From Field to Faucet: Introduction to Farm Conservation Practices

Lesson: 12

National Science Education Standards for Grades 9-12

Content Standard A: Abilities Necessary to Do Scientific Inquiry

- *Design and conduct scientific investigations.*

Content Standard F: Science in Personal and Social Perspectives: Natural Resources

- *Humans use many natural systems as resources. Natural systems have the capacity to reuse waste, but that capacity is limited. Natural systems can change to an extent that exceeds the limits of organisms to adapt naturally or humans to adapt technologically.*

Content Standard F: Science in Personal and Social Perspectives: Science and Technology in Local, National and Global Challenges

- *Humans have a major effect on other species. For example, the influence of humans on other organisms occurs through land use—which decreases space available to other species—and pollution—which changes the chemical composition of air, soil and water.*

Student Learning Objectives

12.1 Identify common conservation practices that farmers adopt to protect water sources from pollution.

12.2 Describe how farmers determine which Best Conservation Practices (BCP) to incorporate to protect sources of drinking water from pollution.

Teacher Info Table Time

Instruction time for this lesson: 45 minutes, over two class sessions if students take their own photos

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Resources, Tools, Equipment and Supplies

12.1 Identify common conservation practices that farmers adopt to protect water sources from pollution.

Resources

- Handout SW.12.1.AS.B, Best Conservation Practices Handouts – one for each group, as needed for locale
- Slide SW.12.1.TM.A, What are Best Conservation Practices for Water Quality Protection?, adjust as necessary
- Slide SW.12.1.TM.B, Examples of Agricultural Best conservation practices for Water Quality Protection
- Worksheet SW.12.1.AS.A, Best Conservation Practices Worksheet – one for each group
- Conservation Problems, USDA/NRCS, http://www.wi.nrcs.usda.gov/programs/erosion.html
- State Offices for USDA Natural Resources Conservation Service, http://www.nrcs.usda.gov/about/organization/regions.html
- USDA/Natural Resources Conservation Service Photo Gallery, http://photogallery.nrcs.usda.gov/
- WI Farm Conservation Solutions, USDA/NRCS http://www.wi.nrcs.usda.gov/programs/solutions/index.html
- EPA/IPM Fact Sheet, http://www.epa.gov/pesticides/factsheets/ipm.htm

Additional resources to explore for background information:

- *Best Management Practices for Georgia Agriculture:* Conservation Practices to Protect Surface Water Quality, Georgia Soil and Water Conservation Commission, 2007, http://www.gaswcc.org/docs/ag_bmp_Manual.pdf
- *Best Management Practices for Water Quality,* U.S. EPA,http://www.epa.gov/agriculture/tsur.html#Best Management Practices
- Colorado WaterWise Develops Water Best Conservation Practices Guidebook, Peter Mayer, American Water Works Association, http://www.awwa.org/files/Publications/Journal/2011/February/PDFs/JAW201102mediapulse.pdf

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Additional resources to explore for background information

- Conservation Technology Information Center Fact Sheets: http://www.ctic.purdue.edu/Core4/Fact Sheets/

  Conservation Buffers: http://www.ctic.purdue.edu/resourcedisplay/284/

  Crop Nutrients: http://www.ctic.purdue.edu/resourcedisplay/282/

  Weed and Pest Management: http://www.ctic.purdue.edu/resourcedisplay/283/
- EPA Watershed Academy Web Page: *Agricultural Management Practices for Water Quality Protection,* http://www.epa.gov/owow/watershed/wacademy/acad2000/agmodule/
- *Agriculture:* Surface and Ground Water, http://www.epa.gov/agriculture/tsur.html#Best%20Management%20 Practices
- *Farmland Conservation Choices: A Guide to Environmentally Sound Practices for Wisconsin Farmers*, USDA/NRCS et al: ftp://ftp-fc.sc.egov.usda.gov/WI/Pubs/farmlandchoices.pdf
- Search online for *"farm drinking water sources"* to find related photos and diagrams
- *Upstream Heroes*, Conservation Technology Information Center provides case studies of national agricultural producers that have successfully applied nutrient BCPs. http://www.ctic.purdue.edu/Upstream%20 Heroes/
- *Water Conservation Best Management Practices Guide for Agriculture in Texas*, Texas Water Development Board, 2005,https://www.tsswcb.state.tx.us/files/contentimages/water_conservation_bmp.pdf
- *Your Water. Your Decision: A Brief Guide For Tomorrow's Agricultural Leaders,* http://www.fieldtofaucet.org

Equipment

Access to PowerPoint to create slides
Cameras (optional)
Access to the Internet

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Resources, Tools, Equipment and Supplies

12.2 Describe how farmers determine which Best Conservation Practices (BCP) to incorporate to protect sources of drinking water from pollution

Resources

- Slide SW.12.2.TM.C, Examples of Tools Used to Create BCPs

Key Terms

Best conservation practices

Berms

Conservation buffers

Conservation tillage

Crop nutrient management

Integrated pest management

Irrigation and drainage water management

Rain barrels

Photodegradation

Phytomass

Soil testing

Stream fencing

Tailwater

Turnrows

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SUMMARY OF CONTENT AND TEACHING STRATEGIES: (BACK-GROUND FOR TEACHERS)

A. Best Conservation Practices (BCPs)

1. Farming practices that protect surface and ground water quality and, therefore, protect human and animal health.

B. Examples of Best Conservation Practices

[Content adapted from http://www.epa.gov/owow/watershed/wacademy/acad2000/agmodule/]

Conservation Tillage and Crop Rotation - leaving crop residue (plant materials from past harvests) on the soil surface reduces runoff and soil erosion, conserves soil moisture, helps keep nutrients and pesticides on the field, and improves soil, water and air quality. Conservation tillage should be practiced with nutrient management and integrated pest management so that excess nutrients and pesticides are not left on the field to seep into groundwater. Rotate crops to break pest cycles, increase soil quality, and reduce need for added nitrogen.

Crop Nutrient Management – appropriate application rate, timing of application, method of application and form of the nutrient. Fully managing and accounting for all nutrient inputs helps ensure nutrients are available to meet crop needs while reducing nutrient movements off fields. It also helps prevent excessive buildup in soils and helps protect air quality.

Integrated Pest Management - varied methods for keeping insects, weeds, disease and other pests below economically harmful levels while protecting soil, water and air quality.

Conservation Buffers - a strip of land, trees, or other vegetation used to “buffer” or filter out chemicals before they reach the water source. From simple grassed waterways to riparian areas along streams and surface waters, buffers provide an additional barrier of protection by capturing potential pollutants that might otherwise move into surface waters.

Irrigation and Drainage Water Management - reducing nonpoint source pollution of ground and surface waters caused by irrigation systems by ensuring the right amount of irrigation. Controlled drainage, such as two-stage ditches or constructed wetlands, help prevent degradation of the water in local streams and lakes by reducing nutrient loads from artificial drainage (tile drains, ditches) that drain agricultural fields.

Grazing Management – practices such as placing a fence near a stream or around a pond to keep livestock out and provide alternate water source for livestock, help minimize water quality impacts of animals and their waste.

Animal Feeding Operations (AFOs) Management - minimizing impacts of animal feeding operations and waste discharges through runoff controls, waste storage, waste utilization and nutrient management.

Erosion and Sediment Control - conserving soil and reducing the mass of sediment reaching a water body, protecting both agricultural land and water quality and habitat.

INTEREST APPROACH:

Lessons 9-11 highlighted the roles of agencies, organizations and individual community members who make decisions that affect drinking water protection. In Lesson 12, students will examine farmers as land use decision makers. Students will learn about common ag-related source water issues and the practices farmers decide to implement to protect and conserve water resources.

A suggestion for getting started:

What is a Best Conservation Practice or BCP? It is an activity or tool to protect, conserve, and/or reduce the potential to contaminate a natural resource, such as our sources of drinking water. Ask students to create a list of best conservation practices that they implement at home that are related to energy conservation. (Examples of acceptable responses – turn off all the lights when I leave a room; turn the thermostat down in the house when I go on vacation; use compact fluorescent light bulbs.) What BCPs do they implement at home that are related to water protection and conservation? (Examples of appropriate responses – turn the water off when brushing my teeth; only run the dishwasher when it's full; limit the use of fertilizers and herbicides on my lawn.)

These are good examples of BCPs that can implemented at the individual level. Ask students to create a list of businesses in their community. What BCPs might those businesses employ to save energy and water? Did farming or agriculture get on the list of businesses? BCPs implemented by farmers for protecting surface and groundwater quality are the focus of this lesson.

OBJECTIVE BY OBJECTIVE:

Activity Outline and Teacher Support Information:

12.1. Identify common conservation practices that farmers adopt to protect water sources from pollution.

This activity will introduce students to the common BCPs used by farmers in their community. Students will work in small groups to create a visual overview of local best conservation practices and the problems they are intended to address.

Getting started:

Read the information below and choose the BCPs you want students to focus on during this activity. Adjust the slide SW.12.1.TM.B accordingly; delete those practices that aren't used in your area or state. Based on this information, decide how many groups you should create. Make copies of worksheet SW.12.1.AS, *Best Conservation Practice* – one for each group. Show slide SW.12.1.TM.A. Ask students to describe what they think an agricultural BCP might look like in practice. Show slide SW.12.1.TM.B and review the content with students.

Assign each group a BCP to study in more depth. Give each group worksheet SW.12.1.AS, *Best Conservation Practices*.

Choosing local BCPs

The following is a list of common BCPs for water quality protection that you should emphasize during this lesson:

- Conservation tillage and crop rotation
- Crop nutrient management
- Integrated pest management
- Conservation buffers
- Irrigation and drainage water management
- Grazing management
- Animal feeding operations (AFOs)

You may want to have students focus on local BCPs. Check the web for information about state and local agricultural best practices for water quality. Go to the USDA Natural Resources Conservation Service office website for your state at http://www.nrcs.usda.gov/about/organization/regions.html In the navigation bar on the left you'll find a link for "Employee Directory." Check the list to find the NRCS field office near you. Contact a local agriculture conservation professional to help you develop a list of BCPs that is focused on local agricultural practices. Also your local conservation district can be found at http://nacdnet.org/about/districts/locate/. If your community ag-related businesses are dominated by crop producers for example, than grazing management could be deleted from the list.

Working in a small group, students will devise a plan to produce two PowerPoint slides that illustrate the group's assigned BCP. Each slide should have at least two photos: One photo to illustrate the problem that the farmer is trying to solve, such as sedimentation in streams from erosion, loss of soil moisture due to poor tillage practices, eutrophication of surface water resources from nitrogen and phosphorus applications; the other photo to illustrate the best conservation practice that was applied to solve the problem, such as the development of a conservation buffer. Note that some conservation practices, like nutrient management, are difficult to document in a photograph, without adding narrative explanation. Similarly, students will not be able to find photographs of problems like nitrate contaminantion of ground water. Ask students to think about what other water quality problems or best conservation practices might be difficult to document in a photograph. Note that it's difficult to think about or be motivated to solve a problem that you can't see. All of the group slides will be combined at the end of the activity to produce a slide show of examples of local BCPs. The class should choose a title for their slide show, which can then to viewed by the entire class. A representative from each group should narrate the two slides from his/her group for the presentation. After the presentation hold a classroom discussion to determine what the students found to be the most common water-related reason(s) farmers implemented best practices (sedimentation, chemical contamination, eutrophication). What are some non-water related benefits of the BCPs (habitat preservation, visual attraction, reduced input costs, soil quality, recreation)?

Students can take photos of local examples of agricultural-related conservation challenges and best practices to use in their slides. Local farmers or conservation professionals might share photos.

Students may also search the Internet for photos. One Internet source for relevant photos is the NRCS photo gallery: http://photogallery.nrcs.usda.gov/. NRCS state office web sites often have photo galleries and/or success stories where students might find applicable photos. The NRCS Regional Boundaries and State Offices provides connection to state NRCS offices: http://www.nrcs.usda.gov/about/organization/regions.html There are photos of conservation problems and solutions on the USDA/NRCS *Conservation Problems* page, http://www.wi.nrcs.usda.gov/programs/erosion.html and the Farm Conservation Solutions page, http://www.wi.nrcs.usda.gov/programs/solutions/index.html.

12.2. Describe how farmers determine which Best Conservation Practices (BCP) to incorporate to protect sources of drinking water from pollution

Students now understand the definition of Best Conservation Practice. In this activity, you'll introduce them to tools farmers use to determine when to apply a BCP in their agricultural operations. Then in Lessons 13 and 14 students will develop their own system of BCPs for an fictitious farm in their county.

Initiate a classroom discussion about the reasons a farmer might want to consider implementing a BCP on his or her farm. Some reasonable responses would be:

- To protect water resources (ground water, surface water, drinking water)
- To realize economic benefit (from minimizing costs of fertilizer/ pesticides/herbicides for example or to take advantage of government monetary incentive to introduce specific BCP)
- To improve wildlife habitat (for ducks, pheasants for example)
- To create a more attractive environment on the farm property
- To reduce loss of valuable top soil

Farmers must create a conservation plan to create an effective system of BCP to solve a conservation problem. This can be a complex process. A number of farm assessments are usually required to create an effective plan. These assessments might cover a variety of areas such as agronomy, engineering, manure storage, feedstock storage, milk house waste discharge, nutrient management, pest management, or soils features. Federal, state and local agencies, such as the USDA Natural Resources Conservation Service (NRCS) and Soil and Water Conservation Districts, provide technical assistance to farmers wanting to develop a conservation plan.

Display slide SW.12.1.TM.C, *Examples of Tools Used to Create BCPs.*

The evaluation might include the following assessments:

- Public health and safety:
  - Wells
  - Mortality disposal procedures
  - Medical waste disposal procedures
  - Disposal of plastic and other solid waste materials
  - Storage and disposal of hazardous products
  - Petroleum storage
  - Pesticide storage and mixing
  - Chemical storage and handling
  - Biosecurity
  - Neighbor issues
- Land and water conservation
- Nutrient management
- Manure and wastewater handling and storage
- Feed management
- Pest management
- Grazing planning

An engineering inventory will provide information about physical nature of the farm facility. It will create a map of the physical relationship of the buildings, wells, septic, surface water and other features of the farm area.

Activity: Ask students to draw from previous activities (see lessons 3-7) about wells and make a list of the types of assessment a farmer might want to make on the farm well system. Ask them to explain their choices. Then ask them to think of a BCP that might have an impact on addressing issues identified through the well assessment.

REVIEW / SUMMARY:

After viewing the slides each group created, which Best Conservation Practice or system of practices seems to have the most dramatic effect? Are these effects we can't see in photos? In your journal, describe why this practice results in so much change. Who benefits from this change? Do you think it is cost effective? What are some examples of locations you think would benefit from using this practice?

EVALUATION AND ANSWERS:

EVALUATION

SW.12.ASSESS

1. Define a Best Conservation Practice (BCP):

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2. List two types of BCPs that farmers employ in our state:

a. ____

b. ____

3. Describe one of the BCPs listed in question 2 in more detail.

____

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____

____

4. Describe how a farmer determines which BCPs to implement on his or her farm.

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Answers to SW.12.ASSESS

1. Farming practices or tools that help protect surface and ground water quality
2. Best Conservation Practices (change this list as needed to reflect local practices)
   - Conservation tillage and crop rotation
   - Crop nutrient management
   - Integrated pest management
   - Conservation buffers
   - Irrigation and drainage water management
   - Grazing management
3. Answers will vary. Use group BCP worksheets as guide for each practice.

ACTIVITY WORKSHEET(S) – AS NEEDED:

SW.12.1.AS.A

Best Conservation Practices (BCPs) Worksheet

Names of students in group:____

Name of ***BCP*** ____

Read the handout about your group's BCP (supplied by your teacher). Use the information from the handout to create text for 2-slide PowerPoint presentation about this BCP. Slide #1 should illustrate with a photo and a very brief amount of text, the water-related problem farmers are trying to solve. Slide #2 should illustrate with a photo and a very brief amount of text a BCP that could be implemented to improve or solve the water resource issue. All groups will submit their two slides to the teacher on completion. The slides will be combined to create a PowerPoint presentation of common BCPs farmers implement in your community.

Use the Internet to find photos or use photos you take yourself per your teacher's instructions. Check the following USDA Natural Resources Conservation Service websites to find photos related to your BCP and state:

NRCS Photo Gallery: http://photogallery.nrcs.usda.gov/

NRCS Regional Boundaries and State Offices (choose your state):

http://www.nrcs.usda.gov/about/organization/regions.html

SW.12.1.AS.A *(continued)*

Slide 1
Briefly describe the problem that the farmer is trying to solve:

____

Photo:

Description ______________________________________

Source/Credit______________________________________

Slide 2
Describe how this ***BCP*** works to help protect surface and ground water quality.

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Photo:

Description ______________________________________

Source/Credit______________________________________

SW.12.1.AS.B

Best Conservation Practices (BCPs) Handouts

Conservation Tillage[1]

When farmers plow the soil or sow crops we refer to that work as “tilling.” These processes of cultivating the land are referred to as “tillage.”

Conservation tillage practices are used in crop production to reduce negative effects on soil, water and air quality. The three primary conservation tillage practices are designed to limit tilling requirements while maintaining a crop residue on the soil surface.

- ***No-till/Strip-till*** are similar systems that can be described as managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year round, while planting crops in narrow slots or tilled strips in previously undisturbed soil. No-till is defined by NRCS as leaving all of the residue on the soil surface and disturbing no more than 10 percent of the soil surface while planting.
- ***Mulch-till*** systems manage crop residue on the soil surface year round, while growing crops where the entire soil surface is tilled prior to or during the planting operation. Residue is partially incorporated using chisels, sweeps, field cultivators or similar farming implements. Mulch-till is defined as leaving 30 percent crop residue cover after planting.
- ***Ridge-till*** systems manage crop residue on the soil surface year round, while growing crops on pre-formed ridges alternated with furrows protected by crop residue.

Although each of the residue management practices can have favorable impacts on soil, water and air quality, they can vary in the degree of this impact. The benefits are gradually being accepted by the farming community, resulting in increased implementation of conservation tillage in the United States.

Water quality benefits of conservation tillage

Sediment is a major source of non-point source pollutant in the United States. Traditional tillage practices completely expose the soil surface, potentially leading to increased rates of erosion and runoff containing significant amounts of sediment. Nutrients, such as phosphorus and nitrogen, and pesticides and herbicides can also be transported off a farmer’s field by dissolving in runoff or attaching to soil particles that are eroded and carried away with runoff. But even clean sediment that builds up excessively in streams can cause physical problems such as degraded stream habitats and fewer fish, suffocation of eggs and young in spawning beds loss of pool depth and increased expense of water filtration.

1 Adapted from Agricultural Management Practices for Water Quality Protection, EPA Watershed Academy Web: http://www.epa.gov/owow/watershed/wacademy/acad2000/agmodule/agbmp1.htm

SW.12.1.AS.B *(continued)*

Because tillage and residue management practices significantly reduce soil erosion and increase infiltration, the amount of sediment leaving the field and reaching surface waters is greatly reduced. Since conservation tillage increases water infiltration, it can also lead to increased nitrogen leaching to ground water. Therefore conservation tillage should always be combined with comprehensive nutrient management.

Conservation tillage practices in combination with other conservation practices limit water quality problems and the potential threats to fish, benthic organisms, and aquatic plants. In addition to keeping valuable soil on the land, conservation tillage also can save farmers time and money through decreased energy use.

Crop Nutrient Management

Crop nutrient management means managing the application rates, application method, timing of application and nutrient farm of plant nutrients (fertilizer, animal manure, sludge) to minimize losses to the environment. Agricultural crops generally obtain their nutrients through roots or leaves, from the soil, water and atmosphere. Sixteen elements have been identified as being essential to plant growth:

- Carbon (C)
- Hydrogen (H)
- Oxygen (O)
- Nitrogen (N)
- Phosphorus (P)
- Potassium (K)
- Sulfur (S)
- Calcium (Ca)
- Magnesium (Mg)
- Iron (Fe)
- Copper (Cu)
- Zinc (Zn)
- Manganese (Mn)
- Molybdenum (Mo)
- Chlorine (Cl)
- Boron (B)

Carbon, hydrogen, and oxygen are not mineral nutrients, but are the products of photosynthesis. N, P, K, S, Ca, and Mg, are considered macronutrients, because they are needed in relatively large amounts and must often be added to the soil for optimum crop production. The others - Fe, Cu, Zn, Mn, Mo, Cl, and B, are considered micronutrients, because they are needed only in minute amounts and are usually (though not always) present in the soil in ample quantities for crop production.

The practice of crop nutrient management serves four major functions:

1. It supplies essential nutrients to soils and plants so that adequate food, forage and fiber can be produced.
2. It provides for efficient and effective use of scarce nutrient resources so that these resources are not wasted.

SW.12.1.AS.B *(continued)*

3. It minimizes environmental degradation caused by excessive nutrients in the environment, especially in waterbodies that receive runoff, and in groundwater that receives water infiltrated from fertilized fields and other agricultural lands.
4. It helps maintain or improve the physical, chemical, and biological condition of the soil.

Proper nutrient management economizes the natural process of nutrient cycling to optimize crop growth and minimize environmental impacts.

Nutrient Properties

All plant nutrients are cycled through the environment. Three of the nutrients most often limiting to crops—nitrogen (N), phosphorus (P), and potassium (K)—have unique cycles dictated by chemical and biological transformations, movement in soils, and transport by runoff and erosion. Nutrients in the soil are absorbed by plants and incorporated in plant phytomass. When these plants die, the nutrients in their phytomass are decomposed by soil organisms, especially microorganisms and returned to the soil where the cycle begins again.

Nutrient cycles are “leaky,” however. If nutrients are present in the soil in greater quantities than they are needed or at times when they cannot be used by crops or soil microbes, they may be lost to the environment through runoff, erosion, leaching or become air-borne (volatilization). Nutrient availability to crops also depends on the chemical form in which nutrients are present. Nutrients present in an unavailable form will not be taken up by plants even though they may be needed, and may be lost from the cycle. Nitrogen in particular undergoes a number of transformations as it is cycled. These transformations occur under different environmental conditions and understanding when they are likely to occur can help improve nutrient management planning.

Nitrogen is usually the most limiting nutrient in crop production systems and is added to crop in the greatest amount of any of the plant nutrients. Up to a certain point additional nitrogen fertilizer increases crop yield. Nitrogen in the soil system can present an environmental risk to the atmosphere, ground water, and surface water. Significant amounts of surface applied ammonium (NH4+) can be lost to the atmosphere as ammonia gas (NH3) through volatilization. These additions of nitrogen to the atmosphere can contribute to global climate change and acid rain. The ammonia will also increase nitrogen loads to water as it falls back to the earth. Excess movement of nitrogen, primarily from runoff and erosion or leaching, into ground water and surface water can lead to degradation of water quality and risks to human animal health.

SW.12.1.AS.B *(continued)*

Phosphorus is also an essential nutrient for plant growth and occurs in the soil as inorganic orthophosphate and organic compounds. Although the total amount of phosphorus in the soil is large, the quantity of plant available phosphorus in the soil solution is very small, ranging from 0.25 to 3.00 pounds per acre. Phosphorus applied to the land surface either as manure or commercial fertilizer is primarily lost through the process of surface runoff and erosion. Approximately 80 to 90 percent of the phosphorus load is carried in the sediment. The remaining 10 to 20 percent is carried in runoff, or in some cases leaching to groundwater. Generally, phosphorus lost in runoff amounts to less than five percent of that applied to agricultural land. From a crop production standpoint, this amount is considered to be insignificant. From a water quality standpoint, this small amount can lead to significant reduction in surface water quality.

Potassium (K) is utilized in relatively large quantities by plants. The nutrient plays an important role in plant hardiness and disease tolerance. If a soil is high in potassium, forage crops will take up potassium at the expense of magnesium, causing an imbalance in the plant. Cattle grazing this forage will not get enough magnesium, which can lead to the ailment grass tetany. Potassium is also showing up as an imbalance in cattle rations when forages grown on high soil K fields are fed to dairy cattle. Again the imbalance of K to other nutrients, namely calcium and magnesium, is the problem. There are no known deleterious effects of potassium in fresh or saline waters except to increase the salt content and electric conductivity.

Excess Nitrogen and Phosphorus and Impact on the Environment

Nutrients are essential for life, but excessive levels can become a burden on the environment and often create an imbalance in the ecosystem. These impacts can vary depending on properties of the nutrient, the concentration and the characteristics of the nutrient cycle. Some examples of nutrients out of balance with the environment are:

- Excess growth of aquatic plants, including algae and submerged weeds can impair the desired uses of the water body. In general, phosphorus tends to be the cause of eutrophication in fresh waters, while nitrogen is primarily the cause in estuarine or marine waters. Human health can be impacted by disinfection byproducts formed when disinfectants (such as chlorine) used to treat drinking water react with organic carbon (from the algae in source waters). Some disinfection byproducts have been linked to cancer; reproductive health risks; and nervous system problems.
- Nutrient enrichment of fresh or saline waters can cause harmful algal blooms. Impacts of these natural phenomena include human illness (or death) from contaminated seafood, marine mammal and seabird deaths and extensive fish kills

SW.12.1.AS.B *(continued)*

- Excess nitrate-nitrogen and nitrite-nitrogen can be a health risk to humans and animals. Water concentrations of nitrate nitrogen greater than 10 mg/L are considered to be unsafe for human consumption, in particular for babies under six months, causing a life-threatening condition called methemoglobinemia or blue baby syndrome. Blue baby syndrome refers to high levels of nitrate in a baby's blood that reduce the blood's ability to deliver oxygen to the skin and organs resulting in a bluish tinge to the skin, causing serious illness and sometimes death.
- Ammonia (NH3) produced in animal manures and other organic nutrient sources can become toxic to aquatic life. Levels greater than 0.02 mg/L are considered toxic to fresh water aquatic life, including fish.
- Nutrition of forages becomes out of balance when levels of potassium are high. Such nutrient imbalances cause poor livestock health and can even lead to serious illness.
- Excess nutrients can lead to air quality problems such as ammonia volatilization, production of greenhouse gases, and offensive odors.

Integrated Pest Management

Integrated Pest Management is a critical component of conservation planning. It should be used as a part of the other conservation systems to address natural resource concerns and to maximize economic returns by enhancing the quantity and quality of agricultural commodities. Pesticides used in pest management can negatively impact non-target plants, animals and humans. Unintentional exposure may occur in the field and after transport away from the field in soil, water and air. Ground and surface water quality impairment due to non-point source pesticide contamination is a major concern in many agricultural areas.

Integrated Pest Management (IPM)[2]

Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property and the environment.

2 Adapted from Integrated Pest Management Principles, EPA, http://www.epa.gov/opp00001/factsheets/ipm.htm

SW.12.1.AS.B *(continued)*

The IPM approach can be applied to both agricultural and non-agricultural settings, such as the home, garden, and workplace. IPM takes advantage of all appropriate pest management options including, but not limited to, the judicious use of pesticides. In contrast, organic food production applies many of the same concepts as IPM but limits the use of pesticides to those that are produced from natural sources, as opposed to synthetic chemicals.

Integrated Pest Management is therefore aimed at both effective and safe pest control strategies. The goals of IPM are summarized again as follows:

- The pest management component of a conservation plan should enhance crop quality and quantity while minimizing negative impacts to identified resource concerns
- IPM should be utilized where it's available
- The conservation plan should be cooperatively developed with whoever makes pesticide recommendations

Specific examples of integrated pest management include setting a level at which pests present a threat, monitor, and use agricultural practices that minimize pests, such as rotating between different crops, selecting pest-resistant varieties, and planting pest-free rootstock. (For more information, see http://www.epa.gov/pesticides/factsheets/ipm.htm)

Environmental Risks of Pesticide Use

More than 1.2 billion pounds of pesticide active ingredients are used annually in the United States in agriculture, forestry, rights-of-way and by homeowners. Pesticides can negatively impact non-target plants, animals and humans when they leave the field in soil, water and the air. Other risks include harming beneficial organisms and risk to personal safety during pesticide application. Many factors govern the potential for pesticide contamination of groundwater and surface water. These factors include soil properties, pesticide properties, hydraulic loading on the soil and crop management practices.

There are many possible environmental fate processes for a pesticide. These processes can be grouped into those that affect persistence, including photodegradation, chemical degradation, and microbial degradation, and those that affect mobility, including sorption, plant uptake, volatilization, wind erosion, runoff, and leaching. Pesticide persistence is often expressed in terms of field half-life. This is the length of time require for one-

SW.12.1.AS.B *(continued)*

half of the original quantity to break down or dissipate from the field. Pesticide mobility may result in redistribution within the application site or movement of some amount of pesticide off site. After application, a pesticide has the potential to:

- Dissolve in water and be taken up by plants, move in runoff, or leach through the soil column
- Volatilize or erode from foliage or soil with wind and become airborne
- Attach (sorb) to soil organic matter and soil particles and either remain near the site of deposition or move with eroded soil in runoff or wind

The presence of pesticides in the environment can contribute to adverse ecological effects ranging from fish and wildlife kills to more subtle effects on reproduction and fitness. Due to the toxic effects pesticides have on pests and potentially to the environment and human health, EPA regulates their use and exposure. For example, EPA has set standards for pesticide residues in drinking water for organic chemicals (See: http://water.epa.gov/drink/contaminants/index.cfm#organic). Concern for these non-target impacts is key to environmentally and economically viable pest management. Non-target impacts are any adverse health or ecological effects, except on the specific pest(s) the pesticide is signed to kill.

Conservation Buffers

Conservation buffers are areas or strips of land maintained in permanent vegetation to help control pollutants and manage other environmental problems. Buffers are strategically located on the landscape to accomplish many objectives.

Conservation buffers use permanent vegetation to enhance certain ecological functions. For example, the roots of plants stabilize soil and the plant foliage block wind or provide shade. Buffers can vary widely in their vegetation and location on the landscape in order to enhance specific ecological functions that achieve conditions landowners and other stakeholders want. The ecological functions of buffers include creating stable and productive soils, providing cleaner water, enhancing wildlife populations, protecting crops and livestock, enhancing aesthetics and recreation opportunities, and creating sustainable landscapes. Buffers that are located above tile drains will not provide the water quality benefits of filtering pollutants. (See lesson 14)

SW.12.1.AS.B *(continued)*

Riparian Forest Buffer

A riparian forest buffer is an area of trees and shrubs located adjacent to streams, lakes, ponds and wetlands. Riparian forest buffers of sufficient width intercept sediment, nutrients, pesticides, and other materials in surface runoff and reduce nutrients and other pollutants in shallow subsurface water flow. Woody vegetation in buffers provides food and cover for wildlife, helps keep water temperatures cooler by shading small streams, and slows out-of-bank flood flows. In addition, the vegetation closest to the stream or water body provides litter fall and large woody debris important to aquatic organisms. Also, the woody roots increase the resistance of stream banks and shorelines to erosion caused by high water flows or waves.

Grassed Waterway with Vegetative Filter

A grassed waterway is a natural or constructed channel that is shaped or graded to required dimensions and established in suitable vegetation for the stable conveyance of runoff. The primary purposes of a grassed waterway are to convey runoff from terraces, diversions, or other water concentrations without causing erosion or flooding and to improve water quality. The additional benefits of grassed waterways include wildlife habitat, corridors connection, vegetative diversity, noncultivated strips of vegetation and improved aesthetics.

Filter Strips

A filter strip is an area of grass or other permanent vegetation used to reduce sediment, organics, nutrients, pesticides and other contaminants from runoff and to maintain or improve water quality. Filter strips intercept undesirable contaminants from runoff before they enter a waterbody. They provide a buffer between contaminant sources, such as crop fields, and waterbodies, such as streams and ponds. Filter strips slow the velocity of water, allowing the settling out of suspended soil particles, infiltration of runoff and soluble pollutants, adsorption of pollutants on soil and plant surfaces, and uptake of soluble pollutants by plants. The mechanisms of filter strip function can vary according to the characteristics of a pollutant. Secondary benefits of filter strips may also include:

- Forage - for farm use or as cash crop
- Field borders
- Turnrows (area at end of plowed land or furrow where plow is turned)
- Access
- Aesthetics

SW.12.1.AS.B *(continued)*

Vegetative Barriers

Vegetative barriers (also referred to as grass hedges) are narrow, parallel strips of stiff, erect, dense grass planted close to the contour. These barriers cross concentrated flow areas at convenient angles for farming. This practice differs from other conservation buffers because vegetative barriers are managed in such a way that any soil berms that develop are not smoothed out during maintenance operations. Vegetative barriers can be used for the following purposes:

- Control sheet and rill erosion, trap sediment and facilitate benching of sloped cropland
- Control rill and gully erosion and trap sediment in concentrated flow areas
- Trap sediment at the bottom of fields and at the ends of furrows
- Improve the efficiency of other conservation practices

Wind Control Buffers

Vegetation can also be used as a buffer to protect soil, crops, animals, and waterbodies from wind. Three common conservation buffers for wind control are cross wind traps, herbaceous wind barriers, and windbreaks. Cross wind traps are plantings resistant to wind erosion and grown perpendicular to the prevailing wind erosion direction.

Irrigation and Drainage Water Management

Irrigation systems consist of two basic elements: the transport of water from its source to the field, and the distribution of transported water to the crops in the field. Transport of irrigation water from the source of supply to the irrigated field via open canals can be a source of water loss if the canals are not lined. In many soils, unlined canals lose water through evaporation and seepage in bottom and side walls. Seepage water can percolate into the ground water, carrying with it any soluble pollutants in the soil and creating potential for pollution of ground or surface water.

Factors that are typically considered in selecting an appropriate irrigation method include land slope, water intake rate of the soil, water tolerance of crops, and wind. Additionally, the chemical characteristics of the soil and the quantity and quality of the irrigation water will determine whether irrigation is a suitable management practice that can be sustained without degrading the soil or water resources.

SW.12.1.AS.B *(continued)*

There are four basic methods of applying irrigation water: surface, sprinkler, trickle, and subsurface. Gravity-based surface systems use canals or ditches to transport the water to the fields. Pressure-based systems, such as sprinklers, depend on pumping water to the fields and applying the water with a variety of equipment types. Micro-irrigation systems, including trickle and subsurface methods, are designed to apply the required water needs at the root zone of each plant, thus minimizing unnecessary losses to the surrounding soil or non-target plants. The following table describes the common types of irrigation systems and the major features of each. The advantages and disadvantages of the various types of irrigation systems are described in a number of existing documents, manuals, videos and software assembled by the U.S. Department of Agriculture.

Ultimately, cost-effective irrigation matches crop needs while limiting erosion from applied water, reducing the movement of pollutants from land into ground or surface waters, and minimizing wasted time, energy, and water. These goals can be achieved through consideration of the following aspects of irrigation systems:

- Irrigation scheduling
- Efficient application of irrigation water
- Efficient transport of irrigation water
- Use of runoff or tailwater
- Management of drainage water

Reducing nutrient loads from artificial drainage (tile drains, ditches) that drain agricultural fields helps prevent degradation of the water in local streams and lakes. Nitrate loss can be quite high from drained land. Because nitrate is very soluble, it flows easily through the soil and into tile lines. Nitrate flow from subsurface drains is one of the main sources of nitrate in streams and rivers in the Midwest. Concern about drinking water quality, stream health, hypoxia (or low oxygen levels), in the Gulf of Mexico have increased concern about this nitrate pathway. Concentrations of nitrate in tile drains are usually quite high (10-40 mg/l). Methods to reduce nutrients in artificial drainage include, controlled drainage, two-stage ditches, and constructed wetlands."

Grazing Management

Grazing management strategies are applied to activities on range, irrigated and non-irrigated pasture, and other grazing lands used by domestic livestock. Range refers to lands such as natural grasslands, savannas, wetlands and certain shrub lands. In most cases, range supports native vegetation that is extensively managed through the control of livestock rather than agronomy practices, such as fertilization, mowing or irrigation. Pastures are improved lands that have been seeded, irrigated and fertilized and are primarily used for the production of adapted, domesticated forage plants for livestock.

SW.12.1.AS.B *(continued)*

There is a wide range of grazing systems for rangeland and pastures that managers may select from. In all cases, however, the key management parameters are:

- Grazing frequency
- Livestock stocking rates
- Livestock distribution
- Timing and duration of each rest and grazing period
- Livestock kind and class
- Forage use allocation for livestock and wildlife

Fencing cattle off from streams and providing alternate water sources are considered the most acceptable best conservation practices to follow in the control of nonpoint source pollution.

Factors to consider in determining the appropriate grazing system for any individual farm or ranch include the availability of water in each pasture, the type of livestock operation, the kind and type of forage available, the relative location of pastures, the terrain and the number and size of different pasture units available.

Table X:

Grazing System	Description	Comments
Continuous	Unrestricted livestock access to any part of the range during the entire grazing season. No rotation or resting.	Difficult to match stocking rate to forage growth rate. Severe overgrazing occurs where cattle congregate. Other areas underutilized. Long-term productivity depends upon moderate levels of stocking. Can be year-long or seasonal continuous grazing. Less fence and labor than for rotation.
Rotation	Intensive grazing followed by resting. Livestock are rotated among two or more pastures during grazing season.	Each pasture may be alternately grazed and rested several times during a grazing season. Cattle are moved to different grazing area after desired stubble height or forage allowance is reached.
Switchback	Livestock are rotated back and forth between two pastures.	Every 2-3 weeks in N.D., in Texas, graze three months on pasture one, three months on pasture two, then six months on pasture one, etc.

SW.12.1.AS.B *(continued)*

Grazing System	Description	Comments
Rest-rotation	One pasture rested for an entire grazing year or longer. Others grazed on rotation. Multiple pastures with multiple or single hers.	In N.D., four pastures used with one rested, one each grazing in spring, summer, and fall. Rest periods are generally longer than grazing periods.
Deferred rotation	Grazing discontinued on different parts of range in succeeding years to allow resting and re-growth. Generally involves multiple hers and pastures.	Length of grazing period is generally longer than the deferment period.
Twice-over rotation	Variation of deferred rotation, with faster rotation. Uses 3-5 pastures.	Long period of rest between rotations. Sequence alternates from year to year.
Short-duration grazing	Grazing for 14 days or less. Large herd, many small pastures (4-8 cells), high stocking density.	Rest period 30-90 days. Allows 4-5 grazing cycles. Requires a high level of grass and herd management skills. Similar to high intensity-low frequency, but length of grazing and rest periods are both shorter for short-duration grazing.
High intensity-low frequency	Heavy, short duration grazing of all animals on one pasture at a time. Rotate to another pasture after forage use goal is met. Multiple pastures with single herd.	Grazing period is shorter than rest period, and grazing periods for each pasture change each year. In Texas, grazing period is more than 14 days, and resting period is more than 90 days. Texas typically has single herd on four or more pastures.
Merrill	Each of four pastures grazed twelve months and rested four months	Three herds.
Decision rotation	No specific number of herds or pastures.	No set movement pattern.

Another focus of grazing management measures, beyond maximizing production efficiency, is the protection of riparian areas and the control of erosion from other grazing lands above the riparian zone. These measures can reduce the physical disturbance to sensitive areas and reduce the discharge of sediment, animal waste, nutrients, pathogens, and chemicals to surface waters. The loss of stream bank stability, riparian vegetation, stream habitat, and modification of the hydrologic regime due to poor grazing practices can have a devastating effect on stream life.

SW.12.1.AS.B *(continued)*

Appropriate grazing management systems ensure proper grazing use by adjusting intensity and duration to reflect the availability of forage and feed designated for livestock uses, and controlling animal movement through the operating unit of grazing land. Proper grazing use will maintain enough live vegetation and litter cover to protect the soil from erosion; will achieve riparian and other resource objectives; and will maintain or improve the quality, quantity, and age distribution of desirable vegetation. Practices that accomplish this are:

- ***Pasture and hay planting*** - establishing native or introduced forage species.
- ***Range planting*** - establishing perennial vegetation such as grasses, forbs (herbaceous flowering plants), legumes, shrubs and trees.
- ***Forage harvest management*** - the timely cutting and removal of forages from the field such as hay.
- ***Prescribed grazing*** - controlled harvesting of vegetation with grazing or browsing animals, managed with the intent to achieve a specified objective.
- ***Use exclusion*** - exclusion of animals, people, or vehicles from an area to protect, maintain, or improve the quantity and quality of the plant, animal, soil, air, water and aesthetic resources and human health.
- ***Grazing management plan*** - a strategy designed to manage the intensity, frequency, and season of grazing to protect and/or enhance environmental values while maintaining or increasing the economic viability of the grazing operation.

POWERPOINT SLIDES – AS NEEDED:

SW.12.1.TM.A

What are *Best Conservation Practices* for Water Quality Protection?

Farming practices that will protect surface and ground water quality and, therefore, protect human and animal health

SW.12.1.TM.B

Examples of Agricultural Best Conservation Practices for Water Quality Protection[3]

Conservation Tillage and Crop Rotation - leaving crop residue (plant materials from past harvests) on the soil surface reduces runoff and soil erosion, conserves soil moisture, helps keep nutrients and pesticides on the field, and improves soil, water and air quality. Conservation tillage should be practiced with nutrient management and integrated pest management so that excess nutrients and pesticides are not left on the field to seep into groundwater. Rotate crops to break pest cycles, increase soil quality, and reduce need for added nitrogen.

Crop Nutrient Management – appropriate application rate, timing of application, method of application and form of the nutrient. Fully managing and accounting for all nutrient inputs helps ensure nutrients are available to meet crop needs while reducing nutrient movements off fields. It also helps prevent excessive buildup in soils and helps protect air quality.

Integrated Pest Management - varied methods for keeping insects, weeds, disease and other pests below economically harmful levels while protecting soil, water and air quality.

3 From U.S. EPA, Watershed Academy Web Module: http://cfpub.epa.gov/watertrain/moduleFrame.cfm?module_id=33&parent_object_id=1362&object_id=1362

SW.12.1.TM.B *(continued)*

Conservation Buffers - a strip of land, trees, or other vegetation used to "buffer" or filter out chemicals before they reach the water source. From simple grassed waterways to riparian areas along streams and surface waters, buffers provide an additional barrier of protection by capturing potential pollutants that might otherwise move into surface waters.

Irrigation and Drainage Water Management - reducing nonpoint source pollution of ground and surface waters caused by irrigation systems by ensuring the right amount of irrigation. Controlled drainage, such as two-stage ditches or constructed wetlands, help prevent degradation of the water in local streams and lakes by reducing nutrient loads from artificial drainage (tile drains, ditches) that drain agricultural fields.

Grazing Management – practices such as placing a fence near a stream or around a pond to keep livestock out and provide alternate water source for livestock, help minimize water quality impacts of grazing and browsing activities on pasture and range lands.

Animal Feeding Operations (AFOs) Management - minimizing impacts of animal feeding operations and waste discharges through runoff controls, waste storage, waste utilization and nutrient management.

Erosion and Sediment Control - conserving soil and reducing the mass of sediment reaching a water body, protecting both agricultural land and water quality and habitat.

SW.12.2.TM.C

Examples of Tools Used to Create BCPs

Sample Assessment:

- Public health and safety:
    - Wells
    - Mortality disposal procedures
    - Medical waste disposal procedures
    - Disposal of plastic and other solid waste materials
    - Storage and disposal of hazardous products
    - Petroleum storage
    - Pesticide storage and mixing
    - Biosecurity
    - Neighbor issues
- Land and water conservation
- Nutrient management
- Feed management
- Pest management
- Grazing planning

Sample Engineering Assessment

- Provides information about the physical nature of the farm facility and practices
- Creates a map of the physical relationships of the buildings, wells, septic system(s), surface water and other features of the farm area