-0037
codycd@bresnan.net

Converse County Natural Resource District
911 Windriver Drive
Douglas, WY 82633
307-358-3050
michelle.huntington@wy.nacdnet.net
www.conserveconverse.org

Crook County Natural Resource District
PO Box 1070
117 S. 21st Street
Sundance, WY 82729
307-283-2501
sdm.mason@gmail.com
www.ccnrd.org

Dubois-Crowheart Conservation District
PO Box 27
706 Meckem Street
Dubois, WY 82513
307-455-2388
dccd@dteworld.com

Hot Springs Conservation District
601 Broadway, Suite A
Thermopolis, WY 82443
307-864-3488
carla.thomas@wy.nacdnet.net

Lake DeSmet Conservation District
621 West Fetterman
Buffalo, WY 82834
307-684-2526
nikki.lohse@wy.nacdnet.net
www.ldcd.org

Laramie County Conservation District
11221 US Highway 30
Cheyenne, WY 82009
307-772-2600
info@lccdnet.org
www.lccdnet.org

Laramie Rivers Conservation District
5015 Stone Road
Laramie, WY 82070
307-721-0072
tony.hoch@wy.nacdnet.net
www.LRCD.net

Lincoln Conservation District
PO Box 98
110 Pine Street
Cokeville, WY 83114
307-279-3256
brenda.lazcanotegui@wy.nacdnet.net
www.lincolnconservationdistrict.org

Lingle-Fort Laramie Conservation District
1441 East M, Suite B
Torrington, WY 82240
307-532-4880
nancy.borton@wy.nacdnet.net
www.goshencountyconservationdistricts.com

Little Snake River Conservation District
PO Box 355
285 North Penland Street
Baggs, WY 82321
307-383-7860
lsrcd@yahoo.com

Lower Wind River Conservation District
508 N. Broadway
Riverton, WY 82501
307-856-7524
cathy.meyer@wy.nacdnet.net

Medicine Bow Conservation District
PO Box 6
510 Utah Street
Medicine Bow, WY 82324
307-379-2221
todd@medbowcd.org
www.medbowcd.org

Meeteetse Conservation District
PO Box 237
2103 State Street
Meeteetse, WY 82433
307-868-2484
mcd@tctwest.net
www.meeteetsecd-wy.gov

Natrona County Conservation District
5880 Enterprise Drive, Suite 100
Casper, WY 82609
307-234-4022
lisa.ogden@wy.nacdnet.net
www.natronacountyconservationdistrict.com

Niobrara Conservation District
PO Box 659
Lusk, WY 82225
307-334-2953
lshaw@wyoming.com

North Platte Valley Conservation District
1441 East M, Suite B
Torrington, WY 82240
307-532-4880
nancy.borton@wy.nacdnet.net
www.goshencountyconservationdistricts.com

Platte County Resource District
1502 Progress Court
Wheatland, WY 82201
307-322-9060
brady.irvine@wy.nacdnet.net
www.conservewy.com/pcrd.html

Popo Agie Conservation District
221 S. 2nd Street
Lander, WY 82520
307-332-3114
pacd@wyoming.com
www.popoagie.org

Powder River Conservation District
PO Box 48
Kaycee, WY 82639
307-738-2321
anita.bartlett@wy.nacdnet.net
www.powderrivercd.org

Powell-Clarks Fork Conservation District
1017 Highway 14A
Powell, WY 82435
307-754-9301
ann.trosper@wy.nacdnet.net
www.pcfcd.org

Saratoga-Encampment-Rawlins Conservation District
PO Box 633
101 Cypress Avenue
Saratoga, WY 82331
307-326-8156
jarrunner@gmail.com
www.sercd.org

Sheridan County Conservation District
1949 Sugarland Drive, Suite 102
Sheridan, WY 82801
307-672-5820
carrie.rogaczewski@wy.nacdnet.net
www.sccdofwyo.org/

Shoshone Conservation District
359 Nevada Avenue
Lovell, WY 82431
307-548-7422
shoshonecd@tctwest.net

South Big Horn Conservation District
408 Greybull Avenue
Greybull, WY 82426
307-765-2483
janet.hallsted@wy.nacdnet.net
www.conservewy.com/sbhcd

South Goshen Conservation District
1441 East M, Suite B
Torrington, WY 82240
307-532-4880
nancy.borton@wy.nacdnet.net
www.goshencountyconservationdistricts.com

Star Valley Conservation District
PO Box 216
61 E. 5th Avenue
Afton, WY 83110
307-885-7823
bashworth@starvalleycd.org
www.starvalleycd.org

Sublette County Conservation District
PO Box 647
1625 W. Pine Street
Pinedale, WY 82941
307-367-2257
sccd@wy.nacdnet.net
www.sublettecountycd.com

Sweetwater County Conservation District
79 Winston Drive, Suite 110
Rock Springs, WY 82901
307-362-3062
admin@swccd.us
www.swccd.us

Teton Conservation District
PO Box 1070
420 W. Pearl Avenue
Jackson, WY 83001
307-733-2110
randy@tetonconservation.org
www.tetonconservation.org

Uinta County Conservation District
PO Box 370
100 East Sage Street
Lyman, WY 82937
307-787-3794
ksabey@bvea.net
www.uintacountycd.com

Washakie County Conservation District
208 Shiloh Road
Worland, WY 82401
307-347-2456
wccd@rtconnect.net
www.washakiecd.com

Weston County Natural Resource District
1225 Washington Boulevard, #3
Newcastle, WY 82701
307-746-3264
jennifer.hinkhouse@wy.nacdnet.net

Wyoming Weed and Pest Districts

Albany Co. Weed & Pest Control District
2919 County Shop Road
Laramie , WY 82070
(307) 742-0834

Big Horn Co. Weed & Pest Control District
PO Box 567
Greybull, WY 82426
(307) 765-2855

Campbell Co. Weed & Pest Control District
PO Box 191
Gillette, WY 82717
(307) 682-4369

Carbon Co. Weed & Pest Control District
PO Box 1126
Rawlins, WY 82301
(307) 324-6584
www.carboncountyweed.com

Converse Co. Weed & Pest Control District
PO Box 728
Douglas , WY 82633
(307) 358-2775

Crook Co. Weed & Pest Control District
PO Box 7
Sundance, WY 82729
(307) 283-2375

Fremont Co. Weed & Pest Control District
450 N. 2nd St., Room 325
Lander, WY 82520
(307) 332-1052
www.fcwp.org

Goshen Co. Weed & Pest Control District
PO Box 757
Torrington, WY 82240
(307) 532-3713
www.goshencounty.org/index.php/departments/weed-a-pest

Hot Springs Co. Weed & Pest Control District
PO Box 543
Thermopolis, WY 82443
(307) 864-2278

Johnson Co. Weed & Pest Control District
123 Flatiron Drive
Buffalo, WY 82834
(307) 684-5715

Laramie Co. Weed & Pest Control District
801 Muddy Creek Drive
Pine Bluffs, WY 82082
(307) 245-3213

Lincoln Co. Weed & Pest Control District
PO Box 1117
Afton, WY 83110
(307) 885-9333

Natrona Co. Weed & Pest Control District
PO Box 1385
Mills, WY 82644
(307) 472-5559
www.natronacountyweeds.co

Niobrara Co. Weed & Pest Control District
PO Box 957
Lusk, WY 82225
(307) 343-3373

Park Co. Weed & Pest Control District
PO Box 626
Powell, WY 82435
(307) 754-4521
www.parkcountyweeds.com

Platte Co. Weed & Pest Control District
PO Box 775
Wheatland, WY 82201
(307) 322-3210

Sheridan Co. Weed & Pest Control District
PO Box 732
Sheridan, WY 82801
(307) 672-3740

Sublette Co. Weed & Pest Control District
PO Box 729
Pinedale, WY 82941
(307) 367-4728
www.sublettecountyweed.com

Sweetwater Co. Weed & Pest Control District
PO Box 173
Farson, WY 82932
(307) 273-9683

Teton Co. Weed & Pest Control District
PO Box 1852
Jackson, WY 83001
(307) 733-8419
www.tcweed.org

Uinta Co. Weed & Pest Control District
PO Box 825
Evanston, WY 82930
(307) 789-9289

Washakie Co. Weed & Pest Control District
PO Box 936
Worland, WY 82401
(307) 347-8582

Weston Co. Weed & Pest Control District
PO Box 411
Newcastle, WY 82701
(307) 746-4555

Wyoming Irrigation Districts

Angel Draw Irrigation District
108 East 20th Avenue
Torrington, WY 82240

Big Horn Irrigation District
1679 Hwy 20 S
Worland, WY 82401

Bluff & Upper Bluff Irrigation District
PO Box 923
Worland, WY 82401
(307) 388-0830

Boulder Irrigation District
Box 217
Boulder, WY 82923

Casper Alcova Irrigation District
755 Connie Street
PO Box 849
Mills, WY 82604
(307) 234-8690

Clarks Fork Irrigation District
PO Box 880
Cody, WY 82414

Cody Canal Irrigation District
242 Southfork Road
Cody, WY 82414
(307) 527-6644

Cottonwood Irrigation District
76219 Hwy 89
Smoot, WY 83126
(307) 886-9655

Crook County Irrigation District
971 MrKean Rd
Moorcroft, WY 82721
(307) 756-3279

Dever Irrigation District
PO Box 205
Deaver, WY 82421
(307) 664-2351

Dry Creek Irrigation District
Box 608
Afton, WY
(307) 83110
(307) 866-9079

Eastside Irrigation District
Box 5042
Etna, WY 83118

Eden Valley Irrigation & Drainage District
PO Box 174
Farson, WY 82932

Elk-Lovell Irrigation District
111 Highway 32
Lovell, WY 82431

Enterprise Irrigation District
615 Willow Creek Rd
Lander, WY 82520

Etna Irrigation District
Box 167
Freedom, WY 83120

Fairview Irrigation District
2637 Bittercreek Road
Afton, WY 83110
(307) 886-3229

Fremont Irrigation District
222 Ehman Lane
Pinedale, WY 82941
(307) 367-2435

Gooseberry Irrigation District
4162 Hwy 431
Worland, WY 82401
(307) 868-2465

Goshen Irrigation District
PO Box 717
Torrington, WY 82240
(307) 532-7031

Green River Irrigation District
PO Box 368
Daniel, WY 83115
(307) 276-3246

Greybull Valley Irrigation District
PO Box 144
Emblem, WY 82422
(307) 762-3555

Hanover Irrigation District
801 West Big Horn Avenue
Worland, WY 82401

Heart Mountain Irrigation District
1206 Road 18
Powell, WY 82435
(307) 754-4685

Highland Irrigation District
PO Box 179
Pinedale, WY 82941
(307) 782-6120

Highland Hanover Irrigation
111 S. Ninth Street
Worland, WY 82401

Highline Ditch Irrigation District
HC 64 Box 65
Ranchester, WY 82839

Hill Irrigation District
4738 Van Tassel Road
Torrington, WY 82240

Hunt Canal Irrigation District
PO Box 243
Lovell, WY 82431
(307) 548-2279

Interstate Irrigation & Reservoir Company
3392 Hwy 414
McKinnon, WY 82938
(307) 974-6010

Lakeview Irrigation District
PO Box 880
Cody, WY 82414
(307) 587-2285

LaPrele Irrigation District
PO Box 115
Douglas, WY 82633
(307) 358-5556

Laramie Valley Municipal Irrigation District
221 Ivinson Street
Laramie, WY 82070
(307) 742-6645

LeClair Irrigation District
PO Box 568
Riverton, WY 82501
(307) 856-4018

Little Popo Agie Irrigation District
277 Lincoln Street
Lander, WY 82520
(307) 332-4331

Lovell Irrigation District
1148 Road 18
Lovell, WY 82431
(307) 548-6422

Lower Clear Water Irrigation District
Box 167
Leiter, WY 82837
(307) 758-4488

Lucerne Irrigation District
Lucerne Rt Box 51A
Thermopolis, WY 82430

Midvale Irrigation District
PO Box 128
Pavillion, WY 82523

New North Platte Irrigation & Ditch Co.
7200 McKenna Road
Torrington, WY 82240
(307) 532-3425

New Fork Lake Irrigation District
PO Box 91
Cora, WY 82925

New North Platte Irrigation Company
PO Box 670
Torrington, WY 82240

Nez Perce Irrigation
11 Nez Perce
Cody, WY 82414
(307) 527-5545

North Fork Irrigation District
11 North Main Street
Buffalo, WY 82834
(307) 684-5454

Owl Creek Irrigation District
PO Box 509
Thermopolis, WY 82430
(307) 864-3058

Park Reservoir Irrigation District
251 Upper Road
Sheridan, WY 82801

Porta Irrigation District
1620 Muddy String Road
Thayne, WY 83127
(307) 883-8001

Powder River Irrigation District
1561 Sussex Rd
Kaycee, WY 82639
(307) 738-2259

Pratte-Ferris Irrigation District
PO Box 998
Torrington, WY 82240
(307) 532-5427

Riverton Valley Irrigation District
420 E. Washington
Riverton, WY 82501
(307) 856-2207

Salt River Irrigation District
2637 Bitter Creek Road
Afton, WY 83110

Shoshoni Irrigation District
337 East First
Powell, WY 82435
(307) 754-5741

Sidon Fork Irrigation District
PO Box 133
Cowley, WY 82420

Silver Lake Irrigation District
Box 2
Boulder , WY 82923
(307) 537-5479

Smith's Fork Irrigation District
105 Dayton Street
Cokeville, WY 83114
(307) 279-3069

Spring Draw Irrigation
150 Upper Road
Sheridan, WY 82801

Stewart Creek Irrigation
PO Box 1224
Jackson, WY 83001
(307) 690-0700

Torrington Irrigation District
PO Box 179
Torrington, WY 82240
(307) 532-2125

Wheatland Irrigation District
PO Box 727
Wheatland, WY 82201
(307) 332-2710

Willwood Irrigation District
1306 Road 9
Powell, WY 82435
(307) 759-3831

Appendix C: Glossary

access roads: Travel-ways that provide fixed routes for vehicular travel necessary for resource activities involved in the management of cropland, wildlife, livestock, and other conservation enterprises. All access roads should be sited, designed, and constructed in such a way that minimizes erosion and sedimentation and protects adjacent soil, water, wildlife, and other natural resources.

best management practice: A practice or combination of practices that are determined by a state or designated area wide planning agency to be the most effective and practicable (including technological, economic, and institutional considerations) means of controlling nonpoint pollutants at levels compatible with environmental quality goals. Abbr. BMP.

biological pest control: Method of controlling pest organisms by means of introduced or naturally occurring predatory organisms, sterilization, the use of inhibiting hormones, or other biological methods.

biological nitrogen fixation: The biological process of converting atmospheric nitrogen to ammonia.

carbon sequestration: The biological process of removing of carbon dioxide from the atmosphere and depositing and storing it in soils or in plants.

check dams: (a) A log or gabion structure placed perpendicular to a stream to enhance aquatic habitat. (b) An earthen or log structure, used in grass swales to reduce water velocities, promotes sediment deposition and enhances infiltration.

chemigation: The application of fertilizers, pesticides, or other chemicals, through irrigation water.

composting: The process of controlled and accelerated aerobic biodegradation and stabilization of organic waste.

conservation crop rotation: The practice of growing various crops on the same piece of land in a planned, recurring sequence. The crop sequence is selected in such a way to provide a high degree of soil cover and provide an adequate amount of residue to help maintain or improve the soils.

conservation tillage: Any tillage or planting system which leaves at least 30 percent of the field surface covered with crop residue after plating has been completed.

contour baselines: The established line often found at the base of the slopes that follows the contour of the land and is used as the guideline for planting crops with contour farming. Contour farming operations should always begin on the contour baselines and follow the baselines in a parallel pattern.

contour buffer strips: Narrow strips of permanent, herbaceous vegetation cover established across the slope and alternated down the slope with parallel, wider cropped strips.

contour farming: The practice of tilling, planting, cultivating, and harvesting crops laterally across slopes as a means to reduce runoff and sheet and rill erosion. Downslope runoff can be intercepted and redirected by using ridges and furrows formed by crop farming operations. Farming on the contour also reduces velocity and volume of runoff, as the ridges and furrows block water movement, promote infiltration, and prevent soil particles from moving.

contour markers: Some form of continuous, permanent, lasting marker that follows the key contour baseline which can be followed in a parallel pattern and used as a guideline for planting crops with contour farming. Field boundaries, unharvested crop rows left near the contour baseline, or established permanent strips of grass can all be used as contour markers.

cover: (1) Plant cover in this document refers to the combined aerial parts of plants, plant residue or stubble, and mulch providing coverage and protection for soil. (2) Shelter and protection for animals and birds.

cover cropping: The practice of establishing close-growing grasses, legumes, forbs, or other herbaceous plants for seasonal or permanent protection and soil improvement. The practice of cover cropping is often applied when the major crops do not furnish adequate cover, after harvest, or during the winter months. Usually they are planted annually but can be used as permanent cover.

cultural pest control: A method of pest control that utilizes various farming practices to impact pest populations.

deep percolation: The movement of water by gravity downward through the soil profile past the plant root zone to regions of deeper ground-water aquifers; this water is not used by plants.

diversions: Channels with supporting ridges on the downhill side that are constructed in a manner to intercept and divert slope runoff to a desired location. Diversion structures are generally placed laterally across a slope and are designed to prevent slope erosion by collecting the down-slope runoff and redirecting the runoff to outlets that can convey the water without causing erosion.

embankment: A mount of earth or stone built to hold back water or to support a crop.

erosion: (1) The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. (2) Detachment and movement of soil or rock fragments by water, wind, ice or gravity.

eutrophication: The natural process whereby a body of water evolves from low productivity and low nutrient concentration to high productivity and high nutrient levels that is greatly accelerated by nutrient enrichment from human activities. Results of eutrophication can include algal blooms, low dissolved oxygen, and changes in community composition.

evapotranspiration: The sum of the evaporation and plant transpiration of water from the land surface to the atmosphere.

field borders: Strips of perennial vegetation established at the edge of a field by planting or by converting it to herbaceous vegetation or shrubs.

forage: (n) All browse and herbaceous foods that are available to grazing animals. It may be grazed or harvested for

grade: The amount of inclination of a surface to the horizontal.

grassed swales: Vegetated channels designed to treat and convey stormwater runoff at a slow, controlled rate. Pollutant and sediment removal in grassed channels is primarily accomplished by gravitational settling, filtration through the grass and soil, and infiltration through the subsoil. Grassed swales are often useful when utilized in a series of BMPs as a pretreatment mechanism.

gravitational settling: The tendency of particulate matter to sink and settle when in water that is at a standstill or that is flowing at a moderate velocity.

habitat: A geographical area that can provide for the key essentials of life, normally considered to be food, water and cover.

harvest: The process of gathering mature crops from the field.

headland: A strip of land left unplowed at the end of a field

infiltration: The flow of a fluid into a substance through pores or small openings.

infiltration rate: Maximum rate at which soil under specified conditions can absorb rain or shallow impounded water, expressed in quantity of water absorbed by the soil per unit of time.

integrated pest management (IPM): A pest management approach aimed at reducing pesticide use to the minimum amount while ensuring high quality and quantity crops and protecting human health and environmental quality. IPM basses its selection of the most suitable pest control methods on the predicted economic, ecological, and sociological consequences and strives to avoid using chemical pesticides.

intercropping: The practice of growing two or more crops in proximity of one another.

invasive species: non-native plants or animals that invade and adversely affect native habitats.

irrigation water management: Determining and controlling the rate, amount, and timing of irrigation water in a planned and efficient manner.

legume: A type of plant that has the ability to fix atmospheric nitrogen due the mutualistic symbiotic relationship it has with the nitrogen-fixing rhizobia bacteria found in its root nodules. Leguminous crops can enrich soils with crops which can benefit succeeding crops.

level spreader: A device used to spread out stormwater runoff uniformly over the ground surface as sheet flow. The purpose of level spreaders is to prevent concentrated, erosive flows from occurring and to enhance infiltration.

management plan: A program of action designed to reach given objectives.

mechanical practices/treatment: (1) Soil and water conservation practices that primarily change the surface of the land or that store, convey, regulate, or dispose of runoff water without excessive erosion. (2) Methods of controlling pests or undesirable vegetation by mechanical means such as mowing, chaining, root plowing, and brush beating.

mulching: A temporary erosion control practice that uses materials such as straw, grass, hay, compost, wood chips, or wood fibers to stabilize exposed or recently planted soil surface. Mulching can decrease soil erosion by stabilizing soils, can reduce the velocity of stormwater runoff over an area, can decrease the volume of runoff by increasing infiltration, and can cool surface runoff. Mulching can also help retain moisture, thereby reducing the need for excessive irrigation and conserving water.

mulch-till: A type of conservation tillage system which disturbs the soil prior to planting. Tillage tools such as chisels, field cultivators, disks sweeps, or blades are used, and at least 30 percent of the soil surface is left covered by plant residue after planting to prevent soil erosion

nitrogen: An element occurring in manure and chemical fertilizer that is essential to the growth and development of plants, but which, in excess, can cause water to become polluted and threated aquatic animals.

nonpoint source water pollution: Pollution arising from an ill-defined and diffuse source, such as runoff from cultivated fields, grazing land, or urban areas.

no-till: A type conservation tillage system which leaves the soil undisturbed from harvest to planting except for nutrient injection. Planting is accomplished in a narrow seedbed or slot created by coulters, row cleaners, disk openers, in-row chisels, or roto-tillers, and at least 30 percent of the soil surface is left covered by plant residue after planting to prevent soil erosion.

nutrient: An element or compound essential as raw materials for organism growth and development, such as carbon, nitrogen, phosphorous, etc.

nutrient management: Managing the amount, source, placement, form, and timing of application of nutrients and soil amendments to help attain optimum crop production levels while protecting water quality and reducing input costs.

perennial vegetation: Vegetation that lives for more than two years.

pest management: The utilization of prevention, avoidance, monitoring, and suppression techniques to manage weeds, insects, diseases, animals, and other pests. When properly implemented, pest management can help maintain healthy crops with high yields, while minimizing the negative impacts of pest control on water, soil, and air quality.

phosphorus: An element occurring in manure and chemical fertilizer that is essential to the growth and development of plants, but which, in excess, can cause water to become polluted and threated aquatic animals.

physical pest control: A method of pest control which utilizes physical barrios, such as netting, screening, or fences, to exclude pests from crops.

plant community: A group of one or more populations of plants in a common spatial arrangement.

prescribed burning: The scientific, intentional application of fire to wild land fuels in either their natural or modified state under such conditions (fuel moisture, soil moisture, etc.) as to allow the fire to be confined to a predetermined area and to produce the intensity of heat and rate of spread required to further certain planned objectives and silviculture, wildlife management, range and prairie management, and fire-hazard reduction.

prescribed grazing: The managed harvest of vegetation with grazing or browsing animals. This practice works through the controlled allowance or exclusion of grazing animals on any given piece of land where grazing or browsing animals are managed.

reclaim: The process of returning disturbed lands to their former uses or other productive uses. syn. rehabilitation

rehabilitation: Returning of the land to farm use or to productivity in conformity with a prior land use plan, including a stable ecological state that does not contribute substantially to environmental deterioration and is consistent with surrounding aesthetic values.

residue: (1) Materials left in an agricultural field after the crop has been harvested, such as stalks, stubble, leaves, or seed pods. Good management of crop residues can increase efficiency of irrigation and control erosion.

residue management: Managing the selection, amount, orientation, and distribution of crop and other plant residues on the soil surface to help protect croplands from erosion.

ridge-till: A type of conservation tillage system that leaves the soil undisturbed from harvest to planting except for nutrient injection. Planting is completed in a seedbed prepared on ridges with sweeps, disk openers, coulters, or row cleaners, and at least 30 percent of the soil surface is left covered by plant residue after planting to prevent soil erosion

rill erosion: The development of small, ephemeral concentrated flow paths, which function as both sediment source and sediment delivery systems for erosion on hill slopes.

riparian area: The banks and adjacent areas of waterbodies, watercourses, seeps and springs whose waters provide soil moisture sufficiently in excess of that otherwise available locally so as to provide a more moist habitat than that of contiguous flood plains and uplands.

riparian buffers: Established areas of dense vegetation located adjacent to and up-gradient from natural watercourses, waterbodies, and associated wetlands. Riparian forest buffers are comprised of trees, shrubs, and grasses and are managed to maintain the integrity of the waterways and to reduce nonpoint source pollution.

runoff: That portion of the precipitation on a drainage area that is discharged from the area in stream channels.

sediment basin: A basin constructed to collect and store debris or sediment.

sedimentation: The process or action of depositing sediment.

seeding: A method of establishing a stand of plants artificially by sowing seed. In broadcast seeding, seed is sown over the surface of the soil. In drill seeding, seed is placed in relatively narrow furrow rows, generally less than a foot apart. Partial seeding may be done in strips, furrow rows, trenches, or in spots.

sheet erosion: Erosion caused by downslope overland water flow as a sheet instead of in definite channels or rills.

soil amendments: A material added to soil to improve plant growth and health by correcting the soil's deficiencies in structure and/or nutrients. Also known as soil conditioner.

soil tilth: The state of aggregation of a soil. Aggregates are conglomerates of clay, silt, and sand particles that are held together by biological, physical, and chemical forces.

soil type: A subdivision of a soil series based on surface texture.

splash erosion: The detachment and airborne movement of small soil particles caused by the impact of raindrops on soil.

strip cropping: The practice of growing alternating crops in a systematic arrangement across a field. Plantings alternate between crops that provide protective soil cover with crops that provide limited soil cover. Erosion-resistant, protective cover strips effectively work as individual buffer strips, and this alternating arrangement can be extremely effective at reducing soil erosion from water and wind, protecting growing crops from damage by wind-borne soil particles, and reducing dust emissions.

summer fallow: Cropland that is purposefully kept out of production during a regular growing season.

tailwater: Irrigation water that reaches the lower end of a field.

tailwater recovery system: A system which includes a facility to collect, store, and transport irrigation tailwater for reuse in the farm irrigation distribution system. The reservoir can help trap and collect sediment and sediment attached pollutants from runoff waters, thereby decreasing downstream yields of these substances.

terrace: An embankment or combination of an embankment and channel constructed laterally across a slope to control erosion by diverting and temporarily storing surface runoff instead of permitting it to flow uninterrupted down the slope. Terraces are often constructed as a series of parallel contour terraces across a cropland slope and spaced at designed widths that allow for the effective cultivation of crops with modern farming equipment.

tillage: The mechanical manipulation of the soil profile for any purpose; but in agriculture, it is usually restricted to modifying soil conditions, managing crop residues and/or weeds, or incorporating chemicals for crop production.

total drainage systems: A system of watercourses or drains designed for carrying off excess water.

vegetated filter strips: Uniformly graded, densely vegetated sections of land that are designed to treat sheet runoff from adjacent land; helps remove sediment, organic matter, and other pollutants from runoff.

vegetation: Plants in general or the sum total of plant life in an area.

watercourses: A natural or artificial channel through which water flows.

watershed: (1) A total area of land above a given point on a waterway that contributes runoff water to the flow at that point. (2) A major subdivision of a drainage basin.

wet swale: A type of swale which utilizes wetland vegetation to increase pollutant removal.

wetland: Land transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetland areas are regulated by the U.S. Army Corps of Engineers under section 404 of the Clean Water Act. There are specific regulatory definitions and requirements for delineation of wetland areas, please refer to these definitions and requirements for more detail.

windbreak: A barrier, often comprised of a planting of single or multiple rows of trees or shrubs in linear configurations, that helps with dust control by obstructing and slowing the wind near the ground and preventing soil from blowing off site. By preventing wind erosion, windbreaks can reduce the transport of sediment and its associated pollutants and can thereby improve local water quality.

Appendix D: Additional References

The following are references for photos that were not listed within the factsheet, along with full references for websites that were provided within paragraphs but not fully cited thereafter. References used for information on individual best management practices can be found at the beginning of each factsheet. If viewing this document in an electronic format, click on the blue underlined text to be redirected to the appropriate website. URL addresses are also provided for those who are viewing the hard copy. For websites outside the WDEQ, the WDEQ is not responsible for the content of or maintenance of those websites.

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